GUIDELINES FOR SUSTAINABLE URBAN TRANSPORT IN SELECTED AREAS OF THE CITY OF TSHWANE

by

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ABSTRACT

In South Africa, the number of households owning private cars has increased from 22.9% in 2003 to 28.5% in 2013. The City of Tshwane Metropolitan Municipality (City of Tshwane) in South Africa had the largest increase in population that was using private cars between 2003 and 2013 of approximately 11.3%; hence, a need was identified to shift from private cars to sustainable modes of transport. The purpose of this study was to develop guidelines for sustainable urban transport. Geographical location was used for quota sampling to ensure that all seven regions of the Tshwane municipal area would be represented. The sample size of the study comprised 418 participants. The primary data were gathered in Tshwane during the month of August 2017 using a structured questionnaire. The Likert scale was employed to ascertain the public's attitudes towards sustainable urban transport. Descriptive statistics, exploratory factor analysis and inferential statistics were used to analyse the data.

The results revealed that the private car is the most frequently used mode of transport in the City of Tshwane. The results further indicated that the majority of the residents of the City of Tshwane had a negative attitude towards sustainable transport modes, which was attributed to safety, reliability and convenience concerns. Regions 4 and 6 differed statistically and significantly from region 5 regarding their opinions on the safety and comfort of private cars. In order to promote sustainable transportation, it is recommended that the City of Tshwane implement transport initiatives that can improve the service quality and safety features of sustainable transport modes. Each region of the City of Tshwane made specific recommendations that were based on the results of the study.

The findings of this study provide insights that can be useful to the city planners to secure sustainable urban transportation for the City of Tshwane. Future research could investigate the feasibility of public bicycle rental programmes in the City of Tshwane.

Key words: Urban transport, sustainable transport, cycling, public transport, private car, walking

ISISHWANKATHELO

EMzantsi Afrika, inani lamakhaya aneenqwelo mafutha landile ukusukela kuma-22.9% ngonyaka wama-2003 ukuya kuma-28.5% ngowama-2013. Umasipala Wesixeko Esimbaxa saseTshwane (Isixeko saseTshwane) eMzantsi Afrika ube nelona nani lamakhaya asebenzisa iimoto zabucala elande ngaphezu kwabo bonke abanye ooMasipala phakathi kowama-2003 nama-2013, landa ngesithuba se-11.3%. Le nto idale isidingo sokushenxa kwisimbo sokusebenzisa iimoto zabucala, ukuze kusetyenziwe ezinye iindlela zokuhamba eziya kuhlala zihleli. Injongo yesi sifundo kukuvelisa isikhokelo seendlela zokuhamba eziya kuhlala zihleli kwimimandla yasezidolophini. Ekukhetheni abathathi nxaxheba, kwasetyenziswa indawo abahlala kuyo abantu, ukuqinisekisa ukuba zosixhenxe iingingqi zomasipala waseTshwane zinabameli. Ubukhulu besampulu yaba ngabathathi nxaxheba abangama-418. Iinkcukacha zolwazi ezingundoqo zaqokelelwa eTshwane ngenyanga yeThupha kowama-2017, kwaye kwasetyenziswa uluhlu lwemibuzo ecwangcisiweyo. Kwasetyenziswa isikali esaziwa ngokuba yi*Likert scale* ekufumaniseni izimvo zoluntu jikelele ngeendlela zokuhamba eziya kuhlala zihleli kwimimandla yasezidolophini. Iinkcukacha zolwazi (idata) zahlelwa ngokusebenzisa indlela yamanani okucacisa iipatheni zezimvo zoluntu (*descriptive statistics*), indlela yokufumana iimpawu eziphambili kulwazi olufunyenweyo (*exploratory factor analysis*) nendlela yokungqinisisa izimvo ebezifudula zikho ngaphambi kophando (*inferential statistics*).

Iziphumo zophando zadiza ukuba ukusebenzisa imoto yabucala yeyona ndlela yokuhamba esetyenziswa kakhulu kwisixeko saseTshwane. Ezi ziphumo zaphinda zabonisa ukuba uninzi lwabahlali besixeko saseTshwane abazithandi iindlela zokuhamba zikawonkewonke ngenxa yokungabikho kokhuseleko, ukuthembeka nokuba luncedo. Ingingqi yesi-4 neyesi-6 zahlukana kakhulu nengingqi yesi-5 ngokwamanani, malunga nezimvo ezingokhuseleko nokuhlala ntofontofo kwiimoto zabucala. Ukuze kukhuthazwe iindlela zokuhamba zikawonkewonke eziya kuhlala zihleli kucetyiswa ukuba Isixeko saseTshwane senze amalinge okuthutha abantu anokuphucula ukunikezelwa kwenkonzo yothutho, iphucule nokhuseleko. Ingingqi nganye yesixeko saseTshwane yenza iingcebiso ezathi zafakwa kwiziphumo zesifundo.

Okufunyaniswe kwesi sifundo kunika iimbono ezinokuba luncedo kubacebi nabalungiseleli besixeko ekuveliseni iindlela zothutho eziya kuhlala zihleli kwisixeko saseTshwane. Uphando

oluzayo lusenokuphanda ngokusetyenziswa kweenkqubo zokuqeshisa ngeebhayisikili kwisixeko sase Tshwane.

Amagama aphambili: Izithuthi zasezidolophini, izithuthi eziya kuhlala zihleli, ukuqhuba iibhayisikili, izithuthi zikawonkewonke, imoto yabucala, ukuhamba ngeenyawo.

OPSOMMING

Die aantal huishoudings in Suid-Afrika wat private motors besit, neem van 22.9% in 2003 tot 28.5% in 2013 toe. In die Stad Tshwane- Metropolitaanse Munisipaliteit (Stad Tshwane) in Suid-Afrika toon die aantal inwoners wat private motors tussen 2003 en 2013 gebruik, die grootste toename van nagenoeg 11.3%. Daar word op grond hiervan ’n behoefte geïdentifiseer om van die gebruik van private motors weg te beweeg na volhoubare vervoerwyses. Die doel van hierdie studie is om riglyne vir volhoubare stedelike vervoer te ontwikkel. Geografiese ligging is vir die kwotasteekproefneming gebruik om te verseker dat al sewe streke van die Tshwane- munisipale gebied verteenwoordig word. Vir die steekproef wat vir die studie geneem word, word 418 deelnemers gebruik. Die primêre data word met behulp van ’n gestruktureerde vraelys in die loop van Augustus 2017 in Tshwane ingesamel. Die publiek se houdings jeens volhoubare stedelike vervoer word aan die hand van die Likert-skaal vasgestel. Beskrywende statistiek, verkennendefaktor-ontleding en inferensiële statistiek word gebruik om die data te ontleed.

Dit blyk uit die resultate dat die private motor die vervoerwyse is wat die gereeldste in die Stad Tshwane gebruik word. In die resultate word verder aangedui dat die meerderheid inwoners van die Stad Tshwane ’n negatiewe houding teenoor volhoubare vervoerwyses het, wat toegeskryf word aan kwessies van veiligheid, betroubaarheid en gerief. Streek 4 en 6 verskil statisties aansienlik van streek 5 betreffende hul menings oor die veiligheid en gemak van private motors. Om volhoubare vervoer te bevorder, word aanbeveel dat die Stad Tshwane vervoerinisiatiewe implementeer wat die diensgehalte en veiligheidskenmerke van volhoubare vervoerwyses kan verbeter. Elke streek van die Stad Tshwane het vorendag gekom met spesifieke voorstelle wat by die resultate ingesluit is.

Die bevindinge van hierdie studie bied insigte wat bruikbaar vir stadsbeplanners kan wees om volhoubare stedelike vervoer in die Stad Tshwane moontlik te maak. Die uitvoerbaarheid van openbare fietshuurprogramme in die Stad Tshwane kan in toekomstige navorsing ondersoek word.

Sleutelwoorde: Stedelike vervoer, volhoubare vervoer, fietsry, openbare vervoer, private motor, stap

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DECLARATION

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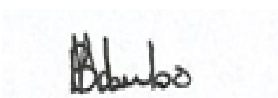
Guidelines for sustainable urban transport in selected areas of the City of Tshwane

I declare that the above dissertation is my own work; and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.



05 June 2018

SIGNATURE DATE

LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
CO_2	Carbon dioxide
CoT	City of Tshwane
DoT	Department of Transport
EU	European Union
ECMT	European Union Council of Ministers for Transport and Telecommunications
GHG	Greenhouse Gas
KMO	Kaiser-Meyer-Olkin
ITF	International Transport Forum
OECD	Organisation of Economic Cooperation and Development
SPSS	Statistical Package for the Social Sciences
UN	United Nations
UNEP	United Nations Environment Programme
UNISA	University of South Africa

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CHAPTER 1

INTRODUCTION TO THE STUDY

1.1 BACKGROUND TO THE STUDY

There is a rapid growth in the world's population and urbanisation, which is leading to unbalanced development and rapid depletion of resources in urban areas (Navamuel, Morollon & Cuartas, 2018). This has led to an increasing number of the world's population that is expected to dwell in cities. It is estimated that by 2050 about 75% of the global population will be living in cities (United Nations [UN], 2015). Research by Cobbinah and Aboagye (2017) states that the increase in urban sprawl has had a direct effect on the transport system. Furthermore, urban transport systems depend heavily on various modes of transport, such as cars, buses, trains and trams (Zhao, Diao & Li, 2017). The increase in individual car ownership and use is fueled by an increase in the global population and the rapid urbanisation in the cities.

Urban transport, particularly motor transport, causes environmental, economic and social externalities[1] that include climate change (Robert, Boren, Ny & Broman, 2017). The transport sector is one of the major contributors to greenhouse gas (GHG) emissions that result in global warming and ultimately in climate change and related environmental decay challenges (Petro & Konečný, 2017; Ramani & Zietsman, 2016). It is reported that the transport sector consumes significant amounts of fossil-based energy, thereby significantly increasing the carbon footprint in the cities. Overall, the transport sector accounts for about 25% of global carbon dioxide (CO_2) emissions with land-based transport emissions accounting for 80% of the total (Klungboonkrong, Jaensirisak & Satiennam, 2017; International Energy Agency [IEA], 2015).

[1]Transport externalities are environmental, social and economic impacts caused by the transport sector, which affects the community; and these externalities are not enjoyed or borne by parties involved in the transaction or action (Cavallaro, 2017).

The energy consumed in the transport sector consists of, amongst others, automobile manufacturing and the use of transport, such as cars, trains, ships and airplanes (ibid).

Urban transport depends amongst other industries on the plastics industry, which produces tonnes of rubber tires for vehicles. Globally, in the United Kingdom, transport is dominated by private vehicles; and it accounts for 83% of passenger traffic (Morton, Budd, Harrison & Mattioli, 2017). In China, the dominating urban transport challenges are those of traffic congestion and air pollution (Lohrey & Creutzig, 2016). Furthermore, it is noted that mega cities in African developing countries, such as Nigeria, South Africa and Kenya, are also experiencing similar sustainable urban transport challenges, such as traffic congestion, air pollution and noise pollution (Chakwizira, Bikam & Adeboyejo, 2014). These developments call for a paradigm shift towards sustainable urban transportation[2].

The concept of sustainability has been reported in the literature since the 1980s (Cheba & Saniuk, 2016; Malasek, 2016). Sustainable urban transport refers to environmentally friendly ways of travelling (Liu, Liddawi & Han, 2015). According to the typical urban set-up, this includes methods, such as walking, cycling and the use of public transport in order to reduce GHG emissions and congestion. Therefore, in the broader sense, sustainable transport refers to transport that result in minimal social, environmental (including climate) and economic impacts (Litman, 2016). According to Khoo and Ong (2015:228), a sustainable transport system has to adhere to the following three aspects:

1. Allow the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations;
2. Operate efficiently, offer a choice of transport mode, be affordable and support a vibrant economy; and

[2] Sustainable urban transportation refers to a transport system that results in minimal social, environmental and economic impacts (Cheba & Sanuik, 2016).

3. Limit emissions and waste within the planet's ability to absorb them, minimise the consumption of non-renewable resources to the sustainable yield level, re-use and recycle its components; and minimise the use of land and the production of noise.

From a global perspective, Amsterdam in the Netherlands and Copenhagen in Denmark are two of the leading cities in the world in terms of sustainable transport usage; while China and India are two of the largest GHG emitters (Hickman & Banister, 2014). In addition, citizens in Amsterdam walk and cycle – not because they are poor; but walking and cycling are perceived as attractive and a healthy way to get to work and access other facilities. Cycling in the city of Copenhagen started at the beginning of twentieth century and the city has successfully driven a massive modal shift from private cars to cycling and walking – by providing the necessary infrastructure for its citizens (Lohrey & Creutzig, 2016). Sustainable urban transport remains a widely acknowledged topic by city officials, institutions and researchers because of negative environmental, social and economic impact caused by transport (Valdes, Monzon & Benitez, 2016; Ramani & Zietsman 2016; UN 2011).

Globally, the biggest challenge in these cities is to reduce individual car use in densely populated areas where the highest traffic flows are observed. To this end, the three main strategies to curb unsustainable transport can be identified as (Bakker, 2014):

- Improving efficiency and reducing the impact of vehicles;
- Using more sustainable transport modes, such as public transport, walking, cycling; and
- Reducing the need to travel.

Based on the study done in India, Verma, Rahul and Dixit (2015) argue that in the absence of proper sustainable urban transport policies, this may lead to an increase in the cost of transport infrastructure; while at the same time, creating environmental, economic and social challenges. In discussing green economy[3] readiness, Nhamo (2013) identifies six readiness pillars, some of which are critical when considering sustainable transport. These readiness pillars include: high level

[3] The green economy is an economy that results in improved human well-being and social equity, while reducing environmental risks and ecological scarcities significantly (United Nations Environment Programme [UNEP], 2011).

political buy-in; financing; institutional and individual capacity development; policy and regulatory framework; research, innovation and development; as well as programmes and projects on the ground.

From a local perspective, South Africa has not been left unscathed by the effects of global warming; and it currently ranks 16th on the global emission list of top 40 countries in the world (The Carbon Report, 2017). The transport sector contributes significant greenhouse gas emissions (14%) in South Africa, due to population and economic growth (Gajjar & Mondol, 2016).

The City of Tshwane is one of the largest cities in the country in terms of population; and it is experiencing urban transport challenges (Nkosi & Masuku, 2016). The City of Tshwane is situated in the Gauteng Province of South Africa. The map of the Gauteng province is shown in Appendix A. The province of Gauteng consists of three metropolitan municipalities, namely: The City of Johannesburg, the City of Tshwane, and Ekurhuleni. The province also has two District Municipalities, namely Sedibeng and West Rand.

According to research done in Poland by Malasek (2016), the author recommends proper formulation and the effective implementation of sustainable transport policies in these cities, in order to support economic growth with minimal harm to the environment and standards of living.

Figure 1.1 represents the percentage of GHG emissions within the transport sector in South Africa.

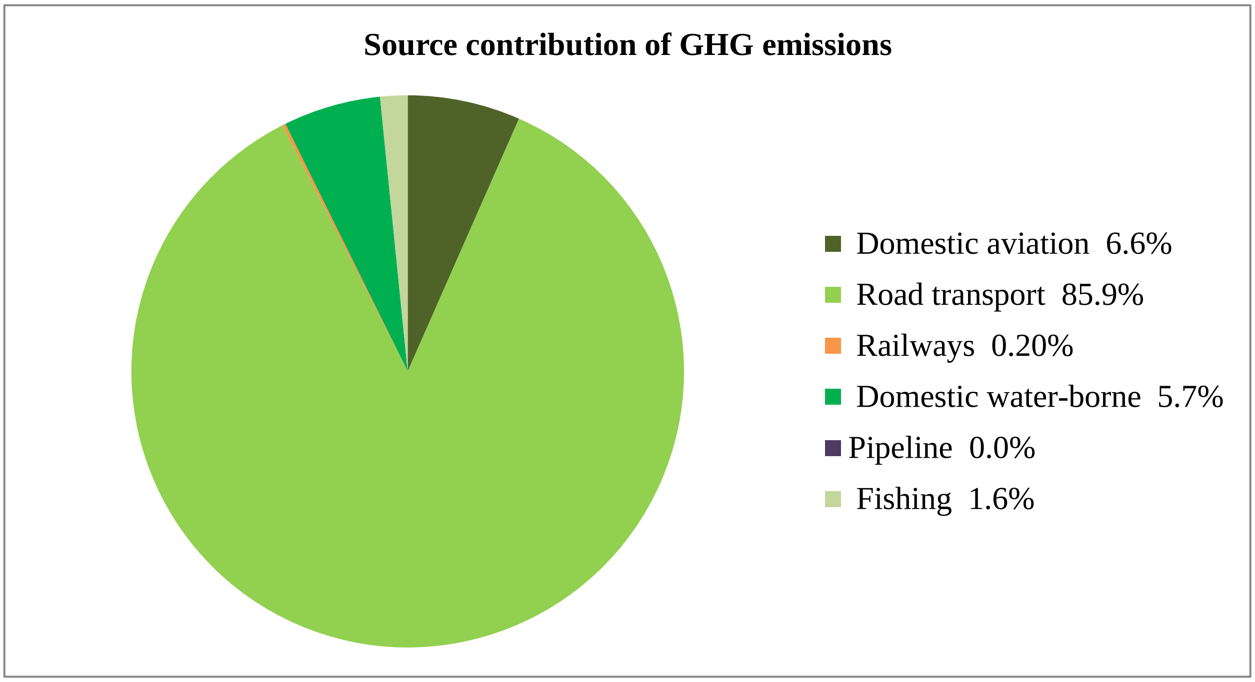

Figure 1.1: South Africa transport sector emissions (2000-2010)

Source: Department of Transport (2016)

In South Africa, the transport sector depends largely on petroleum, which produces CO_2 and other noxious gases when burned (Suleman, Gaylard, Tshaka & Snyman, 2015). As can be seen from Figure 1.1, the major share of carbon emissions is derived from road transport. The transport sector has a critical role to play in reducing GHG emissions. Attard and Shiftan (2015) maintain that the three main threats from the transport sector are: a) local and global environmental degradation; b) the depletion of natural resources that appear to be valuable to the future generation; and c) institutional failures that aggravate the two previous problems. Therefore, South Africa has a role to play; hence there is ample room for improvement in terms of sustainable transport practices and policies, which necessitates further research into this field.

1.2 PROBLEM STATEMENT

Transport plays a critical role in any economy, influencing the location of economic activity, the form and size of cities, and the urban lifestyle (Robert et al., 2017; Jiang, Liu & Lv, 2017). The frequent use of private cars in the city has a significant negative impact on the environment and human life, such as traffic congestion, air pollution and GHG emissions among others (Santos, 2017; Rizzi & Maza, 2017). In South Africa, the number of households owning private cars has increased approximately from 22.9% in 2003 to 28.5% in 2013 (Stats SA, 2014).

The City of Tshwane in South Africa had the largest increase in population using private cars between 2003 and 2013 of approximately 11.3% (ibid). According to Nkosi and Masuku (2016:139), the existing urban transport infrastructure is insufficient to cater for the existing and future transport demand; hence there is a need to shift from private cars to sustainable modes of transport. Various research studies have been done on sustainable urban transport, internationally and locally; which amongst others include the following:

- Khoo and Ong (2015), in their study in Malaysia which investigated the factors that influence public attitude towards sustainable urban transport using a survey method. The attitudinal statements were separated into four factors: ‘awareness’, ‘government action’, ‘service availability’ and ‘willingness to pay’. The findings showed that awareness was the most important factor in influencing car drivers to use sustainable modes of transport. It was also found that the socio-economic background of participants influenced the behaviour towards modes of transport (such as bus, train, bicycle and walking).
- Xia et al. (2017) researched the attitudes of the general public towards sustainable transport in Adelaide, Australia. A survey method was used by using telephone interviews with 381 residents. Descriptive analysis was used to describe the demographic information; while attitudinal statements were factor-analysed into four factors: ‘sustainable transport benefit awareness’; ‘traffic problems awareness’; ‘cycling safety concerns’, and ‘car-use comfort and public transport emission’. The findings of the study showed that it is important to increase the general awareness of traffic problems and the benefits of using sustainable transport to the public. The authors recommended the government to increase the promotion of sustainable transport in Australia.
- In Hong Kong, Chow (2014), carried out a survey method to investigate the effects of urban form on sustainable transport. The factors used in the survey were: density, diversity, design distance to transit and destination accessibility. These findings indicate that better urban designs with integrated planning promote sustainable transport. The author recommended

sustainable initiatives that are already in place in Hong Kong – to encourage the public to use sustainable transport modes, such as the construction of cycling paths and walk pavements.

- Nkosi and Masuku (2016) investigated ways of reducing household travel in the Gauteng province of South Africa. The study was limited to two factors, namely: household attributes and trip-making attributes. A survey-research method was used to carry out the study. The findings indicate that the trip-generation rate had decreased since 2000 due to factors, such as unemployment and reduced household size in the province of Gauteng.
- Venter et al. (2013) conducted research on modal shift in South Africa. The main focus of the research was on shifting the public from private car to public transport in order to attain sustainable transportation in South Africa. The findings showed that different provinces and income groups preferred specific modes of transport, based on three factors, namely: personal, social and environmental factors. Venter et al. (2013), recommended that in order to promote public transport, the national Department of Transport (DoT), needs to fully understand the attitudes of the public towards the different modes of transport.
- Jennings (2015) investigated the opportunities for public bicycle systems in the City of Cape Town, South Africa. The investigation attempted to examine the degree to which a public bicycle system could meet the public transport needs of Cape Town. The limitation of this research is that it only focuses on one mode of sustainable transport.

Venter et al. (2013) clearly state that in South Africa, DoT needs to fully understand the attitudes of the public towards the different modes of transport, in order to guarantee the effectiveness of sustainable transport policy. By doing this research, the attitudes of the public towards sustainable urban transport in the City of Tshwane could provide guidelines to city planners and policy makers and other interested and affected stakeholders, in order to minimise the negative effect of urban sprawl. The guidelines to be developed intend to contribute to a better understanding and satisfaction of public demand, in order to guarantee the effectiveness of sustainable transport policy.

As Liu et al. (2015) observed, the attitudes and perceptions of the public towards sustainable transport contribute to proper alignments of influence and to impartiality.

1.3 RESEARCH OBJECTIVES

1.3.1 Primary research objective

The primary research objective is to develop guidelines for sustainable urban transport in selected areas of the City of Tshwane.

1.3.2 Secondary research objectives

In order to reach the primary objective, the following secondary objectives are needed to:

1. Conceptualise transportation; urban transport; transport externalities, urban sprawl; sustainable development, sustainable urban transport; Greenhouse gases; and congestion;
2. Explore public attitudes towards sustainable urban transport in selected areas of the City of Tshwane;
3. Identify the transport modes used by the residents in selected areas of the City of Tshwane;
4. Determine whether statistically significant differences exist between the regional areas of the City of Tshwane with regard to the attitudes towards sustainable urban transport;
5. Identify transport initiatives that can encourage the public to use sustainable transport modes; and
6. Determine whether statistically significant differences exist between the regional areas of the City of Tshwane in terms of transport initiatives that encourage the public to use sustainable transport modes.

1.4 RESEARCH METHODOLOGY OF THIS DISSERTATION

Research methodology refers to 'the theory of how research should be undertaken' (Saunders & Rojon, 2014:3). It comprehends the philosophical assumptions and underpinnings upon which the research is based and the implications of these for the method or methods that have been used (ibid). The research methodology applied in this study includes both primary and secondary research. Secondary research is discussed in the next section, 1.4.1. It will be followed by primary research in Section 1.4.2.

1.4.1 Secondary research

The term secondary research refers to research principles making use of the primary data collected for one purpose by one party and then put to a second use by another party (McQuarrie, 2015). An extensive literature study was undertaken. This is outlined in Chapter 2 of the dissertation. Previous studies were used as part of the literature review, including books; academic journals; theses and dissertations; internet websites and electronic library databases (Science Direct, Emerald Full Text; Spring Linker; Econ Lit; Sabinet Online Record Display; EBSCO host).

A detailed list of the sources consulted appears in the list of references at the end of this dissertation. The secondary study for this dissertation included the following eight concepts: (1) transportation; (2) urban transport; (3) transport externalities; (4) traffic congestion; (5) urban sprawl; (6) greenhouse gases; (7) sustainable development; and (8) sustainable urban transport.

1.4.2 Primary research

Primary data entail information that has been collected by the researcher of the study and has not been previously used for any other research (van Thiel, 2014:102). Primary research is typically original research.

Primary research was conducted to accomplish the primary objective of the study and to address the secondary objectives of the present study. The primary objective of the study namely: to develop guidelines for sustainable urban transport in selected areas of the City of Tshwane, is supported by secondary objectives. Eight steps were followed during the primary research, and these are discussed next.

The **first** step was to select a research design for the study. The research was of an empirical nature using a survey to collect the primary data. A descriptive approach was adopted, whereby quantitative research was followed.

The **second** step was to select and develop a sampling design for the study. The survey population for this study consisted of the residents from seven regions of the City of Tshwane. A sampling frame of the residents of the City of Tshwane was not available for selecting the sampling elements; therefore, non-probability quota sampling based on the data-collection procedure was used to determine the sample for this study. As the sampling frame was not available, the appropriate sample size recommended was (N=200-500) (Welman, Kruger & Mitchell, 2013; Zikmund & Babin, 2010). Based on Fowler's (2012) table for determining the sample size for a given population, sample size (N=418) was needed to represent a cross section of the population (see Section 3.4.3).

The **third** step in primary research is to select and design the research instrument (the questionnaire). The questions related to the research objectives of the study were compiled in the questionnaire. All the questions were based on the reviewed literature on sustainable transport as well as a previous research related to sustainable transport (Xia et al, 2017; Verma et al, 2016; Liu et al, 2015; Khoo & Ong, 2015; Puhe & Schippl, 2014). The layout of the questionnaire is shown in Table 3.4. The questionnaire consisted of five sections, Sections A, B, C, D and E. A Likert-type scale ranging from 1 to 5 was used in Sections C, D and E (refer to Appendix D).

Section A contained screening questions to determine whether the participant is part of the required population of the study. Screening questions ensured that the correct target demographic was included in the study. Section B gathered general biographic information. The demographic variables that were important to this study were: age, gender, employment status and area of residence. Section C consisted of questions pertaining to transport modes in the City of Tshwane. It was important to identify the modes of transport used by the residents of the City of Tshwane and also to understand the reasons for choosing a particular mode of transport. Section D was concerned with finding out the attitudes of the public towards sustainable transport and the environment. The questions in Section D were grouped by using the factor-analysis method. Lastly, in Section E, the aim was to determine the factors that might increase the attractiveness to residents in using sustainable transport modes. The participants were asked to rate the effectiveness of the suggested transport initiatives. This section attempted to provide some insights on how to improve the sustainable transport system.

The **fourth** step was to carry out a pilot test. Fellow researchers from the University of South Africa, experts and other potential participants (the general public) in the City of Tshwane were asked to complete the pilot questionnaire during the month of July in 2017. Some technical issues were pointed out by the experts. Minor changes were made to the questionnaire following the pilot survey.

The **fifth** step was to conduct the fieldwork for the study. The researcher collected the data from busy areas of the City of Tshwane that were conducive to collecting data such as the city parks, bus stops, sports venues and carwash premises. The data were collected during the month of August in the year 2017. The participants filled out the questionnaires and returned them to the researcher then.

Data processing was the **sixth** step. Once the fieldwork had been conducted and completed, the task of editing, coding, data entry, computer editing and analysing the results took place. General information, such as gender were coded as: male (1) and female (2). Sections C, D and E were coded (1- 5), as shown in Table 3.5. The task of transforming a completed questionnaire was needed, in order to get useable results.

The **seventh** step in the research process was the data analysis. In the process, tables and graphs were used to depict the frequency distribution. A **descriptive analysis** of the data was used for the variables used in the study from Sections C, D and E of the questionnaire. **Exploratory-factor analysis** was conducted to establish whether each of the set of items corresponding to Sections D and E of the questionnaire formed an unidimensional construct, which could be used in subsequent analysis. Exploratory-factor analysis was conducted by using the principal axis factoring-extraction method. **Inferential statistics test** was used to determine whether statistically significant differences existed between the regional areas of the City of Tshwane in relation to Sections D and C of the questionnaire. One-way ANOVA, Krusal-Wallis tests, Chi-square tests, Welch's test and the Tukey-Kramer test were applied in the process of the inferential statistics test.

The e**ighth** and last step was the presentation of the research results. The presentation of the research results was reported in Chapter 5 of the dissertation. The research methodology is outlined in more detail in Chapter 3 of the dissertation. The key terms important in the study will next be discussed.

1.5 DEFINITION OF TERMS

1.5.1 Transportation

Transport (British English) or Transportation (American English) is the movement of people and goods from one location to another (Litman, 2013). Rodrigue (2017), defines transportation as the movement of people, goods and information from one point to another point.

The most important element in the definition of transport is 'movement', regardless of the method whereby this movement is effected. There are four types of transport, namely: land, water, air; and pipeline.

The focus of this study is on urban land-based transport (cars, bus, paratransit modes, walking and cycling) as three quarters of GHG emissions produced from transport sector are from land transport (Andong & Sajor, 2017; Mostert, Caris & Limbourg, 2017; Liu et al., 2015). DoT (2016), reported that land transport, specifically road transport, is the main source of transport-related carbon emissions in South Africa; and it produces 85,9% of the total GHG emission. Therefore, interventions to radically reduce transport carbon emissions are needed. Urban transport will be outlined and defined in the next section.

1.5.2 Urban transport

In the urban areas, there is an increased dependence on individual cars, travel distances and frequency of travelling (Andong & Sajor, 2017). Globally, urban transport is responsible for about three quarters of GHGs produced from the transport sector (Sitanyiova & Masarovicova, 2017; Andong & Sajor, 2017). Urban transport is a term used to describe daily urban mobility that allows access to goods, services, places, networks and opportunities offered by the city (Vecchio, 2017; Makarova, Pashkevich, Shubenkova & Mukhametidinov, 2017).

Urban transport can also be defined as a complex transport system related to (Liu et al. 2015:12):

- People and their daily life activities in cities relating to passengers, freight, activities, work and health;

- Its relationship within society and nature; as seen from aspects, such as the environment, policies, industries, and the economy.

Urban transport also impose negative externalities to both the environment and human health, for example: traffic congestion, road accidents, urban sprawl and air pollution (Rizzi & Maza, 2017; Lohrey & Creutzig, 2016). Transport externalities will be discussed in the next section.

1.5.3 Transport externalities

Transport plays an important role in the development of any nation (Jiang et al., 2017). However, transport, on the other hand, can cause harm both to the environment and to humans that is referred to as transport externalities. In economics, an externality can be defined as 'economic cost normally taken into account in markets or in decisions by market players' (Rodrigue, 2017:9). Externalities can also be described as 'market failures that arise when there is a divergence between social costs and private costs (Eidelwein, 2017:1316). However, in transport, externalities can be defined as environmental, social and economic impacts caused by the transport sector, which affect the community and are not enjoyed or borne by parties involved in the transaction or action (Cavallaro, 2017). Mostert et al. (2017) describe transport externalities as negatives effects produced by transport activities, but not directly supported by the transport sector.

The major distinctions of externalities that are important to transportation are grouped as pecuniary and technological externalities (Button, 2010). Pecuniary externalities result directly from competitive market adjustments and increase the price of a resource (Tresch, 2015). Technological externalities refers to third-party effect that occur in production or consumption and must appear in production or utility function, while it is not same scenario with pecuniary externalities (Petrucelli, 2015; Tresch, 2015). A technological externality can either be positive (benefit) or negative (disbenefit) (Eidelwein, 2018; Stejuha, 2017).

Transport causes transport externalities that go beyond climate change, such as air pollution, accidents, urban sprawl and noise impact (Rizzi & Maza, 2017; Santos, 2017). These transport externalities cause harm to both the environment and humans (ibid). Considering the negative impact of transport, it is therefore necessary to find strategic solutions that can reduce transport externalities.

Some of the transport externalities that are important to this study are discussed in the next section.

1.5.4 Traffic congestion

Traffic congestion is one of the transport externalities that is widely experienced by cities around the world (Santos, 2017; Petro & Konecny, 2017; Rizzi & Maza, 2017; Avila-Torres, Caballero, Litvinchev, Lopez-Irarragorri & Vasant, 2017). There are various definitions of traffic congestion; and the following are some of the definitions used:

Traffic congestion is both a physical phenomenon relating to the manner in which vehicles impede each other's progression; as the demand for limited road space approaches full capacity. It is also a relative phenomenon relating to user expectations vis-à-vis road system performance (Goyal & Kataria, 2015). Santos (2017) describes traffic congestion as the slow moving of vehicles that occurs when the demand for road space is greater than the road space available. Chakrabarrty (2014) highlighted in his definition that the situation of traffic congestion is temporary; whilst Rodrigues's (2017) definitions is similar to that of Santos's definition.

Traffic congestion generates significant externalities, such as the reduction in air quality, long commuting hours and excess fuel consumption (Santos, 2017). Traffic congestion may also lead to higher oil consumption and emissions that are poisoning the air in urban areas (Lohrey & Creutzig, 2016). In South Africa, traffic congestion levels in the cities are high; and they do not seem to be reducing (Luke, 2018). Taking into consideration the impact of traffic congestion, it is necessary to find sustainable solutions to minimise traffic congestion and its negative effects.

1.5.5 Urban sprawl

Cities have undergone a process of urban sprawl in recent decades (Valdes et al., 2016), leaving urban sprawl at the centre of many of the urban transport challenges. Urban sprawl has evolved over time; and the definition of it varies depending on the authors and the areas of study in which they are used. Thus it means different things to different people (Navamuel et al., 2018; Ehrlich, Hilber & Schoni, 2017; Young, Tanguay & Lachapelle, 2016). The following are some of the definitions of urban sprawl:

Urban sprawl can be defined as a 'common phenomenon in cities that have grown following the generalised use of private vehicles as the main mode of transport' (Morollon, Marroquin & Rivero, 2016: 205). Fang, Shenghe, Hong and Qing (2007: 470) define urban sprawl as 'rapid low-efficient and disorderly growth of non-agricultural land towards peripheral areas'. The definition by Cobbinah and Aboagye (2017) is similar to that of Morollon et al. (2016); whilst Young et al. (2016) and Nengroo, Bhat and Kuchay (2017) add a component of the urban-development pattern.

Urban sprawl may translate into increased demand for land, water, energy and infrastructure, such as transport infrastructure (Rodrigue, 2017; Achour & Belloumi, 2016). In addition, urban sprawl is characterised by low-density development, large single-use areas, discontinuous urbanisation and a high rate of private vehicle dependency (ibid). Urban sprawl is detrimental because it creates unnecessary travel, traffic congestion, noise pollution, energy consumption and costs connected to the delivery of urban services (Cobbinah & Aboagye, 2017; Zhou, Jiao, Yu & Wang, 2017). The role of transport is critical; as it provides mobility to the communities within the sprawling urban areas.

1.5.6 Greenhouse gas emissions

In the transport sector, GHG is considered to be one of the important externalities that cause harm to the environment and humans (Taylor, 2017; Santos, 2017; Petrocelli, 2015). GHG refers to the atmospheric gases responsible for causing global warming and climatic change (Zawieska & Pieriegud, 2018; UNEP, 2016). The major GHG gases are CO_2, methane (CH_4) and nitrous oxide (N_2O) (Mir, Purohit & Mehmood, 2017). Less prevalent, but very powerful, GHGs are hydro-fluorocarbons (HFCs), perfluoro-carbons (PFCs) and Sulphur hexafluoride (SF_6) (Liu et al., 2015). GHG emissions contribute to climate change and worsen air quality and human health.

Carbon dioxide, as one of the gases of GHG, is a chemical compound composed of a single carbon atom covalently bonded to two oxygen atoms. Transport sector GHG emissions are largely composed CO_2 (Mansour, Nader, Breque, Haddad & Nemer, 2017; Klungboonkong et al., 2017; Taylor, 2017). Carbon dioxide results from the combustion of vehicle fossil fuels, such as gasoline, diesel and petrol. Therefore, the transport sector has the potential to play a greater role in the enhanced greenhouse effect (ibid). Fossil fuels contain carbon, which when burned with oxygen form CO_2 that enters the atmosphere and impacts on global warming (Santos, 2017).

It is in this context that the development of guidelines for sustainable urban transport becomes important. It could also be important to consider sustainable modes of transport and cleaner fuel for the vehicles as a way of reducing GHG emissions.

1.5.7 Sustainable development

One of the commonly cited definitions of sustainable development is that by the United Nations; and it is regarded as comprehensive (Litman, 2016). In its publication entitled: 'Our Common Future', the UN defines sustainable development as 'development that meets the needs of the current generation without compromising the needs of future generations' (United Nations World Commission on Environment and Development [WCED], 1987:24). Since then, many other definitions for sustainable development have developed (see for example, Verma et al. 2015; Attard & Shiftan, 2015; Malasek, 2016). In summary, the following key points emerge from the definitions:

- In sustainable development, one is considering three main dimensions of sustainability namely: social, economic and environmental;
- The paradigm emerges as a result of biased economic development that considered the environment as an externality; and
- Many resources are infinite and they need serious conservation. In addition, the energy needs, mainly from fossil-based sources have driven the depletion and the pollution of environment (air, land and water).

Sustainable development is not confined to one single sector; it exceeds all traditional limitations; and the transport sector is one of the important areas of sustainable development (Eriksson, 2017) which is focused on safe, efficient, accessible, affordable and inclusive transportation (Makarova et al., 2017). The sustainable nature of transport is outlined and defined in the next section.

1.5.8 Sustainable transport

In view of the transport externalities being faced, there is a need to consider sustainable transport solutions, in order to manage transport externalities. Sustainable transport is complex; as there are various definitions of sustainable transport and there is no standard definition of sustainable transport (Patlins, 2017; Eriksson, 2017; Litman, 2016; Cheba & Saniuk, 2016; Valdes et al., 2017). The definition of sustainable transport takes into account the need for integrating transport, development and climate mitigation, as well as the balance of social, economic and environmental goals (Litman, 2016). The following are some of the definitions of sustainable transport:

Sustainable transport involves the minimisation of transport impact by shifting from unsustainable modes of transport to alternative modes of transport that are friendly to the environment, such as public transport, cycling, walking, car-sharing and clean vehicles (Makarova et al., 2017). Sustainable transport can be defined as a 'transportation system that promotes economic and social growth sustainably, without causing environmental problems now and in the future (Jomnonkwao, Sangphong, Khampirat, Siridhara & Ratanavaraha, 2016).

Attard and Shiftan's (2015) definition is similar to that of Jomnonkwao et al.' s definition; whilst that of Malasek (2016) and Verma et al. (2016) has the additional element of energy consumption.

The ECMT (2001:17) defines sustainable transport as follows:

a) *'It allows the basic access and development needs of individuals, companies, and society to be met safely and in a manner consistent with human and ecosystem health; and it promotes equity within and between successive generations;*
b) *It is affordable it operates fairly and efficiently; it offers a choice of transport mode; and it supports a competitive economy, as well as balanced regional development; and*
c) *It limits emissions and waste within the planet's ability to absorb them; it uses renewable resources at or below their rates of generation; and it uses non-renewable resources at or below the rates of development of renewable substitutes, while minimising the impact on the use of land and the generation of noise.'*

The paradigm of sustainable transport strives for a transport system that does not simply enable the movement of people and goods from one place to another; but rather to accomplish this service, while causing less damage to the environment (Makarova et al., 2017). The objective of this dissertation is to find ways to reduce the role of private vehicles as primary modes of transport and shifting travel towards other sustainable modes, such as walking, cycling and public transport (bus, train and mini-bus taxis).

1.6 OUTLINE OF THE DISSERTATION

The outline of the chapters of this dissertation is illustrated in Figure 1.2.

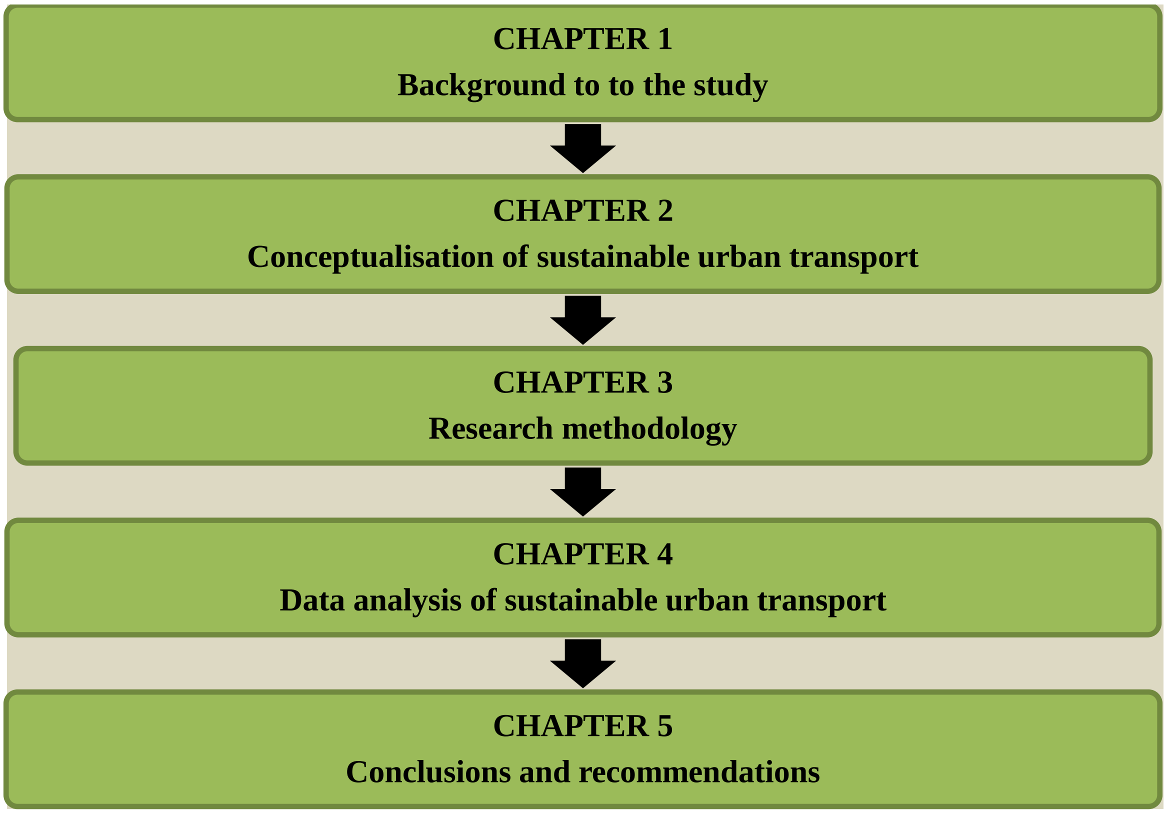

Figure 1.2: Outline of the dissertation

In order to address the problem statement given in the previous section, the chapters in the dissertation are arranged as follows.

Chapter 1 provides the background of the study, the problem statement, the research objectives, the research methodology; and it provides definitions of the important terms used throughout this dissertation.

Chapter 2 consists of a literature review regarding sustainable urban transport. The chapter discusses issues and challenges around sustainable urban transport and important issues regarding transport and climate change.

The research methodology used for the data collection is discussed in Chapter 3. The chapter includes the details for the study area, City of Tshwane, sampling design, measuring instrument, pilot study, data processing and statistical techniques used for analysing the data.

Chapter 4 presents the data analysis and the discussion of the research findings. The chapter provides key research findings drawn from the research study. Based on the previous literature and the results of the study, guidelines for sustainable urban transport were developed for the City of Tshwane.

Lastly, Chapter 5 concludes with a summary of the findings and a discussion of the recommendations for the future research, as well as the study’s limitations.

CHAPTER 2

CONCEPTUALISATION OF SUSTAINABLE URBAN TRANSPORT

2.1 INTRODUCTION

Worldwide, transport plays a major role in the economy and social development of nations, influencing the location of economic activities, the form and size of cities. However, the frequent use of motor vehicles in the city may contribute to a series of health and environmental issues related to greenhouse gas emissions, air and noise pollution (Xia et al., 2017; Savan, Cohlmeyer & Ledsham, 2017; Fazal, 2016; Goyal & Kataria, 2015).

In Chapter 2, the conceptualisation of sustainable urban transport is discussed in more detail. The chapter follows the flow diagram in Figure 2.1.

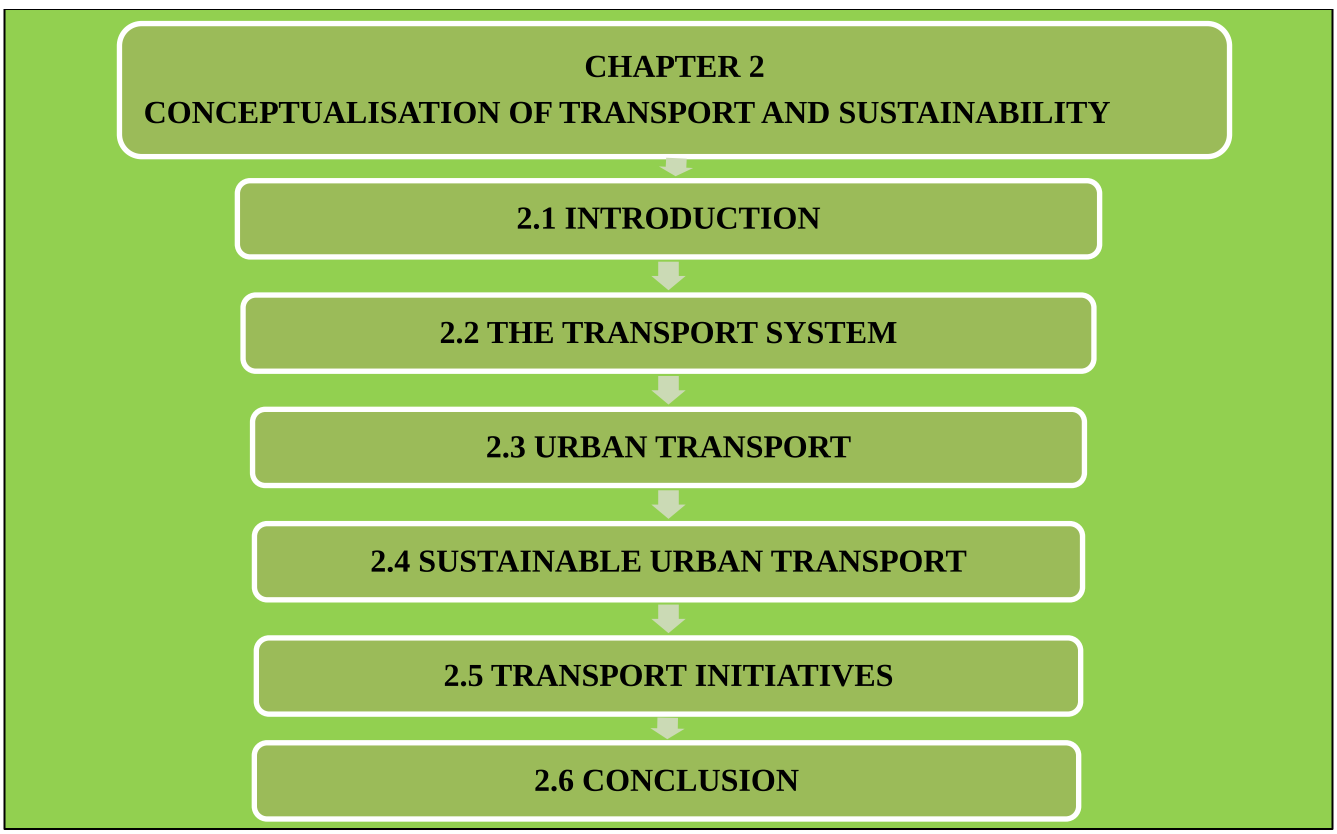

Figure 2.1: Flow diagram of Chapter 2

The aim of this chapter is to conceptualise sustainable transport within an urban context. Sustainable transport involves the minimisation of transport impact by shifting from unsustainable modes of transport to alternative modes of transport that are friendly to the environment (Makarova et al., 2017). The chapter commences by giving a background of the transport system and its components (Section 2.2); and it proceeds to define transport in Section 2.2.1. The importance of transport is discussed in relation to the social and economic benefits to the transport users and the government (Section 2.2.2). Section 2.2.3 is linked to the third secondary research objective: 'to identify the transport modes used by the residents in selected areas of the City of Tshwane'.

However, transport does not exist in isolation; consequently, it is important to set the factors that affect and influence the modal choice. The four main factors that influence modal choice, namely, socio-demographic factors; practical factors; structural factors and psychosocial factors are outlined in section 2.2.4.

This study is based on urban transport (Section 2.3) and the definition of urban transport is provided in Section 2.3.1. Urban transport is divided in to three main subsystems, namely: individual transport; passenger transport; and the freight transport system (Section 2.3.2). The link between urban transport, urbanisation and land use is discussed in Sections 2.3.3 and 2.3.4. The growth in transport use in the city has created a number of serious problems referred to in this study as transport externalities.

The four transport externalities considered important to this study are: traffic congestion, air pollution and GHG emissions, accidents and urban sprawl (Section 2.3.5).

The discussion of transport externalities leads to a discussion on a sustainable transport solution to the transport problems listed in Section 2.4. Various frameworks for sustainable transport have been proposed to deal with the transport problems that are being faced today (Klungboonkong et al., 2017; Mercier et al., 2016; Malasek, 2016). In Thailand, Klungboonkong et al. (2017) developed a framework called Comparative Study on Urban Transport and the Environment (CUTE). Frameworks of sustainable transport developed by various authors are provided in Section 2.4.1.

The effectiveness of sustainable transport policies is largely dependent on the attitudes of the public (Section 2.4.2).

The sustainable development of urban transport systems is only possible if the necessary transport initiatives are implemented and institutionally incorporated into the society. Section 2.5 addresses the fifth secondary objective of the study: ‘to identify those transport initiatives that might encourage the residents of selected areas of the City of Tshwane’. Innovative transport initiatives to reduce the negative transport externalities are needed, in order to move towards a sustainable transport system (Savan et al., 2017; Xia et al., 2017; Liu et al., 2015).

Transport initiatives are classified into four categories, namely: public transport initiatives (Section 2.5.1); cycling initiatives (Section 2.5.2); walking initiatives (Section 2.5.3); and private car initiatives (2.5.4). Lastly, the conclusion is given in Section 2.6.

2.2 THE TRANSPORT SYSTEM

Transport systems play a major role in shaping the nations, influencing the location of economic activity, the form and size of cities – as well as the style and pace of life (Jiang et al., 2017). The transport system is made up of three interconnected components, namely: the transport infrastructure; vehicles and operations (Rodrigue, 2017; Favre, 2014; Button, 2010). Figure 2.2 shows the components that together form the transport system.

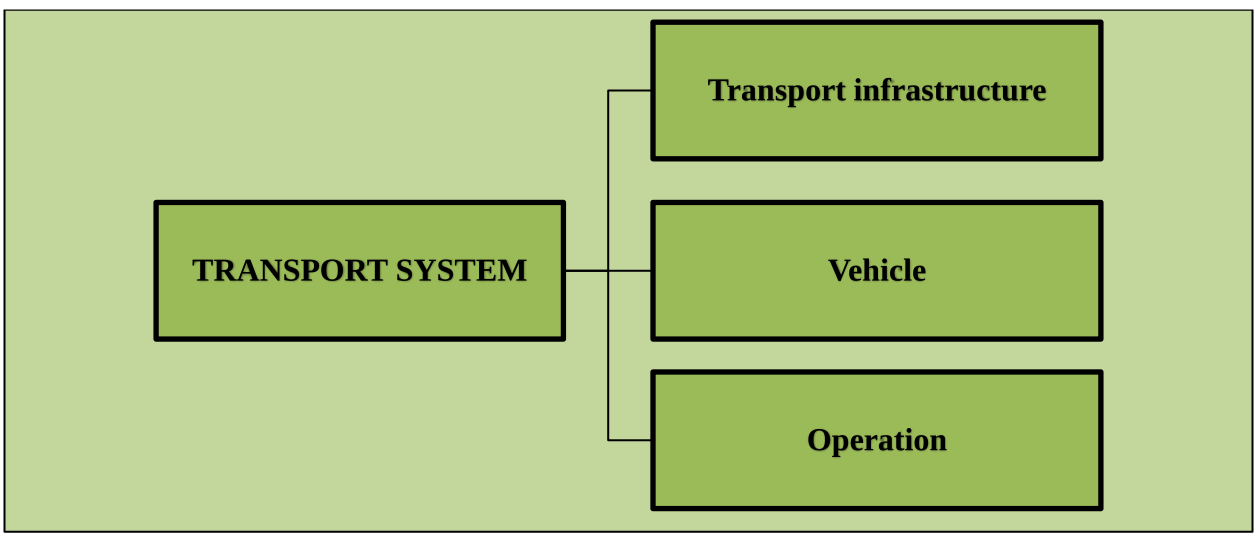

Figure 2.2: Transport system

Source: (Rodrigue, 2017; Favre, 2014; Button, 2010)

In Figure 2.2, the transport infrastructure is regarded as the static component of the transport system that ensures transport operation during the transportation of goods and passengers, such as roads, railways, airports, and harbours (Petrov & Geraskina, 2017). Vehicles are the mobile components of the transport system that aid mobility, such as for example, buses, cars, bicycles and trucks (Rodrigue, 2017). Operations infer management, supervision and the decisions involved in passenger activity and freight activity (Favre, 2014). The transport system is important to this study; as it forms a fundamental point for sustainable urban transport in the City of Tshwane. This is reflected for example in the fifth secondary objective of this study: 'to identify transport initiatives that would encourage the public to use the sustainable transport mode'.

The transport initiatives in Section E of the questionnaire (Appendix E) involve the whole transport system, whereby the three components of the transport system work together, in order to achieve a sustainable urban transport system.

The main function of the transport system is to enable mobility (Sreelekha, Krishnamurthy, Anjaneyulu, 2016). Transport is defined in Section 2.2.1.

2.2.1 Definition of transport

It can be noted from research by Enoch (2012) that over the years, the definition of transport has not changed. Transport can then be defined as the movement of people and goods from one point to another (Litman, 2013). Humphrey (2011) describes transport as a large industry that encompasses passenger and freight transportation. In research by Rodrigue (2017), transport is defined as movement of freight, people and information from one point to another; whilst Enoch's (2012) definition is similar to the definition of Litman. From these definitions, it is clear that movement from point A to B is the central focus. Research by Button, Vega and Nijkamp (2010:xiii), indicates that 'transport is a complex activity involving numerous interactions between actors who are both interested in their own movements; but also those affected by the actions of other'.

The importance of transport to an economy is to promote economic growth (Farhadi, 2015). Transport is associated with various benefits to humans; and these benefits are described in Section 2.2.2.

2.2.2 Importance or benefits of transport

The importance or the benefits of transport in this study are for the general public and government (economic systems). Transport users can be the people in general, local residents hence, for the purpose of this study, the terms transport users, the general public, people in general, local residents, commuters and urban dwellers would be used interchangeably Transportation brings significant social and economic benefits to any nation, as well as improvements in people's standards of living (Jiang et al., 2017; Sreelekha et al., 2016). Various authors (Stejuha, 2017; Petro & Konecny, 2017; Mostert, Caris & Limbourg, 2017; Jiang et al., 2017; Anchour & Belloumi, 2016) classify the importance of transport in relation to economic and social development in the following six areas:

1. Economic development. Robert et al. (2017:53) describe the transport sector as the 'blood system of global economies; ensuring flows of resources and products, connecting organisations and people, and facilitating everyday life and economic development'. Transport fosters economic growth by facilitating trade, permitting access to resources, and enabling greater economies of scale[4] and specialisation (Bakker et al., 2014; Robert et al., 2017). The transport sector directly contributes to GDP through transport infrastructure spending (ibid). Public infrastructure, such as the transport infrastructure can effectively promote the economic growth of any nation through infrastructural expenditure (Farhadi, 2015; Agbelie, 2014; Pradhan & Bagchi, 2013).

Construction of transportation infrastructure can lead to creation, in addition to an increase of intermediate inputs from other sectors; and it stimulates the multiplier effects in the economy (Pradhana & Bagchi, 2013). The Industrial Development Corporation [IDC] reported that the transport sector contributed 10.1% towards South Africa's GDP in 2016 (IDC, 2017). Therefore, the transport sector can be seen as one of the major sectors contributing to the economic growth of any nation.

2. Creation of employment. Transport sectors create a substantial percentage of employment worldwide (Bakker et al., 2014; Rode & Floater, 2014). The transportation infrastructure

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[4] Economies of scales are when the average cost per unit of output declines (Button, 2010).

expenditure causes a significant increase in service-sector employment (Agbelie, 2014). In direct terms, the transport sector creates employment through activities, such as the manufacturing of transport modes (for example cars, bicycles and buses), the construction and maintenance of infrastructure (roads, cycling paths and foot paths) (Mackett, 2015; Agbelie, 2014; Geerling et al., 2012). Ancillary services, such as car parks and petrol stations also play a role in providing employment (Mackett, 2015). Employment in transport can also include the drivers of trucks, bus, trains, mini bus-taxi and logistics companies. In 2016, it was reported that the transport sector of South Africa employed 5.8% workers of the total employed population (IDC, 2017). According to Stats SA 2017, the transport industry employed approximately 468 000 employees between 2015 and 2017.

3. Creation of place utility. Place utility refers to the value created for the product simply by virtue of changing its physical location (CSCMP, Goldsby, Iyengar & Rao, 2014). Industries and markets are often located in different places. Some of their movement may be between rural and urban areas. Therefore, transport bridges the gap between the production and the consumption centres (Farhadi, 2015). Transport links resources and markets in an integrated economy; and it attracts foreign direct investment (Anchour & Belloumi, 2016). Hence, expansion of trading is facilitated.

4. Creation of time utility. Time utility refers to the value created by making the product available when it is demanded (CSCMP et al., 2014). Transport has the ability to compress time and space; and it offers flexibility in movement (Morton, Budd, Harrison & Mattioli, 2017). It enables goods to be distributed in the minimum possible time. Transport enables reduction in travel time for passengers and freight; and it saves time and cost (Anchour & Belloumi, 2016).

5. Increases mobility of labour and capital. Mobility of labour refers to how easy employed population can move from one job to another within the economy. Mobility of the factors of production, such as labour, is increased through an effective and efficient transport system (Farhadi, 2015; Deng, 2013). Transport enables people to move from one place to another in search of jobs. The movement of capital, machinery and equipment is also enabled through transport. Some of the capital machinery may be imported from foreign countries. Without transport, it would not be possible to move such physical assets across geographical boundaries.

6. Increases the welfare of people. Transport infrastructure facilitates a good quality of welfare of people (Anchour & Belloumi, 2016). Transport plays a critical role in the urban development by providing access for people to education, markets, employment and other key services considered vital – resulting in and improved standard of living (Bakker et al., 2017).

The six areas of benefits of transport are revealed as: economic development; the creation of employment; the creation of place utility; the creation of time utility; the mobility of labour and the capital and welfare of people. The economic development indicates the importance of transport to both the general public, as well as to the economy.

In South Africa, the transport sector contributes to employment. Transport creates place utility and time utility, as well as enabling the mobility of labour and capital. The next section defines and discusses the various modes of transport.

2.2.3 Modes of transport

Various modes of transport can enable the mobility of passengers and freight (Litman, 2013). This section is linked to the third secondary research objective, 'to identify the transport modes used by the residents in selected areas of the City of Tshwane'. The mode of transport refers to the means associated with a trip being made by people and goods to achieve mobility (Rodrigue, 2017). Dewi (2010) defines the mode of transport as a 'solution that makes use of a particular type of vehicle, infrastructure and operation'. The main modes of transport can be broadly divided into *three categories,* namely: land transport; water transport; and air transport (Rodrigue, 2017).

1. Land transport involves the movement of goods and passengers on land. Land transport is further divided into road transport, rail transport and pipeline transport.
2. Water transport refers to the movement of goods and passengers on waterways by various means, such as boats, ships and steamers.
3. Air transport involves the movement of goods and passengers through airways by means such as helicopters and airplanes.

From the three modes of transport, land transport is of the significance to the study. This study is focused on land-based transport, specifically urban-passenger transport; as it produces three quarters of the carbon emissions of the transport sector (Zhang, Fujimori, Dai & Hanaoka, 2018; Klungboonkrong et al., 2017; Liu et al., 2015; IEA, 2015). In South Africa, between the year 2000 and 2010, the road transport contributed about 85.9% of total carbon emissions within (the DoT, 2016).

From the three modes of transport, land transport is of significance to the study; as its primary objective is to develop guidelines for sustainable transport in selected areas of the City of Tshwane. The City of Tshwane has a critical role to play in reducing car usage in the city. Therefore, the focus of this study is on land transport specifically road transport, taking into consideration the effects of high car usage in the city.

Urban land transport consists of different modes of transport, such as private cars, public transport and cycling. There are various factors that influence transport users in choosing their mode of transport for specific journeys. The factors influencing the mode of choice are outlined in Section 2.2.4.

2.2.4 Factors influencing the mode choice

Each mode of transport has inherent characteristics, such as infrastructural requirements, fuel needs, operating characteristics, as well as a potential influence on the surrounding land patterns (Rodrigue, 2017; Kutz, 2008). It is important to understand the factors that influence the choice of transport mode; since this affects the urban space devoted to transport the function (Chen, Wu, Chen, Zegras & Wang, 2017). This section is linked to Section C of the questionnaire, which supports the third secondary objective: 'to identify the transport modes used by the residents in selected areas of the City of Tshwane'.

An improved knowledge of the factors that influence the modal choice is essential to policy makers, in order to develop transport policies that are aligned to those factors; since this gives possibility to tackle transport challenges in a correct manner (Pratelli & Brebbia, 2011). People's needs, expectations and knowledge are different; hence, these affect the decisions they make when choosing their mode of transport. According to numerous research studies, choosing a transport mode requires the consideration of multiple issues, which are interrelated to some extent because safety may affect the attitude of an individual towards a certain mode of transport (Cui, Loo & Lin, 2017; McCarthy, Delbosc, Currie & Molly, 2017; Gao, Sun & Li, 2016; Madhuwanthi, Marasinghe, Rajapakse, Dharmawansa & Nomura, 2015; López-Sáez et al., 2014; Pratelli & Brebbia, 2011).

The factors influencing the choice of transport mode can be classified into four categories, namely: the socio-demographic factors, practical factors, structural factors and psychosocial factors (Zhang et al., 2017; Cui et al., 2017; McCarthy et al., 2017; Gao et al., 2016; Madhuwanthi et al., 2015; López-Sáez et al., 2014). The next section discusses the socio-demographic factors that influence the individual's modal choice.

2.2.4.1 Socio-demographic factors

Socio-demographic factors are the first set of factors to be discussed. The movement of people is associated with socio-demographic characteristics, such as age, gender, educational level, income level, work status, household structure, car availability and marital status (Zhang et al., 2017; Madhuwanthi et al., 2015). Rode and Floater (2014) highlighted that the ownership of cars in developing cities and suburban areas is highly influenced by one's status in society. Research by McCarthy et al. (2017) and Susilo et al., (2014) indicates that the household structures have a significant influence on the decision of which mode of transport to use. The higher the number of dependants in a household, the greater the opportunity of using private vehicles.

Pratelli and Brebbia (2011) pointed out that there is no general consensus on gender factor; since some studies report that women are most likely to use cars; as they do more household errands; while, on the other hand, some studies report that men are heavily dependent on cars; while women tend to use the public transport.

2.2.4.2 Practical factors

The second factor to be discussed are the practical factors. In freight, practical factors can be referred to as the transport-service requirements (Meers, Macharis, Vermeiren & van Lier, 2017). Some of the practical factors can be listed as follows: cost, safety, reliability, comfort, security, convenience and route (Xia et al., 2017; Verma et al., 2016; Maduwanthi et al., 2015).

Transport users make conscious decision on mode choice based on *cost* (Zhang et al., 2018; Heinen, 2016, Quin, Chen, Yu & Wang, 2014). According to the research done by Litman (2017a & 2017b) on *cross-elasticities of demand*[5] for transport modes, transport prices are regarded as direct costs of using transport. In addition, prices changes in transport can prompt transport users to shift from one mode of transport to another mode. Previous research indicates that weekend trips are sensitity to price changes while school trips and morning weekday peak time passengers are less sensititvy (Wang, Chen, Wang, & Huang, 2018). However, price sensitivity is influenced by various factors such trips purpose, city geography, period of travel and type of traveller (ibid).

Previous research has shown that *safety* is one of the most important factors to be considered by the commuter, when choosing a mode of transport (Xia et al., 2017; Rode & Floater, 2014; Noor et al. 2014; Fishman et al., 2014; Redman et al. 2013; Stradling et al. 2007). It is reported that the majority of transport users feel safer in the comfort of their own private vehicles. Safety is still a dominating factor in choosing a mode of transport in specific cases, for example in parents with young children (McCarthy et al., 2017).

Transport users that perceive cycling as unsafe are not likely to change their option and consider cycling – unless safety issues are put in place (ibid). Therefore, it could be important for transport planners and policy-makers to improve the safety issues around modes of transport, such as cycling. It is recommended to implement transport initiatives that enhance safety issues in cycling so as to change the mindset of commuters (see Section 2.5.2).

Since public transport is regarded as one of the sustainable transport modes, *service quality* is a factor that influences the commuter perceptions and influences the use thereof (Certeni & Henke, 2017). *Reliability* is a fundamental service quality factor that is especially associated with public transport that influences commuters in choosing public transport for daily trips (Ambrosiano, Disperati, Gini & Mussone, 2017; Jomnonkwao et al., 2016; van Oort, 2016). In order to shift transport users from private cars to public transport it could be important to improve critical issues

[5] Cross- elasticities refer to 'the percentage change in the consumption of a good resulting from a price change in another related good for example increase in price of driving can lead to an increase in demand for public transport', (Litman, 2017a: 2)

such as reliability of service. Some of the public transport initiatives to improve public transport service are discussed in Section 2.5.2.

Comfort and convenience are elements that are associated with private car use; and they are highly regarded by commuters in their modal choices (Jomnonkwao et al., 2017; Rode & Floater, 2014, Fishman; et al., 2014; Chee & Fernandez, 2013). Commuters are of the opinion that public transport is not convenient or really comfortable (see Section 4.3.9). Therefore, it could be important to improve the comfort and the convenience in the public transport service, in order to increase the numbers of public transport commuters.

The next section will discuss the structural factors that influence the public's modal choices.

2.2.4.3 Structural factors

Structural factors comprise the third set of factors that influence modal choice to be discussed. In transport, structural factors that influence modal choice can be classified as the built environment and the transport infrastructure (Ye & Titheridge, 2017; Verma et al., 2016; Chen et al., 2017; Susilo et al., 2012). The infrastructure available affects the decision-making of commuters; since such inadequacies in the urban design are often an impediment to the use of alternative modes of transport (Lopez-Saez et al., 2014). Proximity to transport infrastructure, such as road networks, bus stops, cycling-path networks, foot paths may be considered important by transport users in the community (Pratelli & Brebbia, 2011). It may be assumed that communities coupled with cycling paths are likely to encourage the public to cycle for short trips. Individuals that are close to bus stops may be influenced to use buses in making daily trips into and around the city compared compared to those individuals who live far away from bus stops. In the City of Tshwane, houses that are located closer to the Gautrain shuttle bus stops are more likely to encourage commuters to use the Gautrain shuttle bus to the train station, rather than driving private cars to the train station.

Previous research indicates that the provision of transport infrastructure, such as roads, cycling tracks and walking paths have significant influence on the modal choice, particularly where there are safety concerns (see Section 2.5.2; 4.3.11 and 4.3.10). It is evident from cities, like Copenhagen, that transport infrastructural initiatives, such as dedicated cycling lanes and walking paths increased the modal shift from private cars to alternative modes of transport (Buehler et al., 2017b). Copenhagen, over the years has successfully managed to implement a safe transport infrastructure to accommodate walking and cycling (ibid). Footpaths and pedestrians crossings that are poorly kept or non-existent are highly unsafe and unattractive to young children (McCarthy et al., 2017).

It could be important to improve the transport infrastructure, in order to influence the public to use sustainable transport modes. Psychosocial factors are outlined in Section 2.2.4.4.

2.2.4.4 Psychosocial factors

The last set of factors to be discussed is psychosocial factors. This section is linked to the second secondary objective, 'to explore public attitudes towards sustainable urban transport in selected areas of the City of Tshwane'. Psychosocial factors that influence modal choice can be identified as: attitude, social norms, intentions and perceptions (Jomnonkwao et al., 2016; Pratelli & Brebbia, 2011). All the psychosocial factors will be discussed in this section – with the exception of 'attitude' that is to be discussed in Section 2.4.2.

The theory of planned behaviour (Ajzen, 1991) has long recognised that people are influenced by psychosocial factors; and this is accepted in the transport studies (Verma et al., 2016; Jomnonkwao et al., 2016). Psychosocial factors are more aligned to mode choice in favour of cars (Morton et al., 2017; Xia et al., 2017). The importance of a car is often associated with positive emotion and psychological stimulus; since it represents the identity of the driver of a car (ibid). Han (2010) states that in society, private cars represent and offer power or status in the society, freedom, wealth, privacy and the idea of self-reliance; since such private vehicles are a popular choice because of the appealing factors that are associated with owning private vehicles.

Habits can be described as the repetition of a given behaviour (López-Sáez et al., 2014). Habits have proved to be an obstacle for people to consider sustainable transport modes, even if they are accessible (ibid). This is consistent with previous research indicating that habits influence the choice of mode of transport (Xia et al., 2017). Regular habit patterns, such as work trips and school trips are not conscious processes; they are influenced by the inertia of habits (ibid). Commuters are not likely to consider other choices, once they are settled into a routine, such as using a car for work trips (ibid). However, habits are changed by major life events, such as getting married, having children, moving home, getting a job, getting a driving licence and getting divorced (Ryley & Chapman, 2012).

Major life events break the routine; hence, the re-orientation of modal choice is required (ibid). Figure 2.3, below shows how major events may affect the habits of the commuters.

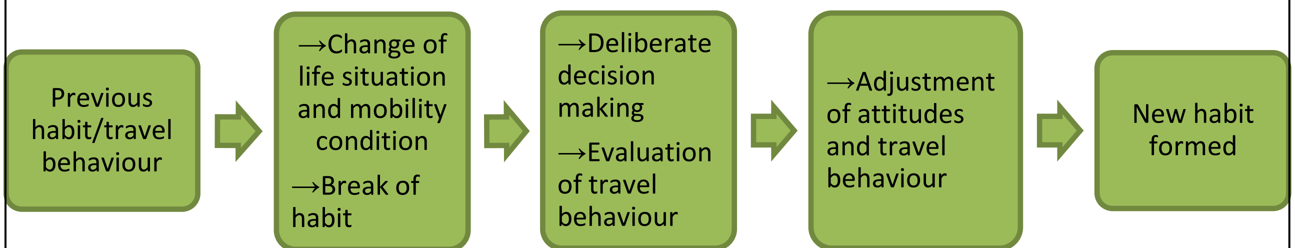

Figure 2.3: How major events affect travel behaviour

Source: Busch-Geertsema & Lanzendorf (2015)

From Figure 2.3, it is clear that when there is a change of a life situation and mobility condition, deliberate decision-making is activated. This leads to an adjustment of attitudes and travel behaviour and new habits or travel behaviour are formed.

Social norms refer to the influence of other people on one's behaviour (Ryley & Chapman, 2012). Social norms are based on social pressure from people, such as parents, reference groups, culture and friends, as well as social networks (de Souza et al., 2014). The decisions that people make when choosing the mode of transport will be based on these people. Positive norms are associated with greater use of a specific mode of transport (ibid). Norms are alleged to be a strong cause of behaviour; and they can be used to steer people towards sustainable transport modes (Ryley & Chapman, 2012).

Therefore, awareness programmes may be used to change the mindset of commuters and steering them towards sustainable transportation. Factors influencing the choice of transport mode were revealed as socio-demographic, requirements of transport, structural and psychosocial factors. Understanding the factors that influence modal choice in the city are important to identify barriers of sustainable transport in the city and to improve areas that matter in the development of urban transport. Urban transport will be discussed in the next section.

2.3 URBAN TRANSPORT

Urban transport in this study focuses on passenger transport; and the terms that will be used to describe transport users are commuters, the public and urban dwellers. For the purpose of this study, the terms will be used interchangeably. Urban transport provides mobility to the urban dwellers, in order to access services and amenities in and around the city. There is an increased dependence on individual cars, travel distances and the frequency of travelling in the urban areas (Andong & Sajor, 2017). However, increased dependence on private cars is associated with various transport externalities and considered to contribute significant levels of carbon emissions in the city in the transport sector (Mostert et al., 2017; Rizzi & Maza, 2017). Globally, urban transport is responsible for about three quarters of GHG produced from the transport sector (Sitanyiova & Masarovicova, 2017; Andong & Sajor, 2017). This section is linked to the first secondary objective of the study, to conceptualise transportation; **urban transport**; transport externalities; urban sprawl; sustainable development, sustainable urban transport; Greenhouse gases; and congestion. Urban transport is defined in Section 2.3.1.

2.3.1 Definition of urban transport

Various authors (Liu et al. 2015:12; Vecchio, 2017; Makarova et al., 2017; Arnott & McMillan, 2007) defined urban transport as:

- *"A complex transport system related to people and their daily life activities in cities relating to passengers, freight, activities, work and health"* (Liu et al. 2015:12).

- *"Daily urban mobility that allows access to goods, services, places, networks and opportunities offered by the city"* (Vecchio, 2017; Makarova et.al, 2017).
- *"deals with transportation in cities" (*Arnott & McMillan, 2007)

From the definitions, it is evident that urban transport is alleged to be more complex than other transport sectors: not just because it involves the integration of different transport systems; but also because it co-produces accessibility, jointly with land use development (Rodrigue, 2017; Rode & Floater, 2014). The spatial needs of transport infrastructure in urban areas are considered to be higher than in rural areas (ibid).

Urban transport is divided into three subsystems and the subsystems are discussed in section 2.3.2.

2.3.2 Subsystems of urban transport

Urban transport is subdivided into three main subsystems: individual transport; passenger transport; and the freight transport system (Rodrigue, 2017; Favre, 2014).

1. **Individual transport**. Individual transport is based on personalised choices, for example cars, walking, cycling and motorcycle. Urban transport is characterised by an extensive and growing use of the car as the main means of transport (Moody, 2016). Cars are transport modes that are the most flexible and convenient of all the transport modes. Cars give individual freedom and independence to travel (Rodrigue, 2017). Basic mobility can be achieved by walking. Walking is the oldest form of transport. In Tokyo, walking accounts for 88%; while in Los Angeles, walking accounts for only 3% (Rodrigue, 2017). Cycling has been adopted in developed countries, like Denmark (Copenhagen) and the Netherlands (Amsterdam) (Bakker et al., 2014).

2. **Passenger transport**. Passenger transport is transportation that provides the public with accessibility in and around the urban areas (Vicente & Reis, 2016). Examples of passenger transport modes are: buses, trains subways and tramways (Nutsugbodo, Amenumey & Mensah, 2018). Passenger transport modes, such as buses, trains and trams, are regarded as the most economical modes; as they make the most efficient use of road space in the urban areas compared with individual transport (Rodrigue, 2017).

3. **Freight transport system**. The freight transport system provides the movement of goods from where they are to a place where they will be of greater value to both the producer and the consumer (Kiba-Janiak, 2017; Favre, 2014). Cities are the locations where economic activities, such as production and consumption, take place (Rodrigue, 2017). As such, these economic activities require large movements of freight between industries, distribution centres and warehouses, as well as terminals, such as airports. Transport modes used for the transportation of freight are mainly from small to large trucks, depending on the technical aspects and the capacity of the vehicle provided.

The three subsystems of urban transport are individual transport, passenger transport and the freight transport system. The subsystems of urban transport enable cities to meet the demand for transport and to function well. There is an increased demand for urban transport that is linked to urbanisation (Fan, Wang, Li, Yu & Zhang, 2017). The next section discusses the link between urban transport and urbanisation.

2.3.3 Urban transport and urbanisation

Urbanisation and urban transport are closely linked; because cities have developed together since the earliest human settlements (Goyal & Kataria, 2015). Urbanisation is a process of transition whereby people living in the rural areas migrate to the urban areas[6] (UN, 2015). Urban areas include a band of urban spatial structures, ranging from small towns to large urban agglomerations (Rodrigue, 2017). The world is undergoing a renaissance, with the increase in urban population, including the development of Megacities, Metacities and Megacity regions[7] (Hickman & Banister, 2014). Examples of large cities can be identified in Japan (Tokyo to Nagoya and Osaka), in China (the Pearl River Delta) and in Africa (Lagos, Johannesburg and Nairobi). Large scale urbanisation

[6] Urban areas can be defined as (Ahmad Oliveira, 2016:107):
1)All places with a municipality, corporation, cantonment board or notified town area committee; and
2)All other places which satisfies the following three criteria: (i) a minimum population of 5000; (ii) at least 75% of the male main working population engaged in non-agricultural pursuits; and (iii) a density of population of at least 400 persons per square kilometer.

[7] Megacity is a city with a population of over 10 million while Metacity is a city with a population of over 20 million and Megacity region is a region with population of over 80 million (Hickman & Banister 2014:1).

is alleged to have started being acknowledged after World War II when global urban population entered a phase of accelerated growth and growth in economic activities (Rodrigue, 2017; Chakrabarrty & Gupta, 2014). Research indicates that continuous urbanisation creates cities that are bigger with higher densities that require more infrastructural investment – especially in transport (Chakrabartty & Gupta, 2014; Han, 2010).

Urbanisation is an important process; but this is contested because of the considerable opportunities and challenges it imposes on humans and the environment (South African Cities Network [SACN], 2016). The world's urban population is expected to grow from 6.4 billion in 2010 to 8.8 billion 2050 (OECD/ITF, 2015; UN, 2015). In the year 2017, it was estimated that approximately 54% of the world's population was now living in towns and cities (Statista, 2018). Current global trends indicate that urbanisation will carry on well into the 21st century (Rodrigue, 2017).

The three main causes of rapid urbanisation are natural increase, rural to urban migrations, and international migration (Rodrigue, 2017; Pirie, 2013). Cities dominate the national economic output; and they are believed to be generating the main sources of employment in areas, such as manufacturing and service provision (Hickman & Banister, 2014). Urbanisation provides access to a wide range of opportunities, such as employment opportunities, good quality of life, and access to improved infrastructure and services (SACN, 2016).

In South Africa, growth in urbanisation has largely been influenced by international migration (Stats SA, 2016). Urban population in South Africa has accelerated since the 1980s partly due to rural-urban migration, increase in population growth and international migration (DoT, 2016; Stats SA, 2017). The national population living in South Africa's cities is estimated to be 62%; and it is expected to exceed 71% by the year 2020 (Turok & Borel-Saladin, 2014).

Therefore, it can be assumed that continuous growth in urban population may lead to increased demand for public infrastructure, such as transport; and this may lead to a change in land-use that is discussed in the next section.

2.3.4 Transport and land-use

The term 'land use' refers to the human activities, such as working, living, shopping, education and leisure, which are held in the urban space (Eboli, Forciniti & Mazzulla, 2012). The relationship between land use and transportation is complex; because it is closely linked to other urban variables, such as demography, interregional migration and technological innovation (Litman, 2017; OKI, 2017; Rodrigue, 2017; Fischer & Nijkamp, 2014). The relationship is described by Eboli et al., (2012) as 'land use transport feedback cycle'; since it is difficult to identify the one that triggers the change in the other. The debate on whether transport triggers the change in land use or land development triggers transportation has been an ongoing matter among transportation professionals (ibid).

Urbanisation brings with it significant changes in land use for residential, commercial and industrial activities and an increased demand for transport (Fazal, 2016). Figure 2.4 illustrates the vicious cycle of land use and transportation.

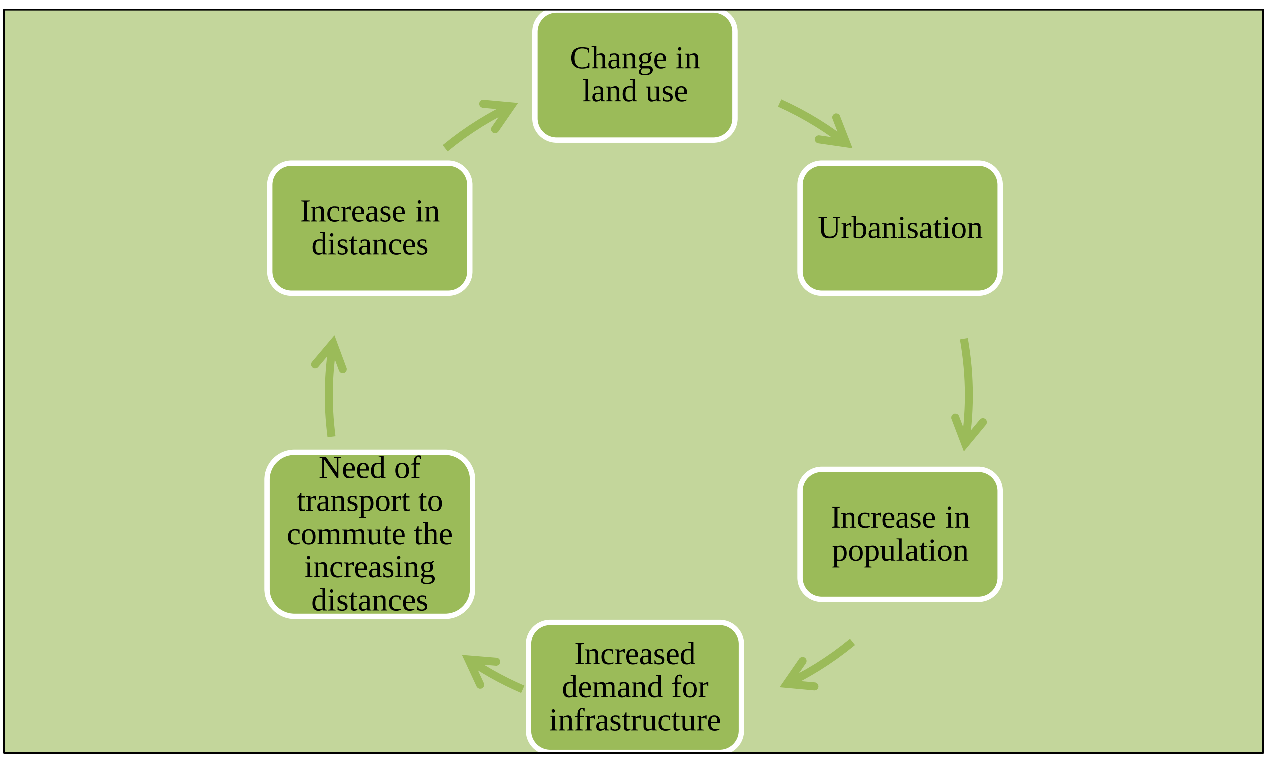

Figure 2.4: Vicious cycle of land use and transportation

Source: Pratelli & Brebbia (2011)

Figure 2.4 indicates that urban transport supports the transport demand generated by the change in land use. The transport system improves accessibility for the area; and, in turn, the area becomes more attractive for the distribution for land uses, such as residential, industrial or commercial uses (Pratelli & Brebbia, 2011). Improved access to transport can then motivate urban dwellers to build on the periphery – thereby increasing urbanisation and other activities. Transport systems evolve and encourage rapid urbanisation (ibid). The increased rate of urbanisation and spatial distribution of household activities ends up in urban sprawl (Rodrigue, 2017; Achour & Belloumi 2016).

In addition, urban sprawl exhibits largely total dependence on automobile use; since urban sprawl cannot be supported without a vast and complex transport system (ibid). Rapid urbanisation develops the urban structure; and that increases the reliance on motorised transport and large distances (Zhao et al., 2017).

The role of transport becomes critical in providing mobility to the urban dwellers within the sprawling areas. Increasing dependence on private cars may result in several negative transport externalities, among others, traffic congestion, air pollution, accidents and GHG emissions (Andong & Sajor, 2017; Young et al., 2016). Transport externalities are discussed in the next section.

2.3.5 Transport externalities

Transport plays a critical role in the social and economic development of any nation (see Section 2.2.2). However, various authors report that the provision and the frequent use of transport generates transport externalities that are harmful to the environment and human health (Santos, 2017; Petro & Konecny, 2017; Cavallaro, 2017; Rizzi & Maza, 2017; Rodrigue, 2017; Petrocelli, 2015; Geerlings, Shiftan & Stead, 2012; Button, 2010).

'Externality is an economic concept that refers to the activities of a group that has consequences, positive or negative, intended or unintended, on other groups' (Rodrigue, 2017:4). Button (2010) describes externalities as activities of one group that have an effect on the welfare of the other group – without any payment or compensation being made. Externalities can also be described as the effects of escalating from production or consumption that affects a party other than the producers and the consumers (Petrocelli, 2015).

The major distinctions of externalities that are important to transportation are grouped as pecuniary and technological externalities (Button, 2010). Pecuniary externalities result directly from competitive market adjustments and increase the price of a resource (Tresch, 2015). Technological externalities refers to third-party effect that occur in production or consumption and must appear in production or utility function, while it is not same scenario with pecuniary externalities (Petrucelli, 2015; Tresch, 2015). A technological externality can either be positive (benefit) or negative (disbenefit) (Eidelwein, 2018; Stejuha, 2017).

In transport, externalities can either be benefits or costs; although benefits are regarded as less important to the transport sector (Button, 2010). An example of positive externality is the improvement of the economy of a State (Stetjuha, 2017). Negative transport externalities can be defined as:

- *Costs related to the negative effects of transport activities imposed on the environment and human health* (Petro & Konečný, 2017);
- *Environmental, social and economic impacts caused by the transport sector, which affect the community and are not enjoyed or borne by the parties involved in the transaction, or action* (Cavallaro, 2017).
- *Negatives effects produced by transport activities, but not directly supported by the transport sector* (Mostert et al., 2017).

From the definition, the negative externalities of transport can be classified into three categories, namely: economic, environmental and social impacts. Table 2.1 summarises the externalities of transport that cause damage to the environment and human health.

Table 2.1: Transport externalities

Economic	Environmental	Social
Traffic congestion	Air pollution	Human health
Tax burden	Climate change	Inequality of impacts
Crash damages	Habitat loss	Mobility
Transportation facility cost	Water pollution	Disadvantaged
Consumer transport cost	Noise pollution	Community cohesion and livability
Depletion of non-renewable resources	Greenhouse gas emissions	Aesthetics

Source: Ugboaja (2013)

In the transport sector, the four common types of transport externalities considered important and that are relevant to the current study are (Rizzi & Maza, 2017; Santos, 2017):

- Traffic congestion (Section 2.3.5.1);
- Short range pollution (air pollution) and long range pollution (GHG emissions) (Section (2.3.5.2);
- Accidents (Section 2.3.5.3); and
- Urban sprawl (Section 2.3.5.4).

Traffic congestion is defined and outlined in Section 2.3.5.1.

2.3.5.1 Traffic congestion

Traffic congestion is the first transport externality to be discussed. Traffic congestion is one of the ancient transport problems, since Julius Caesar in ancient Rome first tried to reduce traffic congestion in the city (Rodrigue, 2017). Various authors concur that traffic congestion is one of the transport externalities that is widely experienced by cities around the world (Santos, 2017; Petro & Konecny, 2017; Rizzi & Maza, 2017; Avila-Torres et al., 2017). Traffic congestion is a condition in which the demand for road space exceeds the supply. The following two definitions of traffic congestion are:

- *"When the capacity of transport infrastructure at a given time has been exceeded by the transport demand" (Button, 2010).*
- *"It is described as the slow moving of vehicles that occurs when the demand for road space is greater than road supply"* (Santos, 2017).

Rodrigue (2017) states that congestion *'occurs when transport demand exceeds transport supply in a specific section of the transport system'.*

Traffic congestion is both a physical phenomenon relating to the manner in which vehicles impede each other's progression; as the demand for limited road space approaches full capacity, as well as a relative phenomenon relating to user expectations vis-à-vis road system performance (Goyal & Kataria, 2015).

Traffic congestion refers to the state that affects transport networks when the demand for a facility temporarily exceeds the capacity thereof (Chakrabarrty, 2014).

It may be concluded that traffic congestion is characterised by slow speed, longer trip times, long vehicular queuing and when the demand for road space is greater than the road capacity. Traffic congestion is caused by various factors, such as high population and employment growth; rapid urbanisation; high growth in motorisation; and relatively fixed and finite road supply (de Souza et al., 2017; Ewing, 2016; Young et al., 2016; Fazal, 2016, Goyal & Kataria, 2015). India is the world's second country with cities that are heavily congested (Chakrabartty & Gupta, 2014). In the European Union, the total cost caused by road congestion is estimated to be around 2% of GDP

(Geerlings et al., 2017). South African cities, especially in the Gauteng province, traffic congestion is increasing at an alarming rate (Suleman et al., 2015).

In summary, *traffic congestion* is an important component of transport externalities created and associated with road users in the urban areas. Some of the negative effects mentioned above are: time losses, long commuting hours, loss of production, high accident rates. Traffic congestion contributes to high levels of air pollution and GHG emissions in the city. GHG emissions are discussed in Section 2.3.5.2

2.3.5.2 Air pollution and GHG emissions

The second transport externality to be discussed is air pollution and GHG emissions. Urban transport activities contribute to local air pollution, leading to severe health problems, such as cardiovascular, respiratory diseases and numerous cancers (Liu et al., 2015; OECD/ITF 2015). Song et al., 2017). It is estimated that globally, air pollution is leading to over three million deaths every year; and it also causes other serious health problems (Song et al., 2017).

GHG refers to the atmospheric gases responsible for causing global warming and climatic change (UNEP, 2016). The major GHG gases are carbon dioxide, methane and nitrous oxide. These are generated from fossil-fuel combustion; and they contribute to global warming (Mir, Purohit & Mehmood, 2017; Santos, 2017; Petrocelli, 2015). Fossil fuels, such as gasoline, diesel and petrol contain carbon, which when burned with oxygen forms carbon dioxide that enters the atmosphere and impacts on global warming (McBain, 2017).

Less prevalent, but very powerful GHGs are hydrofluorocarbons, perfluorocarbons and Sulphur hexafluoride (Liu et al., 2015). Nitrogen dioxide causes brown smog in urban areas (ibid). Nitrogen dioxide is a gas that is highly reactive; and it helps to form ozone (Geerlings et al., 2012).

GHG emissions from the transport sector are largely made by carbon dioxide; and for that reason carbon dioxide receives the most attention (Emberger, 2017; Taylor, 2017; WWF, 2016; Buehler & Pucher, 2011). In South Africa, in the transport sector, the major share of GHG emissions is derived from road transport (see Figure 1.1). Therefore, road transport of South Africa has a major role to play in reducing GHG emissions.

2.3.5.3 Accidents

Accidents are the third transport externality to be discussed. Transport is a human activity that is dangerous and can cause harm to human life (Santos, 2017). Worldwide, road traffic accidents cause approximately 1.2 million deaths and 50 million injuries annually (Soro &Wayoro, 2018). Road accidents are considered to be a major health problem in South Africa (Koekemoer, van Gesellen, van Niekerk, Govender & van As, 2017; Parkinson, Kent, Aldous, Oosthuizen & Clarke, 2014). In addition, the DoT (2017) reported that for the period January-December 2017 a total number of 14 050 fatalities were recorded. Accidents on the road may be influenced by the increase in private car ownerships, the national income level (Soro & Wayoro, 2018); speed and traffic composition (Button, 2014).

Safety is one of the major concerns for road users (Xia et al., 2017; Verma et al, 2016). Previous research indicates that the majority of the commuters are mainly concerned about their safety on the road (Sun, Mobasheri, Hu & Wang, 2017; Xia et al., 2017). This may suggest that safety issues may hamper the use of sustainable transport modes, such as walking and cycling.

2.3.5.4 Urban sprawl

The fourth transport externality to be discussed is urban sprawl. Cities have undergone a process of urban sprawl in recent decades (Valdes, Monzon & Benitez, 2016), thereby placing urban sprawl at the centre of many of the urban transport challenges. Urban sprawl has evolved over time; and the definition of it varies depending on the authors and the areas of study, in which they are used; and it means different things to different people (Navamuel, Morollon & Cuartas, 2018; Ehrlich, Hilber & Schoni, 2017; Young, Tanguay & Lachapelle, 2016). The following are some of the definitions of urban sprawl as:

Urban sprawl can be defined as a ‘common phenomenon in cities that have grown following the generalised use of private vehicles as the main mode of transport’ (Morollon, Marroquin & Rivero, 2016: 205). Fang, Shenghe, Hong and Qing (2007: 470) define urban sprawl as the ‘rapid, low-efficient and disorderly growth of non-agricultural land towards peripheral areas’. The definition by Cobbinah and Aboagye (2017) is similar to that of Morollon et al. (2016); whilst Young et al. (2016) and Nengroo, Bhat and Kuchay (2017) add the component of an urban development pattern.

From the definitions, it is clear that transport is closely linked to urban sprawl. Transport becomes critical to provide mobility to communities within urban sprawl areas.

Urban sprawl is characterised by low-density development, large single-use areas, discontinuous urbanisation and high rate private vehicle dependency (Rodrigue, 2017; Achour & Belloumi, 2016). Urban sprawl may translate into an increased demand for land, water, energy and infrastructure, such as transport infrastructure (ibid). Urban sprawl is detrimental; because it creates unnecessary travel, traffic congestion, noise pollution, energy consumption and costs connected the delivery of urban services (Cobbinah & Aboagye, 2017; Zhou, Jiao, Yu & Wang, 2017).

South Africa is one the countries experiencing urban sprawl challenges. This is partly due to the rapid urbanisation and urban geography of apartheid (Thomas, 2016). The majority of black South African population live far away from work and civilised amenities (Kerr, 2017; Thomas, 2016). This results in transport challenges that may need a viable network of sustainable public transport in such communities. These communities in South Africa experience high transport costs and long commuting hours (ibid). Therefore, the role of transport is critical; since it provides effective and efficient transport to the communities within the sprawling urban areas.

Four transport externalities considered important to this study are: traffic congestion, short range pollution (air pollution) and long range pollution (GHG emissions), accidents and urban sprawl. In the light of the transport externalities discussed, it is important to find sustainable ways to reduce transport externalities. Sustainable urban transport modes, such as cycling, walking and public transport have the ability to reduce private car usage in the city and to create a sustainable city. Sustainable urban transport is discussed in Section 2.4.

2.4 SUSTAINABLE URBAN TRANSPORT

The rapid increase in vehicle ownership and the frequent use of private cars in the city calls for particular attention to be paid to transport policies; as these trends cause negative transport externalities (Verma et al., 2015; Liu et al., 2015).

In view of the transport externalities being faced, there is a need to consider sustainable transport solutions, in order to manage the transport externalities. The literature reports that sustainable transport is complex; as there are various definitions of sustainable; transport and there is no standard definition of sustainable transport (Patlins, 2017; Eriksson, 2017; Litman, 2016; Cheba & Saniuk, 2016; Valdes et al., 2017). The following are some of the definitions of sustainable transport:

Sustainable transport involves the minimisation of transport impact by shifting from unsustainable modes of transport to alternative modes of transport that are friendly to the environment, such as public transport, cycling, walking, car sharing and clean vehicles (Makarova et al., 2017). Sustainable transport can be defined as a 'transportation system that promotes economic and social growth sustainably, without causing environmental problems now and in the future' (Jomnonkwao, Sangphong, Khampirat, Siridhara & Ratanavaraha, 2016). Attard and Shiftan's (2015) definition is similar to that of Jomnonkwao et al.; whilst Malasek 2016 and Verma et al. (2016) added the element of energy consumption. The ECMT (2001:17) defines sustainable transport as one that:

a) 'It allows the basic access and development needs of individuals, companies, and society to be met safely and in a manner consistent with human and ecosystem health; and it promotes equity within and between successive generations';

b) It is affordable; it operates fairly and efficiently; it offers a choice of transport mode; and it supports a competitive economy, as well as balanced regional development; and

c)It limits emissions and waste within the planet's ability to absorb them;it uses renewable resources at or below their rates of generation; and it uses non-renewable resources at or below the rates of development of renewable substitutes, while minimising the impact on the use of land and the generation of noise.'

The World Bank (1996:28) defines sustainable transport as:

a) 'It must ensure that a continuing capability exists to support an improved material standard of living. This corresponds with the concept of economic and financial sustainability.

b) *It must generate the greatest possible improvement in the general quality of life, not merely an increase in traded goods. This relates to the concepts of environmental and ecological sustainability.*
c) *The benefits that transport procedures produce must be shared by all the sections of the community. This we term social sustainability'.*

From the above definitions of sustainable transport, it may be concluded that sustainable transport takes into account the three dimensions of sustainable development, namely: the social, economic and environmental dimensions. In the absence of sustainable transport policy measures, it may lead to an increase of negative transport externalities and cause damage to the environment and human health. Contemporary transport planning is needed to change travel behaviour – with a view to reducing car dependency and encouraging sustainable ways of travelling, such as walking, cycling and public transport (McBain et al., 2017; Babalik-Sutcliffe 2013). A framework for sustainable urban transport is depicted and discussed in section 2.4.1.

2.4.1 A framework for sustainable urban transport

As mentioned earlier, transport contributes largely to climate change, ocean acidity and other problems associated with CO_2 emissions, thereby indicating that it is essential to address this challenge from a wide systems perspective (Robert et al., 2017). In addition, attempts to reduce CO_2 should not lead to backlash effects, such as fertile land degradation or socially sustainable problems.

A framework can be described as a way of structuring information and the further study of a specific concept (Ramani & Zietsman, 2016). Furthermore, frameworks are valuable to help understand and communicate broad concepts, such as sustainable transport. Urban transport systems are increasingly facing irreconcilable problems (Liu et al., 2015). GHG emissions have increased faster than emissions from any other sector. There is a need for transformation from traditional transport systems, in order to achieve sustainable transport systems. Effective sustainable transport policies are essential to address urban transport problems. In general, a policy is an indication statement of intent and principle to guide actions to achieve certain goals. Transport policy refers to the development of objectives related to the social, economic and environmental development and to the functioning and performance of the transport system (OECD, 2016).

Globally, cities are trying to implement sustainable urban transport, in order to reduce the impact of transport (Mercier et al., 2016).

Various frameworks for sustainable transport have been proposed to deal with the transport problems being faced today (Klungboonkong et al., 2017; Mercier et al., 2016; Malasek, 2016). In Thailand, Klungboonkong et al. (2017) developed a framework called Comparative Study on Urban Transport and the Environment (CUTE) framework. This consisted of four scenarios that were used to reduce GHG emission:

- land use planning;
- public transport improvement;
- clean technology; and
- the restriction of private vehicle usage.

Mercier et al. (2016) developed a conceptual framework for American cities that involved mixing policy instruments: proactive/government instruments and interactive/governance instruments. Malasek (2016) proposed six possible tools for making urban transport more sustainable for European cities. This comprised car restriction policies, clean modes of transport, cleaner fuel, information and communication technology and green business models.

A comprehensive and integrated approach is required for the transition to sustainable transport. Figure 2.5 represents the framework for sustainable transport.

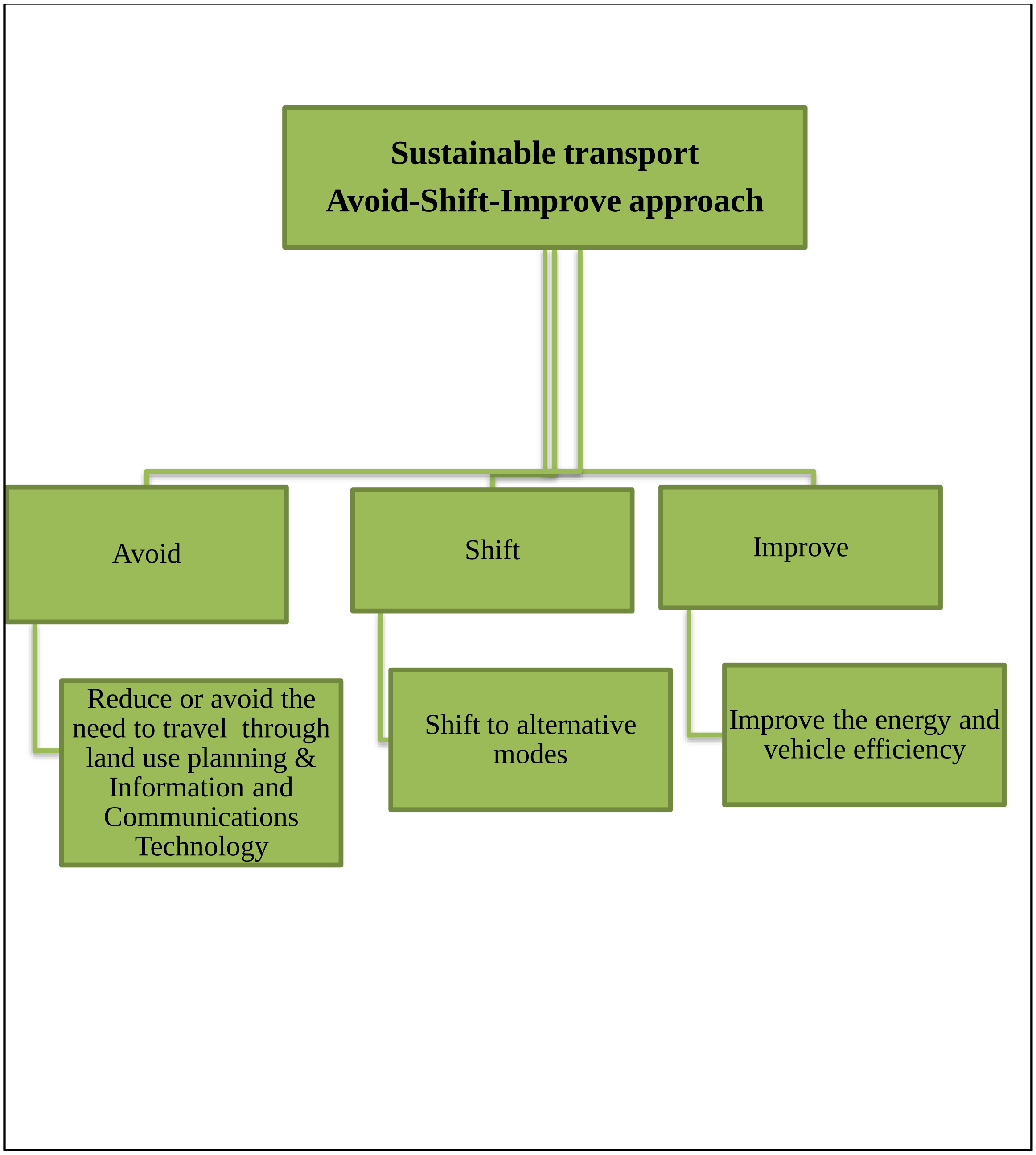

Figure 2.5: Framework for sustainable transport

Source: Dalkmann (2015); Bakker et al., (2014)

The framework displayed in Figure 2.5 is an integration of land use and transport planning. Integrated land use and transport planning are two of the most important strategic initiatives for tackling current transport problems (Malasek, 2016). However, there is a single approach that could be regarded as the best approach, due to the differences in the characteristics of cities, such as geographical, social, economic and morphological characteristics (Mercier et al., 2017). The

Avoid-Shift-Improve (ASI) approach is an organising framework combining land use planning and transport planning (Dalkmann, 2015). The ASI approach fits in various policies, regulatory instruments and best practices. The approach was established in Germany in the early 1990s to reduce transport challenges (Bakker et al., 2014). Countries in Asia and Latin America started to endorse the approach after the Bangkok 2020 Declaration; and most of the elements have also been implanted worldwide (Bakker et al., 2014).

The purpose of sustainable urban transport framework is: a) to issue transport concepts; b) to give the process to city's mobility strategy; c) to repair urban damages; d) to control environmental impacts; and e) to promote sustainable behaviour (Liu et al. 2015).

The three elements of ASI approach are: to avoid/reduce; shift; improve; and they are outlined as follows:

a) **Avoid / reduce**. The element 'avoid' refers to the need to avoid or reduce travel. The element can be achieved by improving the efficiency of transport through integrated land use planning, and transport-demand management, as well as Information and Communications Technology (Dalkmann, 2015). Trip distance is also reduced when proper land use planning is put in place. In urban areas, land use planning encourages rules, such as 'work close to home' and 'shop close to home' (Malasek, 2016). Land-use planning factors in a diversity. Diversity refers to mixed land use in terms of a diverse pattern of residence, commerce, institutions, parks, industry, and transport infrastructure housed by a community or neighbourhood (Pratelli & Brebbia, 2011).

Diversity reduces the need to travel and the possibility of reducing car dependency. There is also a need for the redevelopment of existing urban areas, to ensure that people can live close to their jobs, schools and other important services. High quality public transport can also be achieved through rapid transit.

b) **Shift**. The 'Shift' element aims to improve trip efficiency. In order to achieve transformation in transport, it is important to focus more on sustainable transport and inclusive access for all (Bakker et al., 2014). Transport plays a major role in delivering sustainable development by encouraging the shift from private motorised transport towards sustainable modes, such as public transport, walking, cycling and low and zero-emission vehicles (Inderwildi & King, 2012). It is necessary to shift from the traditional approach (building roads), and of tackling transport problems to a more sustainable system. The use of energy-consuming transport modes, such as cars in the urban areas is highly undesirable for both the environment and for humans. However, the shift to alternative transport modes implies extra infrastructural cost to the government (OECD/ITF, 2015).

The trend of motorisation is reinforced when there is a poor public transport infrastructure (Bakker et al., 2014). Governments need to invest in a transport infrastructure that encourages people to shift from private cars to more environmentally friendly modes. Although public transport generates emissions, emissions per passenger-km are lower than the emissions generated by cars (Hans, 2010). Public transport has a large carrying capacity of passengers compared to cars. Worldwide, funds for urban public transport infrastructure tend to be limited, especially in the developing countries, where poverty issues are priorities.

c) **Improve.** The 'Improve' element focuses on vehicle and fuel efficiency. Improving can be achieved through technological advancement (Dalkmann, 2015). At the moment, extensive research is needed to improve the energy efficiency of transport modes and vehicle technology (Morton et al., 2017; Dalkmann, 2015). Technical innovation in transport requires advanced ICT for a much greater degree of computerisation in vehicles (Morton et al., 2017). In addition, technical innovations give a great opportunity for a transition towards a sustainable transport system. A shift is needed from fossil fuels towards more sustainable fuels, such as methane, electricity/hydrogen and biofuels, synthetic fuels and liquefied petroleum (Emberger, 2017).

The potential of alternative energy use is now acknowledged worldwide (ibid). Morton et al. (2017) concluded that new technologies should be embraced to achieve some sustainability in the transport system; since cars have substantial benefits for society.

The three elements of ASI approach are referred to as: avoid, shift and improve. These elements can be used to reduce transport externalities imposed by motor vehicles. In order for the ASI approach to be effective, it could be important to understand the public attitudes towards sustainable transport so as to change the mindset of the commuters. The next section discusses the public attitudes towards sustainable transport.

2.4.2 Public attitudes towards sustainable transport

This section is linked to the second secondary objective, 'to explore public attitudes towards sustainable urban transport in selected areas of the City of Tshwane'. Public attitudes towards sustainable methods are one of the most important elements of interest to this study; since attitude is one of the factors that influence modal choice (Verma et al., 2016; Puhe & Schippl, 2014). Transport planners and policy-makers consider the attitudes of the public, when making sustainable transport policies for the successful development of sustainable transport as important (Khoo & Ong, 2015; Gehlert et al., 2013). Public attitudes contribute to the success of the implementation of transport policies, as well as to to the effect of the policy.

In a general context, an attitude can be described as:

- *'The degree of favourable or unfavourable opinion towards the acceptance system' (Khoo & Ong, 2015: 232).*
- *'The degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour in question (Ajzen, 1991).*

Psychological-based approaches can be used in transport studies to understand travel behaviour of land-based transport; since the theory of planned behaviour is widely accepted in transport for attitudinal studies (Jomnonkwao et al., 2016; Verma et al., 2016; Ryley & Chapman, 2012). Figure 2.6 depicts the theory of planned behaviour.

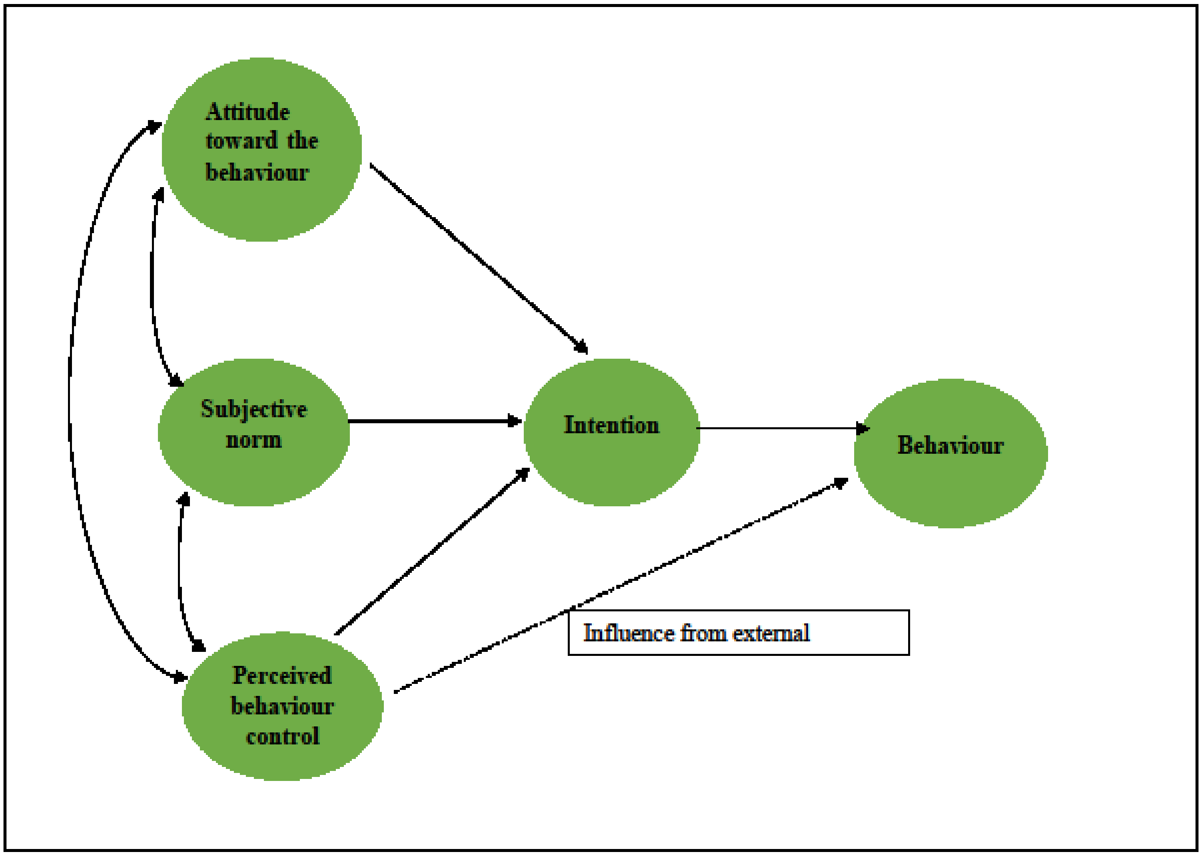

Figure 2.6: Theory of planned behaviour

Source: Ajzen (1991)

The theory of planned behaviour displayed in Figure 2.6 is based on the assumption that an individual is influenced by various factors, such as attitude towards the behaviour, habit, intention, the perceived behavioural control and subjective norms; while adopting a specific behaviour (Ajzen, 1991). Attitudes are closely linked to intention; as an individual's intentions to perform a particular behaviour are determined by his attitude towards that behaviour (Ryley & Chapman, 2012). **Attitude towards behaviour** is the overall performance evaluated by an individual of a specific behaviour, created from behavioural beliefs; and the results of the evaluation could be positive or negative (Jomnonkwao et al., 2016).

Subjective norms refer to the perception of an individual originated from the normative beliefs that may result in a positive or negative evaluation (ibid). **Perceived behaviour control** can be described as the perception of an individual of performing a specific behaviour that originates from control beliefs that may enable or hinder performance of the behaviour (Ajzen, 1991). In order to shift commuters from private cars to sustainable modes of transport, there is a need to understand factors that bring a positive behavioural change among commuters (Verma et al., 2016).

Research done in Australia on attitudes towards traffic, revealed that the public were aware of the environment and health benefits of cycling and walking (Xia et al., 2017). Even though the public is aware of the benefits of cycling to the environment and human health, the majority indicated that they do not wish to use cycling as a mode of transport. It might be assumed that individuals with strong environmental beliefs may want to use sustainable transport modes, such as public transport and cycling (Ryley & Chapman, 2012).

It is believed that negative public attitudes towards sustainable transport polices may pose implementation challenges for transport policies (Xia et al., 2017; Liu et al., 2015). Negative attitudes of the public towards sustainable urban transport may possibly be changed through the implementation of transport initiatives (Malasek, 2016; Verma et al., 2016; Prillwitz, 2011). The next section, 2.5 discusses transport initiatives that could encourage the public to use sustainable transport modes.

2.5 TRANSPORT INITIATIVES

This section addresses the fifth secondary objective of the study: 'to identify transport initiatives that would encourage the public to use sustainable transport modes'. As mentioned earlier, there is no single policy measure to reduce car dependency in the cities. This is consistent with the extensive literature supporting the need of integrated transport and land use planning, so as to encourage the shift from private car to cycling, walking and public transport (Buehler et al., 2017a; Buehler et al., 2017b; Klungboonkrong et al., 2017; Gossling et al., 2016; Malasek, 2016; Bakker et al., 2014).

Table 2.2 shows the transport initiatives that should encourage commuters to use alternative transport modes. The table was constructed through policies that have been successfully implemented by other cities (Buehler et al., 2017a; Buehler et al., 2017b; Malasek 2016).

Table 2.2: Transport initiatives

	Transport Initiatives
Public transport	❖ Cheaper fares for public transport ❖ More reliable public transport ❖ More bus routes ❖ Car-free days ❖ Car sharing schemes ❖ Financial incentives to use public transport ❖ Less parking ❖ Higher parking fees ❖ Online information on transport schedules
Cycling	❖ Space for the bike on public buses ❖ Bicycle rental facilities ❖ Provision of bicycle parking ❖ Dedicated cycling lanes ❖ Improved security and safety of bicycles ❖ Reduced bicycle price ❖ Improved path network for bikes ❖ Bathrooms and locker facilities
Walking	❖ Improved existing walking routes ❖ Provision of bathrooms at workplaces ❖ Car-free days ❖ Bathrooms and locker facilities
Private car	❖ Congestion charge ❖ Car-free zones ❖ Limited parking space ❖ High parking fees ❖ High cost of owning and using a car

Source: Buehler et al. (2017a); Buehler et al., (2017b); Malasek (2016)

Table 2.2 shows the transport initiatives and many of the key transport initiatives to promote the use of a sustainable mode were firstly introduced in Germany, Switzerland and Austria (Buehler et al., 2017a; Fishman, 2016). A brief description of the successful implementation amongst various cities will be provided next, in order to illustrate that the change in behaviour is possible through the implementation of transport initiatives.

Berlin is one of the cities in Germany that already had cycling infrastructure in the 1970s, but the infrastructure was substandard (Buehler et al., 2017a). Trips made by bicycle in Berlin have doubled since 1970s through cycling initiatives, such as the expansion and improvement of cycling infrastructure, integration of cycling with public transport and awareness programmes (ibid).

Copenhagen, the capital city of Denmark, followed the new trend of land use planning to reconnect land use and transport, in order to implement sustainable solutions to the transport system (Gossling et al., 2016). The city has managed to redesign urban space and allocation to accommodate sustainable transport modes; and there is a growing modal share of walking, public transport and cycling (ibid).

Vienna is an affluent city that has one of the best public transport systems and the support for it is strong and widespread (Buehler et al., 2017b). Between 1993 and 2014, Vienna managed to reduce the car share by 13% more than any other of the major cities in Western Europe (Buehler et al., 2017b). In order to reduce car trips, Vienna has successfully managed to implement policies that co-ordinate integrated transport and land use planning. Even though the cycling infrastructure is now well established in Vienna, by comparison, **Dutch, Danish and German** cities have more extensive cycling infrastructure (Fishman, 2016).

The ultimate goal of **Amsterdam**, is to reduce carbon emissions from the transport sector by 40% by the year 2025 (City of Amsterdam, 2017). The environment for cycling in Amsterdam is well planned and developed; hence, Amsterdam city managed to maintain the high level of cycling. Most of the cycling and walking paths in Amsterdam were constructed as early as the 1980s. In the Netherlands, cycling in most of the municipalities is well funded and supported by government (Ligege & Nyarirangwe, 2015).

In 2008, the DoT of **South Africa** developed a Non-Motorised Transport policy to be adopted by South African cities (DoT, 2008). The City of Cape Town initiated infrastructural programmes aimed at the provision of cycling and pedestrian infrastructure since 2008 (Kok, 2017). The mere provision of cycling and pedestrian infrastructure in the City of Cape Town has, however, not been effective enough to promote cycling and walking in the city. It also important to note that there are cycling programmes such as Open Streets Project and The Bicycle Mayor Programme that are currently being implemented in Cape Town, South Africa. The Bicycle Mayor Programme was launched in the month of December, year 2017 (SABC, 2018). However, the implementation of such programmes in City of Tshwane is still in progress. Research done in Limpopo province indicates that there is a lack of pedestrian infrastructure in the province (Mokitimi & Vanderschuren, 2017). However, there are less cycling commuters seen in the cities, such as the City of Tshwane and the City of Johannesburg (Stats SA, 2014).

Each of the transport initiatives will firstly be introduced; and secondly, the practical application thereafter will be addressed. The recommendation of the transport initiatives will be reported in Chapters 4 and 5.

2.5.1 Public transport initiatives

Introduction of initiative

The first of the transport initiatives listed in Table 2.2 is public transport. The mere provision of public transport is not good enough to draw commuters from their private cars; but the good service quality of public transport is considered as a viable, sustainable and alternative mode to that of private cars (Luke, 2018). Public transport is currently regarded as the most important mode in the sustainable transportation system in terms of carrying capacity and low energy consumption (Friman, Garling & Etta, 2018; Shibayama, 2017). Cycling and walking depend on good, wide and affordable provision of public transport. In other words, without good service quality of public transport, cycling and walking suffers (Buehler et al., 2017a). Provision of public transport only is not sufficient to deal with traffic congestion and reduce emissions; hence, it is always important to tackle urban congestion through broader measures (Malasek, 2016). High quality transport networks that offers better accessibility and good information to passengers is perceived to be attractive (ibid).

Practical application

In Singapore, public transport has been made the ‘choice mode’ through high quality of public transport and the incorporation of policies that control private vehicle ownership (Diao, 2018; Han, 2010). Its public transport system is well maintained, in order to be able to offer convenience, comfort, high frequency and diversity to the commuters. The federal government of Germany has dedicated funding to support public transport investments, in order to continuously maintain the good service quality of public transport. Consequently, trips made by public transport in Germany have doubled since 1981 (Gossling et al., 2016).

Many cities in China now offer the Bus Rapid transit (BRT) as an initiative to improve and manage the public transport system (Li & Zhao, 2017). The City of Yichang, in China won the 2016 Sustainable Transport Award for Excellent Leadership in Sustainable Transport Reforms, like BRT, transit-oriented development, cycling and parking (Zhu & Li, 2016). BRT commenced operation in the year 2015 during the month of July. It is reported that by September 2015, significant changes in modal shift were already noticed (Zhu & Li, 2016). In China, the central government provided economic incentives, such as fuel subsidies to urban bus operators, as a way to reduce transport costs to the bus commuters (Li & Zhao, 2017). The city did not only improve the public transport, but also the infrastructure for cycling and walking (ibid).

2.5.2 Cycling initiatives

Introduction of initiatives

Previous research on cycling in the urban settings indicated that cycling offers benefits, such as improvement of public health, savings on fuel costs, less traffic congestion, decrease in air pollution, savings on parking costs and less fuel consumption (Sun et al., 2017; Verma et al., 2016; Taddei, Gnesotho, Forni, Bonaccorsi, Vannucci & Garofalo, 2015; Fernández-Heredia, Monzón, Jara-Díaz, 2014; Grange, Dirks, Costello & Salmond, 2014).

There are various strategies that are in place to encourage people in cities to cycle (see Table 2.3). The main concerns about cycling are inadequate infrastructure and safety issues. Cycling is regarded as an unsafe mode of transport that is associated with the absence of infrastructure to accommodate cyclists (Xia et al., 2017). Maximisation of cycling opportunities in the city can be achieved through the building of a network of safe and comfortable cycling routes that connect residents to potential destinations (Active Living Research, 2013).

Practical applications

Examples of cycling initiatives include, but are not limited to Barclays Cycle Superhighways in London and Bike Share initiative in Portland, Oregon (Grange et al., 2014). Cycle Superhighways in London are routes from the outer city into and across central London that are safer, faster and direct (Transport For London [TfL], 2017). In the year 2016, there were eight cycle superhighways in London (ibid). However, continued growth in cycling is critical to reduce trips made by private cars (TfL, 2017; Hickman & Banister, 2014). In Freiburg, Germany trips made by bicycles have tripled since 1981, due to the cycling initiatives implemented (Gossling et al., 2016).

As part of a transition towards sustainable transport systems, cities around the world have prioritised the provision of cycling infrastructures (Panek & Benediktsson, 2017). Adequate separate bicycle lanes that are bidirectional been successfully implemented in Copenhagen (Fishman, 2016). Dedicated bicycle lanes that separate cyclists and motor vehicles are capable of improving the safety of the cyclists on the road (Sun et al., 2017; Active Living Research, 2013). The bicycle streets in Copenhagen have speed limits for the safety of other cyclist and road users (Gossling et al., 2016).

Research conducted by Verma et al. (2016) revealed that there is a real possibility of increasing bicycle riding if bicycle lanes and cars are separated. Cycling routes need to be linked to bus stops and rail stations, in order to act as a feeder mode of transport for the public.

Bicycle rental facilities have the potential to increase cycling commuters in the city; as they offer rapid and flexible service to the public (Zhang et al., 2017). Cities in Europe, Asia and North America have adapted to bicycle rental systems, as an innovative approach to improve sustainable transport alternatives (Fishman et al., 2015). Most cities in China, such as Guangzhou and Zhongshan have bicycle rental systems to promote a self-service system to the public (Zhang et al., 2017).

Programmes such as Open Streets Project and the Bicycle Mayor Program are ways of promoting cycling in the city. The concept of open streets, also known as Ciclovia is an initiative that temporarily closes streets to motorised traffic to provide an opportunity to engage into physical activity (Kuhlberg, Hipp, Eyler & Chang, 2014). Recent research shows that there is an increase in number of American cities engaging into Open Streets Project (Salazar-Collier, Reininger, Gowen, Rodriguez & Willson, 2018). The Bicycle Mayor Program is a global initiative to promote cycling in cities (Cyclespace, 2018). In addition, Bicycle Mayors work with the general public and the city stakeholders to identify cycling challenges and solutions.

2.5.3 Walking initiatives

Introduction of initiatives

Walking is the oldest basic transport mode (Buehler et al., 2017a). In the recent decades, walking has been given the important attention it deserves (Mokitimi & Vanderschuren, 2017). Walking as a mode of transport is increasingly recognised as an environmentally friendly mode associated with health benefits to those who walk (Sinclair & Zuidgeest, 2016; Grange et al., 2014). Conditions of walking worldwide are not the same; as there are various factors that may influence walking as a mode of transport. For example, the size of the city, the economy of the city, as well as the features of the natural environment, such as the landscape; and these may affect walking in and around the city.

Practical application

In developed countries, walking has become more popular – especially in the Netherlands, Demark, and Austria; while in some of the developing cities, pedestrians are largely ignored or marginalized (Fishman, 2016). Walking levels have declined in Europe since the 1950s. However, in the early 1970s, many European cities started realising the importance of walking and began expanding and improving their pedestrian infrastructure (Buehler et al., 2017a). The improvement of pedestrian amenities is recommended to encourage the public to use walking as a mode of transport among the employed population (Mäki-Opas, Borodulin, Valkeinen, Stenholm, Kunst, Abel, Härkänen, Kopperoinen, Itkonen, Prättälä, Karvonen & Koskinen, 2016).

2.5.4 Private car initiatives

Introduction of initiative

The last transport initiative to be discussed is private car initiatives. Previous research done in Australia revealed that the residents of Adelaide city strongly depend on private cars for work and shopping trips (Xia et al., 2017). Car restriction and parking management policies can be used to reduce car usage in the city. This can be done through the higher cost of owning and using a car, high congestion charges, high cost of parking cars, limited parking and car-free zones (Malasek, 2016). Car restriction policies push the public to drive less; and they motivate them to walk, cycle and to take public transport. Car restriction policies are believed to be more effective in Western

Europe than in the USA. Public transport has a critical role to play in reducing private car usage and ownership (Luke, 2018; Li & Zhao, 2017).

The findings from previous research indicate that car ownership is associated with not only lack of public transport, but also with the service quality of public transport (Luke, 2018).

Practical applications

In cities such as Beijing and Shanghai in China, car restriction policies have been successfully implemented. Some of the policies implemented in Beijing and Shanghai are: congestion charges, car restriction in certain areas, and the prohibition of poor quality cars (Zhao et al., 2017). The federal government of Germany has successfully managed to encourage sustainable transport through comprehensive transport policies. Germany has car-restriction policies that are similar to those of Vienna. It is far more expensive to own and use a car in Germany than it is in the USA. German car taxes are three times higher; and fuel taxes are nine times higher than they are in the USA (Buehler et al., 2017a).

The federal government encourages the production and purchase of vehicles that cause less pollution to the environment, such as electric cars (ibid). In London, private car usage in the city centre has been reduced by introducing congestion charging (Inderwildi & King, 2012). Cities, such as Vienna and Berlin have successfully implemented car restricting policies that have made car ownership and use difficult. At the same time, they have made alternative transport modes more attractive (Buehler et al., 2017).

2.6 CONCLUSION

The lay-out of this chapter follows the flow diagram shown in Figure 2.1. The main focus of this chapter has been on the conceptualisation of sustainable transport within the urban context. The chapter addressed the first secondary objective of the study, ‘to conceptualise transportation; urban transport; transport externalities, urban sprawl; sustainable development, sustainable urban transport; GHG; and congestion.

The first focus in this chapter was on defining transport. This was followed by outlining the importance of transport. The six areas of importance of transport were revealed as: economic development; the creation of employment, creation of place utility; the creation of time utility, the mobility of labour and capital, as well as the welfare of people (see Section 2.2.2). The main modes of transport were identified as: land transport, water transport and air transport in Section 2.2.3, leading to a discussion on the factors that influence the choice of transport mode. Factors influencing the choice of transport mode were revealed as socio-demographic, the requirements of transport, structural, in addition to psychosocial factors (see Section 2.2.4). Section 2.2.4 is linked to Section C of the questionnaire. Four factors that influence modal choice were identified as: socio-demographic factors, the requirements of transport, structural factors and psychosocial factors. Some of the barriers of sustainable transportation were identified as: the lack of transport infrastructure, safety and security, reliability and poor service.

Urban transport is defined in Section 2.3 as a complex transport system related to people and their daily life activities in cities relating to passengers, freight, activities, work and health. The complex nature of the transport system was introduced in Section 2.3.2 by discussing the three main subsystems of urban transport, namely: individual transport, passenger transport and the freight transport system. Urban transport and urbanisation are concepts that are closely linked. The discussion is therefore in Section 2.3.3, which leads to another relationship of transport and land-use (see Section 2.3.4). It may be assumed that continuous growth in urban population may lead to increased demand for public infrastructure, such as transport; and this may lead to a change in the use of land.

Transport plays a critical role in the social and economic development of any nation; but the frequent use of transport in the city generates transport externalities that are harmful to the environment and human health. The four transport externalities that are common and important to this study were identified as: traffic congestion, air pollution and GHG emissions, accidents and urban sprawl; and these were discussed in Section 2.3.4. In the view of transport externalities discussed in Section 2.3.5, sustainable transport solutions are needed to manage the effect of transport externalities. The concept of sustainable urban transport is defined and discussed in Section 2.4. Sustainable transport can be defined as a ‘transportation system that promotes economic and social growth sustainably without causing environmental problems now and in the future’. The theory of planned behaviour is used to understand public attitudes in this study in Section 2.4.2.

The theory of planned behaviour is based on the assumption that an individual is influenced by various factors, such as attitude towards the behaviour, habit, intention, perceived behavioural control and subjective norms, while adopting a specific behaviour. Public attitudes contribute to the success of implementation of transport policies, as well as the effect of the policy.

The last part of the chapter focuses on transport initiatives that can be used to encourage the public to use sustainable transport modes (see Section 2.5). The section addresses the fifth secondary study objective, ‘to identify transport initiatives that may encourage the residents of selected areas of the City of Tshwane’ and the recommendations to be addressed in Chapter 5. Successful implementation of transport initiatives is found in cities, such as Berlin, Copenhagen, Vienna and Amsterdam. The next chapter focuses on the research methodology of the study.

CHAPTER 3

THE RESEARCH METHODOLOGY

3.1 INTRODUCTION

The focus of this chapter is on the the research methodology used for collecting the data on sustainable urban transport in selected areas of the City of Tshwane. The conceptualisation and structuring of the research problem, the research objectives and the secondary research were introduced in Chapter 1 and 2. The primary objective conducted in selected areas of the City of Tshwane is the focus of this chapter. The primary objective of the study was to develop guidelines for sustainable urban transport in selected areas of the City of Tshwane.

To achieve the primary objective, six secondary objectives were identified. The first secondary objective is to conceptualise transportation; urban transport; transport externalities, urban sprawl; sustainable development, sustainable urban transport; GHG; and congestion. The second secondary objective was to explore public attitudes towards sustainable urban transport in selected areas of the City of Tshwane. The third secondary objective was to identify the transport modes used by the residents in selected areas of the City of Tshwane.

In support of the second objective, the fourth objective is to determine whether statistically significant differences exist between the regional areas of the City of Tshwane with regard to the attitudes towards sustainable urban transport. The fifth objective was to identify transport initiatives that could encourage the public to use a sustainable transport mode. The fifth secondary objective was supported by the sixth secondary objective, which was to determine whether statistically significant differences exist between the regional areas of the City of Tshwane in terms of transport initiatives that encourage the public to use sustainable transport modes.

This chapter commences with Section 3.2 to describe the study site, being selected areas of the City of Tshwane, where the primary data were gathered. A detailed explanation of the research design and the methodology will follow, in order to provide answers to the research objectives that were established to achieve the primary objective. The validity and reliability of the study are dealt with in Section 3.9.2. The chapter follows the steps in Figure 3.1. Each of these steps is discussed in this chapter, with the exception of steps 7 and 8, which will be discussed in Chapters 4 and 5.

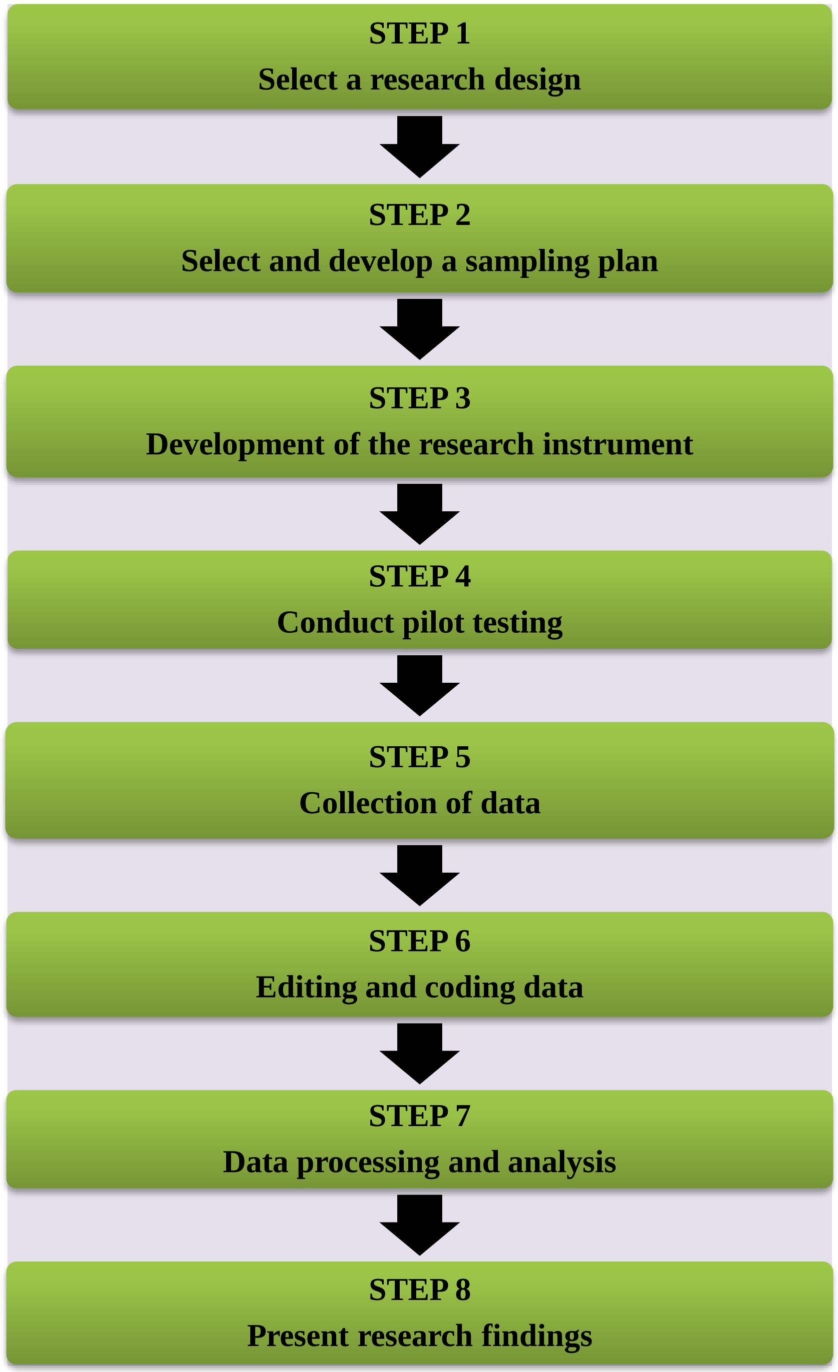

Figure 3.1: Flow diagram of Chapter 3

3.2 STUDY SITE

Research was conducted in the City of Tshwane, South Africa. The City of Tshwane is situated in the Gauteng Province of South Africa. Gauteng province (see Appendix A) consists of three metropolitan municipalities and two district municipalities, namely: The City of Johannesburg, the City of Tshwane, Ekurhuleni, Sedibeng and West Rand (Nkosi & Masuku, 2016). The City of Tshwane is surrounded by Mpumalanga to the east, Limpopo to the north, the Ekurhuleni, and the City of Johannesburg Metropolitan Municipalities to the south and North West on the west (Stats SA, 2016). Figure 3.2 shows the map of regions of the City of Tshwane.

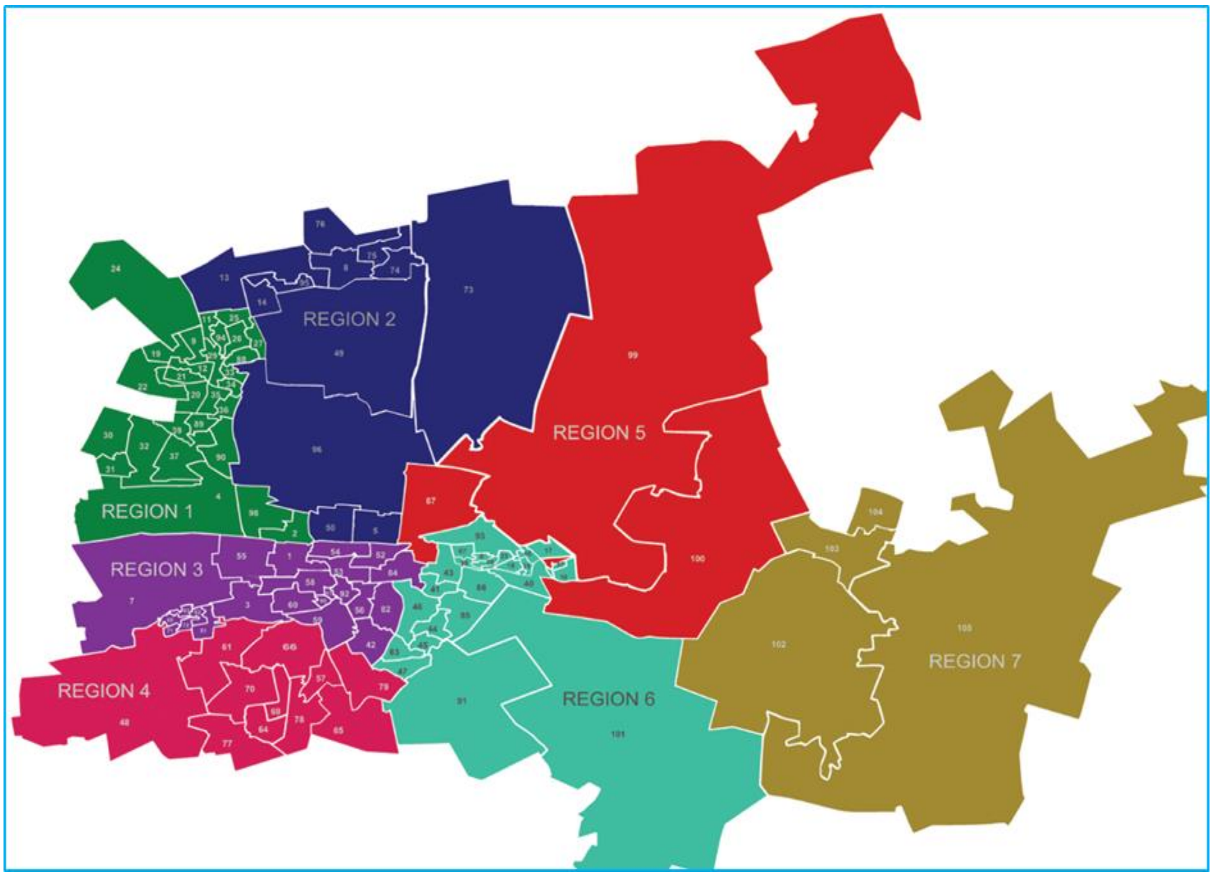

Figure 3.2: City of Tshwane regional map

Source: CoT (2016)

The City of Tshwane is classified as a Category A urban Municipality by the Municipal Demarcation Board in terms of section 4 of the Local Government Municipal Structures Act, 1998 (Act 117 of 1998) (CoT, 2016). The City of Tshwane is the one of the largest metropolitan municipalities in South Africa; and it consists of seven administrative and functional regions, 105 wards and 210 councillors (Stats SA, 2016). It is estimated that the City of Tshwane covers 6 368km^2 of Gauteng's 19 055km^2 (CoT, 2016). The urban structure of the City of Tshwane is not the result of planned growth, but rather, of the extension of its boundaries to integrate new areas over time (ibid). The incorporation of former Metsweding District Municipality, including Dinokeng tsa Taemane and Kungwini on the borders of City of Tshwane was the formation of the new City of Tshwane in 2011 (Stats SA, 2016). This has resulted in a sprawled city form, vast and complex in nature (ibid).

It may be observed that in Region 1 there are more noticeable economic activities in the City of Tshwane, such as manufacturing, electricity, construction, transport and community services (Stats SA, 2016). These economic activities are more concentrated in this region. Region 2 is characterised by urban settlements and limited economic activities; while at same time the region is known for tourism (CoT, 2016). There is also a slight concentration of mining and agricultural activities in Region 2. Region 3 includes the Central business district (CBD), as well as Brooklyn and Hatfield. The administrative heartland of government is located in Region 3. The region has the highest regional Gross Value Added (GVA) (CoT, 2016).

Region 4 is associated with more affluent areas with high-income earners (ibid). The region is dominated with smart industries, activities in finance and business services. Region 5 comprises the largest geographical area, yet the smallest population. It is characterised by agriculture, mining and tourism. The second largest region by population is Region 6 (Stats SA, 2016). Region 6 also constitutes affluent areas with largest number of formal employment. Lastly, Region 7 is known to have some of the best farming land in Gauteng region (ibid). Region 7 is the second smallest region by population; while at the same time, it is the second largest by geographical land area. It may be observed from the above that the regions of the City of Tshwane have different characteristics. The research design followed in the study is discussed next.

3.3 STEP 1: THE RESEARCH DESIGN

From Figure 3.1, Step 1 of the research process was to select a research design to be used in the study. A Research design can be defined as 'the systematic procedure which includes the designing, compiling and analysing of information through the conceptual model, the variable and the construction of a survey' (Mamun, Hafsa & Banik, 2014:16). According to Leedy and Ormrod (2013: 75), the research design gives 'the overall structure for the procedures that the researcher follows, the data that the research collects, and the data analyses the researcher conducts'. In other words, research design is a plan (ibid). Blaikie (2010) describes research design as 'an integrated statement of and justification for the technical decisions involved in planning a research project'. The essential elements of the research design are: The strategy to follow; the method and techniques to follow (van Thiel, 2014). Factors, such as: the research problem; the body of existing knowledge, the researcher's personal preferences and expertise; and the cost, which also has a significant influence on the research design (ibid).

The components of a research design may be structured in different ways (Blaikie, 2010). As mentioned earlier in Chapter 1, the present study followed an **empirical approach,** using a survey to collect the primary data. Empirical approach was followed as new primary data were gathered for this study (van Thiel 2014) and other related research followed the same approach (Yin & Sun, 2018; Xial et al., 2017; Verma et al., 2016). The three common ways to conduct research are: quantitative, qualitative and mixed methods (Creswell, 2014).These research methods are generally used by scholars from different disciplines, while depending on nature, the investigate phenomenon, and the questions to be addressed (Walliman, 2011). For the purpose of the current study, a **quantitative**, non-experimental study was performed, specifically using a survey-research design. Quantitative research is the preferred methodology, based on the characteristics of a quantitative method mentioned above.

Choy (2014) points out that there is no perfect research method. In addition, various sustainable urban transport research projects have used the quantitative method (Xia et al., 2017; Ye & Titheridge, 2017; Verma et al., 2016; Birago et al., 2017; Maduwanthi et al., 2015; Khoo & Ong, 2015; Raha & Taweesin, 2013).

Table 3.1 indicates the basic characteristics of the qualitative and quantitative methods.

Table 3.1: Basic characteristics of the qualitative and quantitative methods

	Qualitative	Quantitative
Objective/ purpose	To gain an understanding of underlying reasons and motivations; to provide insights into the setting of a problem, generating ideas and or hypotheses for later quantitative research; to uncover prevalent trends in thought and opinion	To quantify data and generalise results from a sample to population of interest; to
Sample	Usually a small number of non-representative cases	Usually a large number of cases representing the population of interest; randomly respondents
Data collection	Unstructured or semi-structure techniques	Structured techniques
Data analysis	Non-statistical	Statistical
Outcome	Exploratory and or investigative; findings are not conclusive and cannot be used to make generalization about the population of interest; develop an initial understanding and sound base for further decision making	Used to recommend a final course of action

Source: Park & Park (2016)

The quantitative research method: Various researchers have defined quantitative research and these definitions are as follows:

- Quantitative research methods are 'based on the generation and manipulation of numbers using statistical tools to identify the facts and the causal relationships' (Van Griensven, Moore & Hall, 2014:3).
- Quantitative research is 'research that employs measurement procedures and other techniques to study truly quantitative attributes' (Westerman &Yanchar, 2011: 146).
- Quantitative research is 'an inquiry into an identified problem, based on testing a theory, measured with numbers and analysed by using statistical techniques' (Mamun et al., 2014).

Quantitative research can be classified into three broad categories, namely: descriptive, experimental and causal comparative (Creswell, 2014). The Quantitative research method is highly applicable to situations where the research problem is clearly defined and the questions asked of the participants would lead to brief answers (Younus, 2017). The method is not time consuming; and it is relatively cheaper when compared with the qualitative method (McCusker & Gunaydin, 2015). In addition, the allocation of time and financial resources are effectively managed; as there is a potential of acquiring large amounts of data within a given time period. Accessing quantifiable information and data is generally regarded as simple when compared with qualitative research (ibid).

Qualitative research can be described as a holistic approach that involves discovery (Williams, 2007). The term qualitative research means that the approach is not statistical; and it combines multiple realities (Rahman, 2017). **Mixed research** is the integration of quantitative and qualitative methods in one study. Broadly defined, the mixed method is a type of research in which the investigator collects and analyses the data, integrates the findings and draws inferences – using both quantitative and qualitative methods (Younus, 2017).

The next section discusses the sampling plan.

3.4 STEP 2: THE SAMPLING PLAN

The sampling plan is essential in research. Sampling has a substantial impact on the results. Sampling needs to be done in such a manner that it maximises the researcher's ability to answer the research questions in a study (Younus, 2017). The onion concept of the sampling plan indicates how the population is reduced to the sample. Figure 3.3 shows the relationship between population and sample.

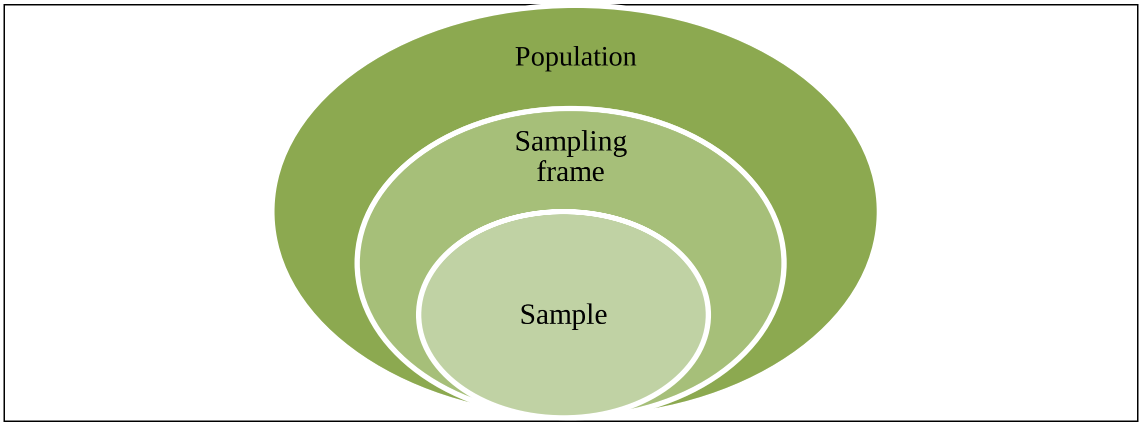

Figure 3.3: Sampling frame in relation to population and sample

Source: Walliman (2011)

The reasons for sampling is that firstly, in the case where sampling, everyone or everything is not possible; sampling makes research possible; and secondly, a sample that is properly selected gives results that are more accurate (Zikmund & Babin, 2010). The stages in the selection of a sample are shown in Figure 3.4.

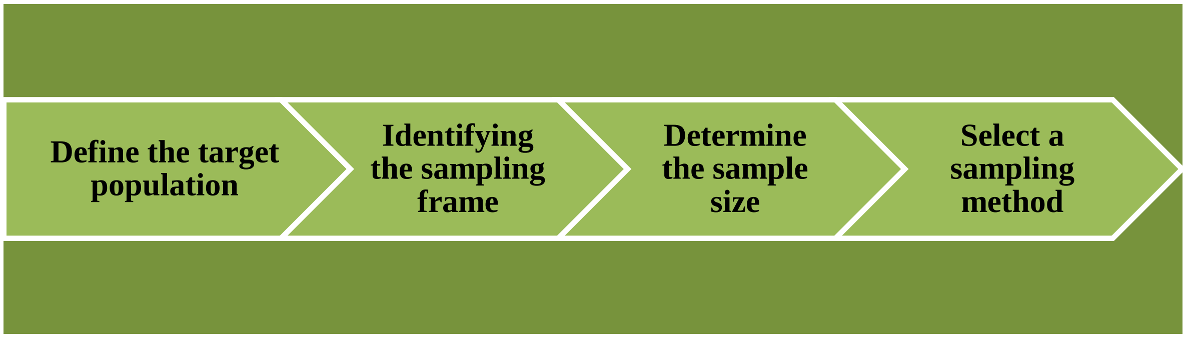

Figure 3.4: Selection process of a sample

Source: Adapted from Zikmund & Babin (2010)

The process of sampling is fundamental in research; as the sample selected is the foundation for estimating and predicting the results, as well as the unknown piece of information (Oum, 2010).

The steps in Figure 3.4 are discussed next.

3.4.1 Defining the target population

The word population is used to describe the target population. Population refers to the object of research (Norris, Plonsky, Ross & Schooned, 2015). The population is the study object; and it comprises groups, individuals, organisations, or the conditions to which they are exposed (Welman, Kruger & Mitchell, 2013; Babbie, 2010; Singh, 2007). For example, the group of students with cars in a class would be considered a sample. In order to produce good and accurate results, the population needs to be defined accurately (Zikmund & Babin, 2010). Zikmund and Babin recommend the approach of 'ask and answer' the crucial questions of population characteristics. The questions include: (a) Is the list available that matches the population? (b) What are the relevant population characteristics that are required? (c) Should the study include multiple populations? (d) Can the population be counted? and (e) What are the geographic restrictions?

These questions help the researcher to establish the right population. For the purpose of the present study, the population for this investigation comprised the residents in selected areas of the City of Tshwane.

The next stage is identifying the sampling frame.

3.4.2 Identifying the sampling frame

After identifying the desired population and selecting a sampling unit, it is then necessary to obtain a sampling frame from which to draw the sample. The sampling frame is also known as the 'working population' (Zikmund & Babin, 2010). The sampling frame can be defined as that subset of the population, which provides a broad and detailed framework for selection of sampling units (Singh, 2007). Babbie (2010) defines sampling frame as the list constituting a population from which a sample is drawn. Depending on the population and the sampling units being used, some examples of sampling frame would be a list of all the members of a church, factory workers, high school students or members of a club (Zikmund & Babin, 2010; Babbie, 2010). It is important for a sampling frame to be accurate, complete, up-to-date and relevant to the use of the study (ibid). In the current study, a sampling frame of the residents of the City of Tshwane was not available for selecting the sample elements, therefore non-probability quota sampling was used to determine the sample size for this study.

3.4.4 Select a sampling method

The purpose of sampling is to establish a small sample from an entire population, such that the sample is representative of the entire population. As such, it is essential to ensure that a sample is certainly representative (Richardson et al., n.d). Sampling is a process of selecting a portion of the population to represent the entire population. Singh (2007) describes sampling as 'the process of selection of sampling units from the population to estimate population parameters in such a way that the sample truly represents the population. It would be impossible to attempt to include all the members of the population in a survey; but neither is it necessary to include every member of the population (Zikmund & Babin, 2010; Richardson et al., n.d).

The two most common ways of sampling a population are probability and non-probability sampling (Walliman, 2011). Table 3.3 presents the types of probability and non-probability sampling.

Table 3.3: Types of probability and non-probability sampling

Probability sampling	Non-probability sampling
Simple random sampling	**Convenience sampling**
Systematic sampling	**Quota sampling**
Stratified sampling	**Snowballing**
Cluster sampling	**Purposive sampling**
Multi-stage sampling	**Deviant sampling**

Source: Adapted from Walliman (2011); Babbie (2010); Singh (2007)

Probability sampling: Probability sampling determines the probability that any element or member of the population will be included in the sample; while non-probability sampling cannot specify this probability (Mamun et al., 2014; Welman et al., 2013). Every unit of the study has the potential to be equally selected (van Thiel, 2014). Probability sampling is established on random methods of selecting the sample (van Thiel, 2014; Walliman, 2011). Probability sampling provides the researcher with the confidence that the sample is not a biased one; and it enables him to assess how accurate the data are likely to be (Fowler, 2012).

Examples of probability sampling techniques are simple random sampling, cluster and stratified sampling, as shown in Table 3.3. Some of the advantages of probability sampling are that it saves time and cost (Oum, 2010). The main reason for using probability sampling is to generalise the findings from a large population (Steinberg, 2015). Probability sampling is more applicable to descriptive, experimental and correlational designs of research (ibid).

Non-probability sampling: Non-probability sampling is the method whereby a sample is selected deliberately and purposively to produce a representative across the population (van Thiel, 2014). Non-probability sample does not use a random process; instead population elements are selected by assumptions, judgement, quotas or convenience (Blair & Blair, 2015; Walliman, 2011). While the ultimate goal of probability is to generalise; non-probability sampling aims to have access to information (Steinberg, 2015). Since non-probability is associated with exploratory studies, it is appropriate to use non-random methods to select a sample for the study. Some of the advantages of using non-probability sampling are that: it is convenient; it eliminates acomplex random process; it becomes possible to access population that would be otherwise impossible to reach; and it is impossible to develop a representative sample, for example, of homeless people in a large city (ibid). Non-probability sampling is useful to other studies, in which surveys are needed quickly; and it is difficult to get access to the whole population. Decisions on inclusion/exclusion are possible with non-probability sampling; and in a way, this makes the study feasible. However, the findings from non-probability sampling cannot be generalised (Walliman, 2011).

Examples of non-probability sampling are: quota, snowball and purposive sampling, as shown in Table 3.3. The study on which the research is based is non-probability sampling, specifically quota sampling; as it improves the representation of particular stratum within the population, as well as ensuring that there is no over-representation of the strata (Ornstein, 2013). Quota sampling should not confused with stratified sampling (Steinberg, 2015).

Quota sampling can be used if probability sampling techniques are not possible (Welman et al., 2013). This research study could not use probability sampling because there was no sample list of the individual members of the population. The results of quota sample can be comparable to stratified sampling data, if applied effectively (Steinberg, 2014; Fowler, 2012; Oum, 2010). Various subgroups in a population are well represented (Oum, 2010). However, one of the disadvantages of quota sampling is that the selection process is not random.

The interviewers are most likely to pick participants from whom they feel they may get a good response; hence, such a selection is highly biased (Richardson et al, n.d). It is therefore important to consider reporting on aspects of context, such as gender, geographical location, racial composition (Steinberg, 2015). For the purpose of this study, geographical location (regions of the City of Tshwane) was used for quota sampling; so that all the regions in the City of Tshwane could be fully represented.

The population will be divided, according to the seven regions of the City of Tshwane and the samples will be taken from each region to meet the required quota. Table 3.3 shows regional population share percentages in the City of Tshwane. (See map of the City of Tshwane, Appendix A).

Table 3.4: Population according to the City of Tshwane's regions

Region	Regional Population (% share)
Region 1: Winterveld area	28
Region 2: Hammanskraal area	12
Region 3: Atteridgeville to Central Business District to N1 Eastern border by-pass	20
Region 4: Centurion to R21 area	13
Region 5: Roodeplaat dam Cullinan area	3
Region 6: Mamelodi to South-East border	20
Region 7: Bronkhorstspruit to Eastern border	4

Source: CoT (2016)

The next section to be discussed is research instrument.

3.4.3 Determining the sample size

Once the sampling frame is established, the sample size can then be determined. There are various factors that can be considered when determining the sample size. The sample size can be determined by factors, such as: (a) the size of the population; (b) the cost of collecting the data; (c) the variance of the variables; and (d) the accessibility of the population elements (Zikmund & Babin, 2010; Richardson et al., n.d). A sample size that is too large may be costly for the goals and the associated degree of precision required at the same time; while a sample that is too small may not produce meaningful results; and the results would be unreliable (Richardson et al., n.d).

The City of Tshwane has a population of approximately 3 275 000 (Stats SA, 2016). Based on Fowler's 2012 table for determining the sample size for a given population, sample size (N= 418) was needed to represent a cross section of the population with a confidence level of 95% and confidence interval of 5%. A sample size (N= 200-500) is regarded as an appropriate sample size (Welman et al., 2013).

Zikmund and Babin (2010) also suggest that a sample size (N=300-500) is adequate to provide accurate results. The sample size used in the study is presented in Table 3.2. The seven regions of the City of Tshwane (see Figure 3.2) were selected, in order to attempt to reflect the public attitudes objectively and comprehensively; since different regions are affected by various characteristics, such as culture and geographical features. The unit of analysis in the study was the general public, the residents of City of Tshwane. Table 3.2 shows the sample size of the study (N=418).

Table 3.2: Sample size

Sample size	
Confidence level	95%
Confidence interval	5%
Population	3 275 000
Sample size	418

Source: Adapted from Fowler (2012)

3.5 STEP 3: THE RESEARCH INSTRUMENT

From Figure 3.1, Step 3 in the research process was to select and design the research instrument (questionnaire). To address the secondary research objectives of this study (see Section 3.1), questions related to the research objectives of the study were compiled in the questionnaire. For the purpose of the current research, a modified questionnaire with structured questions was designed to allow the participants to choose the answer that best represents their view. The lay-out of the questionnaire is shown below in Table 3.4 with a questionnaire consisting of five sections (A-E). All the questions are based on the reviewed literature on sustainable transport, as well as previous surveys relating to sustainable transport, as presented in Table 3.5.

Table 3.5: Research instrument

Section in the questionnaire		Research objectives	Type of question	Study source	Questions contributed
A	**Screening questions**		Closed-ended		
B	**General information** 1.Gender 2.Age 3.Status of employment		Closed-ended	Xia et al, 2017;	B1. B2 B3
				Verma et al, 2016;	B1 B2
				Liu et al, 2015;	B1 B2 B3
				Khoo & Ong, 2015	B1 B2 B3
				Puhe & Schippl, 2014	B1
				Verma et al, 2013;	B1 B2 B3
				Raha & Taweesin, 2013	B1 B2 B3
				Grdzelishvili & Sathre, 2011	B1 B2 B3
				Prillwitz, 2011	B1 B2 B3
C	**Transport modes** 1.Transport modes available 2.The most frequently used mode of transport 3.Factors dictating specific choice of transport	To identify the transport modes that are used in the City of Tshwane	Closed-ended	Xia et al., 2017	C1 C2
				Verma at al., 2016;	C1
				Khoo & Ong, 2015;	C1
				Zacharia, 2005;	C1
				Puhe & Schippl, 2014;	C1
				Grdzelishvili & Sathre, 2011;	C3
				Prillwitz, 2011.	C2 C3
				Nilsson& Kuller, 2000.	C1 C2
D	**Public attitudes towards sustainable transport** 1.Sustainable transport benefits awareness 2.Traffic problems awareness 3.Safety and comfort 4.Feelings about public transport	To explore public attitudes towards sustainable urban transport in the City of Tshwane To identify and compare key factors that influence attitudes of the City of Tshwane residents towards sustainable urban transport	Closed-ended	Xia et al, 2017	D1 D2 D3 D4
				Verma et al, 2016;	D3
				Verma et al, 2013;	D1
				Raha & Taweesin, 2013;	D2 D3
				Prillwitz, 2011;	D1 D2 D3
				Nilsson& Kuller, 2000.	D1 D2 D3 D4
E	**Transport initiatives** 1.Initiatives to encourage the public transport 2.Initiatives to encourage cycling 3.Initiatives to encourage walking	To determine transport initiatives that can encourage the public to use sustainable transport modes	Closed-ended	Xia et al, 2017;	E1 E2 E3
				Verma et al, 2016;	E2
				Liu et al, 2015;	E1 E2 E3
				Raha & Taweesin, 2013;	E2
				Prillwitz, 2011;	E1
				Pucher, 2008.	E2

Section A contained screening questions to determine whether the participant is part of the required population of the study. Those considered ineligible to participate in the study were eliminated from the study. Screening the questions ensured that the correct demographic target was included in the study. The target population comprised any resident of the City of Tshwane who was older than 18 years of age and below the age of 65.

Section B gathered general biographical information. Saris and Gallhoef (2014) defined demographics as the characteristics of the population, such as race, gender, age, education, occupation, income level and marital status. It is of importance to choose demographic variables that are most critical to the study because participants may become aggravated by having to answer a large number of demographic questions (ibid). The demographic variables that are most critical to this study were: age, gender, employment status and area of residence. The section was informed and based on the demographic variables from the previous literature (Xia et al, 2017; Verma et al, 2016; Liu et al, 2015; Khoo & Ong, 2015; Puhe & Schippl, 2014; Verma et al, 2013; Raha & Taweesin, 2013; Grdzelishvili & Sathre, 2011; Prillwitz, 2011), as shown in Table 1.3. As such, demographic variables were important in this study; as they informed the participants' choice of the mode of transport (Grdzelishvili & Sathre, 2011).

Section C consisted of questions pertaining to transport modes in the City of Tshwane. Three subgroups of questions were presented in Section C (1. Transport modes available; 2. The most frequently used mode of transport; 3. Transport service dimensions). The second secondary objective, 'to identify the transport modes used by the residents in selected areas of the City of Tshwane' was addressed. The questions in Section C were based on the previous literature, as presented in Table 3.4. A mode of transport refers to the method of transport, or the way of travelling. Land transport modes that are available in the City of Tshwane include: train, bus, car, paratransit, cycling and walking (CoT, 2015). Each mode of transport has its own advantages and disadvantages, and can be chosen for a trip based on factors including but not limited to cost, convenience, route and capability (Xia et al., 2017; Verma at al., 2017; Khoo & Ong, 2015; Zacharia, 2005).

It is important to understand the travel behaviour and the reasons for choosing a particular mode of transport above another (Brebbia & Dolezel, 2006). Among others, transport features, such as comfort and convenience influence one's choice of transport mode (Grdzelishvili & Sathre, 2011).

The third secondary objective, ‘to explore public attitudes towards sustainable urban transport in selected areas of the City of Tshwane’ was met in Section D of the questionnaire. Section D was concerned with finding out the attitudes of the public towards sustainable transport and the environment. Seventeen items were listed in Section D. The attitudinal questions were based on the previous literature, as displayed in Table 3.4 (Xia et al., 2017; Verma et al., 2016; Verma et al., 2013; Prillwitz, 2011, Nilsson & Kuller, 2000). The questions were grouped by using the factor analysis method (refer to Appendix C). The factor analysis identified four attitude factors namely: Factor 1 (Sustainable transport benefits); Factor 2 (Traffic problems awareness); Factor 3 (Safety and comfort) and Factor 4 (Public transport negative emotions). Factor 1 consisted of statements relevant to the environment and the health benefits of public transport and non-motorised transport (walking and cycling).

Factor 1 also aimed to evaluate whether the participants were aware of the benefits of sustainable transport modes. Factor 2 reflected the individual opinions on the impact traffic problems. Are the participants aware of the health impact caused by vehicles? Factor 3 involved statements on the safety and comfort of the transport modes, such as ‘Cycling is safe for me’ and ‘A car is essential to satisfy my needs’. Factor 4 entails statements on how the participants feel about public transport, such as ‘Public transport is expensive’.

Section E of the questionnaire addressed the fifth objective: ‘to identify transport initiatives that can encourage the public to use sustainable transport modes’. Section E consisted of 23 items related to transport initiatives. The questions on transport initiatives were constructed from the previous literature, as shown in Table 3.4 (Xia et al, 2017; Verma et al, 2016; Liu et al, 2015; Raha & Taweesin, 2013; Prillwitz, 2011; Pucher & Buehler 2008). The aim of this section was to determine the factors that might increase the attractiveness to residents of using sustainable transport modes. The participants were asked to rate the effectiveness of the suggested transport initiatives. Identifying transport initiatives that can influence modal choice is essential for designing sustainable urban transport systems in developing countries like South Africa and India (Ahmad & Puppim de Oliveira, 2016).

This section attempted to provide some insights on how to improve the sustainable transport plan, which would be valuable to policy-makers and the relevant key players working on sustainable transport systems in the City of Tshwane.

3.5.1 Scale used

A five-point Likert-type scale was used to determine the attitudes of the public towards sustainable urban transport. A Likert-type scale was the most appropriate scale, as various research projects on sustainable transport attitudes largely used the Likert-type scale (Xia et al., 2017; Verma et al., 2016; Khoo & Ong, 2015). There are four different types of attitude scales, namely: (Mamun et al., 2014; Welman et al., 2013): a) Likert scale, b) Semantic different, c) The Guttman scale and d) The Thurstone scale. Likert scales are usually used to quantify opinions and personal characteristics (van Thiel, 2014). This study utilised a Likert scale; as it is easier for local residents to understand and to compile than other attitude scales. A Likert-type scale ranging from 1 to 5, as shown below in Table 3.6 was used for this study in Sections C, D and E of the questionnaire.

Table 3.6: Likert scale

Applicable Likert-type scale used							
Section in questionnaire							
C	Not very important	1	2	3	4	5	Very important
D	Strongly disagree	1	2	3	4	5	Strongly agree
E	Not very effective	1	2	3	4	5	Very effective

3.6 STEP 4: PILOT TESTING

Step 4 of the research process was to conduct a pilot testing. Pilot testing is a very important component of the survey procedure that is carried out before conducting the main survey (van Thiel, 2014). Pilot testing gives guidance on aspects such as: The adequacy of the sampling frame; the variability of parameters within the survey population; and the non-response rate (Younus, 2017; Oum, 2010). A pilot testing act as a precaution taken before the main survey is conducted (van Thiel, 2014; Richardson et al., n.d). The effectiveness of a questionnaire wording and design can also be established from a pilot survey (Younus, 2017). Reliability and validity of the questionnaire can be ascertained and improved by a pilot survey carried out during the month of July 2017 within the City of Tshwane (van Thiel, 2014).

The pilot testing for this current study was carried out after ethical clearance was granted by the Ethics review committee in the month of July 2017. Fellow researchers from the University of South Africa, experts in the transport industry and other potential participants (the general public) were asked to complete the pilot questionnaire. Some technical issues were pointed out by experts. Minor changes were done to the questionnaire following the pilot survey. The researcher also checked the viability of distributing the questionnaires in certain areas of the city. It was observed that busy areas of the city were not conducive to the distribution of questionnaires; since most of the people would be preoccupied with their business activities of the day. Some people would not finish completing the questionnaire; as they were in a hurry to get on with their activities. However, areas where people were more relaxed are the ones that were observed to be viable for conducting the survey.

3.7 STEP 5: FIELDWORK AND DATA COLLECTION

This section discusses the process of fieldwork and the data collection for the present study. The data collection was conducted during the month of August in the year 2017 in the City of Tshwane. The researcher distributed questionnaires in selected areas of City of Tshwane that were conducive to conducting a survey, such as city parks, bus stops, sports venues of Athletics Gauteng North, carwash. These areas were identified during the pilot testing. The researcher distributed the questionnaires from Monday to Saturday. Between Monday and Friday, the researcher distributed the questionnaires during off-peak hours, when the residents of the City of Tshwane were more relaxed around city parks, bus stops and other popular places around the city. On Saturdays, the researcher targeted the general public at the athletics sport's venues around the city between 06: 00 to 10: 00.

The following process was followed during the data-collection process:

- The researcher introduced herself and informed the potential participants of the study and asked whether they were interested in taking part in the survey.
- Screening questions were asked of the potential participants who were interested in participating in the survey. The screening questions determined whether the potential participant was part of the required population of the study.

- Once the participant had been verified that he or she was part of the required population, the participant would be asked to sign the informed consent form. The researcher also reminded the participant that taking part in the study is voluntary and they could withdraw at any time and without giving any reasons. Instructions to complete the questionnaire were made simple and easy to understand. The researcher collected the data over a month in the different regions selected. On average, the participants would take 10-15 min to complete the questionnaire.

The participants filled out the questionnaires and returned them to the researcher. Waiting for the questionnaires to be filled out was important; as it reduced the number of incomplete questionnaires.

Editing and coding of the data is discussed in the next section.

3.8 STEP 6: EDITING AND CODING

Step 6 entails the editing and coding of the data. After the fieldwork had been conducted and completed, the task of editing, coding, data entry, computer editing and analysing the results took place. The researcher did the process of editing and coding during the month of September in the year 2017. The task of transforming a completed questionnaire is needed, in order to get useable results (Richardson et al., n.d). At this stage, the research should check the completed questionnaires for errors, consistency, emissions, legibility and delete any unnecessary points (Mamun et al., 2014).

The first stage of data processing was field editing. The researcher performed field editing. Field editing is used to check the completeness of questionnaires and to check the legibility as soon as the participant returns the questionnaire (Richardson et al., n.d). The data were transferred to the computer for ease of editing.

The second stage was coding. Coding is the conversion of data into labelled categories appropriate for computer processing; and in many cases, this is numerical labelling (van Thiel, 2014). General information, such as gender was coded as male (1) and female (2). Sections C to E were coded (1-5), as shown in Table 3.5. Coding makes it possible to compare and merge research data and discover certain patterns (ibid).

3.9 STEP 7: DATA PROCESSING AND ANALYSIS

Data analysis is a mechanism for reducing and organising the data, in order to produce findings that require interpretation by the researcher (Mamun et al., 2014). The data need to be categorised and interpreted, according to the requirements of the study. SPSS statistical software package, descriptive statistics, factor analysis and inferential statistics will be used to analyse the data. Figure 3.5 illustrates the steps of the data analysis followed during the study.

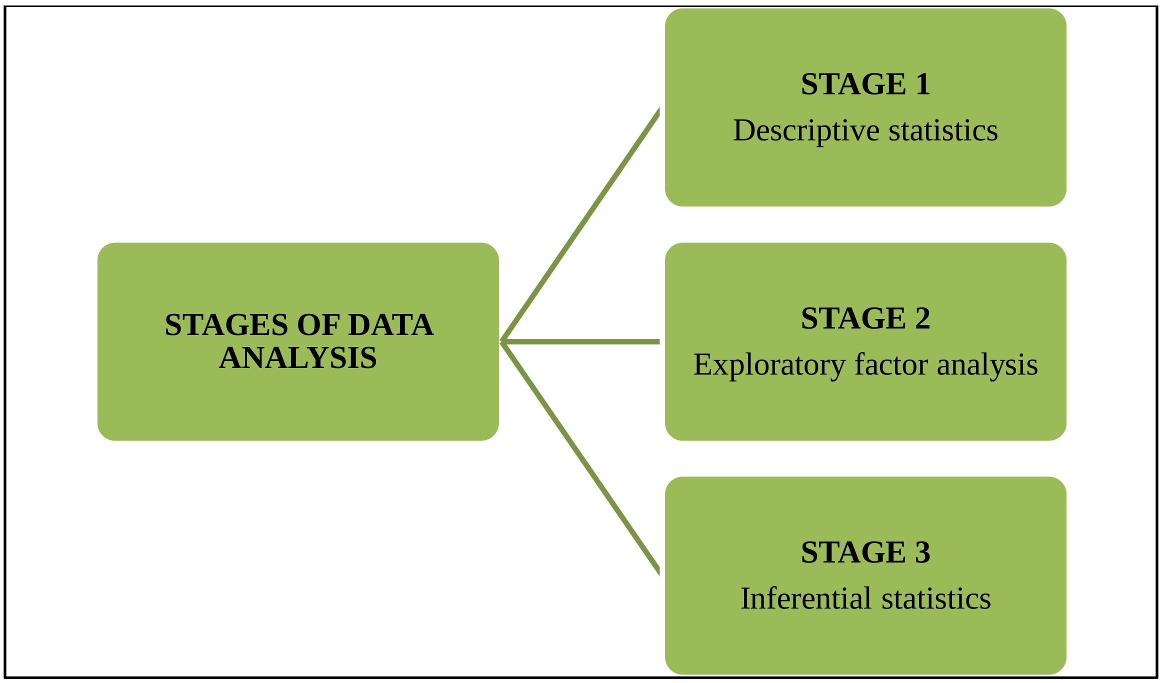

Figure 3.5: Steps followed in the data analysis

Source: own synthesis

3.9.1 Descriptive statistics

Descriptive analyses are simply numbers that summarise the quantitative findings of the study through tables, charts, and graphs. To address secondary research objectives 2, 3 & 5, descriptive analysis was applied (2. To explore public attitudes towards sustainable urban transport in selected areas of the City of Tshwane; 3. To identify the transport modes used by the residents in selected areas of the City of Tshwane; 5. To identify transport initiatives that can encourage the public to use sustainable transport modes). Essentially, the goal of descriptive analyses is to summarise a sample, instead of using the data to learn about the population that the sample was assumed to represent (Steinberg, 2015). Descriptive analysis of the data was used for the variables used in the study from Sections C, D and E of the questionnaire (see Section 4.3).

3.9.2 Exploratory Factor Analysis

Factor analysis is a statistical method used for reformulating a set of natural or observed independent variables into a new set of independent variables (van Thiel, 2014). Factor analysis can also be viewed as a method used to locate regularity and trends in a large dataset (Mvududu & Sink, 2013). The first step in Exploratory Factor analysis is to test the validity of the constructs, followed by a reliability test; and lastly, the calculation of the composite scores (refer to Section 4.4). Exploratory Factor analysis is defined and discussed in Section 4.4. **Validity** is a term used to describe the relationship between an answer and some measure of the true score (Mamun et al., 2014). The validity of the constructs was tested first, in order to test the validity of all the constructs in the questionnaire ('Public attitudes towards sustainable transport', Section D and 'Transport initiatives', Section E of the questionnaire) (see Section 4.4.1.1 and 4.4.1.1).

Reliability is the consistency with which a measuring technique produces a certain result when the unit being measured has not changed. Reliability is an indicator of a construct or measure's internal consistency. Section D of the questionnaire adopted questions that had been previously tested for validity by Xia et al. (2017) (refers Appendix C). Testing the overall reliability of the constructs in the questionnaire was done through the Cronbach Alpha coefficient (refer to Section 4.4.2). The Cronbach Alpha coefficient is the most commonly used method (Zikmund & Babin, 2010). Cronbach Alpha values above 0.8 are considered to have 'good reliability'; Cronbach Alpha's between 0.6 and 0.8 is 'acceptable reliability'; and Cronbach Alpha's below 0.6 is 'unacceptable reliability' (ibid). In order words, a reliable Cronbach Alpha Coefficient Alpha value indicates that the individual items of the dimension measured the same dimension consistently. Composites scores were calculated after the validity and the reliability test (see Section 4.4.3).

3.9.3 Inferential statistics

Stage 3 identified the statistics and the statistical computer program for testing the major inferential research questions (see Section 4.5). Inferential statistics use the mathematical computation programs, such as SPSS, SAS and Excel to carry out tests of statistical significance (Steinberg 2015; Zikmund & Babin, 2010). The purpose of this stage of data analysis was to address the research objectives 4 (to determine whether statistically significant differences exist between the regional areas of the City of Tshwane with regard to the attitudes towards sustainable urban transport) and 6 (to determine whether statistically significant differences exist between the regional areas of the City of Tshwane with regard to transport initiatives that encourage the public to use sustainable transport modes).

ANOVA was used to determine whether statistically significant differences exist between the regional areas of the City of Tshwane with regard to 'Public attitudes towards sustainable transport' (Section D of questionnaire) and 'Transport initiatives' (Section E of the questionnaire). In this section, both parametric and non-parametric tests were applied, including the Kruskal-Wallis tests[8], Chi-square tests[9], Welch's test[10] and Tukey-Kramer test[11]. One-way ANOVA was the most appropriate statistical tool; because the means of groups (regional areas of City of Tshwane) to be compared amounted to more than two (Zikmund & Babin, 2010). The underlying assumptions[12] are:

- Normality; and
- Homogeneous variances.

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[8] Kruskal-Wallis test is a non-parametric test for comparing two or more samples that are independent (Jett & Speer, 2016)

[9] Chi-square test determines whether there is a significant relationships between two nominal variables or between two groups of respondents (van Thiel, 2014).

[10] Welch's test is used when data for different groups shows different standard deviations (McDonald, 2014)

[11] Tukey-Kramer test is used to compare different pairs of means in order to check significant differences from each other (McDonald, 2014)

[12] ANOVA assumes that the observations within each group are normally distributed. ANOVA also assumes that data are homogeneous, meaning that the standard deviations are equal in the groups (McDonald, 2014).

3.10 STEP 8: PRESENTATION OF THE RESEARCH FINDINGS

Step 8 is the final step in the research process where the presentation and the interpretation of the results is done in the form of tables or figures; and the interpretation of the results from the statistical test. The research findings can be presented in various ways, depending on the audience the researcher wishes to address (van Thiel, 2014). Finally, a conclusion will be drawn from the results. The research findings are presented in Chapter 4.

3.11 ETHICAL CLEARANCE

Ethical clearance of the present study was granted by the University of South Africa on the 5th of July 2017. The certificate is attached as an Appendix B. This research adhered to all the ethical procedures, according to the University of South Africa's (UNISA) policy on ethical clearance certification. Informed consent forms were generated. The participants in this research signed a consent form to indicate that they had been informed about the research; and that they had agreed to participate in the research. This form included the information for each of the participants:

- The purpose of the research;
- Assurance for confidentiality;
- Potential benefits to you, as well as to society;
- Whether the participants would receive incentives in this study; and
- How you can get a copy of the results.

The next section is the conclusion of the chapter.

3.12 CONCLUSION

This chapter has discussed the research methodology used in the study. The chapter outlined the six steps of the research process that was followed in the present study. The chapter commenced by providing the details of the study site, which is the City of Tshwane. The City of Tshwane is situated in the Gauteng Province of South Africa; and it consists of seven administrative and functional regions. Step 1 discussed the research process used in the study. The present study was an empirical study using a survey to collect the primary data during the month of August 2017. Step 2 described the sampling plan of the study. The sampling plan provided the sampling procedures for the study. Geographical location was used for the quota sampling; so that all the seven regions in the Tshwane would be represented. The target population comprised the residents of the City of Tshwane with a sampling size of (N=418). Step 3 in the research process was to select and design the research instrument (questionnaire). A modified questionnaire with structured questions was designed to allow the participants to choose the answer that represents their view. Step 4 of the research process was to conduct a pilot test and this was done in July 2017 after the ethical clearance.

After the pilot tested was conducted, the primary data were gathered in the City of Tshwane during the month of August in 2017 by a structured questionnaire; while the Likert scale method was employed to collect the public attitudes regarding sustainable urban transport (Step 5). Data processing and analysis took place after the data collection (Step 6). The researcher verified the completed questionnaire for errors, consistency, omissions, legibility; and deleted any unnecessary points.

Steps 7 and 8 are discussed in more detail in Chapters 4 and 5. Descriptive statistics, exploratory factor analysis and inferential statistics were used to analyse the data. Exploratory Factor analysis was used to test the validity of the constructs, followed by a reliability test. Exploratory Factor analysis is discussed in Section 4.4. Chapter 4 presents the outcome of the data analysis, which was step 7 of the research process; while Chapter 5 concludes by outlining the research findings of the study, as step 8 of the research process.

CHAPTER 4

DATA ANALYSIS OF SUSTAINABLE URBAN TRANSPORT

4.1 INTRODUCTION

Sustainable transport involves the minimisation of transport impact by shifting from unsustainable modes of transport to alternative modes of transport. The primary objective of the study was to develop guidelines for sustainable urban transport in selected areas of the City of Tshwane. To achieve the primary objectives, six secondary objectives were identified. The first secondary objective: 'To conceptualise transportation; urban transport; transport externalities, urban sprawl; sustainable development; sustainable urban transport; GHG; and congestion', was achieved in Chapter 2. Section 4.2 reports on the biographical information of the residents of selected areas of the City of Tshwane.

Section 4.3 presents the descriptive statistics of the study. Section 4.3.1 and Section 4.3.2 report on the results for the second secondary objective: 'To identify the transport modes used by the residents in selected areas of the City of Tshwane'. Exploratory Factor Analysis is reported in Section 4.4. The results for the third secondary objective: 'To explore public attitudes towards sustainable urban transport in selected areas of the City of Tshwane' are reported in section 4.4.3.1.

Inferential statistics is presented in Section 4.5, to answer the secondary objectives four and five, 'to determine whether statistically significant differences exist between the regional areas of the City of Tshwane with regard to the attitudes towards sustainable urban transport.' And 'To determine whether statistically significant differences exist between the regional areas of the City of Tshwane in terms of transport initiatives that encourage the public to use sustainable transport modes. Based on the literature and the results of this study, a set of guidelines for sustainable urban transport were developed for the City of Tshwane. These guidelines are presented in section 4.6.

The chapter will be discussed, according to the flow diagram in Figure 4.1.

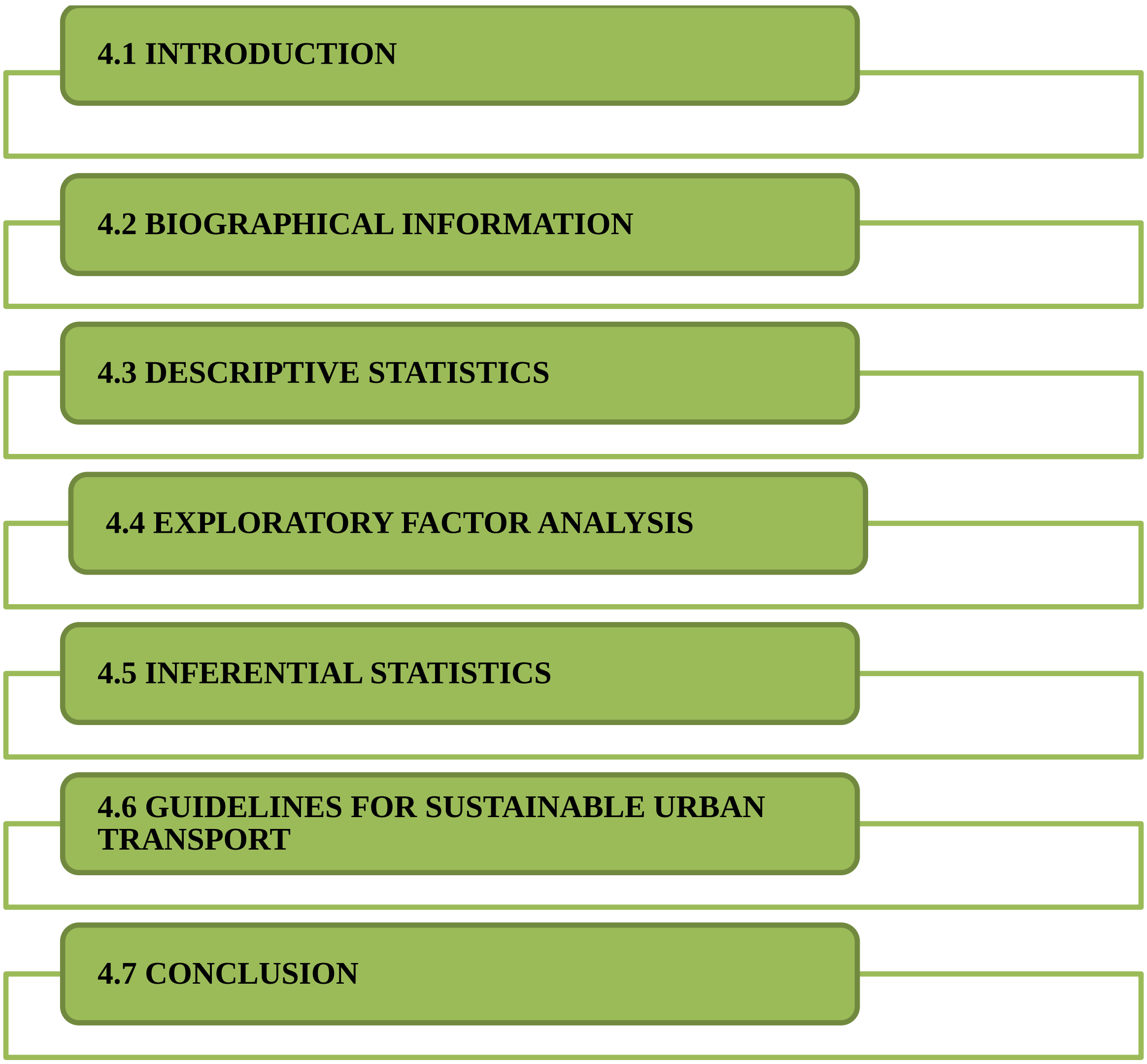


Figure 4.1: Flow diagram of Chapter 4

The results and the empirical findings of the study are discussed according to the flow diagram, Figure 4.1.

4.2 BIOGRAPHICAL INFORMATION

This section includes the biographical information of the residents of selected areas of the City of Tshwane, such as age, status of employment and gender, in order to identify the results with different groups of people. The results of the biographical information are summarised in Table 4.1.

Table 4.1: Biographical information

	Frequency	%
Age group		
18-24	100	24
25-45	248	59
46-64	69	17
Gender		
Male	182	44
Female	235	56
Work status		
Unemployed	98	24
Employed	279	67
Self-employed	38	9
Area		
Region 1	107	26
Region 2	46	11
Region 3	77	18
Region 4	50	12
Region 5	30	7
Region 6	77	18
Region 7	30	7

The interpretation of the results is provided in sections 4.2.1; 4.2.2; 4.2.3; 4.2.4; and 4.2.5. The results are discussed next.

4.2.1 Age categories

The study targeted the economically active population; this comprised the respondents between the ages of 18 and 64. Figure 4.2 indicates the age categories of the respondents.

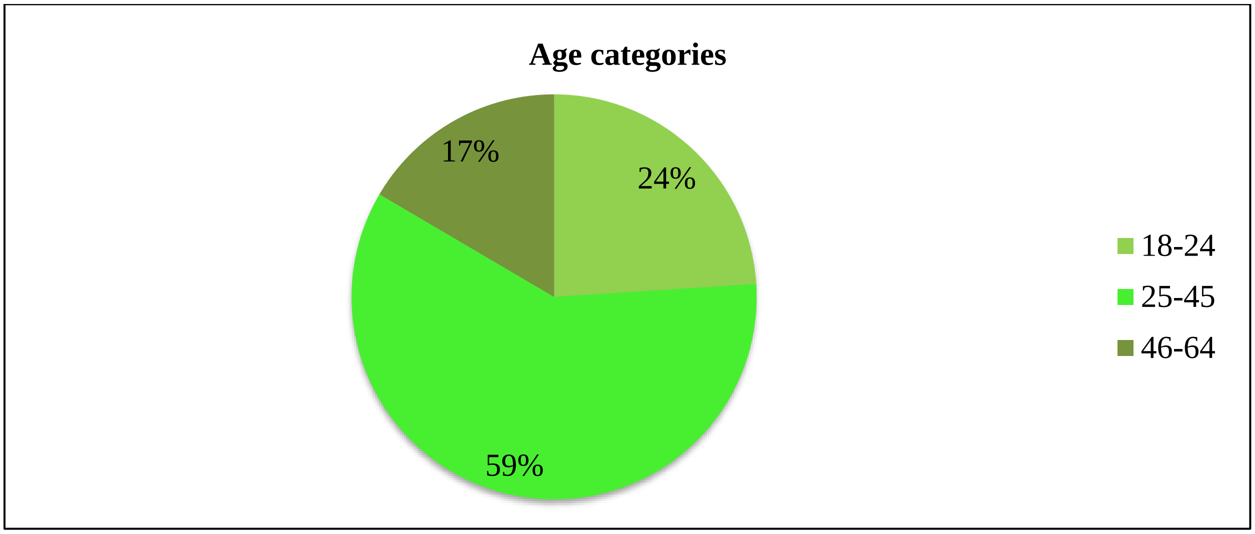


Figure 4.2: Age categories of the respondents

The total number of respondents from the local residents of the selected areas of the City of Tshwane was (N=417). The majority of the respondents were between the ages of 25 and 45 years (59%), followed by the ages of those between 18 and 24 who comprised 24%. The age group 46-64 consisted of 17%. The results suggest that the age group of 25-45 is among the employed population (refer Appendix G).

The findings of the results are consistent with those of previous research, thereby indicating that age is one of the important factors that influence mode choice and the attitude towards sustainable transport (McCarthy et al., 2017; Madhuwanthi et al., 2015). It may therefore be assumed that there could be more trips generated by the work trips from the age group of 25-45. Section 4.3.2 reports on the 'most frequently used mode of transport', according to the age categories. Further interpretation on age against mode of transport used is provided in section 4.3.2.

4.2.2 Gender

Gender might play an important role in the choice of transport mode. The second question determined the gender of the respondents. The second question asked was on gender. Figure 4.3 indicates the gender of the respondents.

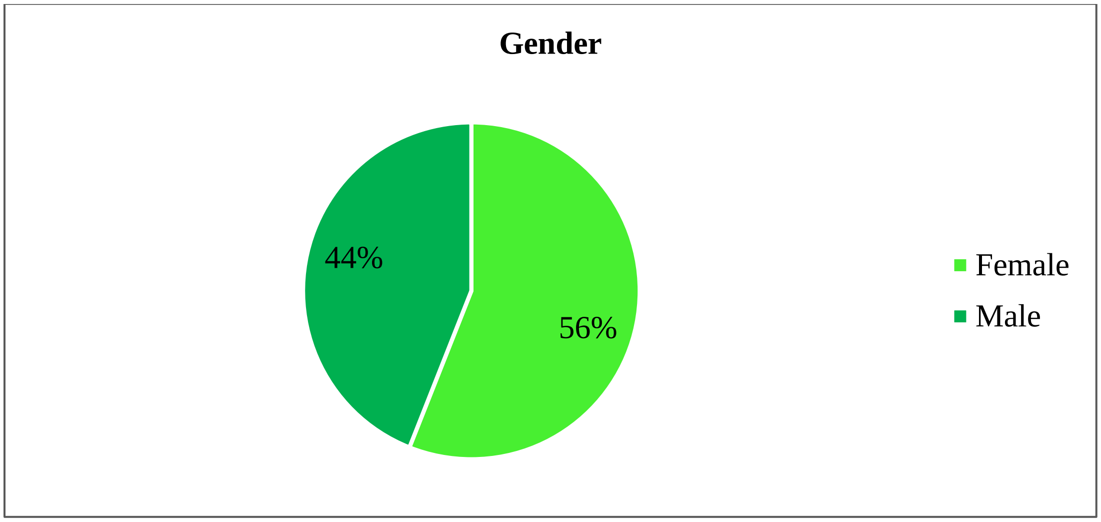


Figure 4.3: Gender respondents

Total number of respondents was 417 out of 418. Females numbered slightly more than the male respondents. It is evident from Figure 4.3 that females were 56%; while the male respondents amounted to 44%. Previous research indicates that gender is an important factor that affects the choice of the mode of transport (Prillwitz, 2011; Khoo & Ong, 2015; Verma et al., 2016; Xia et al., 2017). A higher percentage of women (52%) used private vehicles for work trips (refer to Appendix G). This result is consistent with those of previous research projects. This indicates that the poor service of public transport may discourage females from using public transport (Chee & Fernandez, 2013).

It may be assumed that females prefer private vehicles to the alternative sustainable modes of transport, such as cycling, walking and public transport. Therefore, it could be beneficial for the City of Tshwane to consider improving and promoting sustainable modes of transport; as these modes are friendly to the environment; and they can improve the quality of health. The provision of sustainable transport infrastructure, such as cycling and pedestrian infrastructures is part of the transition to sustainable urban transportation that may promote sustainable transportation (Panek & Benediktsson, 2017).

4.2.3 Status of employment

The respondents were asked to state their status of employment under the following categories: unemployed; employed; and self-employed. Figure 4.4 indicates the current status of the respondents.

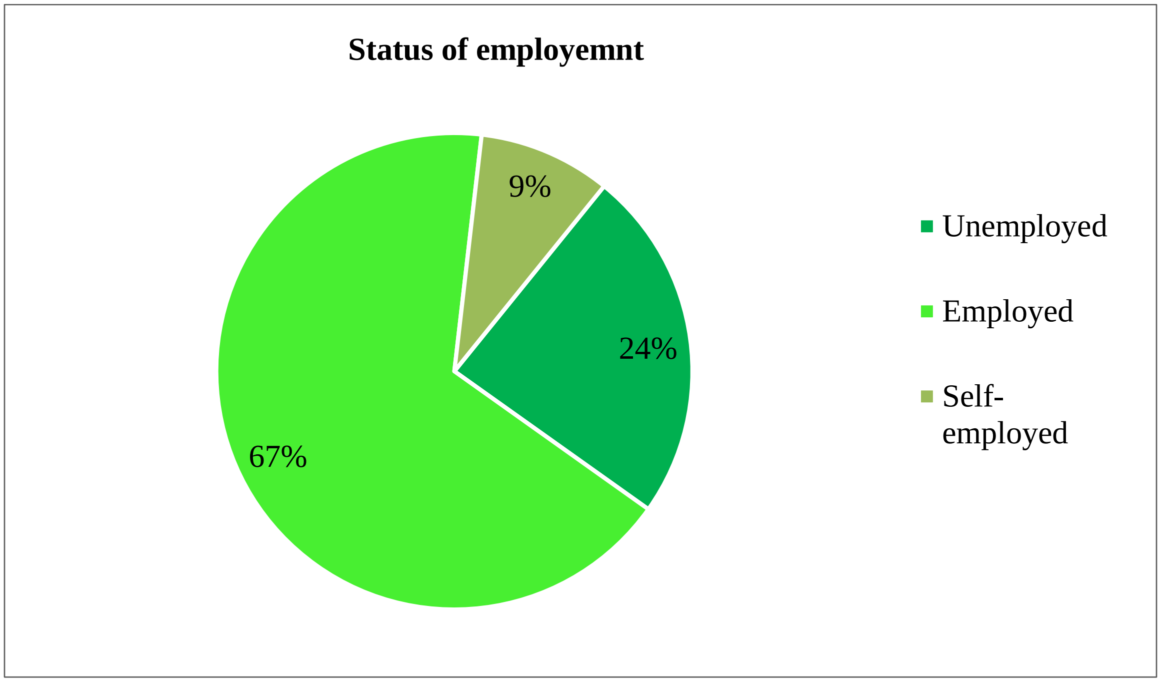


Figure 4.4: Status of employment

A total number of 415 responded to the question. Figure 4.4 shows that the majority of the respondents were employed (67%). The percentage of unemployed respondents was 24%. Self-employed respondents constitute 9%. Employment status is considered an important factor of socio-demographics for this survey, because it influences the choice of transport (Khoo & Ong et al., Liu et al., 2015; Cui et al., 2017; Xia et al., 2017). Local residents who are employed are said to be more mobile than those that are not employed (ibid). Most of the local residents that are employed usually commute every day to work. Therefore, it could be important to promote and encourage the use of sustainable urban modes of transport among the employed population; since the most frequently used mode of transport to travel to work is the private car (refer to Appendix G).

4.2.4 Regions of the City of Tshwane

The last question on biographical information was on the residential areas of the respondents. The City of Tshwane is divided into seven administrative and functional regions, as shown below in Figure 4.5.

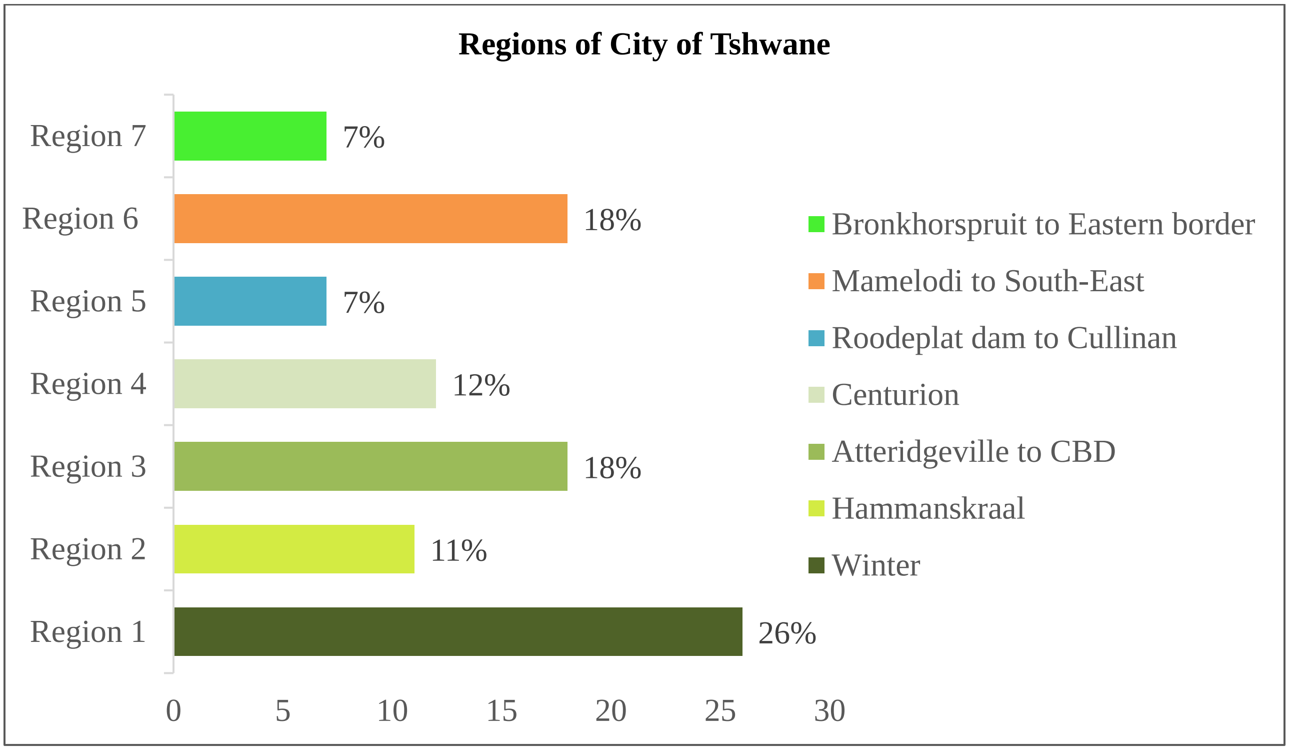


Figure 4.5: Regions of City of Tshwane

The respondents were asked to indicate the region in which they reside. A total number of 417 respondents reported accordingly. The majority of the respondents were from Region 1 (26%), followed by Regions 6 and 3, each region constituting 18%. Region 4 was slightly higher than Region 2 by 1%. The regions with the least of the population share are Regions 5 and 7, each region constituting 7%. Region 1 is a densely populated (1664 p/km^2) region in the City of Tshwane with the highest number of unemployed persons (CoT, 2016). Region 2 is characterised by low-density urban settlements and limited economic activities. Region 3 is the second largest region with respondents formally employed. Region 4 is one of the affluent areas with the highest household income in the City of Tshwane. Region 5 has the smallest population of the City of Tshwane; yet it covers the largest geographical area.

It may be assumed that various regions of the City of Tshwane do not experience the same type of transport problems, due to the different characteristics that these regions have. Some regions have a higher population share than the other regions. Higher population shares would probably put more pressure on the demand for transport; and that may lead to the more frequent use of motorised vehicles; and this, in turn, could increase the GHG emissions and cause harm to both the environment and human health (Pratelli & Brebbia et al., 2011).

Consequently, it may be beneficial for the City of Tshwane to apply sustainable transport solutions, according to the needs of a region. It could also be important to make public transport the mode of choice in the regions with high populations of people; since public transport opportunities (available) have the capacity to carry large numbers of commuters at a time; hence this might reduce the number of motor vehicles on the road.

4.3 DESCRIPTIVE STATISTICS FOR SUSTAINABLE TRANSPORT

This section provides a descriptive analysis of the data for the variables used in the study from Section C to section E of the questionnaire (refer to Appendix D). Descriptive analysis is simply numbers that summarise the quantitative findings of the study through tables, charts, and graphs. Essentially, the goal of descriptive analyses is to summarise a sample, instead of using the data to learn about the population that the sample of data is assumed to represent (Steinberg, 2015). A five-point Likert-type scale was used ranging from 1 to 5; and the items were collapsed into three categories for clear interpretation. The Likert-type scale, 'Not important to important' was applied to Section 4.3.3 'Transport service dimensions'. 'Disagree to agree' scale was applied to 4.3.5 (Sustainable transport benefits awareness); 4.3.6 (Traffic problems awareness); 4.3.7 (Safety and comfort); and 4.3.8 (Feelings about public transport). The last scale, 'Not effective to effective' was applied to sections 4.3.9 (Public transport initiatives); 4.3.10 (Cycling initiative); and 4.3.11 (Walking initiatives).

4.3.1 Transport modes

Transport modes were the first concepts measured to determine the main modes of transport that were available to the respondents. Figure 4.6 illustrates the results for the transport modes that are available to the residents of the City of Tshwane.

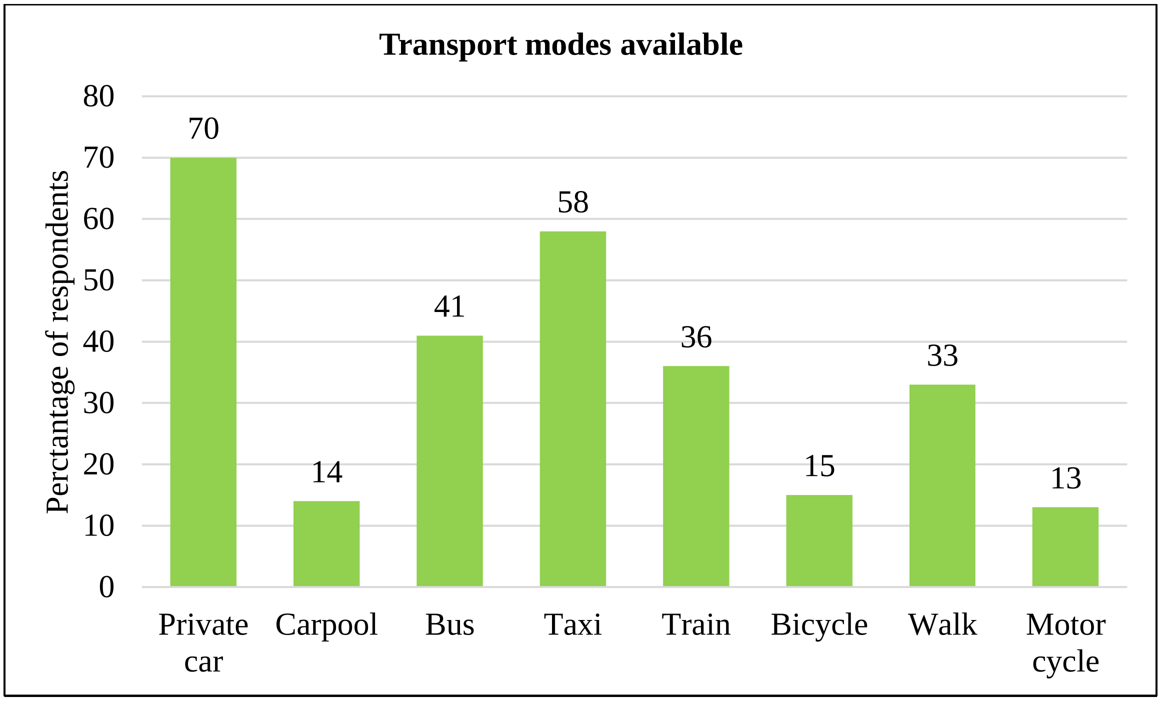
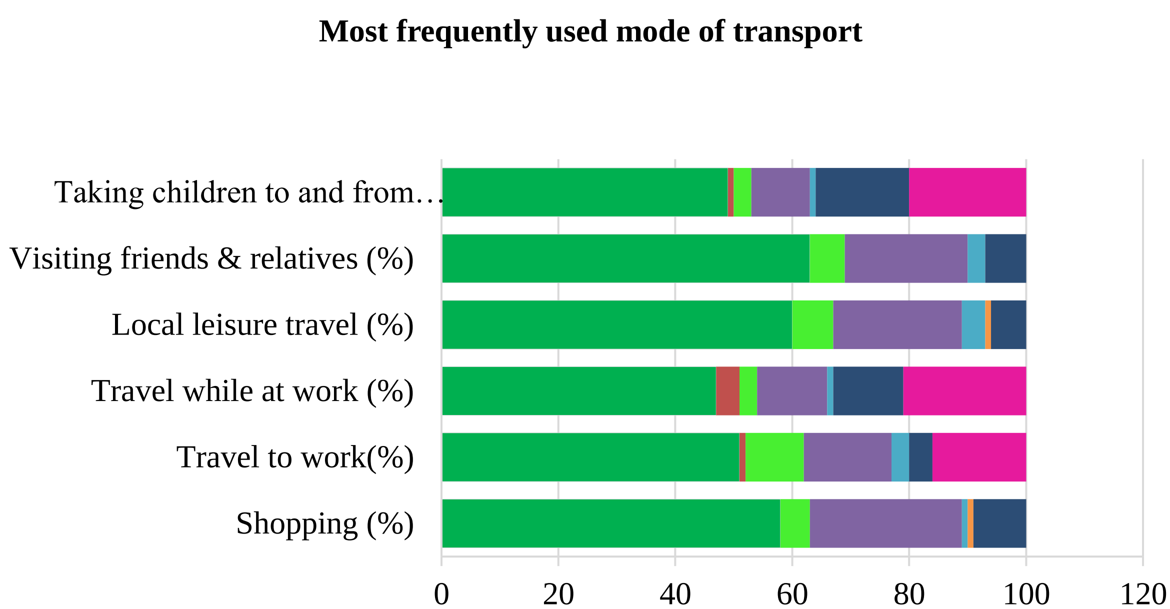


Figure 4.6: Transport modes available

The respondents were asked to indicate the main modes of transport that were available to them from the given options (private car, carpool, bus, taxi, train, bicycle, walk and motor cycle). It is evident from Figure 4.6 that the private car was by far the most popular mode of transport with 70%. This result is in line with previous research that indicates that the private car is the mode of transport that is most wanted (Susilo et al., 2012). Other modes of transport, such as taxis had a percentage of 58%, followed by the bus with 41%. Walking had a percentage of 33% of the respondents. Motor cycle was the least used mode of transport with 13%. The results indicate that the most desirable mode of transport was the private car; hence, it may be assumed that the residents of City of Tshwane are likely to use the mode of transport that is available to them. It may be important for the City of Tshwane to improve the provision of sustainable urban modes of transport that are less harmful to the environment and human health.

4.3.2 Most frequently used mode of transport

The most frequently used mode of transport was the second concept measured. Figure 4.7 illustrates the results from most frequently used mode of transport in selected areas of the City of Tshwane.



	Shopping (%)	Travel to work(%)	Travel while at work (%)	Local leisure travel (%)	Visiting friends & relatives (%)	Taking children to and from school (%)
Private car	58	51	47	60	63	49
Carpool	0	1	4	0	0	1
Bus	5	10	3	7	6	3
Taxi	26	15	12	22	21	10
Train	1	3	1	4	3	1
Bicycle	1	0	0	1	0	0
Walk	9	4	12	6	7	16
N/A	0	16	21	0	0	20

Figure 4.7: Most frequently used mode of transport

Overall, the most frequently used mode of transport for all the trips was the private car. 'Visiting friends and relatives' had the highest percentage of private car use of 63%, followed by 'local leisure travel' with 60%. 'Shopping'; 'travel to work'; 'taking children to and from school'; and 'travel while at work' had 58%, 51%, 49% and 47%, respectively. The contingency analysis of 'most frequently used mode of transport by age of the respondents (refer to Appendix G) indicates that overall, the age group 25-45 most frequently used a private car on a daily basis for all the trips in Figure 4.7. The results are consistent with those of previous research, which indicates that the private car is the most frequently used mode of transport for most of the trips; and it is still dominant (Xia et al., 2017; Uttley & Lovelace, 2016; Carse et al., 2013).

This finding suggests the need for reducing car usage. Therefore, it could be beneficial for the City of Tshwane to implement deterrents to driving private cars – in an effort to increase sustainable urban transportation. Cities, such as Berlin, London and Vienna have successfully implemented car restriction policies in an effort to discourage the use of private cars (Buehler et al., 2017). Examples of car restriction policies are car free zones in the CBD, limited and high parking fees, and the high costs of owning a car (Malasek, 2016; Fishman, 2014).

4.3.3 Transport-service dimension

The third concept to be measured was the transport-service dimension. The respondents were asked to rate the importance of the transport-service dimension when choosing a mode of transport to use. The results of the concept are illustrated in Figure 4.8.

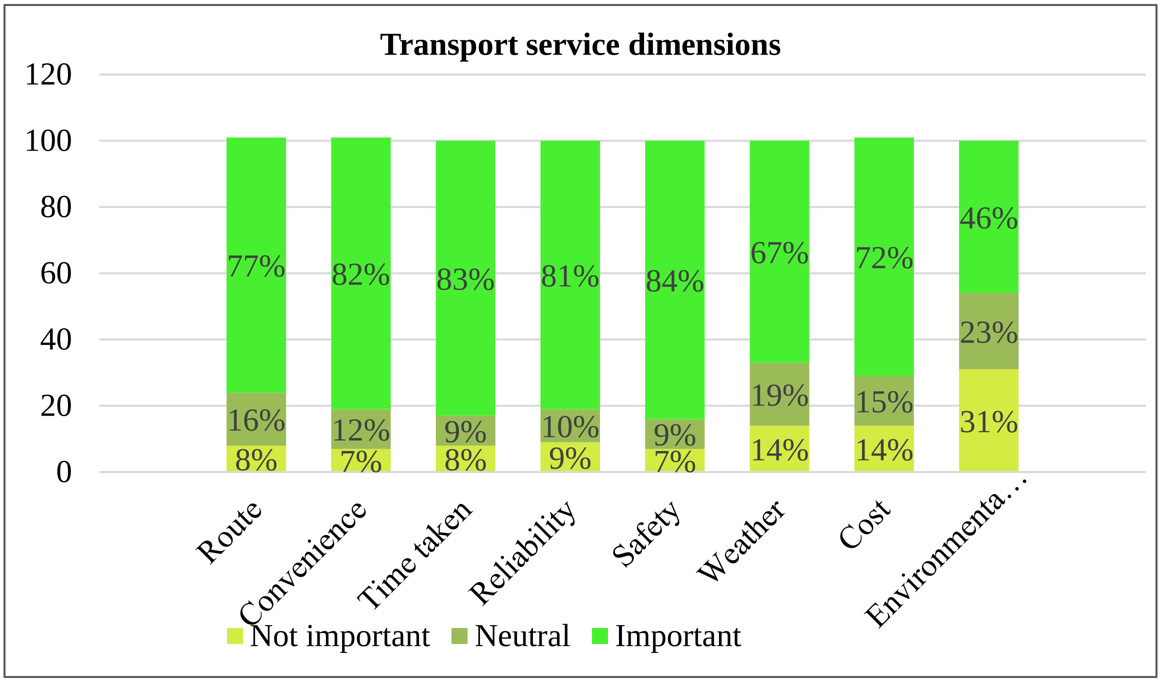


Figure 4.8: Transport-service dimensions

Most respondents considered 'safety' as one of the most important transport-service dimensions when choosing a transport mode with a percentage of 84%. This result is consistent with previous research, which showed that the most important factor in choosing the mode of transport is safety (Lopez-Saez et al., 2014; Madhuwanthi et al., 2015; McCarthy et al., 2017). Each mode of transport has inherent characteristics. The needs, expectations and knowledge of individuals are different; hence, these affect the decisions made in choosing the mode of transport. Other transport-service dimensions, such as 'convenience', 'time taken' and 'reliability', were almost equally important – with the exception of 'Environmental benefits' that was considered not important by 31% of the respondents. The 'environmental benefits' response is in line with previous research, which showed that the environmental benefit factor does not have much significant influence on the modal choice (Susilo et al., 2012; Xia et al., 2017).

It can be assumed that residents of the City of Tshwane are not aware of the environmental impact imposed by transport. The residents of the City of Tshwane may also have considered the environmental benefits as not important, because of habitual behaviour; consequently, once people are settled into a routine, they are less likely to change, unless there is a major life event (Busch-Geertsema & Lanzendorf, 2015). Therefore, the City of Tshwane might need to consider awareness programmes to educate the public on the impacts of transport modes on the environment, such as pollution and natural resource consumption. It could also be important to improve the transport dimensions, such as safety, reliability, time and convenience; since these dimensions were regarded as important when choosing the transport mode by the residents of the City of Tshwane.

The provision of a sustainable-transport service should aim to attain those transport dimensions regarded as important, in order to encourage the residents of the City of Tshwane to use sustainable transport modes.

4.3.4 Alternative modes of transport

An alternative mode of transport was the fourth concept to be determined – whether the residents of the City of Tshwane would consider alternative modes of transport as a way of promoting sustainable urban transportation. Figure 4.9 illustrates the results on alternative modes of transport.

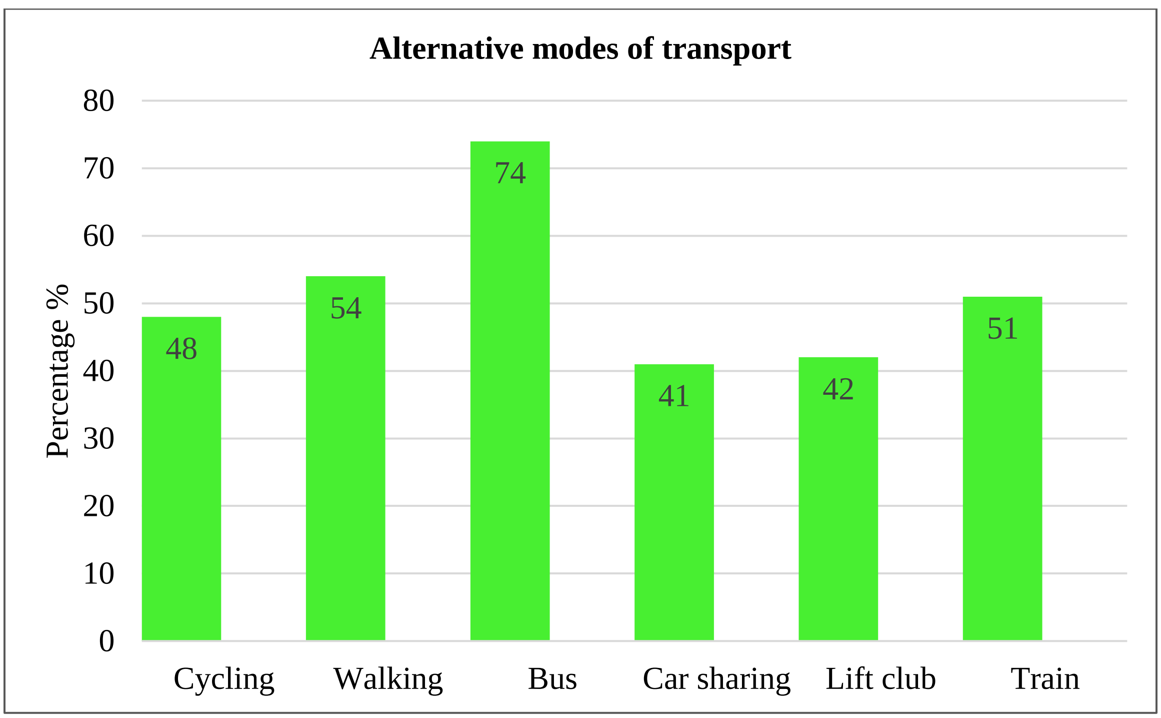


Figure 4.9: Alternative modes of transport

Figure 4.9 indicates that the majority of the respondents considered the bus as the preferred alternative mode of transport (70%), followed by walking with 54% (N=226); and then train, with 51% (N=214). Cycling had a percentage of 48% (N=201). Lift club (N=177) and car sharing (N=173) were almost at a par, 42% and 41%, respectively.

This finding suggests that bus transport was the most popular alternative mode of transport. It is assumed that there is a high opportunity and possibility of shifting the mode of choice to bus transport in the City of Tshwane. Therefore, it could be beneficial for the City of Tshwane to consider improving the service of the bus transport, in an effort to increase bus travelling. China's cities embarked on an operation to create transit cities, so as to increase the use of public transport in an effort to reduce air pollution and traffic congestion (Li & Zhao, 2017).

It may also be assumed that some of the alternative modes may not be safe for the respondents to use; as it is evident in Section 4.3.3 (transport service dimensions) that safety was the most important factor, when choosing the mode of transport. In order to increase the use of other alternative modes of transport, it could be important to implement transport initiatives to encourage commuters to use other modes, such as improving the cycling and walking infrastructure, and thereby improving safety.

4.3.5 Sustainable transport benefits

Sustainable transport benefits awareness was the fifth concept measured. This section is concerned with finding out how the respondents felt about sustainable transport benefits. Figure 4.10 illustrates how the respondents reported on the section.

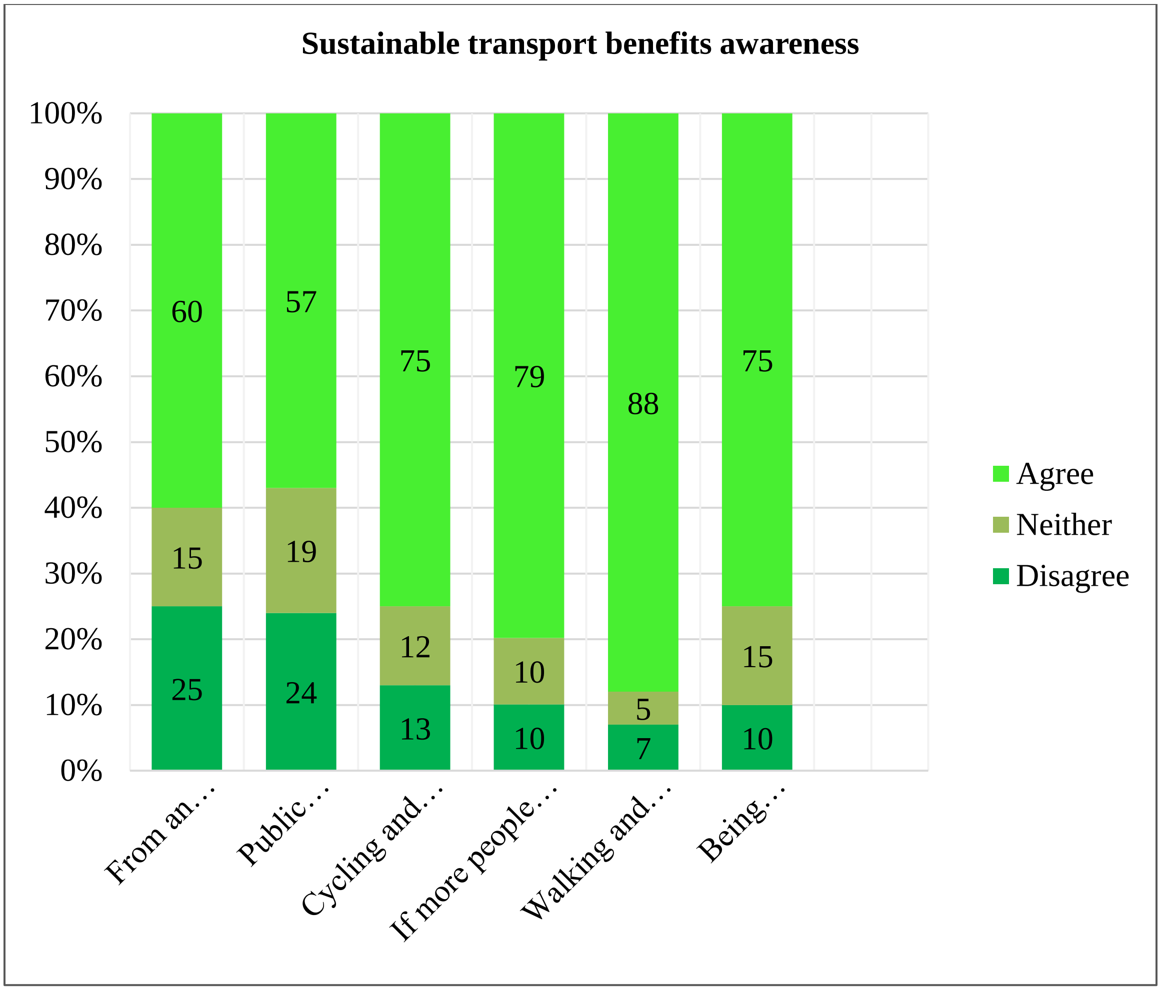


Figure 4.10: Sustainable transport benefits awareness

Figure 4.10 indicates that the majority of the respondents agreed with the statement that: ‘walking and cycling can help me keep fit and healthy’ with 88%. The respondents also fairly agreed with the other statements on sustainable transport benefits awareness. A considerable percentage of the respondents disagreed with the first statements (From an environmental point of view, it is important that we reduce car use) and with the second statement (Public transport is a more environmentally friendly option than driving a car) with 25% and 24%, respectively.

The item, ‘From an environmental point of view, it is important that we reduce car use’ shows that a percentage of 25% of the respondents disagreed with this item. It may be assumed that the respondents are well aware of the benefits of cycling and walking. The finding of the study is consistent with the previous research, which indicates that the respondents agreed that cycling and walking are good for human health and the environment (Gatersleben & Appleton, 2007; Verma et al 2016). New studies also reveal the positive impact of cycling and walking to the environment and human health (Taddei et al., 2015; Avila-Palencia et al., 2017; Maizlish et al. 2013).

The results also suggest that even though the majority of the respondents agreed that 'being environmentally responsible is important', the respondents, nevertheless, do not entirely agree that there is a need to reduce car usage. Therefore, it could be important for the City of Tshwane to implement car restriction policies – in an effort to reduce car usage. Educating the younger generation at school level to change behaviour at a young age could be important for the long-term solution, in order to create a generation that is responsible for keeping the environment safe and clean.

4.3.6 Awareness of traffic problems

The awareness of traffic problems was the sixth concept measured. Figure 4.11 illustrates the result of the awareness of traffic problems.

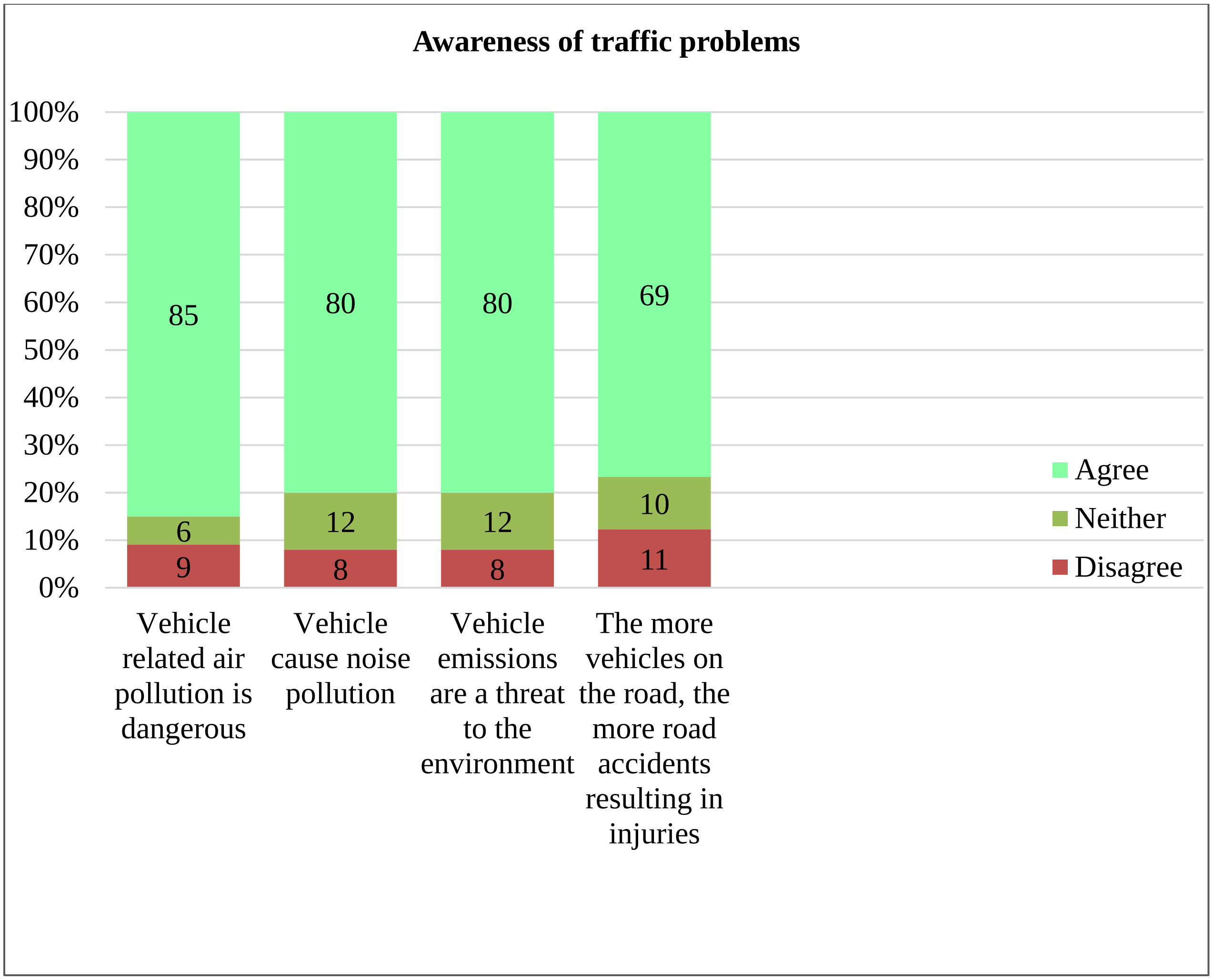


Figure 4.11: Awareness of traffic problems

There were four statements under 'Awareness of traffic problems'. The first statement was: 'vehicle-related air pollution is dangerous to our health'; and 85% of the respondents agreed with the statement. The second statement was: 'vehicles cause noise pollution'; and 80% of the respondents agreed with this statement. 'Vehicle emissions are a threat to the environment' was the third statement; and 80% of the respondents agreed with the statement. The last statement was: 'the more vehicles on the road, the more road accidents resulting in injuries and deaths'; and 69% of the respondents agreed with the statement.

It may be assumed that even though the respondents are aware of the traffic problems, the views of the respondents did not agree with their most frequently used mode of transport in Section 4.3.2

(most frequently used mode of transport). Therefore, comprehensive policies restricting access to driving may be recommended to reduce car usage. It could also be beneficial for the City of Tshwane to promote sustainable transport modes – in an effort to reduce car usage; and transport planners need to consider creative ways to change this notion.

4.3.7 Safety and comfort

Safety and comfort was the seventh concept measured. Figure 4.12 illustrates how the respondents felt about the safety and comfort of private cars and cycling.

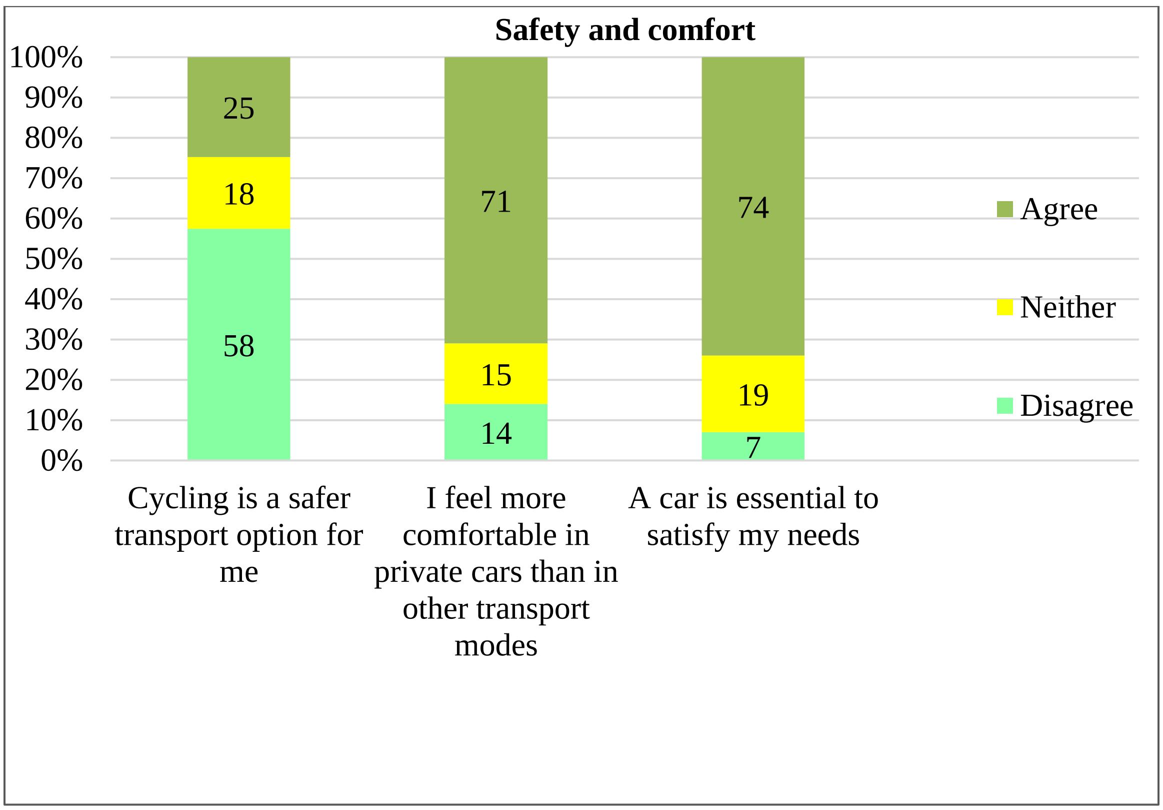


Figure 4.12: Safety and comfort

The first statement 'cycling is a safer transport option for me' illustrates that the majority of the respondents disagreed with the statements (58%); 18 % neither agreed nor disagreed with the statement; and 25% of the respondents agreed that cycling is a safer transport option. This finding is consistent with the previous research, which indicated that cycling is not a safe mode of transport

(Gatersleben & Appleton, 2007; Fernandez-Heredia et al., 2014; Fishman et al., 2014; Verma et al., 2016; Xia et al., 2017). This result suggests that there is a need to improve the image of cycling. It could be beneficial for the City of Transport to promote cycling – starting among school-going children, so as to create a generation of confident cyclists. Transport planners, city planners and policy-makers should eliminate barriers to cycling. Comprehensive town planning that creates a cycling-friendly environment could be of the utmost importance. Cycling policies that improve the safety of cycling tend to increase the usage of cycling as a mode of transport (Sun et al., 2017).

The second statement, 'I feel more comfortable in private cars than in other transport modes' illustrates that 71% of the respondents agreed with the statement. It may be assumed that most of the respondents feel more comfortable in private cars, which may lead to the frequent use of private cars and is confirmed in Section 4.3.2 (most frequently used mode of transport). Commuters are not likely to choose alternative modes of transport if they feel more comfortable and safe in private cars (Xia et al., 2017). Therefore, it could be important to introduce policies designed to improve the comfort, security and safety of alternative modes as a way of reducing the driving of private cars.

The last statement 'A car is essential to satisfy my needs' illustrates that 7% of the respondents disagreed with the statement; 19% neither disagreed nor agreed with the statement; and 74% agreed with the statement. It may be assumed that the respondents are satisfied with the utility benefit they get from the car as a mode of transport. Therefore, it could be important for the CoT to improve alternative modes of transport – in an effort to persuade the commuters to get the same value they get from the cars. For example a well-connected transport network system could be appealing to the residents of the City of Tshwane.

4.3.8 Feelings about public transport

Feelings about public transport was the eighth concept measured. Figure 4.13 illustrates how the respondents reacted to public transport as a mode of transport.

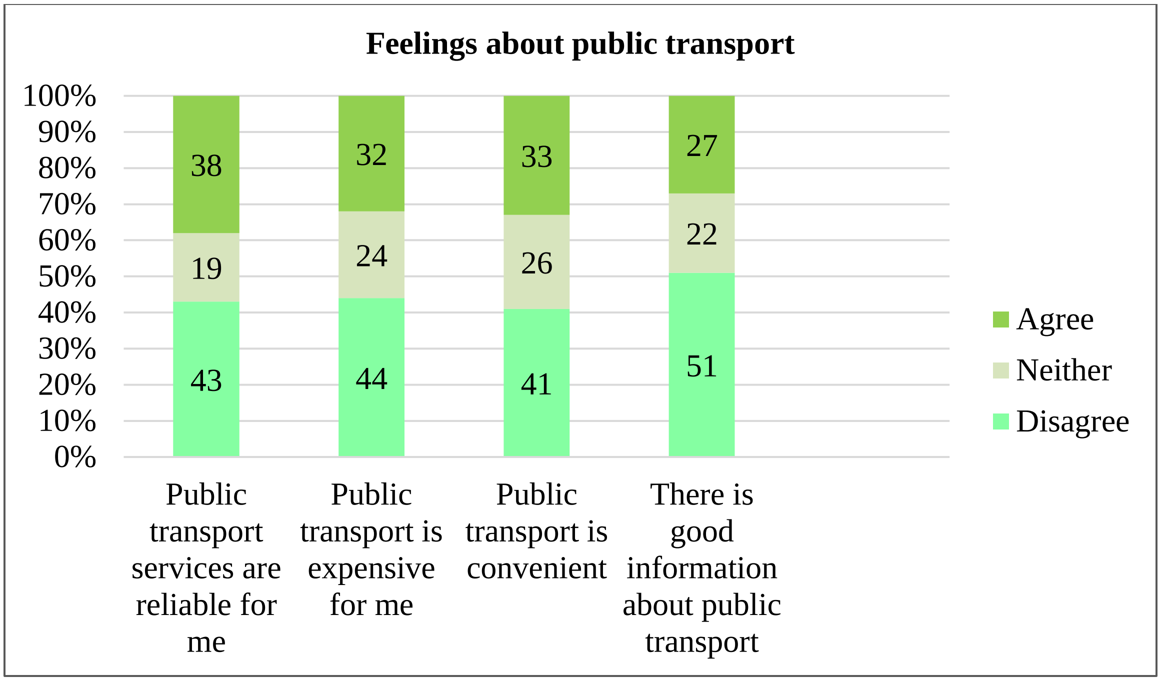


Figure 4.13: Feelings about public transport

Four statements pertaining to the respondents' feelings towards public transport were asked. The first statement: 'Public transport services are reliable for me', shows that 43% of the respondents disagreed; 19% neither disagreed nor agreed; and 38% agreed with the statement. The second statement: 'Public transport is expensive for me' illustrates that 44% disagreed; 24% neither agreed nor disagreed; and 32% agreed with the statement. The third statement: 'Public transport is convenient' indicates that 42% of the respondents disagreed; 26% neither disagreed nor agreed; and 33% agreed with the statement. The last statement: 'There is good information about public transport' shows that 51% of the respondents disagreed; 22% neither disagreed nor agreed; and 27% agreed with the statement.

In Section 4.3.3 (transport service dimensions), reliability, cost, convenience were regarded as important dimensions to be considered when choosing the mode of transport. It is evident from Figure 4.13 that the majority of the respondents do not agree that public transport is reliable and convenient. The finding suggests the implementation of projects to improve the quality of service. It may also be assumed that there is good information about public transport. Therefore, it could be important to have a good national passenger information system, in order to increase the use of public transport (Malasek, 2016); since Figure 4.13 indicates that the majority of the respondents feel that there is no good information about public transport. The City of Tshwane could provide transport information through flyers, websites and phone applications.

4.3.9 Public transport initiatives

Public transport initiatives was the ninth concept measured. Various public transport initiatives can be implemented to encourage the use of public transport. Figure 4.14 illustrates how the respondents rated public transport initiatives.

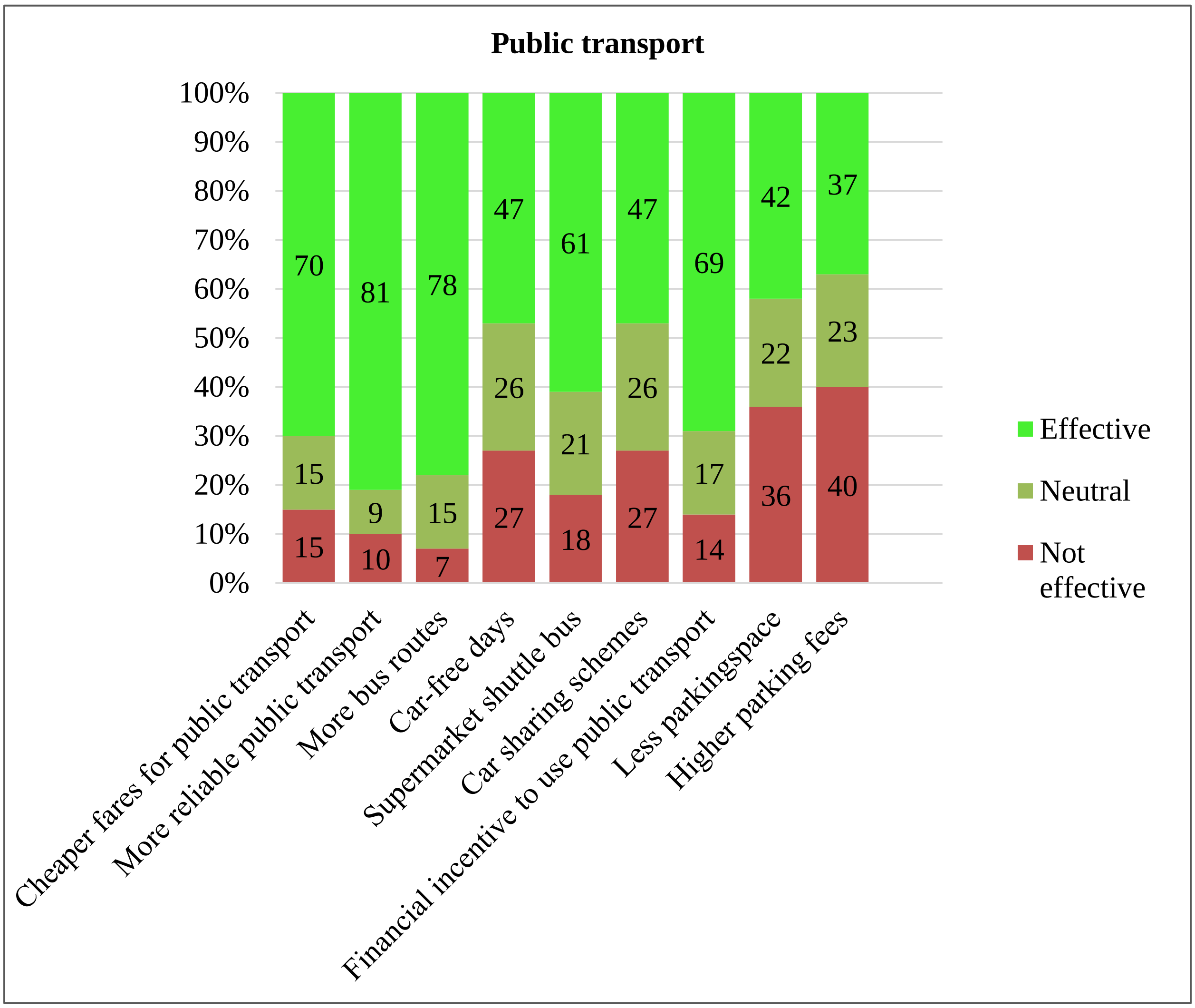


Figure 4.14: Public-transport initiatives

The respondents were asked to rate how effective the given public transport initiatives were. The respondents considered ‘More reliable public transport’ initiative as the most effective initiative with a percentage of 81%. ‘More bus routes’ and ‘Cheaper fares for public transport’ initiatives were also rated as being effective, with a percentage of 78% and 70%. This finding is in agreement with the transport-service dimensions (Section 4.3.3) that are important when choosing one’s mode of transport. Reliability, cost and routes were among the transport-service dimensions that were regarded as important when choosing a mode of transport. It could be beneficial for the City of Tshwane to consider the provision of additional public transport routes to increase the coverage of the public transport service network to less-populated areas, such as Regions 5 and 7. Reliability in public transport is regarded as a very important factor that can attract commuters to use public transport (Vilakazi & Govender, 2014).

In terms of ‘High parking fees’, the majority of the respondents (41%) considered this initiative as not effective. ‘Car-free days’, ‘Car-sharing’ and ‘Less-parking’ were considered as not effective by a number of respondents with 27%, 27% and 36%, respectively. These car-restricting policies were alleged to have worked more effectively in the Western European countries than in the US (Buehler et al., 2017). The finding in the City of Transport also suggests that these three initiatives may not be effective in encouraging commuters to use public transport. The City of Tshwane could focus on car restrictions that are supported by parking management.

4.3.10 Cycling initiatives

Cycling initiative was the tenth concept measured. Figure 4.15 illustrates how the respondents rated the effectiveness of cycling initiatives.

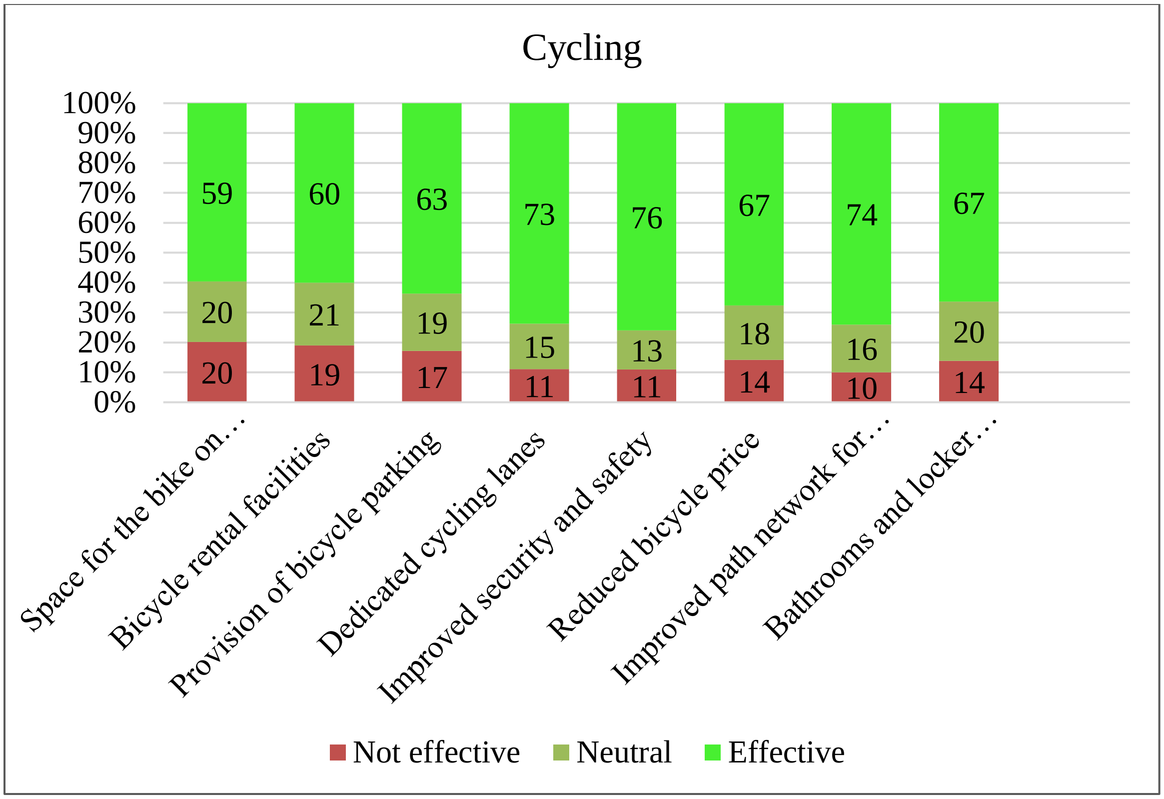


Figure 4.15: Cycling initiatives

The respondents were asked to rate the cycling initiatives that were provided. Cycling initiatives were all fairly rated as effective (59-76%). The most popular initiative considered effective was 'improved security and safety' with a percentage of 76%. This result is in line with previous research, which indicates that bicycle riding is likely to increase if security and safety are improved for the cyclists (Fernandez-Heredia et al., 2014; Verma et al., 2016). The concern is that one is terribly vulnerable on a bike – particularly in heavy traffic. The motorists do not allow cyclists to get in their way. It can be assumed that lack of security and safety with regard to cycling is a barrier to cycling. The finding suggests that it could be beneficial to improve the overall image of cycling. Previous research indicates that a better cycling infrastructure could increase the usage of bicycles (Sun et al., 2017); building facilities, such as showers and lockers can encourage commuters to cycle to workplaces (Fernandez-Heredia et al., 2014); and a dedicated cycling lane can encourage non-cyclists to start cycling (Fishman et al., 2014).

The City of Tshwane is advised to improve the safety and the security of cyclists through the provision of a better cycling infrastructure.

4.3.11 Walking initiatives

Walking initiatives was the last concept measured. Figure 4.16 illustrates how the respondents rated walking initiatives.

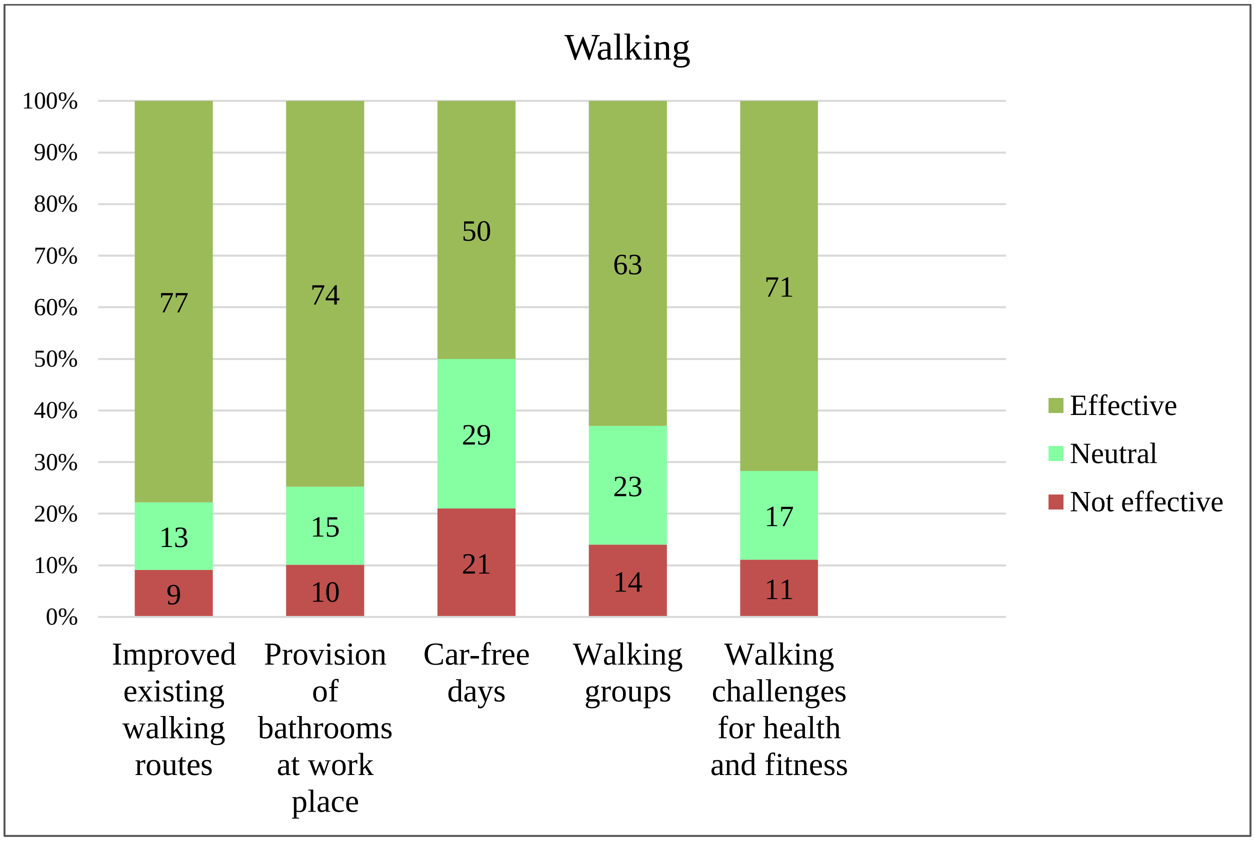


Figure 4.16: Walking initiatives

Respondents were asked to rate the effectiveness of the walking initiatives. The majority of the respondents (63%-77%) considered walking initiatives as effective with the exception of 'car-free days' that had 21% of the respondents considering it as not effective. 'Improved existing walking routes' initiative was considered to be effective with a percentage of 77%. Previous research indicates that pedestrian networks and good infrastructure have the potential of promoting walking among the employed population (Maki-Opas et al., 2016). It is evident from this study that the most frequently used mode of transport for work trips by the employed population is the private car. It could be beneficial for the City of Tshwane to encourage organisations to support their employees with the provision of showers, lockers and changing rooms – in an effort to encourage employees that are living within a walking distance from workplaces to start walking to work. Improved existing walkways to maintain cleanliness and safety could improve the image of walking in the City of Tshwane.

4.4 EXPLORATORY FACTOR ANALYSIS

The purpose of this stage of the data analysis was to address objectives 3 and 5 ('to explore public attitudes towards sustainable urban transport in selected areas of the City of Tshwane'; and 'to identify transport initiatives that can encourage the public to use sustainable transport modes'). It was important to establish whether each of the set of items corresponding to 'Public attitudes towards sustainable transport' and 'Transport initiatives' form a unidimensional construct, which could be used in subsequent analyses. Factor analysis is a statistical method used for reformulating a set of natural or observed independent variables into a new set of independent variables (van Thiel, 2014).

The first step for EFA is to test the validity of the constructs, followed by a reliability test; and lastly, the calculation of the composite scores.

4.4.1 Validity of constructs

The 'Validity of the constructs' was tested first, in order to test the validity of all the constructs in the questionnaire ('Public attitudes towards sustainable transport', Section D and 'Transport initiatives', Section E of the questionnaire). Validity is a term used to describe the relationship between an answer and some measure of the true score (Mamun et al., 2014). Validity can also be defined as the accuracy of a measure, or the extent to which a score truthfully represents a concept (Zikmund & Babin, 2010:250). The next section reports on the validity test for 'Public attitudes towards sustainable transport'.

4.4.1.1 Validity test: Public attitudes towards sustainable transport

The Kaiser-Meyer-Olkin (KMO) and Bartlett's test for Sphericity were conducted first to determine whether it is viable to conduct factor analysis. The results of tests are displayed in the form of tables. The KMO value ranges from 0 to 1, with 0.5 as a cut-off point to conduct a viable EFA. It is not viable to conduct an EFA if the correlation structure between the individual variables is too weak. Table 4.2 shows the output from SPSS.

Table 4.2: KMO and Bartlett's Test for Public attitudes towards sustainable transport variables

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.799
Bartlett's Test of Sphericity	Approx. Chi-Square	2146.623
	Df	136
	Sig.	0.000

The KMO value of 0.5 is acceptable to conduct an EFA (Zikmund & Babin, 2010). KMO value in the table is 0.799. The P-value is below 0.05, which indicates a statistically significant structure that is viable to perform EFA on the items. From Table 4.2, it is evident that it is useful to conduct factor analysis. Then the next step was to determine the number of factors from the individual statements (Section D). The EFA yields one or more factors from statements under consideration. The following criteria were used to determine the number of factors:

- Cumulative percentage explained by the factors > 60%
- Eigen values > 1 (also called the Kaiser Guttman rule)
- Scree plot

Table 4.3 illustrates the total variance of the Eigenvalues and extraction sums of squared loadings.

Table 4.3: Cumulative variance explained for by factors: Public attitudes towards sustainable transport

	Total Variance Explained					
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1.Traffic problem awareness	4.404	25.906	25.906	3.954	23.260	23.260
2.Public transport	2.525	14.854	40.760	2.024	11.907	35.167
3.Environm ental awareness	1.396	8.213	48.973	.907	5.334	40.501
4.Private car	1.296	7.622	56.596	.745	4.385	44.885
5.Cycling and walking	1.121	6.596	63.192	.614	3.614	48.499

The factors in Table 4.3 are: Factor 1 – Traffic problem awareness; Factor 2 – Public transport; Factor 3 – Environmental awareness; Factor 4 – Private car; and Factor 5 – Cycling and walking. Table 4.3 shows 63.192% cumulative variance explained for by five factors. All the five factors have Eigen values greater than 1.

Figure 4.17 illustrates the scree plot of ‘Public attitudes towards sustainable transport.

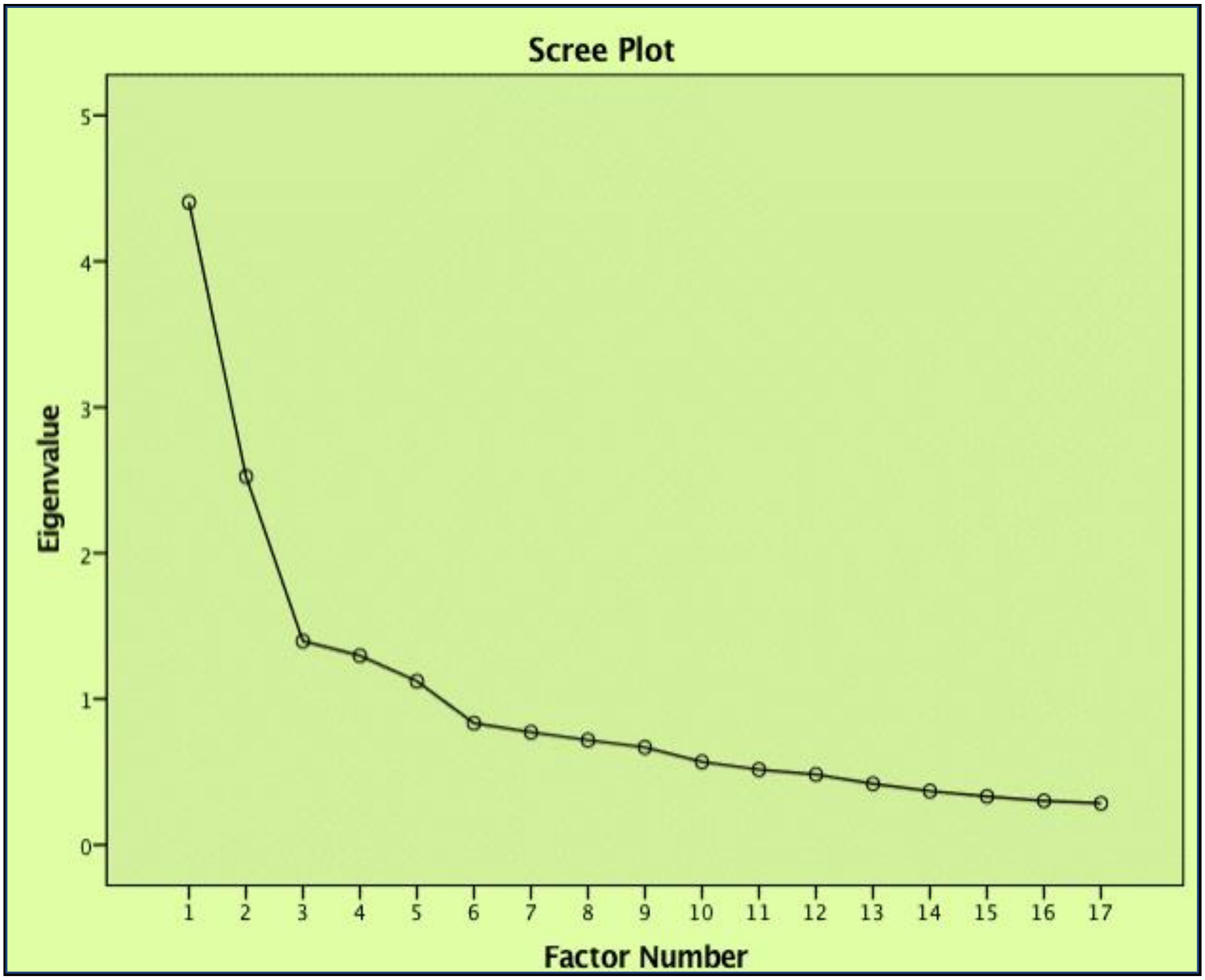


Figure 4.17: The Scree plot: Public attitudes towards sustainable transport

From the above Figure 4.17, it is evident that only the first five factors exhibited Eigenvalues greater than or near 1, with a cumulative variance ≥ 60%. The results of a scree test suggested that only the first three to five factors were meaningful. Therefore, only the first five factors were retained for rotation, namely: Traffic problem awareness; Public transport; Environmental awareness; Private car; and Cycling and Walking.

Table 4.4 summarises the results of the analysis of 'Public attitudes towards sustainable transport' (Section D of the questionnaire).

Table 4.4: Rotated factor pattern and final communality – Public attitudes towards sustainable transport

Items	Communalities	Factor loadings
Factor 1 – Traffic problem awareness		
D2.2 Vehicles cause noise pollution	0.677	0.836
D2.3 Vehicle emissions are a threat to the environment	0.616	0.709
D2.1 Vehicle related air pollution is dangerous to our health	0.578	0.672
D2.4 The more vehicles on the road, the more road accidents resulting in injuries and deaths	0.450	0.645
Factor 2- Public transport		
D4.3 Public transport is convenient	0.654	0.790
D4.1 Public transport service is reliable for me	0.694	0.721
D4.4 There is good information about public transport	0.448	0.674
D4.2 Public transport is expensive for me	0.201	0.413
Factor 3 – Environmental awareness		
D1.1 From an environment point of view, it is important that we reduce car use	0.505	0.712
D1.2 Public transport is a more environmentally friendly option than driving a car	0.387	0.561
D1.6 Being environmentally responsible is important to me	0.341	0.390
Factor 4- Private car		
D3.3 A car is essential to satisfy my needs	0.450	0.650
D3.2 I feel more comfortable in private cars than in other transport	0.435	0.600
Factor 5- Cycling and walking		
D1.5 Walking and cycling can help me keep fit and healthy	0.637	0.710
D1.4 If more people walked and cycled, this would have a positive effect on our environment	0.615	0.668
D1.3 Cycling and walking are more environmentally friendly options than driving a car	0.483	0.584

The communalities indicated the extent to which an individual item ‘relates’ to the factor structure. A value near 1 indicates a high proportion of ‘common’ variance, meaning that the item relates to other items, as opposed to a communality near 0, where the item is unique. Loadings of statement D3.1 were low. Low communality values of 0.2 or lower are not to be included.

The EFA was applied to responses of the seventeen items of 'Public attitudes towards sustainable transport' (Section D of the questionnaire). The principal axis-factoring extraction method was used to extract the factors (Appendix G). In interpreting the rotated factor pattern, an item is assumed to load on a given factor, if the factor loading was 0.40 or greater for that factor; and less than 0.40 for the others. Using these criteria, **four items** were found to load on the first factor, which was subsequently labelled "Traffic problem awareness". **Four items** loaded on the second factor, labelled "Public transport". **Three items** loaded on the third factor labelled "Environmental awareness". **Two items** loaded on the fourth factor labelled "Private car" and **three items** loaded on the firth factor labelled "Cycling and walking". Please note that question D3.1 was considered not part of the constructs; as it did not load (Appendix G). It may be interpreted that the communality values of the above items are all above 0.2; and as such, the items are considered to belong to the respective factor structures. With this information, reliability tests for 'Public attitudes towards sustainable transport' constructs can be carried out next (Section 4.5.2.1).

4.4.1.2 Validity test: Transport initiatives

The validity test of 'Transport initiatives' variables starts with KMO and Bartlett's Test to determine whether it is important to conduct an EFA. Table 4.5 below summarises the results from KMO and Bartlett's Test in relation to 'Transport initiatives' variables.

Table 4.5: KMO and Bartlett's Test for Transport initiatives' variables

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0.882**
Bartlett's Test of Sphericity	Approx. Chi-Square	**4337.617**
	df	**231**
	Sig.	**0.000**

The KMO value that is 0.5 is reasonable to conduct an EFA (Zikmund & Babin, 2010). The KMO value in the table is 0.882. Table 4.5 shows that it is viable to conduct an EFA.

Table 4.6 below shows the initial Eigenvalues and the extraction sums of the squared loadings.

Table 4.6: Cumulative variance explained for by the factors: Transport initiatives

	Total Variance Explained					
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1. Cycling initiatives	7.207	32.759	32.759	6.773	30.788	30.788
2. Walking initiatives	2.957	13.439	46.199	2.486	11.301	42.090
3. Public transport initiatives	1.654	7.517	53.715	1.217	5.532	47.622
4. Parking management	1.488	6.765	60.480	.989	4.497	52.119

The factors in Table 4.6 can be identified as: Factor 1- Cycling initiatives; Factor 2- Walking initiatives; Factor 3- Public transport; and Factor 4- Parking management. Table 4.6 indicates 60.480% cumulative variance explained for by the four factors. All the four factors have Eigen values greater than 1. Figure 4.18 below shows the scree plot for ‘Transport initiatives’.

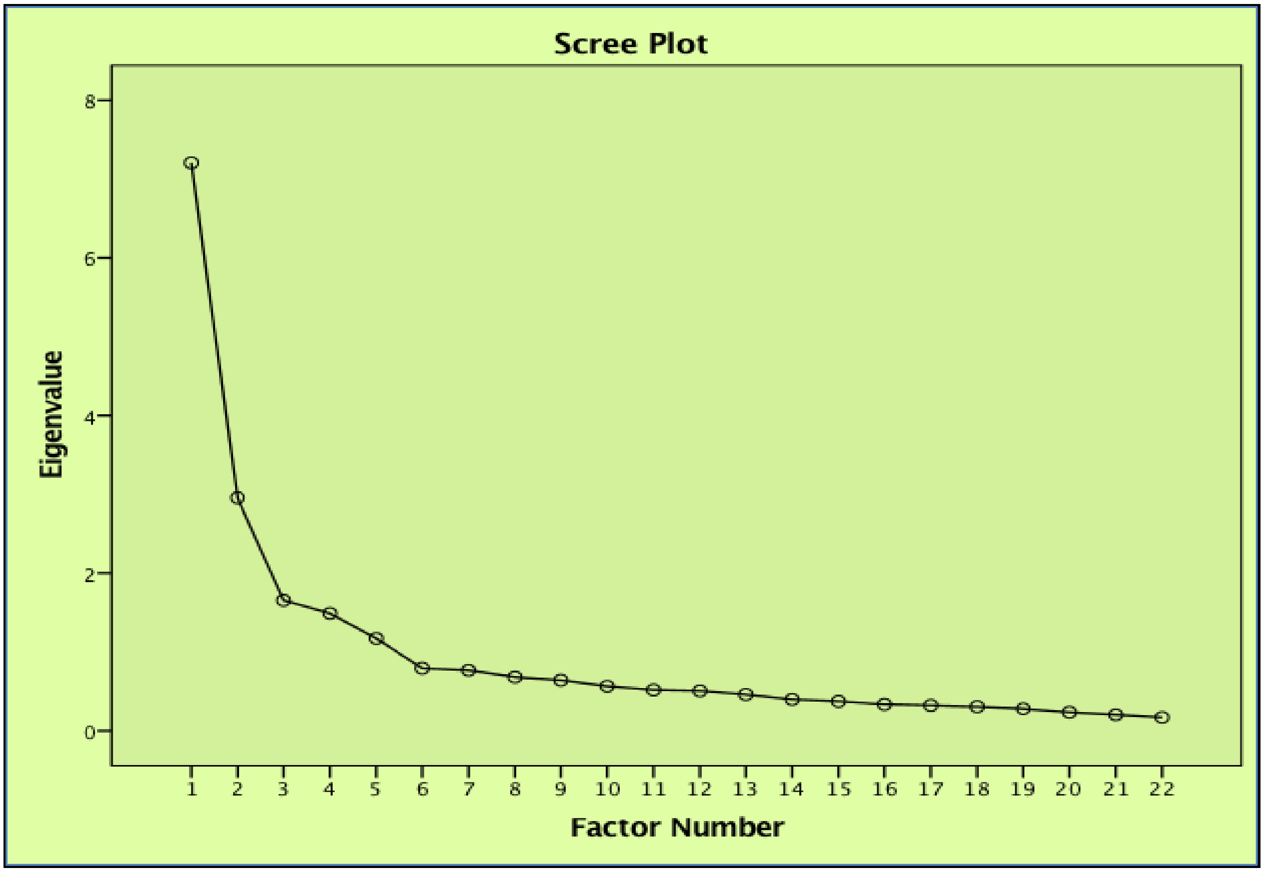


Figure 4.18: The Scree plot: Transport initiatives

From the above Figure, it is evident that only the first three to four factors exhibited Eigenvalues greater than or near 1; and the results of a screen test suggested that only the first four were meaningful. Therefore, only the first four factors were retained for rotation (Cycling initiatives; Walking initiatives; Public transport initiatives; and Parking management).

Table 4.7 represents the summarised results of communalities and factor loadings produced in relation to the variable under Transport initiatives.

Table 4.7: Rotated factor pattern and final communality: Transport initiatives

Items	Communalities	Factor loadings
Factor 1- Cycling		
E2.7 Improved path network for bikes	0.721	0.844
E2.3 Provision for bicycle parking	0.698	0.817
E2.4 Dedicated cycling lanes	0.657	0.802
E2.5 Improved security and safety of bicycles	0.671	0.795
E2.2 Bicycle rental facilities	0.613	0.793
E2.8 Bathrooms and locker facilities available for bicycle users	0.614	0.768
E2.6 Reduced bicycle price	0.554	0.719
E2.1 Space for the bike on public buses	0.555	0.707
E3.2 Provision of bathrooms at work place	0.357	0.433
Factor 2- Walking		
E3.4 Walking groups	0.641	0.811
E3.5 Walking challenges for health and fitness	0.541	0.747
E3.3 Car-free days	0.534	0.661
E3.1 Improved existing walking routes	0.340	0.392
Factor 3- Public transport		
E1.3 More bus routes	0.685	0.856
E1.2 More reliable public transport service	0.624	0.826
E1.1 Cheaper fares for public transport	0.344	0.566
E1.7 Financial incentive to use public transport	0.336	0.460
Factor 4- Parking management		
E1.9 Higher parking fees	0.497	0.706
E1.8 Less parking space	0.443	0.653

Exploratory Factor analysis was applied to the responses of the twenty-two items of Section E of the questionnaire. The principal axis factoring-extraction method was used to extract the factors. In interpreting the rotated factor pattern, an item was said to load on a given factor if the factor loading was 0.40 or greater for that factor and less than 0.40 for the other. Using these criteria, nine items were found to load on the first factor, which was subsequently labelled "Cycling". Four items loaded on the second factor, labelled "Walking". Four items loaded on the third factor labelled "Public transport"; and two items loaded on the fourth factor labelled "Parking management". The loadings for items E1.5 and E1.6 did not load (Appendix G). The communality values of the above items are all above 0.2; as such, the items are considered to belong to the respective factor structures.

4.4.2 Reliability of constructs

In general, reliability is the consistency with which a measuring technique produces a certain result when the unit being measured has not changed. Reliability is an indicator of a construct or measure's internal consistency. Testing the reliability of the constructs in the questionnaire was done through the Cronbach Alpha coefficient. The Cronbach Alpha coefficient is the most commonly used method (Zikmund & Babin, 2010). Cronbach Alphas above 0.8 indicate 'good reliability'; Cronbach Alphas between 0.6 and 0.8 indicate an 'acceptable reliability'; and Cronbach Alphas below 0.6 indicate an 'unacceptable reliability' (ibid). In other words, a reliable Cronbach Alpha Coefficient Alpha value indicates that the individual items of the dimension measured the same dimension consistently.

4.4.2.1 Reliability of 'Public attitudes towards sustainable transport' constructs

The reliability of 'Public attitudes towards sustainable transport' constructs was tested. There are five constructs found under 'Public attitudes towards sustainable transport' namely: 'Traffic problem awareness'; 'Public transport'; 'Environmental awareness'; 'Private car'; and 'Cycling and walking'. Table 4.8 summarises the results of the reliability tested on the items of 'Public attitudes towards sustainable transport'.

Table 4.8: The reliability of the variables of public attitudes towards sustainable transport

Variables	Items	Items left out	Cronbach	Reliability
Construct 1: Traffic problem awareness	D2.2, D2.3, D2.1, D2.4		0.833	Good
Construct 2: Public transport	D4.3, D4.1, D4.4		0.722	Acceptable
Construct 3: Environmental awareness	D1.1, D1.2, D1.6		0.633	Acceptable
Construct 4: Private car	D3.3, D3.2		0.601	Acceptable
Construct 5: Cycling and walking	D1.5, D1.4, D1.3		0.777	Acceptable

Estimates of internal consistency, as measured by Cronbach's alpha, all exceeded 0.6; and they are reported in Table 4.8. Reliability estimates were 0.833; 0.722; 0.633; 0.601; and 0.777 for responses to 'Traffic problem awareness', 'Public transport', 'Environmental awareness', 'Private car' and 'Cycling and walking' respectively. In conclusion to the above table, the constructs were found to be reliable.

In the next section, 'Transport initiatives' constructs are presented.

4.4.2.2 Reliability of 'Transport initiatives' constructs

Table 4.9 summarises the results of the reliability tested on items of 'Transport initiatives'.

Table 4.9: Reliability of the variables of transport initiatives

Variables	Items	Items left out	Cronbach	Reliability
Construct 1: Cycling	E2.7, E2.3, E2.4, E2.5, E2.2, E2.8, E2.6, E2.1, E3.2		0.921	Good
Construct 2: Walking	E3.4, E3.5, E3.3, E3.1		0.780	Acceptable
Construct 3: Public transport	E1.3, E1.2, E1.1, E1.7		0.776	Acceptable
Construct 4: Parking management	E1.9, E1.8		0.755	Acceptable

Table 4.9 shows that reliability estimates were 0.921, 0.780, 0.776 and 0.7755 for responses to 'Cycling', 'Walking', 'Public transport' and 'Parking management', respectively. Item E1.5 and E1.6 had lower loadings and do not belong to the factor structure; and their commonality values were below 0.2. In conclusion, to the above table, the constructs were found to be reliable.

In the next section, the construct scores for the constructs are presented.

4.4.3 Construct scores

It is evident from Table 4.9 and Table 4.10 that the constructs in the questionnaire are reliable. Composites scores are calculated next. Factor-based scale is a variable that contains factor-based scores. A single score can be determined for each construct by calculating the average of the individual items/statements.

4.4.3.1 Construct scores – Public attitudes towards sustainable transport

This section deals with the third objective of the study, 'To explore public attitudes towards sustainable urban transport in selected areas of the City of Tshwane (refer to Appendix E:

Questionnaire, Section D). The summarised statistics presented in Table 4.10 are for 'Public attitudes towards sustainable transport'.

Table 4.10: Construct scores – Public attitudes towards sustainable transport

Factors	Mean	Std Dev	Std Err Mean	Upper 95%	Lower 95%	N	Skewness	Kurtosis
Traffic problem awareness (1)	4.2	0.87	0.04	4.3	4.1	416	-1.268	1.63
Public transport (2)	2.8	1.12	0.05	2.92	2.7	418	0.24	-0.65
Cycling and walking (3)	4.2	0.90	0.04	4.31	4.1	415	-1.21	0.96
Private car (4)	4.0	0.96	0.05	4.11	3.9	412	-0.85	0.35
Environmental awareness (5)	3.7	1	0.05	3.82	3.63	416	-0.52	-0.35

Table 4.10 illustrates the construct scores for Section D of the questionnaire. The scale used was a five-point Likert scale (1 = Strongly disagree, 2 = disagree, 3= Neutral, 4= Agree, 5 = Strongly agree). Factors 1, 'Traffic problem awareness' has the highest mean score of (M=4.2); while the lowest mean score was found in factor 2, 'Public transport' (M=2.8). The distributions of the above factors are attached in the appendices (Appendix J). Factors 1, 3 and 4 mean scores are equal or greater than (M=4), thereby indicating that on average the respondents agreed with the factors. Factor 2, 'Public transport' indicate a low score, meaning that the majority of the respondents did not respond positively to the factor. It is also evident from Figure 4.13 in Section 4.3.8 that the majority of the respondents considered public transport as unreliable, not convenient, and lacking in information on public transport. It may be assumed that public transport does not offer a good quality of service. The respondents might not be satisfied with the service of public transport. It could be beneficial for the City of Tshwane to improve its public transport system. Further tests are done to determine whether statistically significant differences exist between the regions of the City of Tshwane in terms of 'Public attitudes towards sustainable transport'.

4.4.3.2 Construct scores – Transport initiatives

This section is linked to the fifth objective of the study, 'To identify transport initiatives that should encourage the public to use sustainable transport modes' (refer to Appendix E: Questionnaire, section E). Table 4.11 presents the summarised statistics for 'Transport initiatives'.

Table 4.11: Construct scores – Transport initiatives

Factors	Mean	Std Dev	Std Err Mean	Upper 95% Mean	Lower 95% Mean	N	Skewness	Kurtosis
Cycling initiatives (1)	3.9	1.0	0.05	3.99	3.79	416	-0.85	0.44
Walking initiatives (2)	3.8	0.9	0.04	3.93	3.75	418	-0.59	0.03
Public transport initiatives (3)	4.1	0.9	0.04	4.17	4.00	415	-1.12	1.12
Parking management (4)	3.03	1.27	0.06	3.16	2.91	415	-0.005	-0.98

Table 4. 11 represents the construct scores for Section E of the questionnaire. A five-point Likert type scale was used (1=Not very effective, 2= Not effective, 3= Neutral, 4 = Effective, 5 = Very effective). Factor 3, 'Public transport initiatives' had the highest mean score of (M=4.1) indicating that on average the respondents rated public transport initiatives as effective, followed by factor 1 with a mean score of (M= 3.9). Factors 2 and 4 had mean scores of (M= 3.8) and (M=3.0), respectively. The lowest score was found in factor 4 (M=3.03), indicating that on average, the respondents were neither effective, nor ineffectual. Table 4.11 indicates that all the initiatives were positively received, with the exception of the 'Parking management'. This result refers to Sections 4.3.9; 4.3.10; and 4.3.11. With such positive responses towards transport initiatives, it may be assumed that there is a high chance and possibility of implementing sustainable transportation system in the City of Tshwane. Therefore, it could be important for the City of Tshwane to implement transport initiatives that were considered as effective, in an effort to encourage

sustainable urban transport modes. A further test must be done to determine whether statistically significant differences exist between the regions of the City of Tshwane.

4.5 INFERENTIAL STATISTICS

The purpose of this stage of the data analysis is to address the research objectives 4 (to determine whether statistically significant differences exist between the regional areas of the City of Tshwane with regard to the attitudes towards sustainable urban transport) and 6 (to determine whether statistically significant differences exist between the regional areas of the City of Tshwane with regard to transport initiatives that encourage the public to use sustainable transport modes). ANOVA was used to determine whether statistically significant differences exist between the regional areas of the City of Tshwane with regard to 'Public attitudes towards sustainable transport' (Section D of questionnaire) and 'Transport initiatives' (Section E of the questionnaire). In this section, both parametric and non-parametric tests were applied, including the Kruskal-Wallis tests, Chi-square tests, Welch's test and Tukey-Kramer test.

One-way ANOVA was the most appropriate statistical tool; because the means of the groups (regional areas of City of Tshwane) to be compared are more than two (Zikmund & Babin, 2010). The underlying assumptions are:

- Normality; and
- Homogeneous variances.

4.5.1 Oneway analysis of 'Public attitudes towards sustainable transport' by area (Section D)

This section is linked to the fourth objective of the study, 'To determine whether statistically significant differences exist between the regional areas of the City of Tshwane with regard to attitudes towards sustainable urban transport'. The section interprets the results from the ANOVA analysis of the variables that are in Section D of the questionnaire, 'Public attitudes towards sustainable transport'. The variables in the analyses in this section are: 'Traffic awareness', 'Public transport', 'Cycling and walking', 'Private car' and 'Environmental awareness'.

In the next section, the results from 'traffic-problem awareness' are presented.

4.5.1.1 Traffic problem awareness

Table 4.12, below shows the ANOVA descriptives for 'Traffic-problem awareness'.

Table 4.12: ANOVA descriptives – Traffic problem awareness

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Winterveld (1)	107	4.39486	0.08265	4.2324	4.5573
Hammanskraal (2)	46	4.20109	0.12605	3.9533	4.4489
Atteridgeville to CBD (3)	76	4.20285	0.09806	4.0101	4.3956
Centurion to R21 (4)	49	4.15306	0.12213	3.9130	4.3931
Roodeplaat dam to Cullinan (5)	30	3.63333	0.15608	3.3265	3.9402
Mamelodi to South-East border (6)	77	4.30736	0.09743	4.1158	4.4989
Bronkhorstspruit to Eastern border (7)	30	4.18333	0.15608	3.8765	4.4902

The Standard Error uses a pooled estimate of error variance

ANOVA tests were done to determine whether there was a significant difference between the mean 'Traffic-problem awareness' scores for the different regional areas of City of Tshwane. From the table above, it is clear that Roodeplaat dam to Cullinan area (Region 5) had the lowest mean score of (M=3.63) indicating that the majority of the residents of the City of Tshwane from Region 5 are not aware of any traffic problems. The Winterveld (Region 1) shows the highest mean score (M=4.39), indicating that the majority of the residents of City of Tshwane from Region 1 are aware of traffic problems.

It is evident from Table 4.12 that there are differences that exist among the regional areas of the City of Tshwane in terms of 'Traffic-problem awareness'. Region 5 has the largest geographical area; yet, it has the smallest percentage of Tshwane's population (City of Tshwane, 2016). Because of the characteristics of Region 5, the residents in the area would probably not experience traffic problems – unlike the residents in Region 1, where there is a higher percentage of population of the City of Tshwane. The residents in Region 1 are probably aware of the traffic problems; as the region has the highest population share in the City of Tshwane. Previous research indicates that the higher the population in a region, the higher the demand for transport to commute (Pratelli & Brebbia, 2011; Achour & Belloumi, 2016).

It could beneficial for the City of Tshwane to apply transport solutions, according to the characteristics of the region and the needs of the residents in the area.

To reduce traffic problems in Region 1, a viable and sustainable public transport network is needed to transport the mass of commuters. In South Africa, poor communities live far away from amenities and their places of works (Turok & Borel-Saladin, 2014) and Region 1 is one of those communities. The findings of this study show that the majority of the respondents in Region 1 depend on a private car for their work trips. Public transport can become a mode of choice for these communities if the City of Tshwane may improve the image of public transport and design transport infrastructure that is appealing to the commuters. Public transport has the potential to reduce carbon emission; as it transports a large number of people at any given time.

Anova descriptive can also be presented in the form of a diamond plot. Figure 4.19 is a diamond plot in relation to ‘Traffic-problem awareness’.

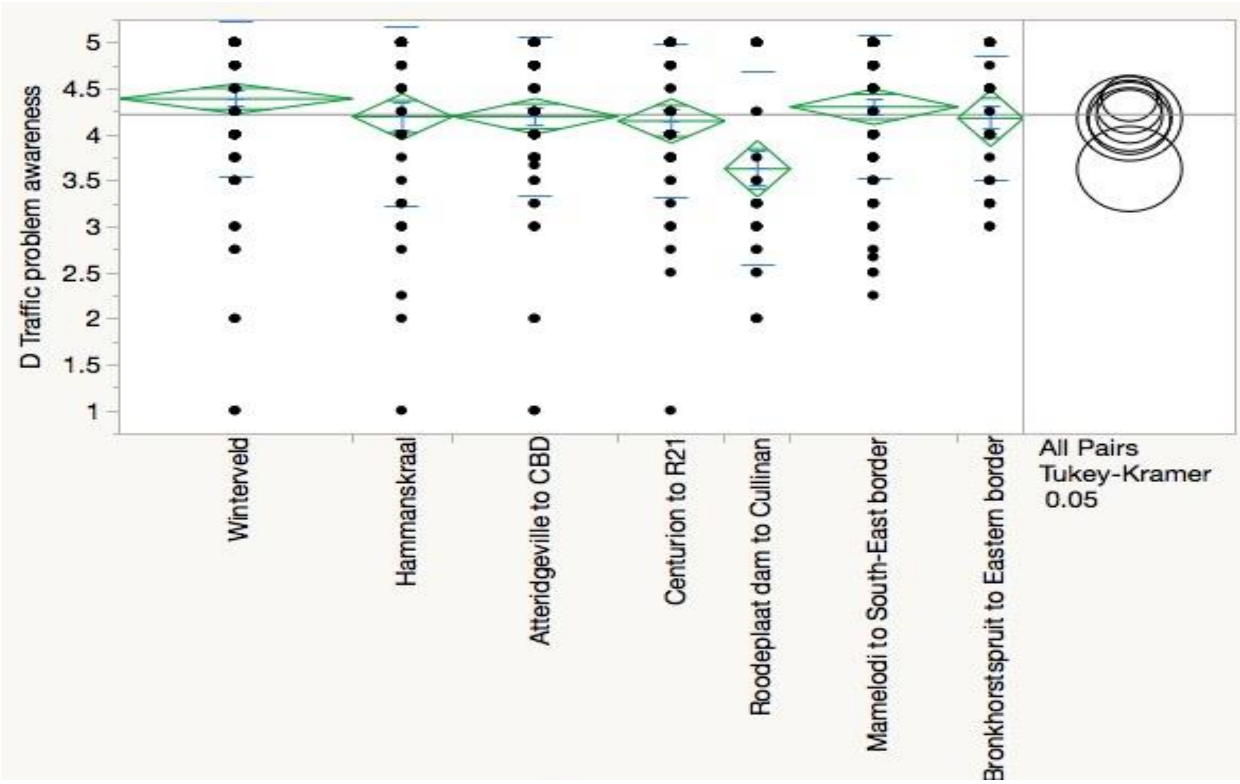


Figure 4.19: Diamond plot – Traffic-problems awareness

The middle line in the diamond in Figure 4.19 represents the mean score of the regional areas; while the width of the diamond shows the relative sample size. The vertical endpoints form the 95% confidence interval of the mean. It is clear from Figure 4.19 that the diamond for 'Winterveld' is much higher than the diamond of 'Roodeplaat to Cullinan'. This indicates a difference in mean scores of the regional areas in terms of 'Traffic-problem awareness'.

Table 4.13: Summary of Fit-Traffic problem awareness

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
B4 Area	6	14.47933	2.41322	3.3019	0.0035*
Error	408	298.19243	0.73086		
C. Total	414	312.67175			

The F-test was used as a part of ANOVA, in order to determine whether the difference between the means is statistically significant, which produces a probability value (p-value). The underlying assumption is that the p-value indicates statistical significance at a 95% level of confidence, if the calculated p-value is smaller than 0.05. Prob >F value is the p-value of the F-test. The results revealed statistically significant differences between the regional areas of the City of Tshwane, ($F_{(6,414)} = 3.30$, $p=0.0035$). Table 4.13 shows that the p-value is smaller than 0.05 (0.0035), indicating that there is a significant difference between the regional areas in terms of 'Traffic-problem awareness' at a 95% level of confidence.

The construct score is not normally distributed; a non-parametric test (Kruskall-Wallis) was used to produce the appropriate results. The results revealed that there was a significant difference between the regional areas (Chi square value = 18.63, df = 6 p= 0.0048) and the assumption of homogeneous variance holds good.

Non-parametric comparisons for each pair, using the Wilcoxon Rank Sum test

To assess where the specific differences exist among the various regions of the City of Tshwane in terms of 'Traffic-problem awareness', non-parametric comparisons for each region were performed. There are different types of tests that can be used to assess the specific differences. For the purpose of this study, the Wilcoxon method was used to assess the specific differences among the regional areas of the City of Tshwane with regard to 'Traffic-problem awareness' because the construct score is not normally distributed. The results from the Wilcoxon test are attached in the appendices (Appendix J.1).

Please note that the connecting letters report is only for interpretation purposes.

Table 4.14: Connecting letters report – Awareness of traffic problems

Level			Mean
Winterveld (Region 1)	A		4.395
Mamelodi to South-East border (Region 6)	A		4.307
Atteridgeville to CBD (Region 3)	A		4.203
Hammanskraal (Region 2)	A	B	4.201
Bronkhorstspruit to Eastern border (Region 7)	A	B	4.183
Centurion to R21 (Region 3)	A	B	4.153
Roodeplaat dam to Cullinan (Region 5)		B	3.633

The Tukey letter grouping shows the mean score for the seven regions of the City of Tshwane. Regions that are not connected by a common letter, but differ statistically; while the regions connected by the same letter are not significantly different either.

In Table 4.14, regions 1, 6, 3, 2, 7 and 3 are connected by the letter A. The connection indicates that these regions do not differ at the 0.05 significance level. Regions 2, 7, 3 and 5 are connected by the letter B, indicating that they do not differ statistically. However, regions 1, 6 and 3 and Region 5 are not connected by a common letter, thereby indicating that these regions are statistically different.

4.5.1.2 Public transport

Table 4.15 shows ANOVA descriptives for ‘Public transport’.

Table 4.15: ANOVA descriptives – Public transport

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Winterveld (1)	107	2.68847	0.10350	2.4850	2.8919
Hammanskraal (2)	46	3.44203	0.15785	3.1317	3.7523
Atteridgeville to CBD (3)	77	3.12121	0.12201	2.8814	3.3611
Centurion to R21 (4)	50	2.22667	0.15141	1.9290	2.5243
Roodeplaat dam to Cullinan (5)	30	3.11111	0.19547	2.7269	3.4954
Mamelodi to South-East border (6)	77	2.65584	0.12201	2.4160	2.8957
Bronkhorstspruit to Eastern border (7)	30	2.52222	0.19547	2.1380	2.9065

The Standard Error uses a pooled estimate of error variance

ANOVA tests were done to determine whether there was a significant difference between the mean 'Public transport' scores for the different regional areas of the City of Tshwane. From the above table, it is evident that differences do exist. Region 2 had the highest mean score (M= 3.44), thereby indicating that the majority of residents in Region 2 are satisfied with the public transport service. It could be important for the City of Tshwane to maintain a good service of public transport in Region 2, in order for commuters to continue using the public transport.

Region 4 had the lowest mean score of (M=2.22). It may be assumed that the majority of the residents of Region 4 are not satisfied with the public transport service. This could probably mean that public transport is not convenient, or reliable; and it does not provide good information about public transport. If the residents in Region 4 are not happy with the public transport, this could lead to a high private vehicle dependency. High and frequent use of private cars has a significant impact on the environment, as well as on human health (Khoo & Ong, 2015). It could be of the utmost importance for the City of Tshwane to improve the quality of public transport, in order to encourage the residents in Region 4 to use public transport and reduce their car usage.

The above results illustrated in Figure 4.20 are in the form of a diamond plot.

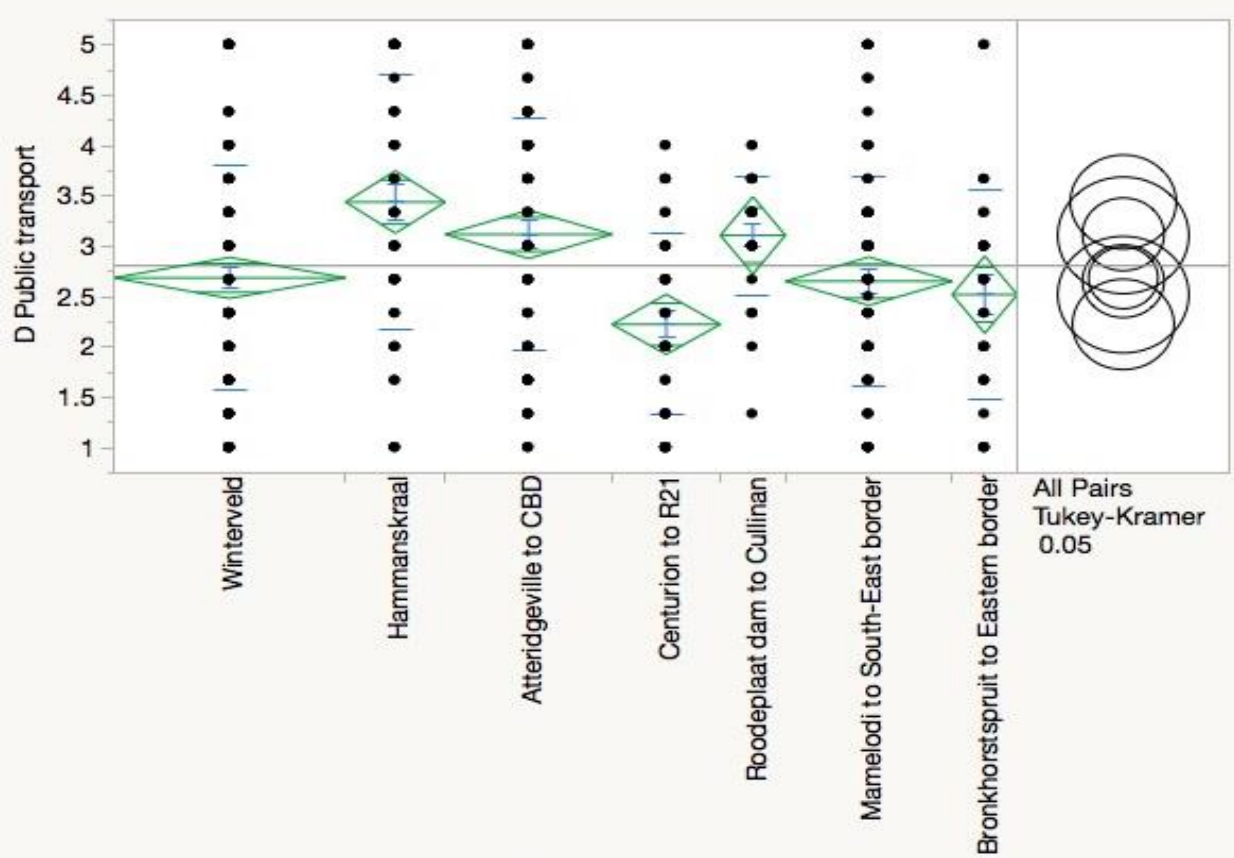


Figure 4.20: Diamond plot – Public transport

The figure above shows the diamond for the regional areas with regard to ‘Public transport’. The position of diamond for ‘Hammanskraal’ area is much higher than the diamond for ‘Centurion to R21’ area. This indicates differences between the regional areas of the City of Tshwane. To determine whether the difference between the means for the regional areas is statistically significant, the F-test was used; and Table 4.16, shows a summary of the results.

Table 4.16: Summary of Fit-Public transport

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
B4 Area	6	51.46048	8.57675	7.4826	<0.0001*
Error	410	469.95012	1.14622		
C. Total	416	521.41060			

Further tests were carried out. The F-test was used as part of ANOVA, in order to determine whether the difference between the means is statistically significant, which produces a probability value (p-value). The underlying assumption is that the p-value indicates statistical significance at a 95% level of confidence, if the calculated p-value is smaller than 0.05. Prob >F value is the p-value of the F-test. The results revealed statistically significant differences between the regional areas of the City of Tshwane, ($F(6,416) = 7.48$, $p=0.0001$). Table 4.16 shows that the p-value is smaller than 0.05 (even smaller than 0.0001), indicating that there is a significant difference between the regional areas in terms of 'Public transport' at a 95% level of confidence.

The assumption of homogeneous variances in this case does not hold; as the p-value for the Levene test is p= (0.0002), thereby indicating that the variances are not equal. Welch's test revealed ($F(8.30) = 8.30$, $df = 6$, $p = 0.001$).

Multiple means comparison test: Games-Howell

To assess where the specific differences exist among the various regions of the City of Tshwane in terms of 'Public transport', the appropriate test performed was the multiple means comparison test (Games-Howell). The results from the multiple comparison is attached in the appendices, (Appendix K.2). Table 4.17 below shows a summary of the connecting letters report. **Please note that the connecting letters report is only for interpretation purposes.**

Table 4.17: Connecting letters report – Public transport

Level				**Mean**
Hammanskraal	A			3.4420290
Atteridgeville to CBD	A	B		3.1212121
Roodeplaat dam to Cullinan	A	B		3.1111111
Winterveld		B	C	2.6884735
Mamelodi to South-East border		B	C	2.6558442
Bronkhorstspruit to Eastern border		B	C	2.5222222
Centurion to R21			C	2.2266667

The Tukey letter grouping shows the mean score for the seven regions of the City of Tshwane. The regions that are not connected by a common letter differ statistically; while the regions connected by the same letter are not significantly different.

In Table 4.17, the letter A connects regions 2, 3 and 5. The connection indicates that these regions do not differ at the 0.05 significance level. Regions 3, 5, 1, 6 and 7 are connected by the letter B, indicating they do not differ statistically; while letter C connects regions 1, 6,7 and 3 and do not differ statistically. However, Region 2 and Region 3 are not connected by a common letter, indicating that these regions are statistically different. It may therefore be concluded that statistically significant differences do exist among the regional areas of the City of Tshwane.

4.5.1.3 Cycling and walking

Table 4.18 below shows the ANOVA descriptives for 'Cycling and walking'.

Table 4.18: ANOVA descriptives – Cycling and walking

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Winterveld (1)	107	4.28349	0.08153	4.1232	4.4438
Hammanskraal (2)	46	4.04348	0.12435	3.7990	4.2879
Atteridgeville to CBD (3)	76	4.39912	0.09674	4.2090	4.5893
Centurion to R21 (4)	49	4.36735	0.12048	4.1305	4.6042
Roodeplaat dam to Cullinan (5)	30	3.18889	0.15398	2.8862	3.4916
Mamelodi to South-East border (6)	76	4.46053	0.09674	4.2704	4.6507
Bronkhorstspruit to Eastern border (7)	30	4.11111	0.15398	3.8084	4.4138

The Standard Error uses a pooled estimate of error variance

It is evident from the above table that 'Roodeplaat dam to Cullinan', Region 5 had the lowest mean score of (M=3.19). 'Mamelodi to South-East border', Region 6 had the highest mean score of (M=4.46). Other regions had almost the same mean score. Region 1 had a mean score of (M=4.28); Region 2 had (M=4,04); Region 3 had (M=4.40); Region 4 had (M=4.37) and Region 7 had

(M=4.11). Mean score above (M=4) indicates that most of the residents agreed with the items under ‘Cycling and walking’. The items include issues related to the environment and fitness and health. The attitudes of most of the residents were positive towards the environment and fitness and health. However, the attitude of most of the residents in Region 5 was neutral.

It may be assumed that the residents in Region 5 are not aware of the benefits of cycling and walking towards the environment and human health. Therefore, it could be beneficial for the City of Tshwane to bring awareness programmes of the benefits of cycling and walking to Region 5.

Figure 4.21 is a diamond plot in relation to ‘Cycling and walking’. Figure 4.21 is another way of presenting the results in Table 4.18.

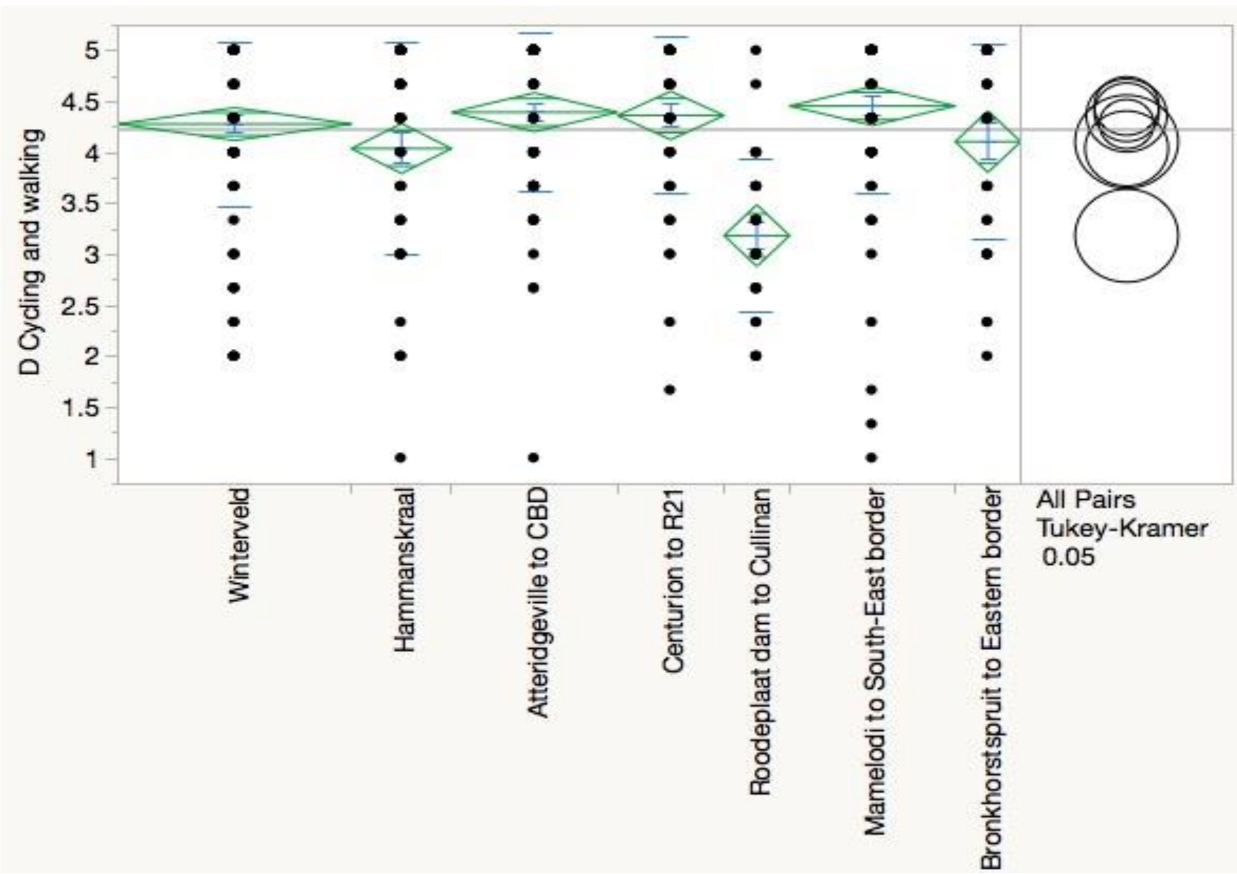


Figure 4.21: Diamond plot – Cycling and walking

The figure above shows the diamond for the regional areas with regard to ‘Cycling and walking’. The diamonds for ‘Atteridgeville to CBD’, ‘Centurion to R21’ and ‘Mamelodi to South-East border' are much higher than the diamond for 'Roodeplaat dam to Cullinan' area. This indicates the differences between the regional areas of the City of Tshwane.

To determine whether the difference between the means for the regional areas is statistically significant, the F-test was used; and Table 4.19 below shows a summary of the results.

Table 4.19: Summary of Fit-Cycling and walking

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
B4 Area	6	41.98412	6.99735	9.8381	<0.0001*
Error	407	289.48019	0.71125		
C. Total	413	331.46430			

The F-test was used as a part of ANOVA, in order to determine whether the difference between the means is statistically significant, which produces a probability value (p-value). The underlying assumption is that, p-value indicates statistical significance at the 95% level of confidence; but, if the calculated p-value is smaller than 0.05. Prob >F value is the p-value of the F-test. The results revealed statistically significant differences between the regional areas of the City of Tshwane, ($F(6,414) = 9.84$, $p=0.0001$). Table 4.19 shows that the p-value is smaller than 0.05 (even smaller than 0.0001), thereby indicating that there is a significant difference between the regional areas in terms of 'Cycling and walking' at the 95% level of confidence.

The construct score is not normally distributed; thus, a non-parametric test (Kruskall-Wallis) was used to produce the appropriate results. The results revealed that there was a significant difference between the regional areas (Chi square value = 52.16, df = 6, p= 0.0001). The assumption of homogeneous variances holds.

Non-parametric comparisons for each pair: Wilcoxon Rank Sum

To assess where the specific differences exist among the various regions of the City of Tshwane in terms of 'Cycling and walking', a non-parametric comparisons test was performed. For the purpose of this study, the Wilcoxon method was used to assess the specific differences among the regional areas of the City of Tshwane. The results from the Wilcoxon method are to be found in the appendices (Appendix K3). Table 4.20 below shows the connection letter group. **Please note that the connecting letters report is only for interpretation purposes.**

Table 4.20: Connecting letters report – Cycling and walking

Level			Mean
Mamelodi to South-East border	A		4.4605263
Atteridgeville to CBD	A		4.3991228
Centurion to R21	A		4.3673469
Winterveld	A		4.2834891
Bronkhorstspruit to Eastern border	A		4.1111111
Hammanskraal	A		4.0434783
Roodeplaat dam to Cullinan		B	3.1888889

In Table 4.20, the Regions that are not connected by a common letter to show that they differ statistically; while the regions connected by the same letter are not significantly different.

In Table 4.20, regions 1, 6, 3, 2, 7 and 3 are connected by the letter A. The connection indicates that these regions do not differ at the 0.05 significance level. Letter B, identifies Region B only. However, all the regions connected by letter A and letter B are not connected by a common letter, thereby indicating that these regions are statistically different.

4.5.1.4 Private car

Table 4.21 below shows ANOVA descriptives for the 'Private car'.

Table 4.21: ANOVA descriptives- Private car

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Winterveld (1)	107	4.01869	0.09166	3.8385	4.1989
Hammanskraal (2)	46	4.10870	0.13979	3.8339	4.3835
Atteridgeville to CBD (3)	75	3.84667	0.10948	3.6315	4.0619
Centurion to R21(4)	49	4.28571	0.13544	4.0195	4.5520
Roodeplaat dam to Cullinan (5)	30	3.50000	0.17310	3.1597	3.8403
Mamelodi to South-East border (6)	75	4.14000	0.10948	3.9248	4.3552
Bronkhorstspruit to Eastern border (7)	29	4.03448	0.17606	3.6884	4.3806

The Standard Error uses a pooled estimate of error variance

Table 4.21 illustrates the differences that exist among the regional areas of City of Tshwane. It is clear from the above table that Region 4 had the highest mean score of (M=4.29). The lowest mean score was found in Region 5 (M=3.50). Regions 1, 2, 4, 6 and 7 had a mean score above (M=4) indicating that most of the residents in those regions agree that a private car is essential to satisfy their needs; and also that they are more comfortable in their private car than in other transport modes. The majority of the residents in Regions 3 and 5 neither agreed nor disagreed with those items under 'Private car'. It may be assumed that the residents in regions 1, 2, 4, 6 and 7 depend on their private car. It could be important for the City of Tshwane to consider car-restriction policies in the regions, where there is a heavy dependence on the private car. However, the implementation of car-restriction policies is likely to succeed only if the public transport is effective and efficient.

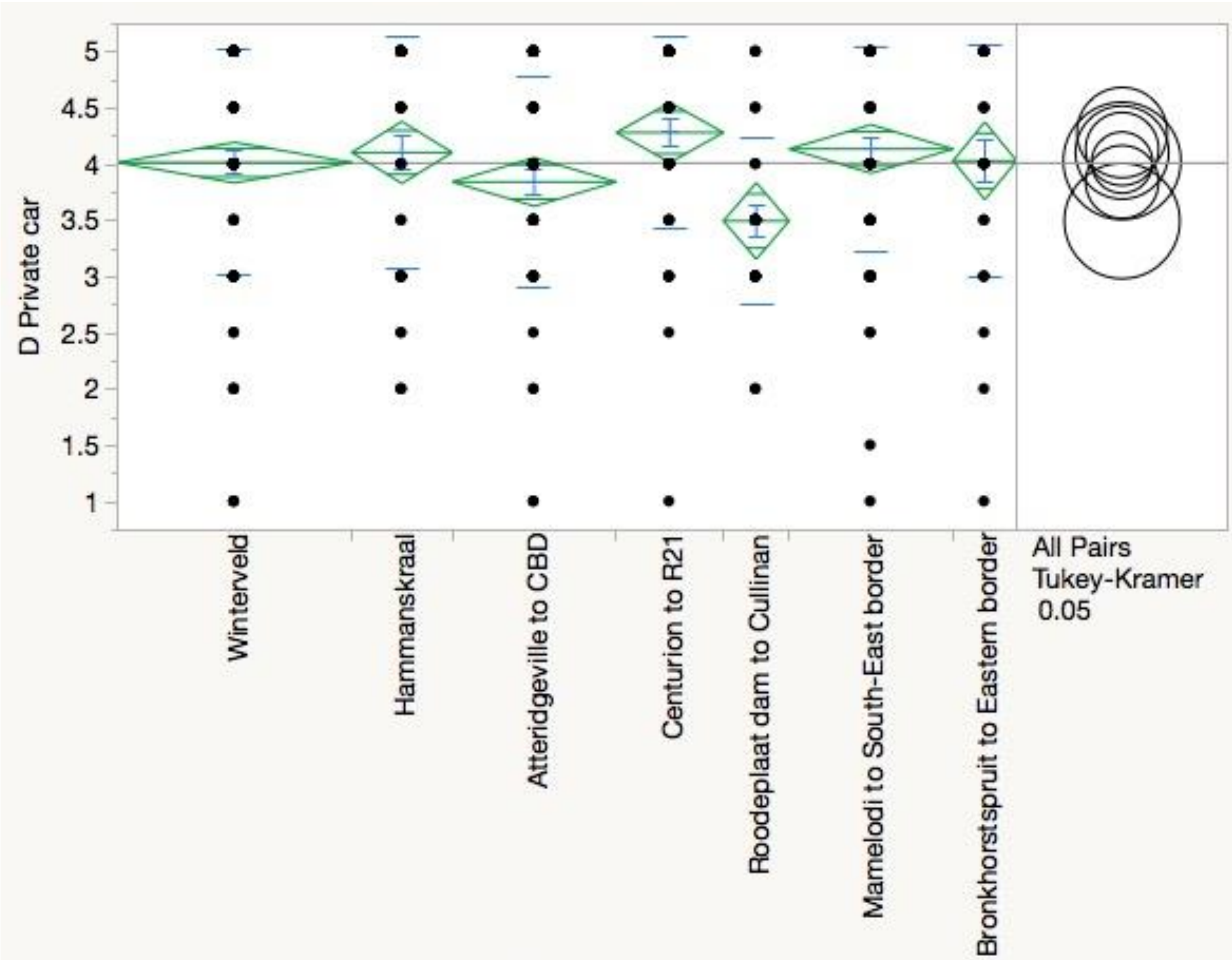


Figure 4.22: Diamond plot- Private car

Figure 4.22 shows the diamond for the regional areas with regard to 'Private car'. The diamond for 'Centurion to R21' is much higher than that of 'Roodeplaat to Cullinan'. This indicates differences between the regional areas of the City of Tshwane. To determine whether the difference between the means for regional areas is statistically significant, the F-test was used; and Table 4.22 shows a summary of the results from the F-tests in relation to a 'Private car'.

Table 4.22: Summary of Fit-Private car

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
B4 Area	6	15.26109	2.54351	2.8296	0.0104*
Error	404	363.15132	0.89889		
C. Total	410	378.41241			

TheF-test was used as a part of ANOVA, in order to determine whether the difference between the means is statistically significant, which produces a probability value (p-value). The underlying assumption is that the p-value indicates statistical significance at a 95% level of confidence, if the calculated p-value is smaller than 0.05. Prob >F value is the p-value of the F-test. The results revealed statistically significant differences between the regional areas of the City of Tshwane, ($F_{(6,410)} = 2.83$, $p=0.0104$). Table 4.22 shows that p-value is smaller than 0.05 (0.0104), indicating that there is a significant difference between the regional areas in terms of 'Private car' at the 95% level of confidence.

The construct score is not normally distributed, a non-parametric test (Kruskall-Wallis) was used to produce accurate results. The results revealed that there was a significant difference between the regional areas (Chi square value = 21.49, df = 6, p= 0.0015). The assumption of homogeneous variances holds good.

Non-parametric comparisons for each pair: Wilcoxon Rank Sum

To assess where the specific differences exist among the various regions of the City of Tshwane in terms of 'Private car', non-parametric comparisons was performed. For the purpose of this study, the Wilcoxon method was used to assess the specific differences among the regional areas of the City of Tshwane. The results from the non-parametric comparison are in the appendices, (Appendix K.4). Table 4.23 below shows the connecting letters report. **Please note that the connecting letters report is only for interpretation purposes.**

Table 4.23: Connecting letters report – Private car

Level			Mean
Centurion to R21	A		4.2857143
Mamelodi to South-East border	A		4.1400000
Hammanskraal	A	B	4.1086957
Bronkhorstspruit to Eastern border	A	B	4.0344828
Winterveld	A	B	4.0186916
Atteridgeville to CBD	A	B	3.8466667
Roodeplaat dam to Cullinan		B	3.5000000

From the table above, it is clear that the letter A grouped together Regions 1, 2, 3, 4, 6 and 7; while the letter B grouped together Regions 1, 2, 3, 5 and 7. The Tukey letter grouping shows that the means for 'Centurion to R21' and 'Mamelodi to South-East border' are the same; and that they are significantly different from the 'Roodeplaat dam to Cullinan' mean score.

4.5.1.5 Environmental awareness

Table 4.24 below shows ANOVA descriptives for 'Environmental awareness'.

Table 4.24: ANOVA descriptives – Environmental awareness

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Winterveld (1)	107	3.61215	0.09335	3.4286	3.7957
Hammanskraal (2)	46	3.68841	0.14237	3.4085	3.9683
Atteridgeville to CBD (3)	76	4.14474	0.11076	3.9270	4.3625
Centurion to R21 (4)	50	3.80333	0.13656	3.5349	4.0718
Roodeplaat dam to Cullinan (5)	30	3.23333	0.17630	2.8868	3.5799
Mamelodi to South-East border (6)	76	3.83333	0.11076	3.6156	4.0511
Bronkhorstspruit to Eastern border (7)	30	3.24444	0.17630	2.8979	3.5910

The Standard Error uses a pooled estimate of error variance

ANOVA tests were done to determine whether there was any significant difference between the mean 'Environmental awareness' scores for the different regional areas of the City of Tshwane. 'Atteridgeville to CBD', Region 3 had the highest mean score of (M=4.14); while 'Roodeplaat dam to Cullinan' Region 5, had the lowest mean score of (M=3.23). It is clear the majority of the residents in Region 5 are not aware of the environmental damage imposed by transportation. It could be important for the City of Tshwane to implement environmental awareness programmes in Region 5.

ANOVA descriptives can also be presented in the form of a diamond plot. Figure 4.23 below illustrates the ANOVA descriptive results for 'Environmental awareness'.

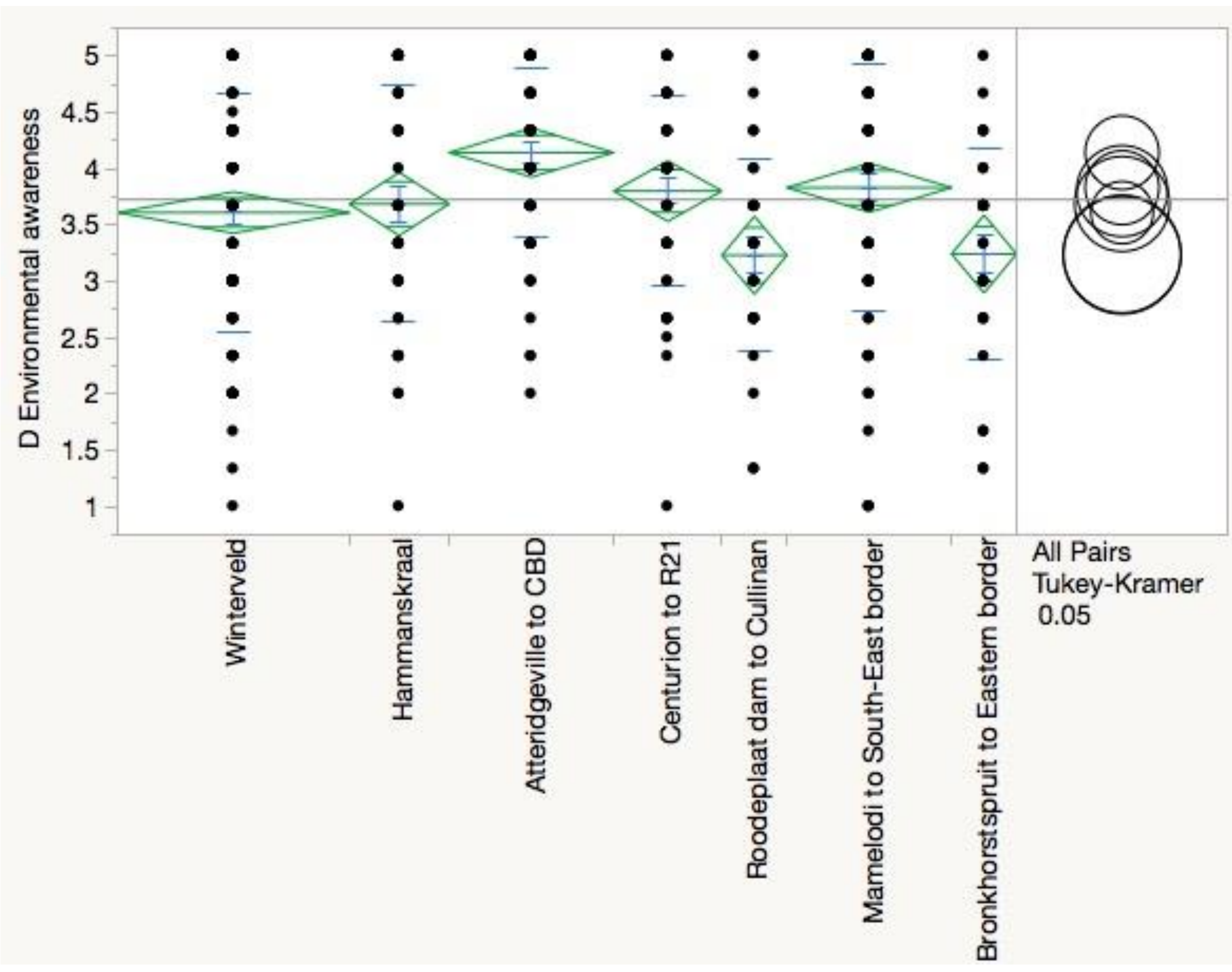


Figure 4.23: Diamond plot – Environmental awareness

The figure above shows the diamond for the regional areas with regard to 'Environmental awareness'. The diamond for 'Atteridgeville to CBD' is much higher than that of 'Roodeplaat to Cullinan' and 'Bronkhorstspruit to Eastern border'. This indicates the differences between the regional areas of the City of Tshwane. To determine whether the difference between the means for the regional areas is statistically significant, the F-test was used; and Table 4.25 below shows a summary of the results.

Table 4.25: Summary of Fit-Environmental awareness

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
B4 Area	6	30.18967	5.03161	5.3962	<0.0001*
Error	408	380.43055	0.93243		
C. Total	414	410.62021			

The F-test was used as part of ANOVA, in order to determine whether the difference between the means was statistically significant; and this produces a probability value (p-value). The underlying assumption is that the p-value indicates statistical significance at the 95% level of confidence, if the calculated p-value is smaller than 0.05. Prob >F value is the p-value of the F-test. The results revealed statistically significant differences between the regional areas of the City of Tshwane, ($F(6,414) = 5.40$, $p=0.0001$).

Table 4.25 shows that the p-value is smaller than 0.05 (even smaller than 0.0001), indicating that there is a significant difference between the regional areas in terms of 'Environmental awareness' at the 95% level of confidence.

The construct score is not normally distributed; so, a non-parametric test (Kruskall-Wallis) was used to produce accurate results. The results revealed that there was a significant difference between the regional areas (Chi square value = 32.26, df = 6, p= 0.0001).

The assumption of homogeneous variances in this case does not hold. The p-value for the Levene test is p= (0.0009) indicating that the variances are not equal. Welch's test revealed (Welch value =7.08, df = 6, p = 0.001).

Non-parametric comparisons for each pair: Wilcoxon Rank Sum and SPSS (Games-Howell)

To assess where the specific differences exist among the various regions of the City of Tshwane in terms of 'Environmental awareness', a non-parametric comparisons test was performed. For the purpose of this study, the Wilcoxon method and Games-Howell were specifically used to assess the specific differences among the regional areas of the City of Tshwane. The results from the Wilcoxon test and the Games-Howell test are in the appendices, Appendices J.5.1 and J.5.2. The table below shows connecting letters report. **Please note that the connecting letters report is only for interpretation purposes.**

Table 4.26: Connecting letters report – Environmental awareness

Level			Mean
Atteridgeville to CBD	A		4.1447368
Mamelodi to South-East border	A	B	3.8333333
Centurion to R21	A	B	3.8033333
Hammanskraal	A	B	3.6884058
Winterveld		B	3.6121495
Bronkhorstspruit to Eastern border		B	3.2444444
Roodeplaat dam to Cullinan		B	3.2333333

Letter A identifies Regions 3, 6, 4, and 2; while letter B identifies all the regions except Region 3. 'Atteridgeville to CBD' is significantly different from 'Winterveld', 'Bronkhorstspruit to Eastern border' and 'Roodeplaat dam to Cullinan' regional areas.

4.5.2 One-way analysis of 'Transport initiatives' by area (Section E)

This section is linked to the sixth objective of the study. The section interprets the results from the ANOVA analysis in terms of the variables in Section E of the questionnaire. The variables in Section E are 'Cycling initiatives', 'Walking initiatives', 'Public transport initiatives' and 'Parking management'.

4.6.2.1 Cycling initiatives

Table 4.27 summarises the ANOVA descriptives for 'Cycling initiatives'.

Table 4.27: ANOVA descriptives for 'Cycling initiatives'

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Winterveld (1)	107	4.14887	0.09536	3.9614	4.3363
Hammanskraal (2)	46	3.89674	0.14544	3.6108	4.1826
Atteridgeville to CBD (3)	76	3.97321	0.11315	3.7508	4.1956
Centurion to R21 (4)	50	3.69714	0.13950	3.4229	3.9714
Roodeplaat dam to Cullinan (5)	30	3.48750	0.18009	3.1335	3.8415
Mamelodi to South-East border (6)	76	3.67857	0.11315	3.4561	3.9010
Bronkhorstspruit to Eastern border (7)	30	4.00417	0.18009	3.6501	4.3582

The Standard Error uses a pooled estimate of error variance

ANOVA tests were done to determine whether there was a significant difference between the mean 'Cycling' scores for the different regional areas of the City of Tshwane. From the table above, it is clear that 'Winterveld' Region 1 had the highest mean score of (M=4.14); while the lowest mean score of (M=3.49) was found in 'Roodeplaat dam to Cullinan', Region 5. The results in the above table indicate that the majority of the residents in 'Winterveld', Region 1 and 'Bronkhorstspruit to Eastern border', region 7 are most likely to cycle if cycling initiatives are implemented. Bike awareness campaigns in Region 5 are most likely to change the mindset of the commuters.

Figure 4.24 is a diamond plot in relation to cycling initiatives.

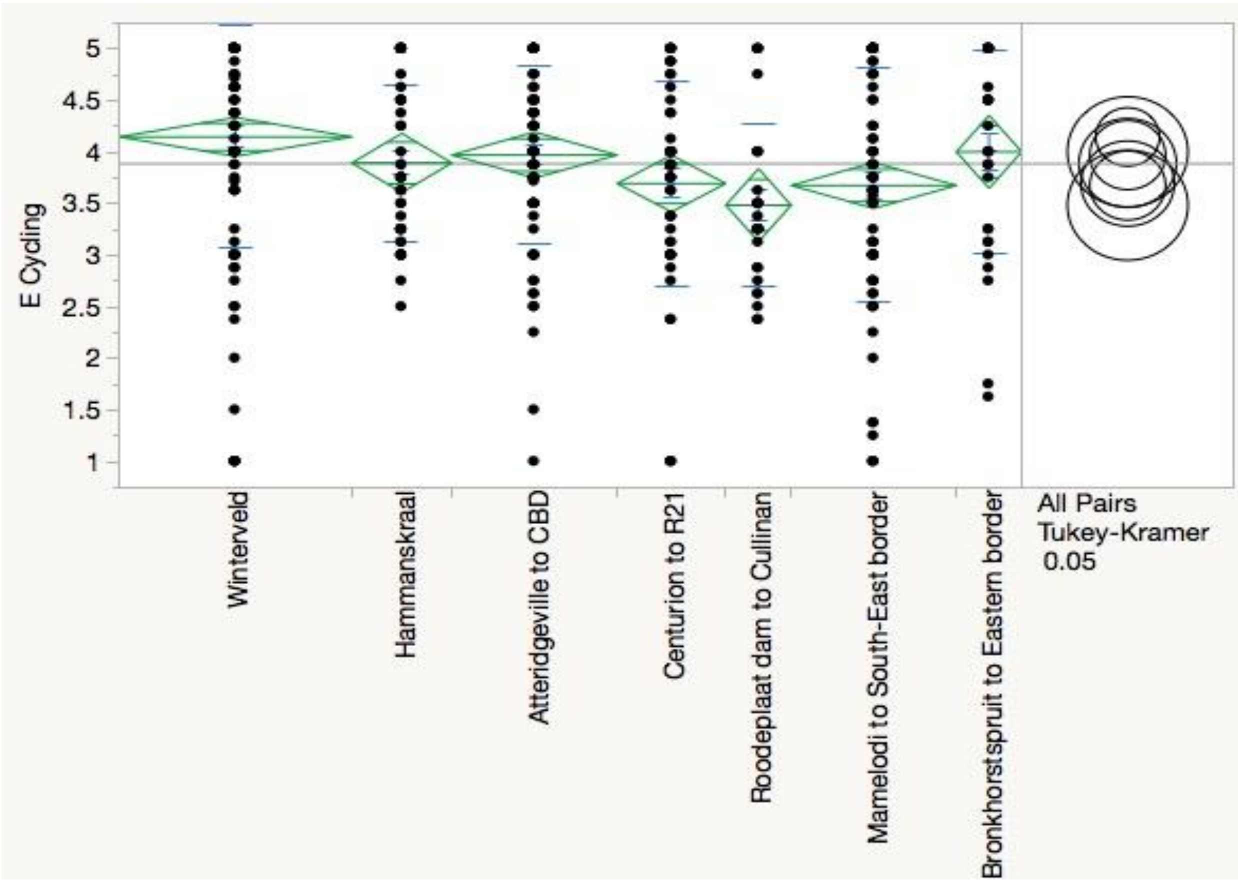


Figure 4.24: Diamond plot – Cycling initiatives

Figure 4.24 shows the diamond for the regional areas with regard to 'Environmental awareness'. The diamond for 'Roodeplaat dam to Cullinan', Region 5 seems to be the lowest. This indicates differences between the regional areas of the City of Tshwane. To determine whether the difference between the means for regional areas is statistically significant, the F-test was used; and Table 4.28 shows a summary of the results.

Table 4.28: Summary of Fit-Cycling initiatives

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
B4 Area	6	18.20681	3.03447	3.1187	0.0053*
Error	408	396.98670	0.97301		
C. Total	414	415.19351			

F-test was used as part of ANOVA, in order to determine whether the difference between the means is statistically significant, which produces a probability value (p-value). The underlying assumption is that the p-value indicates statistical significance at the 95% level of confidence, if the calculated p-value is smaller than 0.05. Prob >F value is the p-value of the F-test. The results revealed statistically significant differences between the regional areas of the City of Tshwane, ($F(6,414) = 3.12$, $p=0.0053$). Table 4.28 shows that the p-value is smaller than 0.05 (0.0053), indicating that there is a significant difference between the regional areas in terms of 'Cycling' at the 95% level of confidence.

The construct score is not normally distributed. A non-parametric test (Kruskall-Wallis) was used to produce accurate results. The results revealed that there was a significant difference between the regional areas (Chi square value = 27.21, df = 6 p= 0.0001). The assumption of homogeneous variances holds good.

Non-parametric comparisons for each pair: Wilcoxon Rank Sum

To assess where the specific differences exist among the various regions of the City of Tshwane in relation to cycling initiatives, a non-parametric comparisons test was performed. There are different types of tests that can be used to assess the specific differences. For the purpose of this study, the Wilcoxon method was used to assess the specific differences among the regional areas of the City of Tshwane. The results from the Wilcoxon tests are shown in the appendices, (Appendix K6). The table below shows connecting letter report. **Please note that the connecting letters report is only for interpretation purposes.**

Table 4.29: Connecting letters report – Cycling initiatives

Level			Mean
Winterveld	A		4.1488652
Bronkhorstspruit to Eastern border	A	B	4.0041667
Atteridgeville to CBD	A	B	3.9732143
Hammanskraal	A	B	3.8967391
Centurion to R21	A	B	3.6971429
Mamelodi to South-East border		B	3.6785714
Roodeplaat dam to Cullinan		B	3.4875000

The Tukey letter grouping shows the mean score for the seven regions of the City of Tshwane. Letter A identifies Regions 1, 7, 3, 2 and 4; while letter B groups all the regions together except Region 1. From the above table, it is clear that 'Winterveld' is significantly different from 'Mamelodi to South-East border' and 'Roodeplaat dam to Cullinan' at 0.005 alpha levels.

4.5.2.2 Walking initiatives

Table 4.30 summarises the ANOVA descriptive for 'Walking initiatives'.

Table 4.30: ANOVA descriptives for 'Walking initiatives'

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Winterveld (1)	107	3.79206	0.08698	3.6211	3.9630
Hammanskraal (2)	46	4.13043	0.13266	3.8697	4.3912
Atteridgeville to CBD (3)	77	4.00649	0.10254	3.8049	4.2081
Centurion to R21 (4)	50	3.96500	0.12725	3.7149	4.2151
Roodeplaat dam to Cullinan (5)	30	3.24167	0.16427	2.9187	3.5646
Mamelodi to South-East border (6)	77	3.76407	0.10254	3.5625	3.9656
Bronkhorstspruit to Eastern border (7)	30	3.70833	0.16427	3.3854	4.0313

The Standard Error uses a pooled estimate of error variance

ANOVA tests were done to determine whether there was a significant difference between the mean 'Walking' scores for the different regional areas of City of Tshwane. From the table above, it is clear that the highest mean score among the regions was found in 'Hammanskraal', Region 2 (M=4.13); while the lowest was found in 'Roodeplaat dam to Cullinan', Region 5 (M=3.24). This indicates that most of the residents in Region 2 rated walking initiatives as effective; while most of the residents from Region 5 rated walking initiatives as neutral. Walking awareness campaigns – in the areas where walking initiatives were regarded as ineffective – could be of great importance.

Figure 4.25 is a diamond plot in relation to walking initiatives.

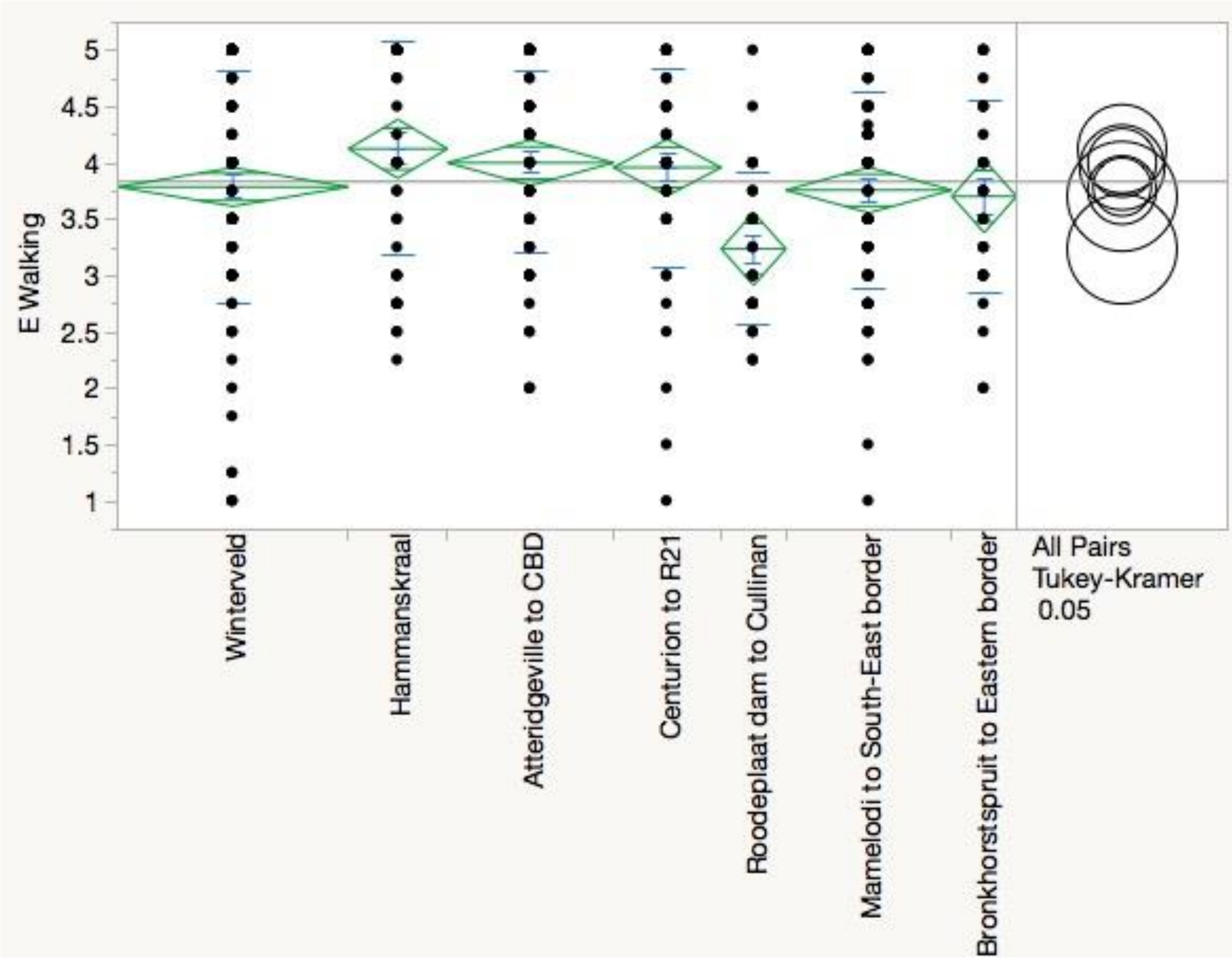


Figure 4.25 Diamond plot – Walking initiatives

The figure above shows the diamond for the regional areas with regard to 'Environmental awareness'. The diamond for 'Hammanskraal', Region 2 is much higher than that of 'Roodeplaat to Cullinan', Region 5. This indicates the differences between the regional areas of the City of Tshwane.

To determine whether the difference between the means for regional areas is statistically significant, the F-test was used and Table 4.31 shows a summary of the results.

Table 4.31: Summary of Fit-Walking initiatives

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
B4 Area	6	18.74549	3.12425	3.8592	0.0009*
Error	410	331.92201	0.80957		
C. Total	416	350.66750			

The F-test was used as a part of ANOVA, in order to determine whether the difference between the means is statistically significant, which produces a probability value (p-value). The underlying assumption is that the p-value indicates statistical significance at the 95% level of confidence, if the calculated p-value is smaller than 0.05. Prob >F value is the p-value of the F-test. The results revealed statistically significant differences between the regional areas of the City of Tshwane, ($F(6,416) = 3.86$, $p=0.0009$). Table 4.31 shows that the p-value is smaller than 0.05 (0.0009), indicating that there is a significant difference between the regional areas in terms of 'Walking' at the 95% level of confidence.

The construct score is not normally distributed; and a non-parametric test (Kruskall-Wallis) was used to produce accurate results. The results revealed that there were significant differences between the regional areas (Chi square value = 26.81, df = 6, p= 0.0002). The assumption of homogeneous variances holds true.

Non-parametric comparisons for each pair: Wilcoxon Rank Sum

To assess where the specific differences exist among the various regions of the City of Tshwane in relation to walking initiatives, a non-parametric comparisons test was performed. There are different types of tests that can be used to assess the specific differences. For the purpose of this study, the Wilcoxon method was used to assess the specific differences among the regional areas of the CoT. The results from the Wilcoxon tests are shown in the appendices (Appendix J.7). Table 4.32 shows the connecting letter report. **Please note that the connecting letter report is only for interpretation purposes.**

Table 4.32: Connecting letters – Walking initiatives

Level			Mean
Hammanskraal	A		4.1304348
Atteridgeville to CBD	A		4.0064935
Centurion to R21	A		3.9650000
Winterveld	A	B	3.7920561
Mamelodi to South-East border	A	B	3.7640693
Bronkhorstspruit to Eastern border	A	B	3.7083333
Roodeplaat dam to Cullinan		B	3.2416667

From the above table, letter A groups all the regions except Region 5; while letter B groups regions 1, 6, 7 and 5 together. It is evident that 'Hammanskraal', 'Atteridgeville to CBD' and 'Centurion to R21' are significantly different from 'Roodeplaat dam to Cullinan'.

4.5.2.3 Public transport initiatives

Table 4.33 below summarises the ANOVA descriptives for the public transport initiatives.

Table 4.33: ANOVA descriptives – Public transport

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Winterveld (1)	107	4.17991	0.08665	4.0096	4.3503
Hammanskraal (2)	46	4.02717	0.13216	3.7674	4.2870
Atteridgeville to CBD (3)	76	4.19079	0.10282	3.9887	4.3929
Centurion to R21 (4)	48	3.99479	0.12938	3.7405	4.2491
Roodeplaat dam to Cullinan (5)	30	3.58333	0.16365	3.2616	3.9050
Mamelodi to South-East border (6)	77	4.17316	0.10215	3.9724	4.3740
Bronkhorstspruit to Eastern border (7)	30	3.98333	0.16365	3.6616	4.3050

The Standard Error uses a pooled estimate of error variance

ANOVA tests were done to determine whether there was a significant difference between the mean 'Public transport' scores for the different regional areas of City of Tshwane. From the table above, it is clear that the highest mean score was found in 'Atteridgeville to CBD', Region 3 (M=4.19). 'Roodeplaat dam to Cullinan'. Region 5 had the lowest mean score of (M=3.58). This indicates that the majority of the residents from Region 1 agree that the public initiatives suggested are effective; and they are likely to use public transport if there is an improvement in terms of public transport. Regions 1, 2 and 6 also indicate that the public transport stated is effective. However, if all the figures of mean scores are rounded off, the mean score of all the regions become (M=4) and above.

Figure 4.26 below, is a diamond plot in relation to public transport initiatives.

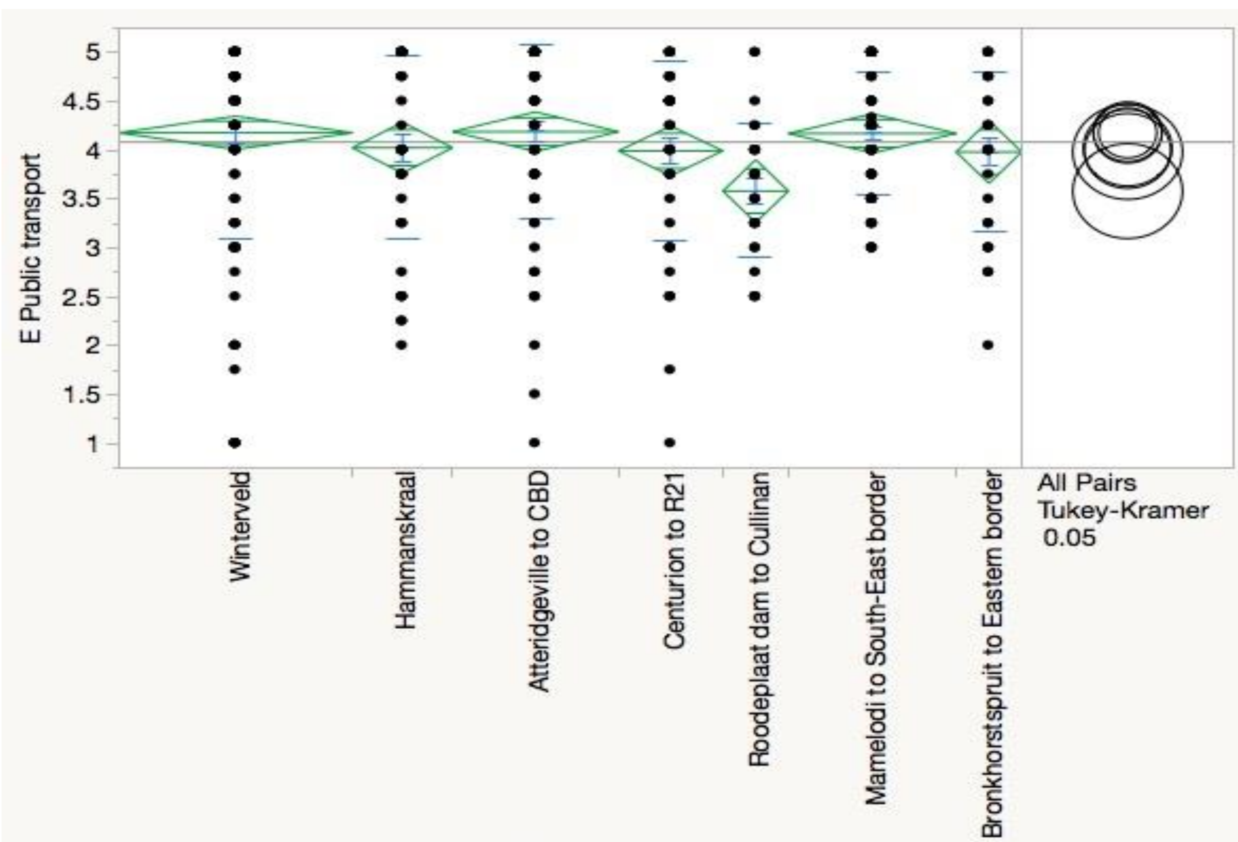


Figure 4.26: Diamond plot – Public transport initiatives

The figure above shows the diamond for the regional areas with regard to ‘Environmental awareness’. The diamond for ‘Roodeplaat to Cullinan’ seems to be the lowest. This indicates that there are differences between the regional areas of the City of Tshwane. To determine whether the difference between the means for the regional areas is statistically significant, the F-test was used; and Table 4.34 below shows a summary of the results.

Table 4.34: Summary of Fit-Public transport initiatives

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
B4 Area	6	10.81734	1.80289	2.2439	0.0384*
Error	407	327.00822	0.80346		
C. Total	413	337.82557			

The F-test was used as a part of the ANOVA, in order to determine whether the difference between the means is statistically significant, which produces a probability value (p-value). The underlying assumption is that the p-value indicates the statistical significance at a 95% level of confidence, provided the calculated p-value is smaller than 0.05. Prob >F value is the p-value of the F-test. The results revealed statistically significant differences between the regional areas of the City of Tshwane, (F (6,413) = 2.24, p=0.0384). Table 4.34 shows that the p-value is smaller than 0.05 (0. 0384), indicating that there is a significant difference between regional areas in terms of ‘Public transport’ at the 95% level of confidence.

The construct score is not normally distributed; but a non-parametric test (Kruskall-Wallis) was used to produce accurate results. The results revealed that there was a significant differences between the regional areas (Chi square value = 23.66, df = 6, p= 0.0006).

The assumption of homogeneous variances in this case does not hold. The p-value for the Levene test is p= (0.0113), thereby indicating that the p-value is on the border line. The Welch test revealed (Welch value = 3.34, df = 6, p =0.0042).

Non-parametric comparisons for each pair: Wilcoxon Rank Sum and SPSS: Games-Howell

To assess where the specific differences exist among the various regions of the City of Tshwane in relation to public transport initiatives, multiple comparison and non-parametric comparison tests were performed. There are different types of tests that can be used to assess specific differences. For the purpose of this study, the Wilcoxon method and Game-Howell were used to assess the specific differences among the regional areas of the City of Tshwane. The results from the Wilcoxon method and the Games-Howell are attached in the appendices, Appendix J.8.1 and appendix J.8.2. The table below shows the connecting letters report. **Please note that the connecting letter report is only for interpretation purposes.**

Table 4.35: Connecting letters report – Public transport initiatives

Level			Mean
Hammanskraal	A		4.1304348
Atteridgeville to CBD	A		4.0064935
Centurion to R21	A		3.9650000
Winterveld	A	B	3.7920561
Mamelodi to South-East border	A	B	3.7640693
Bronkhorstspruit to Eastern border	A	B	3.7083333
Roodeplaat dam to Cullinan		B	3.2416667

From the table above, it is clear that letter A grouped together Regions 1, 2, 3, 4, 6 and 7. The letter B grouped together Regions 2, 3, 5 and 7. Therefore, the conclusion is that the mean scores of ‘Atteridgeville to CBD’, ‘Winterveld’, ‘Mamelodi to South-East border’ are significantly different from those of ‘Roodeplaat dam to Cullinan’. While the means for the regional areas grouped by letter A do not differ significantly; neither do the regional areas grouped by letter B.

4.5.2.4 Parking management

Table 4.36 shows the ANOVA descriptive for ‘Parking management’.

Table 4.36: ANOVA descriptives – Parking management

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Winterveld (1)	107	3.25234	0.12292	3.0107	3.4940
Hammanskraal (2)	46	2.91304	0.18748	2.5445	3.2816
Atteridgeville to CBD (3)	76	2.94737	0.14585	2.6606	3.2341
Centurion to R21 (4)	48	2.98958	0.18353	2.6288	3.3504
Roodeplaat dam to Cullinan (5)	30	3.10000	0.23215	2.6436	3.5564
Mamelodi to South-East border (6)	77	2.94805	0.14490	2.6632	3.2329
Bronkhorstspruit to Eastern border (7)	30	2.83333	0.23215	2.3770	3.2897

The Standard Error uses a pooled estimate of error variance

Table 4.36 show that ‘Winterveld’, Region 1 had the highest mean score of (M=3.25); while the lowest mean score was found in ‘Bronkhorstspruit to Eastern border’, Region 7 (M=2.83). The majority of the residents of the City of Tshwane felt neutral about the parking initiatives.

Figure 4.27 is a diamond plot showing the mean scores of the regional areas in terms of ‘Parking management’.

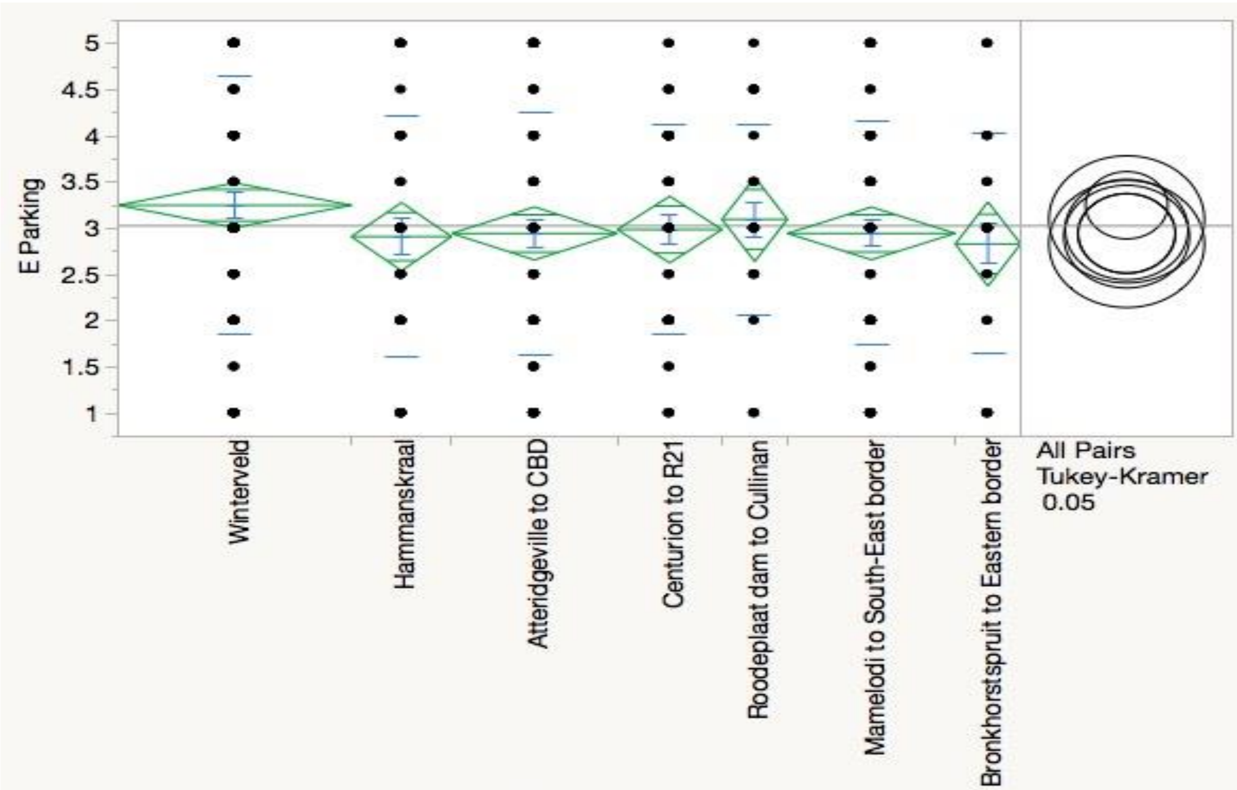


Figure 4.27: Diamond plot- Parking management

The figure above shows the diamonds for the regional areas with regard to 'Parking management'. The diamonds for the regional areas are almost at the same position. This indicates that there may be no significant difference among the regional areas of the City of Tshwane. To determine whether there are any statistically significant differences, the F-test was used; and Table 4.37 below shows a summary of the results.

Table 4.37: Summary of Fit-Parking management

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
B4 Area	6	8.34035	1.39006	0.8598	0.5246
Error	407	658.03223	1.61679		
C. Total	413	666.37258			

The F-test was used as a part of ANOVA, in order to determine whether the difference between the means is statistically significant, which produces a probability value (p-value). The underlying assumption is that the p-value indicates statistical significance at a 95% level of confidence, if the calculated p-value is smaller than 0.05. The Prob >F value is the p-value of the F-test. The results revealed statistically significant differences between the regional areas of the City of Tshwane, (F (6,413) = 0.86, p=0.5246). Table 4.37 shows that the p-value is larger than 0.05 (0.5246), indicating that there is no significant difference among the regional areas in terms of 'Parking management' at the 95% level of confidence.

The construct score is not normally distributed; a non-parametric test (Kruskall-Wallis) was used to produce accurate results. The results revealed that there was a significant differences between the regional areas (Chi square value = 4.48, df = 6 p= 0.6115).

One of the assumptions of ANOVA analysis is homogeneous variances. The p-value for Levene test is p= (0.0154) indicating that the p-value is on the borderline. Welch's test revealed (Welch 0.76, df =6, p= 0.5999).

In conclusion, there is no significant difference among the seven regions of the City of Tshwane in terms of 'Parking management'; therefore it is not necessary to perform any further tests.

4.6 GUIDELINES FOR SUSTAINABLE URBAN TRANSPORT

Based on the literature and the results of this study, a set of guidelines for sustainable urban transport have been developed for the City of Tshwane. Figure 4.28 illustrates the guidelines for sustainable urban transport for the City of Tshwane.

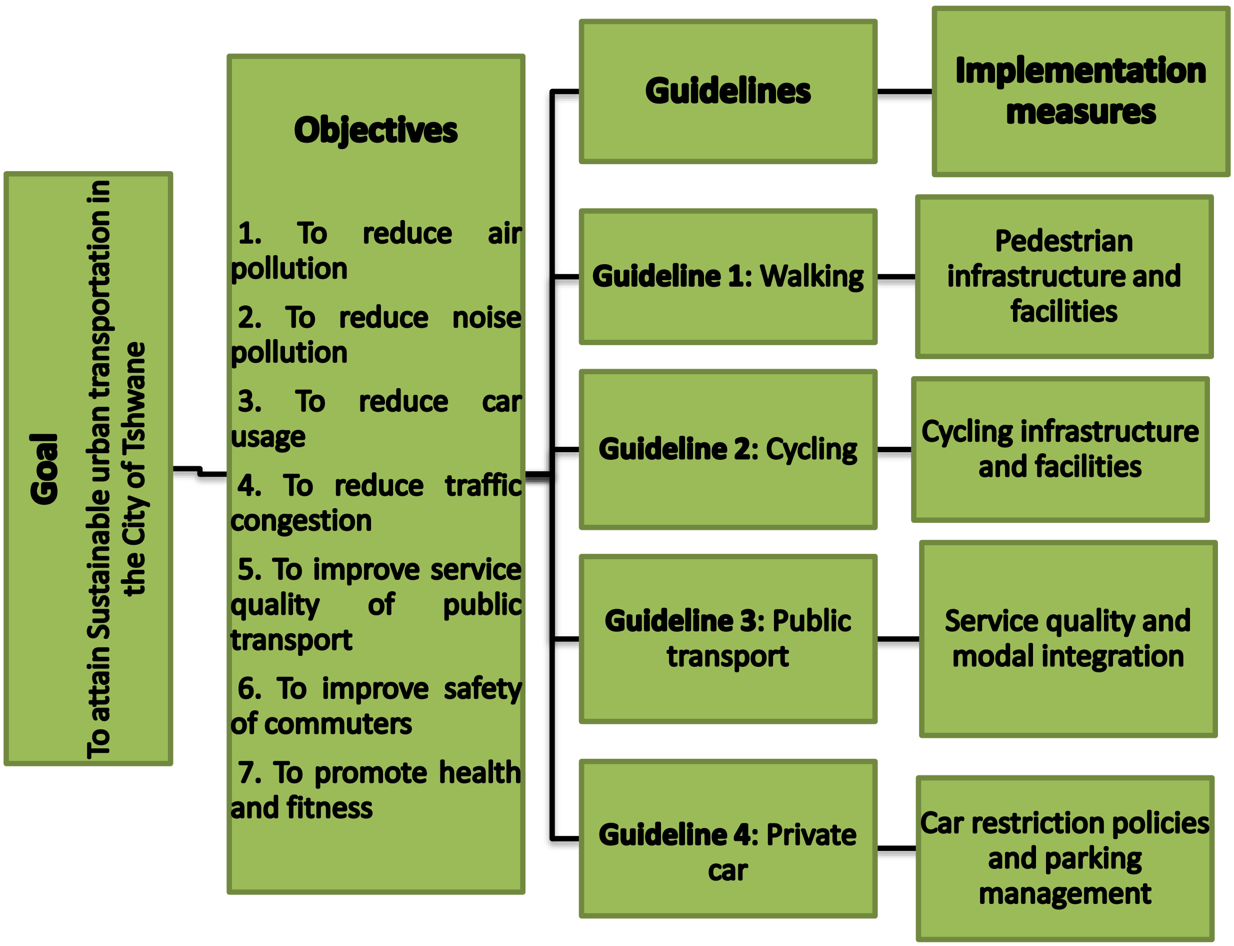


Figure 4.28: Guidelines for sustainable urban transport

Source: Own Synthesis

To attain sustainable urban transportation in the City of Tshwane, a comprehensive approach that integrates transport planning and urban land use planning is needed. It is important to incorporate all the various modes of transport and their connections, so as to address transportation problems. The guidelines for sustainable urban transport for the City of Tshwane from Figure 4.28 are described next and these include walking, cycling, public transport and a private car.

Guideline 1: Walking

Walking is the oldest basic mode of transport that is friendly to the environment and has health benefits to the humans. In this category, the following items are proposed: improvement of pedestrian infrastructure, for example the provision of end-of-trip facilities (EOTF)[13], such as bathrooms, locker rooms within places like workplace, shopping centres, hospitals and educational institutions and awareness programmes. As safety is one of the objectives of sustainable transportation, it is advisable to improve the pedestrian infrastructure, such as walking paths and signage. The EOTF in a building play a very important role in promoting sustainable transportation. The latter enhances the attractiveness, convenience and safety of sustainable transport modes. Equally, if a building does not provide access for sustainable transport modes, users may be discouraged from walking. For example, a person may be encouraged to walk to work – if only there were showers within the office building. Walking can also be promoted through awareness campaigns.

Recommendations

The City of Tshwane is recommended to implement walking initiatives, in order to encourage the public to shift from private car use to sustainable transport modes, such as walking. It could be important to construct and improve the walking infrastructure, so as to improve the safety of the public. The Provision of a walking infrastructure is regarded as a necessary condition to promote more active travel (Song et al., 2017; Maki-Opas et al., 2016). The provision of facilities, such as bathrooms and locker rooms at workplaces has the potential to encourage the employed population to use the walking transport mode for short trips. End-of-trip facilities can enhance the

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[13] EOTF can be described as facilities that can be used at the end of a trip to support people using sustainable transport modes such as cycling and walking (Randall, 2016; Queensland, 2017).

attractiveness and the convenience to the employed population that may want to use walking as a sustainable mode of transport (Bueno et al., 2017). Programmes, such as car-free days may encourage the public to walk for short journeys. Awareness campaigns can be used by the City of Tshwane as a way of educating the public on the negative impacts that are associated with the private car use. Awareness campaigns can also educate the public on the benefits of walking to the humans. The campaigns can be carried out through schools, workplaces, billboards, television and radio programmes. Television and radio programmes have the potential to reach greater populations and change the way people get around in the City of Tshwane. Schools have the potential to educate the younger generation and change their perceptions on private cars and walking. It could be essential for the City of Tshwane to involve the urban dwellers in finding the most appropriate solutions that may encourage them to use sustainable transport modes, such as walking. All the seven regions of the City of Tshwane could benefit from walking as a mode of transport.

Guideline 2: Cycling

Cycling is a cleaner mode of transport that is not only regarded as effective and efficient; but it also acts as a feeder mode for other public transport modes, such as buses and trains (Hopkins & Mandic, 2017; Li et al., 2013). In cities, such as Guangzhou and Copenhagen, a considerable number of commuters initiate and finish their journeys with bicycles (Zhang et al., 2017). In Amsterdam, there was a sharp decrease in cycling in the year 1970 from 75% to 25% (Taddei et al., 2015). However, effective transport initiatives adopted by Amsterdam increased cycling again by the year 2008 by 38% (ibid). In order to improve the key concerns that are associated with cycling, the City of Tshwane is recommended to adopt some of the cycling initiatives that have been successfully implemented in other cities, such as Amsterdam, Copenhagen and London. Based on the results of this study, the main concerns about cycling were safety and security. The following items are proposed to curb issues around cycling: the creation of a 'public bike system'[14] (bike-renting system); the construction and improvement of cycling infrastructure and facilities.

[14] A public bike system is a system whereby bikes are rented to the public for short-term use and the bikes are located at numerous stations in and around the city (Zhang et al., 2017).

Recommendation

In the City of Tshwane, safety and security for cycling may be achieved through the provision of separate cycling lanes, secure bicycle parking, as well as clear road rules that protect cyclists. The public in general may consider cycling for short distance trips, once safety and security measures for cycling have been improved. School trips made by private cars in and around the City of Tshwane constitute a considerable percentage. Hence, improvements in safety and security measures for cycling may also lead to parental confidence in cycling for the school children; and thereby reduce car use and also improve the fitness of the children.

Public bike systems play a role in promoting cycling and sustainable public transport. The systems for public cycling that are in cities such as New York, London and Guangzhou can also be adopted by the City of Tshwane, in order to encourage the public to cycle for short distances. Cycling may not be possible in all the regions of the City of Tshwane because of the geographic characteristics of the regions. However, it could be of great value to create a network of a safe and comfortable public bike system in and around Region 3 (Sunnyside, Pretoria West and CBD) that connect residents to potential destinations; since the terrain in most of these areas is flat.

It is equally important to look at the destination of a trip, so as to make cycling appealing to commuters. EOTF for cyclist are essential to cater for the needs of cyclists at the end of a trip. EOTF such as showers, lockers and bicycle racks within an office building can encourage the employed population to cycle to work. The City of Tshwane may consider providing incentives to building owners or companies; so that they can facilitate EOTF within the buildings for their employees. Research done in New York and New Jersey in the US confirms that bicycle commuting is influenced by EOTF; hence, employees provided with EOTF at a workplace are more likely to commute with a bicycle (Bueno et al., 2017).

Awareness is one of the important tools that can change the mindset of people. Awareness programmes can be promoted through school programmes, workplaces, institutions and car-free days (Active Living Research, 2013). In the northern European cities, schools offer education on transport and sustainability (Buehler et al., 2017a). In the long-term solutions, it is important to encourage the young population to cycle and create a generation of population that is confident with cycling (Fernández-Heredia et al., 2014).

Guideline 3: Public transport

Public transport has the potential to reduce emissions per passenger kilometre from transportation as compared to private cars, especially with full passenger loads. However, the mere provision of public transport is not good enough to attract the public to use public transport. In order to promote the use of public transport in the City of Tshwane, the following is proposed: incentive policies; improvement of service and modal integration. Incentive policies, such as discounted fares, free shuttles can be used to encourage the public to use public transport and minimise the use of private cars.

Recommendation

High quality public transport that is well connected to other sustainable transport modes could be perceived as attractive. For example, a person can cycle to a bus station or train station; or a person can change from a bus to the train or vice versa. The City of Tshwane may consider providing public transport that could offer convenience and diversity to the commuters through **integrated ticketing**. Integrated ticketing allows commuters to use a single smart card to pay for different transport modes, as well as paying for other services. Innovations in ticketing systems are changing the way transport users think about urban transport (Calabrese, 2013). Such qualities of public transport can attract the public to shift away from private cars to public transport. Some of the well-developed public transport systems can be found in Hong Kong, Guangzhou and Singapore. Commuters in Hong Kong use the Octopus card; while in Sydney commuters use smart card called Opal cards. As a way of attracting the public to use the public transport, In Hong Kong, trains pass through all the malls around the city. Linking potential destinations with public transport could reduce car usage.

Space features to accommodate bikes, baby buggies or strollers are capable of encouraging and attract the public to use public transport as these features offers convenience. The City of Tshwane could also encourage the public transport operators to invest in vehicles with space features that offer integration of public transport with other sustainable transport modes.

The findings of research done between New York and the New Jersey region of US revealed that incentive programs by employers to reduce the share of employees using private cars to work can promote the use of public transport among the employees; and thus increasing the sustainable way of daily travelling among the employed population (Bueno, Gomez, Peters & Vassallo, 2017). Some of these incentives are free shuttles to and from work premises, subsidies and reimbursements for public transport payments. The governments can work together with the employers to facilitate such incentives to the employed population. It could be important for the City of Tshwane to involve employees in such incentive programs that may encourage the employees to shift from private car use to public transport.

Other public transport initiatives that could be recommended for the City of Tshwane are the provision of passenger-transport information; car-free days and more bus routes. Transport information and awareness are critical in informing the public on the available transport that may be used for their journeys. Car-free day programs have the potential to draw the urban dweller from his private car to public transport. The availability of more bus routes improves the access of public transport, therefore increasing the ridership of public transport in the City of Tshwane.

Regions 1 and 6 could benefit from public transport initiatives. Some of the areas in Regions 1 and 6 are far away from places of work; yet in these regions reside the highest population of people in the City of Tshwane. Viable and sustainable public transport is needed to transport the masses of commuters in these regions. Hence, public transport has the potential to reduce carbon emission; as it transport large numbers of commuters at a time. Region 4 could also benefit from high quality public transport; as the region is not satisfied with the service quality of public transport.

Guideline 4: Private car

Guideline 4 thrives only if alternative modes of transport, as well as the public transport system are effective and efficient. In order to reduce the traffic congestion caused by higher levels of private car used in the city, it could be important for the City of Tshwane to implement policies that make car use less attractive. In this category, the following solutions are proposed to reduce private car usage: car restriction policies and parking management. To reduce car usage, car park management strategies may be applied through high parking fees, time limitations for on-street parking and less parking space. Car restriction policies could be implemented in such a way that it becomes difficult and expensive to use a private car. For example, congestion charging in designated central zones, strict and expensive car licensing and high fuel prices. In cities, such as

London and Vienna, the policy of ‘no car zones in designated central zones’ has been successfully implemented.

Recommendations

One of the main recommendations that may help reduce car use in the City of Tshwane is an improvement of provision of service of public transport. If the service quality of public transport is good, urban dwellers may be attracted to use public transport and reduce car use in the city. The City of Tshwane is recommended to adopt some of the private car initiatives that have been successfully implemented by other cities, such as London, Amsterdam and Vienna. Car-restriction policies and parking management strategies have the potential to reduce car use in the City of Tshwane and to shift private car use to sustainable transport modes, such as walking, cycling and public transport. The City of Tshwane could implement car-restriction policies in such a way that it becomes difficult to own and a car in the city. Region 4 is one of the most affluent areas in the region where the private car is the general mode of choice. Car-restriction policies could be used, in order to reduce car used by the residents in Region 4 of the City of Tshwane.

Awareness programmes are essential to bring about awareness among the public that frequently use of private cars has negative effectives on the environment and to the human life. Since private car use is perceived as resemblance of wealth especially in developing countries, awareness programmes could be used to educate the public that even the rich people in other countries such as Germany and the Netherlands cycle, walk and use public transport to commute to work places and for other journeys (Verma et al., 2016).

The guidelines proposed above are by no means exhaustive; but they are an indication of potential approaches that may be used in the City of Tshwane, to reduce the negative impacts of transportation. The section has attempted to provide a guideline for sustainable urban transport that gives reference to the policy-makers and the local decision-makers. The guidelines for sustainable urban transport in Figure 4.28 are summarised in Figure 4.29, so that the City of Tshwane can focus on the transport initiatives recommended for each region.

Table 4.38: Guidelines for sustainable transport per region of the City of Tshwane

Region 1: Winterveld area • Car-restriction policies reduce car usage that could be done through the higher cost of owning and using a car, such as, high congestion charges • A viable and reliable sustainable public transport network is needed to reduce traffic congestion and carbon emission • An improvement in public transport is needed to attract the public to use public transport • The implementation of cycling initiatives to promote cycling in the region, such as reduced bicycle prices; as some of the communities in the regions are poor.
Region 2: Hammanskraal area • Car-restriction policies to reduce car usage that can be done through the higher cost of owning and using a car, such as, high congestion charges. • Public transport users are happy with the public transport service; so it could be important to implement public transport initiatives to retain commuters that are using public transport. This could be done through discounted fares,
Region 3: Atteridgeville to Central Business District • Car-restriction policies can reduce car usage; and this could be done through the higher cost of owning and using a car, such as, high congestion charges. • Cycling initiatives are needed; as the terrain in most of the area in the region is fairly flat and conducive for cycling. Some of the initiatives that could help are reduced bicycle prices, bicycle-rental facilities and improved bicycle lanes.
Region 4: Centurion to R21area • Improvement of service quality of public transport through offering safe and reliable transport, as well as adequate passenger transport information. • Car-restriction policies reduce car usage that can be done through the higher cost of owning and using a car, such as, high congestion charges.
Region 5: Roodeplaat dam to Cullinan area • The promotion of cycling and walking through awareness campaigns in the form of community engagement, school programs, flyers, billboards, media and car-free days. • Awareness programs to educate the public on the impact of transport on the environment through community engagement, school programs, flyers, billboards, media and car-free days
Region 6: Mamelodi to South-East border • Car-restriction policies reduce car usage; and that can be done through the higher cost of owning and using a car: for example high congestion charges. • Public transport initiatives are needed to promote the use of public transport; as the region has a high population: for example, cheaper fares, more bus routes and a reliable transport service.
Region 7: Bronkhorstspruit to the Eastern border • Car-restriction policies reduce car usage; and that can be done through the higher cost of owning and using a car, such as, high congestion charges. • Public transport initiatives are needed to promote the use of public transport among the employed population that work in other regions, especially Region 3, for example cheaper fares.

To address the primary objective of the study: 'to develop guidelines for sustainable urban transport in selected areas of the City of Tshwane', the transport initiatives recommended per region are summarised in Figure 4.29.

4. 7 CONCLUSION

The data analysis and discussion of the results were presented in this chapter. The results were presented by means of graphs, figures and tables; and the chapter was arranged as follows:

Firstly, biographical information (Section B of the questionnaire) was interpreted. Biographical information presented information on age, gender, status of employment and residing areas of the respondents. Age was divided into three categories namely: 18-24; 25-45; and 46-64. The largest number of respondents were in the age category of 25 to 45. Female respondents were slightly more than male respondents. Those respondents, who were employed constituted the largest number in terms of the status of their employment. It was found that the employed population most frequently used private cars for work trips. The majority of the respondents were from Region 1. After the biographical information had been interpreted, a descriptive analysis followed.

Secondly, the descriptive analysis was discussed in Section 4.3. Descriptive statistics provided the analysis of the data for the variables used in the study from Section C to E of the questionnaire. A five-point Likert-scale ranging from 1 to 5 was used to answer the questions in section D (Public attitudes towards sustainable transport) and Section E (Transport initiatives). The main mode available in the City of Tshwane was private cars; while the least-available mode of transport was the motor cycle. Overall, the most frequently used mode of transport for all the trips was the private car.

The most important dimension considered when choosing the mode of transport was safety. The majority of the respondents indicated that they preferred public transport as an alternative mode of transport – even though the respondents felt that public transport was not reliable, convenient; and that there was a lack of good information on public transport. The majority indicated that they were willing to use alternative transport modes if various transport initiatives were implemented – to enhance these alternative transport modes.

Thirdly, in Section 4.4, the validity and the reliability of the constructs in relation to 'Public attitudes towards sustainable transport' and 'Transport initiatives' were tested. The validity of constructs was confirmed; and the constructs were found to be reliable. Additional tests were done in Section 4.5 to determine whether statistically significant differences existed between the regional areas of the City of Tshwane in terms of the variables of 'Public attitudes towards sustainable transport' and 'Transport initiatives'. Both parametric and non-parametric tests were applied, including the ANOVA, Kruskal-Wallis tests, Chi-square tests, Welch's test and the Tukey-Kramer test. Some of the statistically significant differences found were:

- Traffic-problem awareness – Regions 1, 6 and 3 were statistically different from Region 5.
- Public transport – Region 2 was statistically different from Region 3.
- Cycling and walking – Regions 1, 2, 3, 4, 6 and 7 were statistically different from Region 5.
- Private car – Regions 4 and 6 were statistically different from Region 5.

Finally, in section 4, a set of guidelines for sustainable urban transport were proposed, in order to achieve the primary objective of the study, namely to develop guidelines for sustainable urban transport in selected areas of the City of Tshwane. The guidelines were developed, based on the literature and the results of this study.

The next chapter presents the conclusions and recommendations of the study.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS FOR SUSTAINABLE URBAN TRANSPORT

5.1 INTRODUCTION

In this chapter, the conclusions and recommendations derived from the study are presented. The conceptualisation and structuring of the research problem and the research objectives were introduced in Chapter 1. According to Nkosi and Masuku (2016:139), the existing urban transport infrastructure in South Africa is insufficient to cater for the existing and future travel demand for goods and services. As such, continual upgrades of the existing road infrastructure to accommodate increasing transport demand may not be sustainable for the future of the environment. Sustainable ways are therefore required to cater for the existing and future transport demand – without harming the environment (ibid).

The primary objective of the study is to develop sustainable urban transport for selected areas of the City of Tshwane. The City of Tshwane is one of the largest cities in South Africa in terms of the population experiencing urban-transport problems, which form part of the study.

The literature review was conducted and reported on in Chapter 2 to meet the first secondary objective, namely: to conceptualise transportation, urban transport and transport externalities, congestion, urban sprawl, sustainable development, sustainable urban transport, GHG and congestion. The concepts were firstly defined in Chapter 1; and then they were further outlined in more detail in Chapter 2.

Emanating from the literature review, the research methodology followed a questionnaire drafted, according to the literature findings in Chapter 2; and this was reported in Chapter 3. The data analysis was presented in Chapter 4. Section A of the questionnaire contained screening questions, to determine whether the participant is part of the required population. Section B gathered the demographic information; and the important demographic variables in this study were: age, gender, employment status and area of residence. Research objective number 2 (to explore public attitudes towards sustainable urban transport in selected areas of the City of Tshwane) was achieved in section D of the questionnaire. Research objective number 3 (to identify the transport modes used by the residents in the selected areas of the City of Tshwane) was met in Section C of the questionnaire. Research objective number 5 (to identify transport initiatives that could encourage the public to use sustainable transport modes) was met in Section E of the questionnaire.

Chapter 4 presents the data analysis and the discussion of the research findings. The chapter provides key research findings drawn from the research study. Based on the previous literature and the results of the study, guidelines for sustainable urban transport were developed for selected regions of the City of Tshwane. In Chapter 4. The last two objectives, 4 and 6, were met in section 4.5 of the dissertation, namely:

- to determine whether statistically significant differences exist between the regional areas of the City of Tshwane with regard to the attitudes towards sustainable urban transport; and
- to determine whether statistically significant differences exist between the regional areas of the City of Tshwane in terms of transport initiatives that would encourage the public to use sustainable transport modes. Finally, the primary objective of the study was achieved by using the findings in the literature, as well as the results of the empirical study. The primary objective was to develop guidelines for sustainable urban transport in selected areas of the City of Tshwane (see Section 4.6).

Finally, the primary objective of the study was achieved by using the findings in the literature, as well as the results of the empirical study, to develop guidelines for sustainable urban transport in selected areas of the City of Tshwane, as reported in Chapter 4 Section 4.6.

The outline of this chapter is as follows: Section 5.2 is a summary of the findings in the literature study; followed by Section 5.3, the conclusion, drawn from the data analysis; Section 5.4 outlines the limitations of the study; then Section 5.5 lists the recommendations for future research; and lastly, Section 5.6 provides the conclusion.

5.2 SUMMARY OF THE FINDINGS FROM THE LITERATURE STUDY

In this section, the conclusions are drawn from the findings in the literature study, as reported in Chapter 2. The main focus of this chapter was on the conceptualisation of sustainable transport within an urban context. A comprehensive overview of the conceptualisation of sustainable urban transport was discussed, based on the findings from the literature. The chapter addressed the first secondary objective of the study, 'to conceptualise transportation; urban transport; transport externalities, urban sprawl; sustainable development, sustainable urban transport; GHG; and congestion.

The first focus in this chapter was on defining transport; this was followed by outlining the importance of transport. The main modes of transport were identified as: land transport, water transport and air transport. The four factors that influence modal choice were listed as: the socio-demographic factors; the requirements of transport; structural factors and psychosocial factors. Some of the barriers of sustainable transportation were identified as: lack of transport infrastructure, safety and security, reliability and poor service.

Urban transport was defined in Section 2.3. The complex nature of the transport system was introduced in Section 2.3.2 by discussing the three main subsystems of urban transport, namely: individual transport, passenger transport and the freight transport system. Urban transport and urbanisation were concepts that are closely linked; and the discussion is found in Section 2.3.3.

Transport plays a critical role in the social and economic development of any nation; but frequent use of transport in the city generates transport externalities that are harmful to the environment and human health. The four transport externalities that are common and important to this study are identified as: traffic congestion, air pollution and GHG emissions, accidents and urban sprawl; and these were discussed in Section 2.3.4. In view of the transport externalities discussed in Section 2.3.5, sustainable transport solutions are needed to manage the effect of transport externalities. The concept of sustainable urban transport is defined and discussed in Section 2.4. The attitudes of the public towards sustainable transport are outlined in Section 2.4.2. The theory of planned behaviour is used to understand the public attitudes in this study.

The last part of the chapter focuses on transport initiatives that can be used to encourage the public to use sustainable transport modes (see Section 2.5). The section addresses the fifth secondary study objective: ‘to identify transport initiatives that might encourage the residents of selected areas of the City of Tshwane to use sustainable transport modes’. The successful implementation of transport initiatives is found in cities, such as Berlin, Copenhagen, Vienna and Amsterdam.

5.3 CONFIRMATION, CONCLUSION AND RECOMMENDATIONS

Based on the findings of the study, the following confirmation, conclusion and recommendations from the analysis of data are discussed in terms of the objectives of the study; and they are presented under the subheadings, followed by descriptive statistics.

5.3.1 Biographical information of the residents of the City of Tshwane

- The majority of respondents in the **age categories** (see Figure 4.2) were between the ages of 25 and 45 years (59%), followed by the ages of those who were between 18 and 24, which came to 24%. The age group 46-64 comprises 17%. The findings of the results are consistent with those of previous research, indicating that age is one of the important factors that influence mode choice and the attitude towards sustainable transport (McCarthy et al., 2017; Madhuwanthi et al., 2015).
- In terms of **gender**, female respondents were slightly more than male respondents (see Figure 4.3). A higher percentage of women (52%) used private vehicles for work trips. The higher dependency of private vehicles among women may be due to the poor service of public transport (Chee & Fernandez, 2013). Some of the factors that dissuade women from using public transport are safety and comfort (Verma et al, 2016).
- **Employment status** was an important factor of socio-demographics to this study because it influences the choice of transport (Cui et al., 2017; Xia et al., 2017; Khoo & Ong et al., Liu et al., 2015). The majority of the respondents indicated that they were employed (67%). The percentage of unemployed respondents was 24%. Self-employed respondents constituted 9%. People who are employed are alleged to be more mobile than those that are not employed (ibid); as most of the people who are employed commute on a daily basis to work (see Appendix G). Region 1 of City of Tshwane is characterised by high employment (CoT, 2016).
- The last question on biographical information was on the residing areas of the respondents (**Regions of the City of Tshwane**). The majority of the respondents were from Region 1

(26%), followed by Regions 6 and 3, each region constituting 18%. Region 4 was slightly higher than Region 2 by 1%. The regions with the least share of the population are Region 5 and 7, each region constituting 7%. Region 1 is a densely populated (1664 p/km^2) region; while Region 5 has the smallest population in the City of Tshwane (CoT, 2016).

The biographical information of the local residents of the selected areas in the City of Tshwane revealed the age, gender, employment status, as well as the respective regions in which the residents reside in the city. The main conclusions drawn from the descriptive statistics for sustainable transport are discussed in Section 5.3.2.

5.3.2 Conclusions drawn from the descriptive statistics for sustainable transport

These results provided some valuable information on Sections C (Transport modes), D (Public attitudes towards sustainable transport) and E (Transport initiatives), according to the questionnaire. The objectives 2, 3 and 5 were met (to explore the public attitudes towards sustainable urban transport in selected areas of the City of Tshwane; to identify the transport modes used by the residents in selected areas of the City of Tshwane; and to identify transport initiatives that should encourage the public to use sustainable transport modes).

- Figure 4.6 indicates the **transport modes** used by the residents in selected areas of the City of Tshwane, revealing that the private car as the most available mode of transport to the residents of the City of Tshwane, with a percentage of 70%. This shows that on average most people rely on their private cars. On the other hand, motor cycles (13%) were found to be the least available mode of transport in selected areas of the City of Tshwane. Taxi and bus had a percentage of 58% and 41%, respectively, showing that taxi and bus are available for a considerable number of people in the City of Tshwane. Cycling was found to have a lower percentage of 15%. Overall, the private car was the most frequently used mode of transport for all the trips made. This result is in line with previous research that indicates that the private car is the mode of transport that is most used (Susilo et al., 2012). Bicycle transport was found to be the least used mode of transport. A recommendation could be made that the City of Tshwane should improve on the provision of sustainable urban modes of transport that are environmentally friendly. More sustainable urban modes of transport should be made available to the public.

- Figure 4.7 depicts the **most frequently used transport** by the respondents, indicating that overall, the most frequently used mode of transport for all trips is the private car. 'Visiting friends and relatives' had the highest percentage of private car use of 63%, followed by 'local leisure travel' with 60%. 'Shopping'; 'travel to work'; 'taking children to and from school'; and 'travel while at work' had 58%, 51%, 49% and 47%, respectively. The age group 25-45 most frequently used the private car on a daily basis for all the trips. The results are consistent with those of previous research, which indicates that the private car is the most frequently used mode of transport for most of the trips; and it is still dominant (Xia et al., 2017; Uttley & Lovelace, 2016; Carse et al., 2013). The City of Tshwane should consider implementing deterrents to driving private cars – in an effort to shift from private car use to sustainable transport modes.

- Figure 4.8 depicts the **Transport-service dimension** considered when choosing the mode of transport to use by the respondents, indicating 'safety' as the most important factor considered; while 'environmental benefits' were the least important factor considered. Previous research also indicates that the most important factor considered when choosing transport by the public is safety (McCarthy et al., 2017; Madhuwanthi et al., 2015; Lopez-Saez et al., 2014). Each mode of transport has its own inherent characteristics. The needs, expectations and knowledge of individuals are different; hence, these affect the decisions made in choosing the mode of transport. Other transport service dimensions, such as 'convenience', 'time taken' and 'reliability' were almost equally important. This should be considered by the City of Tshwane, when providing the public with transport.

- Figure 4.9 depicts the **alternative modes of transport** that may be considered by the residents of the City of Tshwane**,** as a way of promoting sustainable urban transportation, indicating bus transport as the most preferred alternative mode of transport. It may be assumed that there is a great opportunity and possibility of shifting the mode of choice to bus transport in the City of Tshwane. China's cities created transit cities, so as to increase the use of public transport – in an effort to reduce air pollution and traffic congestion (Li & Zhao, 2017). Therefore, it might be beneficial for the City of Tshwane to consider improving the service of the bus transport as a sustainable alternative to driving (Ranjbari et al., 2017). The other alternative modes that were not popular may have been due to transport services dimension in Section 4.3.3. It could also be important to improve the transport-service dimension, so as to encourage the public to cycle or walk; as cycling and walking are cleaner sustainable alternative modes of transport (Sun et al., 2017).

- Figure 4.10 indicates that the majority of the respondents are aware of **sustainable transport benefits**; however, their actions do not match their awareness (for example, see the most frequently used mode of transport in Figure 4.7). The majority of the respondents agree that ‘cycling and walking can help me keep fit’ (88%); while ‘cycling and walking are more environmentally friendly options than driving’ (75%). Previous studies also revealed the positive impact of cycling and walking to the environment and human health (Avila-Palencia et al., 2017; Verma et al 2016; Taddei et al., 2015; Maizlish et al 2013). A significant percentage indicated that it was not important to reduce car use (25%). It could be important for the City of Tshwane to implement car- restriction policies – in an effort to reduce car usage. Educating the younger generation at an early stage on transport problems could be important for the long-term solution, in order to create a generation that is responsible for keeping the environment safe and clean.

- Figure 4.11 depicts **awareness of traffic problems**, revealing that the majority of the respondents are aware of traffic problems. Even though the majority are aware of traffic problems, their actions do not match the mode of transport used. Therefore, comprehensive car-restriction policies could be recommended, in order to reduce car usage.

- Figure 4.12 depicts how the respondents felt about the **safety and comfort** of cycling and car use. The majority of the respondents indicated that cycling is not a safe transport option; and the respondents felt more comfortable in private cars than in other transport modes. This finding is consistent with that of the previous research, which indicates that cycling is not a safe mode of transport (Xia et al., 2017; Verma et al., 2016; Fernandez-Heredia et al., 2014; Fishman et al., 2014; Gatersleben & Appleton, 2007). This result suggests that there is a need to improve the image of cycling. It could be beneficial for the City of Tshwane to promote cycling – starting among school-going children, so as to create a generation of confident cyclists. Transport planners, city planners and policy-makers should eliminate barriers to cycling. Comprehensive town planning that creates a cycling-friendly environment could be of the utmost importance. Cycling policies that improve the safety of cycling tend to increase the usage of cycling as a mode of transport (Sun et al., 2017).

- Figure 4.13 depicts the **feelings about public transport**, revealing that public transport does not offer good service. The majority of the respondents indicated that public transport is unreliable, inconvenient, and that there is a lack of information on public transport. In Section 4.3.3, (transport-service dimensions), reliability, cost and convenience, were regarded as the important dimensions considered, when choosing a mode of transport in the City of Tshwane. It is recommended to have good national passenger information system, in order to increase public transport usage (Malasek, 2016). It could also be important for the City of Tshwane to improve the infrastructure and provision of public transport.

- The mere provision of public transport is not good enough to draw commuters from their private cars. Figure 4.14 depicts **public transport initiatives** that can be used to encourage commuters to use public transport. Overall, the majority of respondents indicated that the public transport initiatives suggested were effective; and they would encourage them to use public transport. However, the most effective initiative among other public transport initiatives considered by the respondents was ‘more reliable public transport’ followed by ‘more bus routes’. This finding is in agreement with the transport-service dimensions (Section 4.3.3) that are important when choosing the mode of transport. Reliability, cost and routes were among the transport-service dimensions that were regarded as important, when choosing a mode of transport. It is recommended to implement public transport initiatives; as there is a potential for the shift from private car to public transport.

- Figure 4.15 depicts **cycling initiatives** that may encourage commuters to cycle, revealing that overall, cycling initiatives are effective. The most popular initiative considered effective was ‘improved security and safety’ with a percentage of 76%. This result is in line with the previous research, which indicates that bicycle riding is likely to increase, if the security and safety is improved for cyclists (Fernandez-Heredia et al., 2014; Verma et al., 2016). Previous research indicates that a better cycling infrastructure increases the usage of bicycles (Sun et al., 2017); building facilities, such as showers and lockers, could encourage commuters to cycle to their workplaces (Fernandez-Heredia et al., 2014); and dedicated cycling lane should encourage non-cyclists to start cycling (Fishman et al., 2014).

- Figure 4.16 indicated that the majority of the respondents considered **walking initiatives** as effective, with the exception of 'car-free days' that had 21% of the respondents considering it as not effective. 'Improved existing walking routes' initiative was considered to be the most effective initiative among other initiatives, with a percentage of 77%. Previous research indicates that pedestrian networks and good infrastructure have the potential of promoting walking among the employed population (Maki-Opas et al., 2016). It is evident from this study that the most frequently used mode of transport for work trips by the employed population is the private car. It could be beneficial for the City of Tshwane to encourage organisations to support their employees with the provision of showers, lockers and changing rooms – in an effort to encourage employees living within a walking distance from their workplaces.

The conclusions drawn from descriptive statistics for sustainable transport reveal the mode of transport that is available to the residents of the City of Tshwane; and the most frequently used mode of transport, the attitudes of the residents towards sustainable transport, as well as the transport initiatives that might encourage them to use sustainable transport in the city. The main conclusions from the exploratory factor analysis are discussed in Section 5.3.3.

5.3.3 Conclusions from the exploratory factor analysis

The purpose of exploratory factor analysis was to establish whether each of the set of items corresponding to 'public attitudes towards sustainable transport' (Section D of the questionnaire) and 'transport initiatives' (Section E of the questionnaire) forms a unidimensional construct, which could be used in subsequent analyses. The first step for exploratory factor analysis was to test the validity of constructs, followed by a reliability test; and lastly, the calculation of the composite scores. The KMO and Bartlett's test for Sphericity were conducted first to determine whether it was viable to conduct a factor analysis.

- The validity test for **Public attitudes towards sustainable transport** was conducted first. KMO indicated value of 0.799 confirming a statistically significant structure that is viable to conduct an EFA (see Table 4.2). The EFA was applied to responses of the seventeen items of 'public attitudes towards sustainable transport' (Section D of the questionnaire). The principal axis factoring-extraction method was used to extract the factors (Appendix H). In interpreting the rotated factor pattern, an item is assumed to load on a given factor, if the factor loading was 0.40 or greater for that factor; and less than 0.40 for the other. Using these criteria, **four items** were found to load on the first factor, which was subsequently labelled "Traffic problem awareness". **Four items** loaded on the second factor, labelled "Public transport". **Three items** loaded on the third factor labelled "Environmental awareness". **Two items** loaded on the fourth factor labelled "Private car"; and **three items** loaded on the fifth factor labelled "Cycling and walking". With this information, a reliability test for 'public attitudes towards sustainable transport' construct was carried out next (Section 4.4.2.1).
- **The Validity test of** '**transport initiatives'** variables started with KMO and Bartlett's Test to determine whether it is viable to conduct an EFA; and it was confirmed that it was viable to conduct an EFA. The KMO value was 0.882 (see Table 4.5). An EFA was applied to the responses of the twenty-two items of Section E of the questionnaire. The principal axis factoring-extraction method was used to extract the factors. The factors identified were: Factor 1 – Cycling initiatives; Factor 2 – Walking initiatives; Factor 3 – Public transport; and Factor 4 – Parking management. Table 4.6 indicates 60.480% cumulative variance explained by four factors. All the four factors have Eigen values greater than 1.

- **Reliability of 'public attitudes towards sustainable transport**' constructs was tested (see Section 4.4.2.1). Estimates of internal consistency as measured by Cronbach's alpha, all exceeded 0.6 (see Table 4.8). Reliability estimates were 0.833; 0.722; 0.633; 0.601; and 0.777 for the responses to 'traffic problem awareness', 'public transport', 'environmental awareness', 'private car' and 'cycling and walking' respectively. In conclusion, to the above table, the constructs were found to be reliable.

- **The reliability of** ‘**transport initiatives**’ constructs was reported in Section 4.4.2.2, revealing that the reliability estimates were 0.921, 0.780, 0.776 and 0.7755 for responses to ‘cycling initiatives’, ‘walking initiatives’, ‘public transport initiatives’ and ‘parking management’ respectively. In conclusion, the constructs were found to be reliable.

- Summarised **construct scores for ‘public attitudes towards sustainable transport’** were presented in Table 4.10. The scale used was a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3= neutral, 4= agree, 5 = strongly agree). Factors 1, ‘traffic problem awareness’ had the highest mean score of (M=4.2); while the lowest mean score was found in factor 2, ‘public transport’ (M=2.8). The distributions of the above factors are attached in the appendices (refer to Appendix J). Factors 1, 3 and 4 mean score were equal or greater than (M=4) indicating that on average the respondents agreed with the factors. Factor 2, ‘public transport’ indicated a low score, meaning that the majority of the respondents did not respond positively to the factor. It is also evident from Figure 4.13 in Section 4.3.8 that the majority of the respondents considered public transport as unreliable, inconvenient and lacking in information on public transport. It may be assumed that public transport does not offer good quality of service. The respondents might not be satisfied with the service of public transport. It is recommended for the City of Tshwane to improve the public transport system.
- Construct scores for ‘**transport initiatives**’ were presented in Table 4.11. Factor 3, ‘public transport initiatives’ had the highest mean score of (M=4.1), indicating that on average the respondents rated public transport initiatives as effective, followed by factor 1 with a mean score of (M= 3.9). Factors 2 and 4 had mean scores of (M= 3.8) and (M=3.0), respectively. The lowest score was found in factor 4 (M=3.03), indicating that on average, the respondents were neither effective, nor ineffectual. All the transport initiatives were positively received, with the exception of the ‘parking management’. This result refers to Section 4.3.9; 4.3.10; and 4.3.11. With such a positive response towards transport initiatives, it may be assumed that there is a high chance and possibility of implementing sustainable transportation system in the City of Tshwane. Therefore, it is recommended for the City of Tshwane to implement transport initiatives that are considered as effective – in an effort to encourage sustainable urban transport modes.

EFA confirmed that the constructs were valid and reliable. Further tests were done to determine whether statistically significant differences exist between the regions of the City of Tshwane. The main conclusions from inferential statistics are discussed in Section 5.3.4

5.3.4 Conclusions from inferential statistics

To address the objectives 4 (to determine whether statistically significant differences exist between the regional areas of the City of Tshwane with regard to the attitudes towards sustainable urban transport) and 6 (to determine whether statistically significant differences exist between the regional areas of the City of Tshwane with regard to transport initiatives that encourage the public to use sustainable transport modes), One-way ANOVA was used. Both parametric and non-parametric tests were applied, including the Kruskal-Wallis tests, Chi-square tests, Welch's test and the Tukey-Kramer test for further testing of specific statistically significant differences.

- Table 4.12 indicates ANOVA descriptives for '**awareness of traffic problems**', revealing differences among the regions of the City of Tshwane. Region 1 had the highest mean score (M=4.39), indicating that the majority of the residents of Region 1 are aware of traffic problems. The lowest mean score was found in Region 5. Further tests for specific differences (Wilcoxon method) revealed that Regions 1, 3 and 6 were statistically different from Region 5. Because of the characteristics of Region 5, the residents in the area could probably not have experienced traffic problems – unlike the residents in Region 1, where the highest percentage of population of the City of Tshwane is found. Region 5 has the largest geographical area, yet the smallest percentage of Tshwane's population (CoT, 2016). Residents in Region 1 are probably aware of traffic problems; as the region has the highest population share in the City of Tshwane. It is recommended to implement a viable and sustainable public transport network in Region 1.

- Table 4.15 shows how the regions of the City of Tshwane feel about **public transport**. Region 2 had the highest mean score (M= 3.44), indicating that the majority of the residents in Region 2 are satisfied with the public transport service. It could be important for the City of Tshwane to maintain a good service of public transport in Region 2, in order for commuters to continue using public transport. Region 4 had the lowest mean score of

(M=2.22). It may be assumed that the majority of the residents of Region 4 are not satisfied with the public transport service. This could probably mean that public transport is not convenient, and reliable; and it does not provide good information about public transport. Multiple-means comparison tests (Games-Howell) confirmed that Region 2 was statistically significantly different from Region 3. It could be of the utmost importance for the City of Tshwane City of Tshwane to improve the quality of public transport, so as to encourage the residents in Region 4 to use public transport and reduce their car use.

- Table 4.18 shows ANOVA descriptives for **cycling and walking**, confirming that Region 5 had the lowest mean score of (M=3.19); while Region 6 had the highest mean score of (M=4.46). The attitude of the majority of residents in Region 6 was positive towards the environment, fitness and health; while the attitude of most residents in Region 5 was neutral. The Wilcoxon method was used to assess the specific differences among the regional areas of the City of Tshwane. It was confirmed that Regions 1, 2, 3, 4, 6 and 7 were statistically different from Region 5. It could be beneficial for the City of Tshwane to bring sustainable transport awareness programmes on the benefits of cycling and walking to the residents of Region 5.

- ANOVA descriptives for **private car** in Table 4.21 reveal that Region 4 had the highest mean score of (M=4.29); while the lowest mean score was found in Region 5 (M=3.50). This result shows that the residents of the City of Tshwane in Region 4 are more comfortable with private cars than with other modes of transport. The Wilcoxon method was used to assess the specific differences among the regional areas of the City of Tshwane. It was confirmed that Regions 4 and 6 are statistically different from Region 5. It is recommended for the City of Tshwane to consider car-restriction policies in the regions where there is a heavy dependence on the private car. However, the implementation of car-restriction policies is likely to succeed if public transport is effective and efficient.

- Table 4.24 indicates ANOVA descriptives for **environmental awareness** scores for the regions of the City of Tshwane. Region 5 had the lowest mean score of (M=3.23); while Region 3 had the highest mean score (M=4.14). The results indicate that the majority of the residents of the City of Tshwane in Region 3 are aware of environmental problems caused by transport; while the majority in Region 5 are neutral. The results from the Wilcoxon test and Games-Howell confirm that Region 3 is statistically different from Regions 1, 5 and 7. It could be important for the City of Tshwane to implement environmental awareness programmes in Region 5.

- Table 4.27 shows ANOVA descriptives for **cycling initiatives**, revealing that Region 1 had the highest mean score of (M=4.14); while the lowest mean score was found in Region 5 (M=3.49). The results indicate that the majority of the residents in Region 1 are most likely to cycle if cycling initiatives are implemented. The Wilcoxon method confirms specific statistical differences between Region 1 and Regions 6 and 5. Bike awareness campaigns might change the mindset of the commuters in Regions 5 and 6.

- Table 4.30 summarises the ANOVA descriptives for **walking initiatives**. The highest mean score was found in Region 2 (M=4.13); while the lowest mean score was found in ‘Region 5 (M=3.24). This indicates that most of the residents in Region 2 rated walking initiatives as effective; while most of residents from Region 5 rated walking initiatives as neutral. The Wilcoxon method confirmed that Regions 2, 3 and 4 were significantly different from Region 5. Walking awareness campaigns in the areas where walking initiatives were regarded as ineffective could be of great importance.

- Table 4.33 summarises the ANOVA descriptives for **public transport initiatives**, showing that Region 3 had the highest mean score of (M=4.19); while the lowest mean score was found in Region 5 (M=3.58). The majority of the residents of the City of Tshwane in Region 3 rated public transport initiatives as effective. The Wilcoxon method and Game-Howell were used to assess the specific differences among the regional areas of the CoT. The results from the tests confirmed that Region 5 was significantly different from Regions 1, 3 and 6.

- Table 4.36 summarises the ANOVA descriptives for **parking-management initiatives**, indicating that Region 1 had the highest mean score (M=3.25); while the lowest mean score was found in Region 7 (M=2.83). Overall, parking-management initiatives were rated as neutral. The p-value for the Levene test indicated that the p-value was on the borderline, meaning that there was **no significant difference** among the regions of the City of Tshwane.

Based on the literature and the results of this study, a set of **guidelines for sustainable urban transport** have been developed for the City of Tshwane (see Section 4.6). The guidelines for sustainable urban transport in the City of Tshwane were divided into the following four categories:

- **Walking** was classified as guideline 1. Walking is the oldest basic mode of transport that is friendly to the environment; and it has health benefits to the humans. In this category, the following items were proposed: (1) improvement of pedestrian infrastructure, for example, walking routes and the provision of EOTF, such as bathrooms, locker rooms within workplaces, shopping centres, hospitals and educational institutions and awareness programmes; and (2) awareness programmes. Since safety is one of the objectives of sustainable transportation, it is advisable to improve the pedestrian infrastructure, such as walking paths and signage. EOTF has the potential to encourage, for example, the employed population to shift from private cars to walking for short distances to places of work. It could be important to raise the awareness of the benefits of walking to both the environment and human health, so as change the mind-set of the public. Region 5 could benefit from walking awareness campaigns, so as to change the mind-set of the residents in the region.

- Guideline 2 was **cycling**. Cycling is a cleaner mode of transport that is not only regarded as effective and efficient, but also act as a feeder mode for other public transport modes, such as buses and trains (Hopkins & Mandic, 2017; Li et al., 2013). Based on the results of this study, the main concerns about cycling were safety and security. The following items are proposed to deal with the issues around cycling: (1) The creation of 'public bike system' (bike-renting system); (2) construction and improvement of cycling infrastructure; and (3) the provision of end-of-trip facilities. In the City of Tshwane, safety and security for cycling may be achieved through the provision of separate cycling lanes, secure bicycle parking and clear road rules that protect cyclists. The public, in general, may consider cycling for short distance trips once safety and security measures for cycling have been improved. School trips made by private cars in and around the City of Tshwane constitute a considerable percentage. Hence, improvements in safety and security measures for cycling may also lead to parental confidence in cycling for the school children and reducing car usage, and also improving the fitness of children.

Public bike systems play a role in promoting cycling and sustainable public transport. The systems for public cycling that are in cities, such as New York, London and Guangzhou, could also be adopted by the City of Tshwane, so as to encourage the public to cycle for short distances. Cycling may not be possible in all the regions of the City of Tshwane because of the geographic characteristics of the regions. However, it could be of great value to create a network of safe and comfortable public bike system – especially in and around Region 3 (Sunnyside, Pretoria West and CBD) that connects the residents to their potential destinations; as the terrain in most of these areas is flat. Regions 5 and 6 could benefit from bike awareness campaigns, so as to change the mind-set of the commuters in those regions.

EOTFs are recommended to encourage the public to cycle; and they are essential to cater for the needs of cyclists at the end of a trip. EOTF, such as showers, lockers and bicycle racks within an office building could encourage the employed population to cycle to work. The CoT may consider providing incentives to building owners or companies, so that they can facilitate EOTF within the buildings for the employees. Research done in New York and New Jersey in the US confirms that bicycle commuting is influenced by EOTF; hence, employees provided with EOTF at a workplace are more likely to commute with a bicycle (Bueno, Gomez, Peters & Vassallo, 2017).

- **Public transport** was guideline 3; since Public transport has the potential to reduce emissions per passenger kilometre from transportation when compared to private cars, especially with full passenger loads. In order to promote the use of public transport in the City of Tshwane, the following suggestions are proposed: (1) Incentive policies; (2) improvement of service; and (3) modal integration. Incentive policies, such as discounted fares; and free shuttles could be used to encourage the public to use public transport and minimise the use of private cars. High quality public transport that is well connected to other sustainable transport modes could be perceived as attractive. For example, a person can cycle to a bus station or train station, or a person can interchange from a bus to the train or *vice versa*. The City of Tshwane is recommended to consider providing public transport that could offer convenience and diversity to the commuters through **integrated ticketing**. Integrated ticketing allows commuters to use a single smart card to pay for different transport modes, as well as paying for other services. The integrated-ticketing system has the potential to attract the public to move away from private cars to public transport. Some of the well-developed public transport systems with such systems can be found in Hong Kong, Guangzhou and Singapore. Commuters in Hong Kong use the Octopus card; while in Sydney, commuters use a smart card called the Opal card. Linking potential destinations with public transport could reduce car usage.

Regions 1 and 6 could benefit from public transport initiatives. Some of the areas in Regions 1 and 6 are far away from places of work; yet in these regions reside the highest population of people in the City of Tshwane. Viable and sustainable public transport is needed to transport the masses of commuters in these regions. Hence, public transport has the potential to reduce carbon emission; as it can transport large numbers of commuters at a time. Region 4 could also benefit from high quality public transport; as the region is not satisfied with the service quality of public transport.

- The success of Guideline 4. The **Private car** thrives only if alternative modes of transport, as well as the public transport system are ineffectual and inefficient. In order to reduce the traffic congestion caused by higher private car usage in the city, it could be important for the City of Tshwane to implement policies that make private car usage less attractive. In this category, the following solutions are proposed to reduce private car usage: car-restriction policies and parking management. To reduce car usage, car-park management strategies may be applied through high parking fees, time limitation for on-street parking and fewer parking spaces. Car restriction policies could be implemented in such a way that it becomes difficult and expensive to use a private car. For example, congestion charging in designated central zones, strict and expensive car licensing; and high fuel prices. In cities, such as London and Vienna, the policy of ‘no car zones in designated central zones’ has been successfully implemented. Region 4 is one of the affluent areas in the region; where the private car is the mode of choice. Car-restriction policies could be used, in order to reduce car usage by the residents in Region 4 of the City of Tshwane.

The guidelines proposed above are by no means exhaustive; but they are an indication of potential approaches that could be used in the City of Tshwane to reduce the negative impacts of transportation. The proposed guidelines provide for sustainable urban transport that give reference to the policy-makers and the local decision-makers. Limitations of the study are discussed in Section 5.4.

5.4 LIMITATIONS OF THE STUDY

The following limitations of the study are reported:

- In terms of sampling, a limitation of the study might be the non-probability sampling that was used to select the sample. This may limit the ability to make broader generalisations from the results.
- The study had an age restriction of up to 65; yet there are drivers who are over the age of 65 in the City of Tshwane.
- The study's focus was on the residents of the City of Tshwane only; yet there is also an employment population from other metropolitan municipalities that work in the City of Tshwane.
- Research into the cross elasticities of demand to measure travel behaviour was excluded as costs were not captured in the survey.

5.5 RECOMMENDATIONS FOR FUTURE RESEARCH

The following recommendations are made with respect to future research:

- To implement the guidelines and test the elements of transport initiatives per region in the City of Tshwane.
- The research indicated that there is a higher degree of dependence on individual cars in the City of Tshwane, especially in Region 4. Further research could investigate the extent that improvements to the public transport system might have on car dependence in Region 4.

- As a way of decongesting the Central Business District that is located in Region 3, future research could explore the impact of car restriction policies such as congestion charge around the Central Business District.
- To investigate the role of politics in developing and implementing sustainable transport policies in the City of Tshwane.
- In terms of the most frequently used transport, the findings of the present study show that overall, the private vehicle is still the most frequently used mode of transport. Future research could attempt to explore the distances travelled to places of amenities.
- As a way of increasing cycling in the city, future research could investigate the feasibility of public bike rental programs in Region 3 of the City of Tshwane.
- These suggestions could be implemented as the guidelines for sustainable transport developed in this study in the City of Tshwane.
- Future research could determine the extent of price changes such as congestion charges in private vehicle transport in order to measure the expected modal shift to sustainable transport modes.

5.6 CONCLUSION

Transport plays a critical role in any economy, influencing the location of economic activity, the form and size of cities and the lifestyle. However, the frequent use of private vehicles in the city has a significant impact on the environment and on human health. In South Africa, there is an increased use of private vehicles and the existing urban transport infrastructure is insufficient to cater for the existing and future travel demands for transport. The City of Tshwane is one of the largest cities in South Africa that has been highly urbanised and is currently experiencing urban transport problems.

The results of the study also revealed the private car as the most frequently used mode of transport amongst various regions in the City of Tshwane; therefore, it is recommended to implement car-restriction policies, such as the high cost of owning a car; car-free zones in the CBD; and congestion charges. However, in order for an effective shift from the private car to sustainable alternative modes of transport, it would be important for the city to improve the quality of public transport and other sustainable alternative modes of transport. Furthermore, it could be important to raise the awareness of the impacts of private car use through workplaces, media, communities and education in schools.

The validity of constructs was confirmed and the constructs were found to be reliable. Additional tests were done in Section 4.5 to determine whether statistically significant differences existed between the regional areas of the City of Tshwane in terms of the variables of 'Public attitudes towards sustainable transport' and 'Transport initiatives'. Both parametric and non-parametric tests were applied, including ANOVA, the Kruskal-Wallis tests, Chi-square tests, Welch's test and the Tukey-Kramer test. Some of the statistical differences found were:

- Traffic problem awareness – Regions 1, 6 and 3 were statistically different from Region 5.
- Public transport – Region 2 was statistically different from Region 3.
- Cycling and walking – Regions 1, 2, 3, 4, 6 and 7 were statistically different from Region 5.
- Private car – Regions 4 and 6 were statistically different from Region 5.

The value added by the study is finding transport initiatives that may encourage and promote the use of sustainable transport modes in the City of Tshwane. The main deterrent against cycling in the City of Tshwane was the lack of safety that is associated with the absence of infrastructure. However, the most effective cycling initiative was found to be 'improved security and safety'. Cycling is a cleaner and feeder mode of transport for other modes; it is therefore recommended that the City of Tshwane should invest in cycling infrastructure, so as to improve the safety issues and the image of cycling. In addition, it could be beneficial for the city to promote cycling starting among school-going children, so as to create a generation of confident cyclists. In terms of public transport initiatives, the majority of the residents of selected regions in the City of Tshwane rated 'more reliable public transport' as the most effective initiative that might encourage them to use public transport. While the majority of the residents of selected regions of the City of Tshwane regarded 'improved existing walking routes, as the most effective initiative in terms of walking initiatives.

The contribution of the study is its focus on developing guidelines for sustainable urban transport that would provide reference to the city planners and policy-makers in the City of Tshwane. This reference may contribute to a better implementation of sustainable transport policy and reduce car usage in the city. The value added is that such guidelines may also be applied to other metropolitan municipalities of South Africa, and thereby reduce car usage in the country. Awareness of sustainable transport options in the various regions of the City of Tshwane can contribute to the needs of the current generation; and see that these be met without compromising the needs of the future generation.

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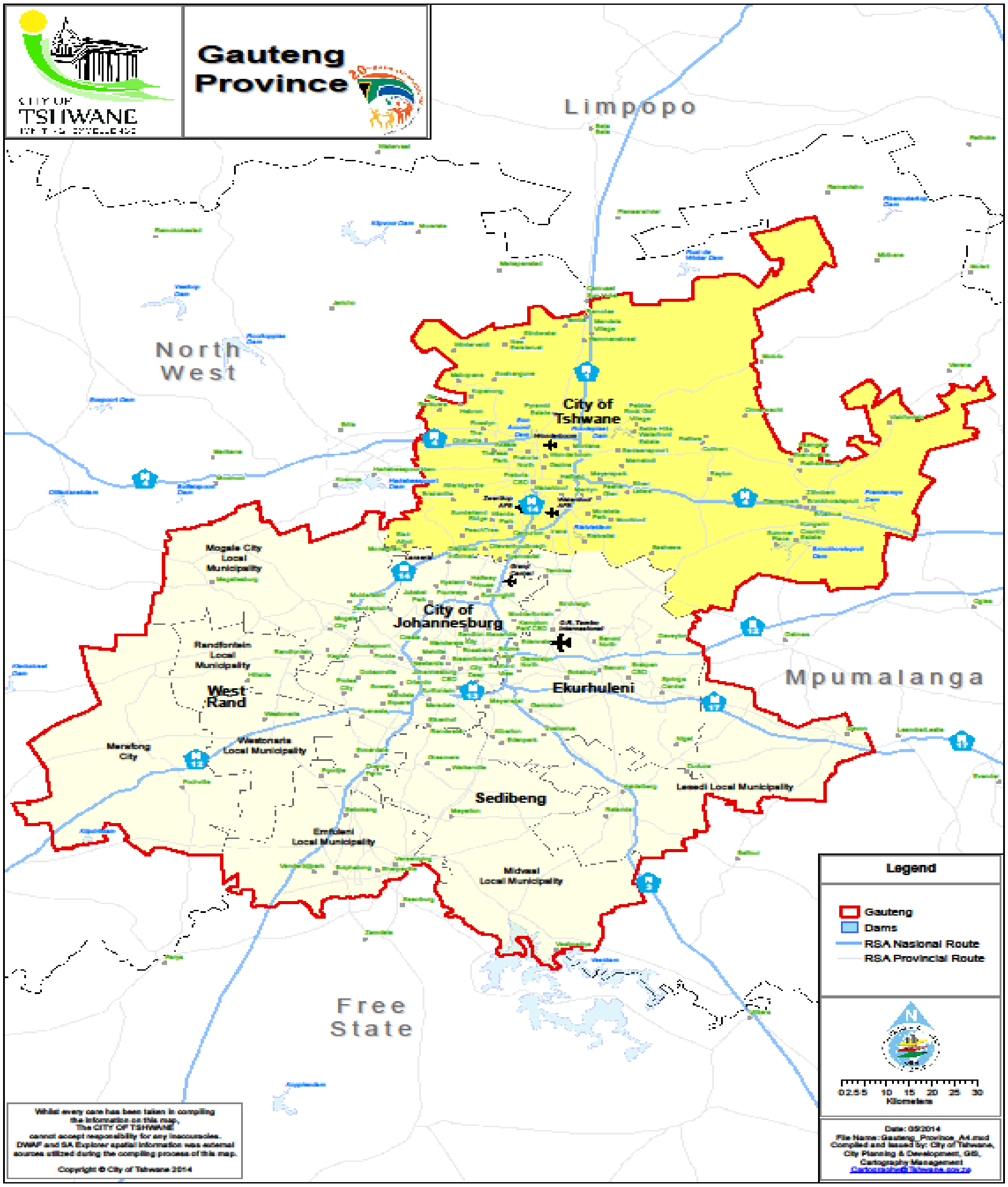
APPENDICES

Appendix A: Gauteng Province



Source: CoT (2016)

Appendix B: Ethical clearance certificate

UNISA university of south africa

05 July 2017

Ref #: 2017_CEMS_ESTTL_011

DEPARTMENT OF ENTREPRENEURSHIP, SUPPLY CHAIN, TRANSPORT, TOURISM AND LOGISTICS MANAGEMENT RESEARCH ETHICS REVIEW COMMITTEE

This is to certify that the application for ethics clearance submitted by

Mrs Babra Duri (student number 43380689, duribm@unisa.ac.za)

"Guidelines for sustainable urban transport in selected areas of the City of Tshwane"

received Ethics Approval

The application for ethics clearance for the above mentioned research was reviewed (as an expedited review) by the Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management Research Ethics Review Committee in July 2017 in compliance with the Unisa Policy on Research Ethics. Ethical Clearance for the project is granted. You may proceed with the research project.

The research ethics principles outlined by the Unisa Policy on Research Ethics must be adhered to throughout the project. Please be advised that the committee needs to be informed should any part of the research methodology as outlined in the Ethics application (Ref #2017_CEMS_ESTTL_011) change in any way or in case of adverse events. This certificate is valid for one year from date of issue. The ESTTL Research Ethics Review Committee wishes you all the best with this research undertaking.

Kind regards,

Mrs C Poole
Chairperson

Executive Dean: CEMS

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Appendix C: Factor analysis of public attitudes towards sustainable transport

	Factors	Cronbach's alpha	Proportion of total variance (%)
Factor 1	Sustainable transport benefits awareness	0.76	26.2
Factor 2	Traffic problems awareness	0.67	11.1
Factor 3	Safety and comfort	0.46	8.6
Factor 4	Public transport negative emotion	0.44	1.2

Source: Xia et al, (2017*)*

Appendix D: Questionnaire

2017

MCom Transport Economics

Dept of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics

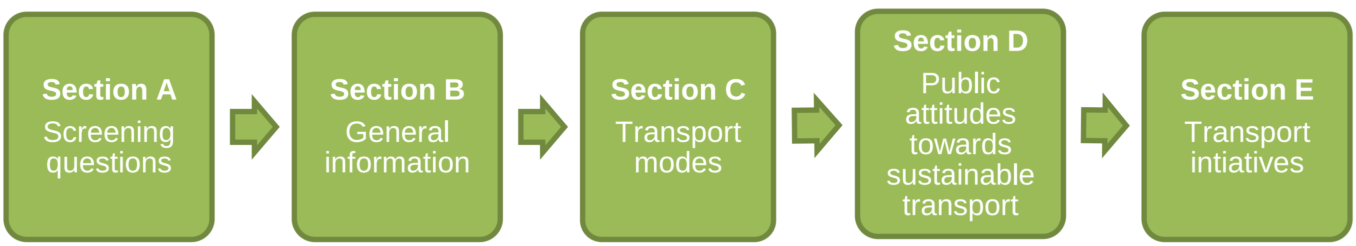
Duri, Babra

UNISA

Dear Sir/Madam

You are invited to participate in a research project conducted by Mrs Babra Duri, a master's student in Transport Economics at the Department of Entrepreneurship, Supply Chain, Transport, Tourism and Logistics Management at the University of South Africa. The aim of the research is to investigate the public attitudes of local residents towards sustainable[15] urban transport in the City of Tshwane. Should you have any queries or comments regarding this survey, you are more than welcome to contact me on 012 433-4614 or at duribm@unisa.ac.za . The questionnaire consists of the following four sections:

Structure of the questionnaire



Please note the following:

- Participation is voluntary and you are under no obligation to participate.
- You are free to withdraw at any time and without giving any reasons.
- Your identity will be anonymous and no one will be able to connect you to the answers.
- The results of the study will be used for academic purposes only and may be published in an academic journal or presented at a conference. We will provide you with a summary of our findings on request.

Please sign the form to indicate that:

- you have read and understand the information provided above, and that
- you have given your consent to participate in the study on a voluntary basis.

Participant's signature ____________________Date_______________

[15] The emphasis of sustainable urban transport in this questionnaire is on reducing the role of private vehicles as prime mode of transport and shifting travel towards other sustainable modes such as walking, cycling and public transport (bus and mini bus taxi) (Liu, 2015).

PUBLIC ATTITUDES TOWARDS SUSTAINABLE URBAN TRANSPORT

INSTRUCTIONS TO COMPLETE THE QUESTIONNAIRE

This questionnaire contains a number of statements about transport in general and sustainable transport. As a local resident in the area you are requested to mark with an **X** the number that most accurately represents how you feel about each statement. Once you have read each question, please decide the extent to which your answer describes your own opinion using the following 5-point Likert scale:

1.	Vehicles cause noise pollution	Strongly disagree	1---2---3---4---5	Strongly agree

Example: If you strongly feel that **vehicles cause noise pollution**, place an **X** on 5. On the other hand, if you feel that **vehicles do not cause pollution**, place an **X** on 1. If you neither agree nor disagree with the statement place an **X** on 3.

SECTION A: SCREENING QUESTIONS

(Mark with an **X** or fill in your answer.)

1. Are you a local resident of City of Tshwane?

	Yes		No

2. Are you over 18 years of age?

	Yes		No

3. Are you under the age of 65?

	Yes		No

If you answered **YES** to questions 1, 2 and 3 please answer Section B.

If you answered **No** to any of the questions above, please return the questionnaire to the researcher. We thank you for your participation in this study

SECTION B: GENERAL INFORMATION

This section includes general information about participants. The questions in the questionnaire include the age of participants, gender, status of employment and residing area of participant.

(Mark with an **X** or fill in your answer.)

	Question	**Answer**							
1.	**Age in years**	18-24		25-45		46-64		65 +	
2.	**Gender**	Female		Male					
3.	**Current status of employment**	Unemployed		Employed		Self-employed			

4. The City of Tshwane (COT) is divided into seven administrative and functional regions as shown below. In which region of the CoT do you reside? Please mark your answer with an X. (The map of CoT is shown in page 9 of the questionnaire)		
Region	**Name of Region**	**Answer**
Region 1	Winterveld	
Region 2	Hammanskraal	
Region 3	Atteridgeville to Central Business District to N1 Eastern border by-pass	
Region 4	Centurion to R21	
Region 5	Roodeplaat dam to Cullinan	
Region 6	Mamelodi to South-East border	
Region 7	Bronkhorstspruit to Eastern border	

Please continue with Section C

SECTION C: TRANSPORT MODES

Mode of transport refers to the method of transport or way of travelling such as by car, bus and taxi. Each mode has its own advantages and disadvantages and can be chosen for a trip based on factors such as cost, capability and route.

1. The table below shows the main modes of transport that are available in the City of Tshwane. Which transport modes are currently available to you? Please indicate your answer with an X.

Transport modes			
1.	**Private car**	Yes	No
2.	**Carpool**	Yes	No
3.	**Bus**	Yes	No
4.	**Taxi**	Yes	No
5.	**Train**	Yes	No
6.	**Bicycle**	Yes	No
7.	**Walk**	Yes	No
8.	**Motor cycle**	Yes	No
9.	**Other**	Yes	No

2. Which mode of transport do you use most frequently for each of the following activities? Please mark with an X.

	Purpose of trip on a daily basis	Car	Motor cycle	Bus	Train	Taxi	Bicycle	Walk	Other
a.	**Shopping**	1	2	3	4	5	6	7	8
b.	**Travel to work**	1	2	3	4	5	6	7	8
c.	**Travel while at work**	1	2	3	4	5	6	7	8
d.	**Local leisure travel (Within CoT)**	1	2	3	4	5	6	7	8
e.	**Visiting friends and relatives within CoT**	1	2	3	4	5	6	7	8
f.	**Taking children to school or nursery or fetching them**	1	2	3	4	5	6	7	8

3. How important are these transport service dimensions to you as local resident when deciding on the specific choice of transport mode to use? (1 = not very important, 2 = not important, 3 = neutral, 4 = important 5 = very important). Please circle your answer.				
a.	**Environmental benefits**	Not very important	1---2---3---4---5	Very important
b.	**Cost**	Not very important	1---2---3---4---5	Very important
c.	**Weather**	Not very important	1---2---3---4---5	Very important
d.	**Safety**	Not very important	1---2---3---4---5	Very important
e.	**Reliability**	Not very important	1---2---3---4---5	Very important
f.	**Time taken**	Not very important	1---2---3---4---5	Very important
g.	**Convenience**	Not very important	1---2---3---4---5	Very important
h.	**Route**	Not very important	1---2---3---4---5	Very important
i.	**Other**	Not very important	1---2---3---4---5	Very important

4. Would you as local resident consider these alternative modes of transport in order to promote sustainable urban transport? Please indicate your answer with an X.			
Mode of transport			
a.	**Cycling**	Yes	No
b.	**Walking**	Yes	No
c.	**Public transport e.g. bus, train & taxi**	Yes	No
d.	**Car sharing**	Yes	No
e.	**Lift club**	Yes	No
f.	**Train**	Yes	No

Please continue with Section D

SECTION D: PUBLIC ATTITUDES TOWARDS SUSTAINABLE TRANSPORT

Research indicates an increased use of motor vehicles which contribute to a series of environmental and health issues related to greenhouse gas emissions, air and noise pollution. This section is concerned with finding out your attitude towards sustainable transport and the environment. The following statements are based on transport and the environment. Please indicate your answer with **X** or circle correct answer. (1 = Strongly disagree, 2 = Disagree, 3 = Neither, 4 = Agree, 5 = Strongly agree)

1.Sustainable transport benefits awareness				
a.	**From an environment point of view, it is important that we reduce car use.**	Strongly disagree	1---2---3---4---5	Strongly agree
b.	**Public transport is a more environmentally- friendly option than driving a car.**	Strongly disagree	1---2---3---4---5	Strongly agree
c.	**Cycling and walking are more environmentally-friendly options than driving a car.**	Strongly disagree	1---2---3---4---5	Strongly agree
d.	**If more people walked and cycled, this would have a positive effect on our environment.**	Strongly disagree	1---2---3---4---5	Strongly agree
e.	**Walking and cycling can help me keep fit and healthy.**	Strongly disagree	1---2---3---4---5	Strongly agree
f.	**Being environmentally responsible is important to me.**	Strongly disagree	1---2---3---4---5	Strongly agree

2.Traffic problems awareness				
a.	**Vehicle related air pollution is dangerous to our health.**	Strongly disagree	1---2---3---4---5	Strongly agree
b.	**Vehicles cause noise pollution.**	Strongly disagree	1---2---3---4---5	Strongly agree
c.	**Vehicle emissions are a threat to the environment.**	Strongly disagree	1---2---3---4---5	Strongly agree
d.	**The more vehicles on the road, the more road accidents resulting in injuries and deaths.**	Strongly disagree	1---2---3---4---5	Strongly agree

Please continue with Section D

3.Safety and comfort				
a.	**Cycling is a safer transport option for me.**	Strongly disagree	1---2---3---4---5	Strongly agree
b.	**I feel more comfortable in private cars than in other transport modes.**	Strongly disagree	1---2---3---4---5	Strongly agree
c.	**A car is essential to satisfy my needs.**	Strongly disagree	1---2---3---4---5	Strongly agree

4.Feelings about Public transport				
a.	**Public transport services are reliable for me.**	Strongly disagree	1---2---3---4---5	Strongly agree
b.	**Public transport is expensive for me.**	Strongly disagree	1---2---3---4---5	Strongly agree
c.	**Public transport is convenient.**	Strongly disagree	1---2---3---4---5	Strongly agree
d.	**There is good information about public transport.**	Strongly disagree	1---2---3---4---5	Strongly agree

Please continue with Section E

SECTION E: TRANSPORT INITIATIVES

Various transport initiates may be implemented to encourage the use of public transport and non-motorised vehicles (walking and cycling). Please rate how effective these initiatives would be in encouraging you to use sustainable transport modes.

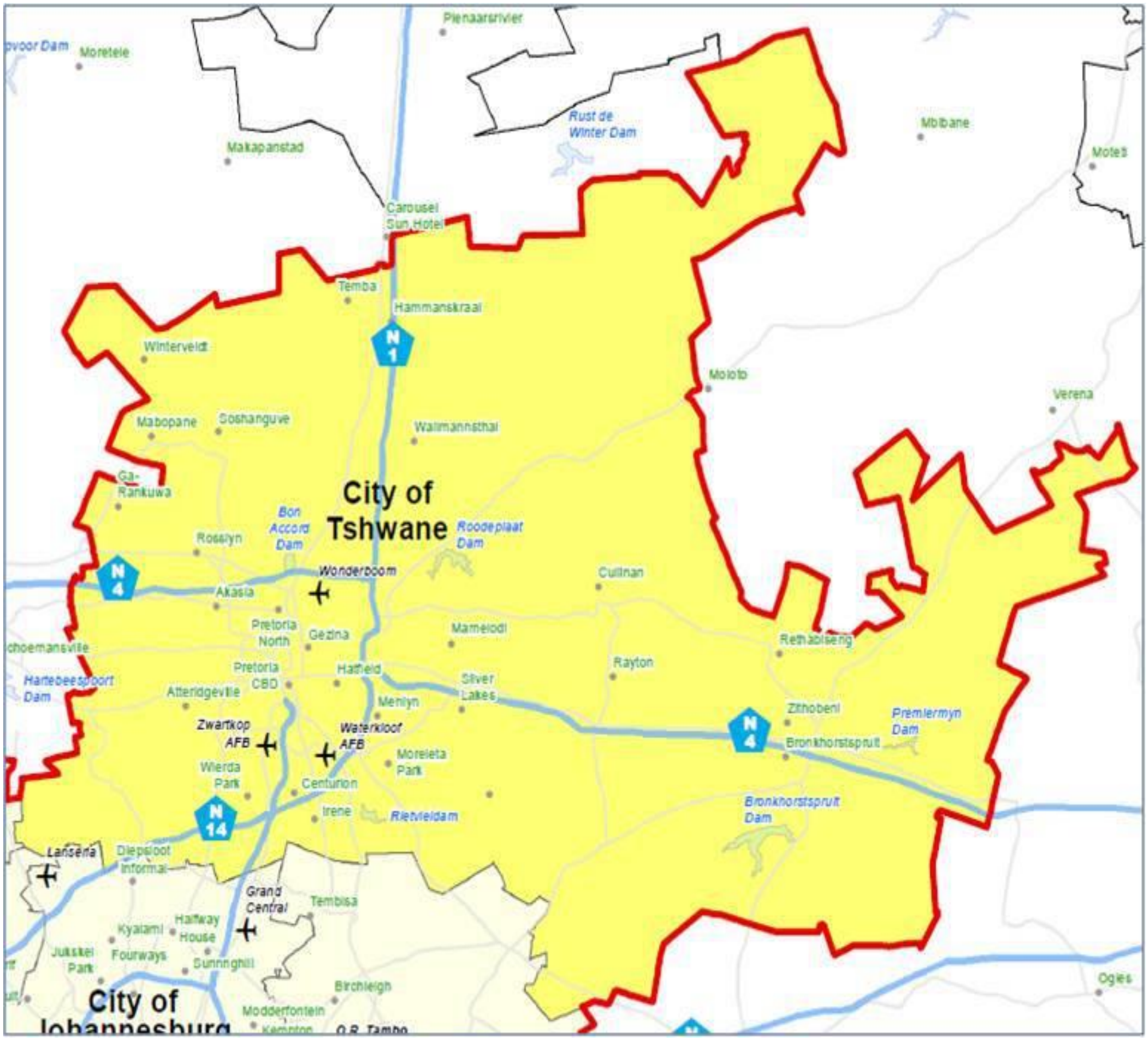
1. How effective do you think the following initiatives would be in encouraging you to use public transport?				
a.	**Cheaper fares for public transport**	Not very effective	1---2---3---4---5	Very effective
b.	**More reliable public transport service**	Not very effective	1---2---3---4---5	Very effective
c.	**More bus routes**	Not very effective	1---2---3---4---5	Very effective
d.	**Car-free days**	Not very effective	1---2---3---4---5	Very effective
e.	**Supermarket shuttle bus**	Not very effective	1---2---3---4---5	Very effective
f.	**Car-sharing schemes**	Not very effective	1---2---3---4---5	Very effective
g.	**Financial incentives to use public transport**	Not very effective	1---2---3---4---5	Very effective

h.	**Less parking space**	Not very effective	1---2---3---4---5	Very effective
i.	**Higher parking fees**	Not very effective	1---2---3---4---5	Very effective

2. How effective do you think the following initiatives would be in encouraging you to cycle?				
a.	**Space for the bike on public buses**	Not very effective	1---2---3---4---5	Very effective
b.	**Bicycle rental facilities**	Not very effective	1---2---3---4---5	Very effective
c.	**Provision of bicycle parking**	Not very effective	1---2---3---4---5	Very effective
d.	**Dedicated cycling lanes**	Not very effective	1---2---3---4---5	Very effective
e.	**Improved security and safety of bicycles**	Not very effective	1---2---3---4---5	Very effective
f.	**Reduced bicycle price**	Not very effective	1---2---3---4---5	Very effective
g.	**Improved path network for bikes**	Not very effective	1---2---3---4---5	Very effective
h.	**Bathrooms and locker facilities available for bicycle users**	Not very effective	1---2---3---4---5	Very effective

3. How effective do you think the following initiatives would be in encouraging you to walk?				
a.	**Improved existing walking routes**	Not very effective	1---2---3---4---5	Very effective
b.	**Provision of bathrooms at work place**	Not very effective	1---2---3---4---5	Very effective
c.	**Car-free days**	Not very effective	1---2---3---4---5	Very effective
d.	**Walking groups**	Not very effective	1---2---3---4---5	Very effective
e.	**Walking challenges for health and fitness**	Not very effective	1---2---3---4---5	Very effective

Map: City of Tshwane



Thank you for taking the time to complete the questionnaire.

Appendix E : Variable type and analysis

Section in the survey		Research objectives	Type of question	Study source		Questions contributed	Variable type	Analysis
A	**Screening questions**		Closed-ended					
B	**General information** 1.Gender 2.Age 3.Status of employment		Closed-ended	Xia et al, 2017;		B1. B2 B3	Categorical variable	Frequencies and percentages
				Verma et al, 2016;		B1 B2 .	Categorical variable	Frequencies and percentages
				Liu et al, 2015;		B1 B2 B3	Categorical variable	Frequencies and percentages
				Khoo & Ong, 2015		B1 B2 B3	Categorical variable	Frequencies and percentages
				Puhe & Schippl, 2014		B1	Categorical variable	Frequencies and percentages
				Verma et al, 2013;		B1 B2 B3	Categorical variable	Frequencies and percentages
				Raha & Taweesin, 2013		B1 B2 B3	Categorical variable	Frequencies and percentages
				Grdzelishvili & Sathre, 2011		B1 B2 B3	Categorical variable	Frequencies and percentages
				Prillwitz, 2011		B1 B2 B3	Categorical variable	Frequencies and percentages
C	**Transport modes** 1.Transport modes available 2.The most frequently used mode of transport 3.Factors dictating specific choice of transport	To identify the transport modes that are used in the CoT	Closed-ended	Xia et al., 2017		C1 C2	Categorical variable	Frequencies and percentages
				Verma at al., 2016;		C1	Categorical variable	Frequencies and percentages
				Khoo & Ong, 2015;		C1	Categorical variable	Frequencies and percentages
				Zacharia, 2005;		C1	Categorical variable	Frequencies and percentages
				Puhe & Schippl, 2014;		C1	Categorical variable	Frequencies and percentages
				Grdzelishvili & Sathre, 2011;		C3	Categorical variable	Frequencies and percentages
				Prillwitz, 2011.		C2 C3	Categorical variable	Frequencies and percentages
				Nilsson& Kuller, 2000.		C1 C2	Categorical variable	Frequencies and percentages
D	**Public attitudes towards sustainable transport** 1.Sustainable transport benefits awareness 2.Traffic problems awareness 3.Safety and comfort 4.Feelings about public transport	To explore public attitudes towards sustainable urban transport in the CoT To identify and compare key factors that	Closed-ended	Xia et al, 2017		D1 D2 D3 D4	Construct – continuous variable	Cronbach alpha test reliability means and standard deviation ANOVA if comparing areas
				Verma et al, 2016;		D3	Construct – continuous variable	Cronbach alpha test reliability means and standard deviation ANOVA if comparing areas

		influence attitudes of the CoT residents towards sustainable urban transport		Verma et al, 2013;		D1	Construct – continuous variable	Cronbach alpha test reliability means and standard deviation ANOVA if comparing areas
				Raha & Taweesin, 2013;		D2 D3	Construct – continuous variable	Cronbach alpha test reliability means and standard deviation ANOVA if comparing areas
				Prillwitz, 2011;		D1 D2 D3	Construct – continuous variable	Cronbach alpha test reliability means and standard deviation ANOVA if comparing areas
				Nilsson& Kuller, 2000.		D1 D2 D3 D4	Construct – continuous variable	Cronbach alpha test reliability means and standard deviation ANOVA if comparing areas
E	**Transport initiatives** 1.Initiatives to encourage the public transport 2.Initiatives to encourage cycling 3.Initiatives to encourage walking	To determine transport initiatives that can encourage the public to use sustainable transport modes	Closed-ended	Xia et al, 2017;		E1 E2 E3	Categorical variable	Frequencies and percentages
				Verma et al, 2016;		E2	Categorical variable	Frequencies and percentages
				Liu et al, 2015;		E1 E2 E3	Categorical variable	Frequencies and percentages
				Raha & Taweesin, 2013;		E2	Categorical variable	Frequencies and percentages
				Prillwitz, 2011;		E1	Categorical variable	Frequencies and percentages
				Pucher, 2008.		E2	Categorical variable	Frequencies and percentages

Appendix F: Frequency table

	Count	%
Age group		
18-24	100	24
25-45	248	59
46-64	69	17
Gender		
Male	182	44
Female	235	56
Work status		
Unemployed	98	24
Employed	279	67
Self-employed	38	9
Area		
Region 1	107	26
Region 2	46	11
Region 3	77	18
Region 4	50	12
Region 5	30	7
Region 6	77	18
Region 7	30	7
Transport modes available		
Private car	293	70
Carpool	58	14
Bus	172	41
Taxi	243	58
Train	151	36
Bicycle	63	15
Walk	138	33
Motor cycle	53	13
Most frequently used modes of transport		
Shopping	415	
Travel to work	412	
Travel while at work	407	
Local leisure travel (within City of Tshwane)	410	
Visiting friends and relatives locally	412	
Taking children to and from school	408	
Alternative modes of transport		
Cycling	201	
Walking	226	
Public transport	310	
Car sharing	173	
Lift club	177	
Train	214	
Importance of transport service dimensions		
Environmental benefits	413	

Cost	415	
Weather	415	
Safety	415	
Reliability	415	
Time taken	412	
Convenience	415	
Route	411	
Other	375	
Public attitudes towards sustainable transport		
D1a	416	
D1b	414	
D1c	415	
D1d	414	
D1e	414	
D1f	409	
D2a	412	
D2b	413	
D2c	414	
D2d	415	
D3a	412	
D3b	412	
D3c	410	
D4a	416	
D4b	415	
D4c	416	
D4d	415	
Transport Initiative		
E1a	414	
E1b	415	
E1c	414	
E1d	413	
E1e	413	
E1f	413	
E1g	413	
E1h	414	
E1i	415	
E2a	415	
E2b	412	
E2c	413	
E2d	413	
E2e	412	
E2f	413	
E2g	412	
E2h	413	
E3a	417	
E3b	415	
E3c	415	

E3d	416	
E3e	416	

Appendix G: Factor Analysis- Validation of constructs

1. Factor analysis: Public attitudes towards sustainable transport

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.799
Bartlett's Test of Sphericity	Approx. Chi-Square	2146.623
	df	136
	Sig.	.000

Communalities

	Initial	Extraction
D1.1 From an environment point of view, it is important that we reduce car use	.291	.505
D1.2 Public transport is a more environmentally friendly option than driving a car	.319	.387
D1.3 Cycling and walking are more environmentally friendly option than driving a car	.442	.483
D1.4 If more people walked and cycled, this would have a positive effect on our environment	.527	.615
D1.5 Walking and cycling can help me keep fit and healthy	.487	.637
D1.6 Being environmentally responsible is important to me	.325	.341
D2.1 Vehicle related air pollution is dangerous to our health	.539	.578
D2.2 Vehicles cause noise pollution	.545	.677
D2.3 Vehicle emissions are a threat to the environment	.554	.616

D2.4 The more vehicles on the road, the more road accidents resulting in injuries and deaths	.439	.450
D3.1 Cycling is a safer transport option for me	.149	.176
D3.2 I feel more comfortable in private cars than in other transport modes	.287	.435
D3.3 A car is essential to satisfy my needs	.263	.450
D4.1 Public transport service is reliable for me	.475	.594
D4.2 Public transport is expensive for me	.185	.201
D4.3 Public transport is convenient	.476	.654
D4.4 There is good information about public transport	.355	.448

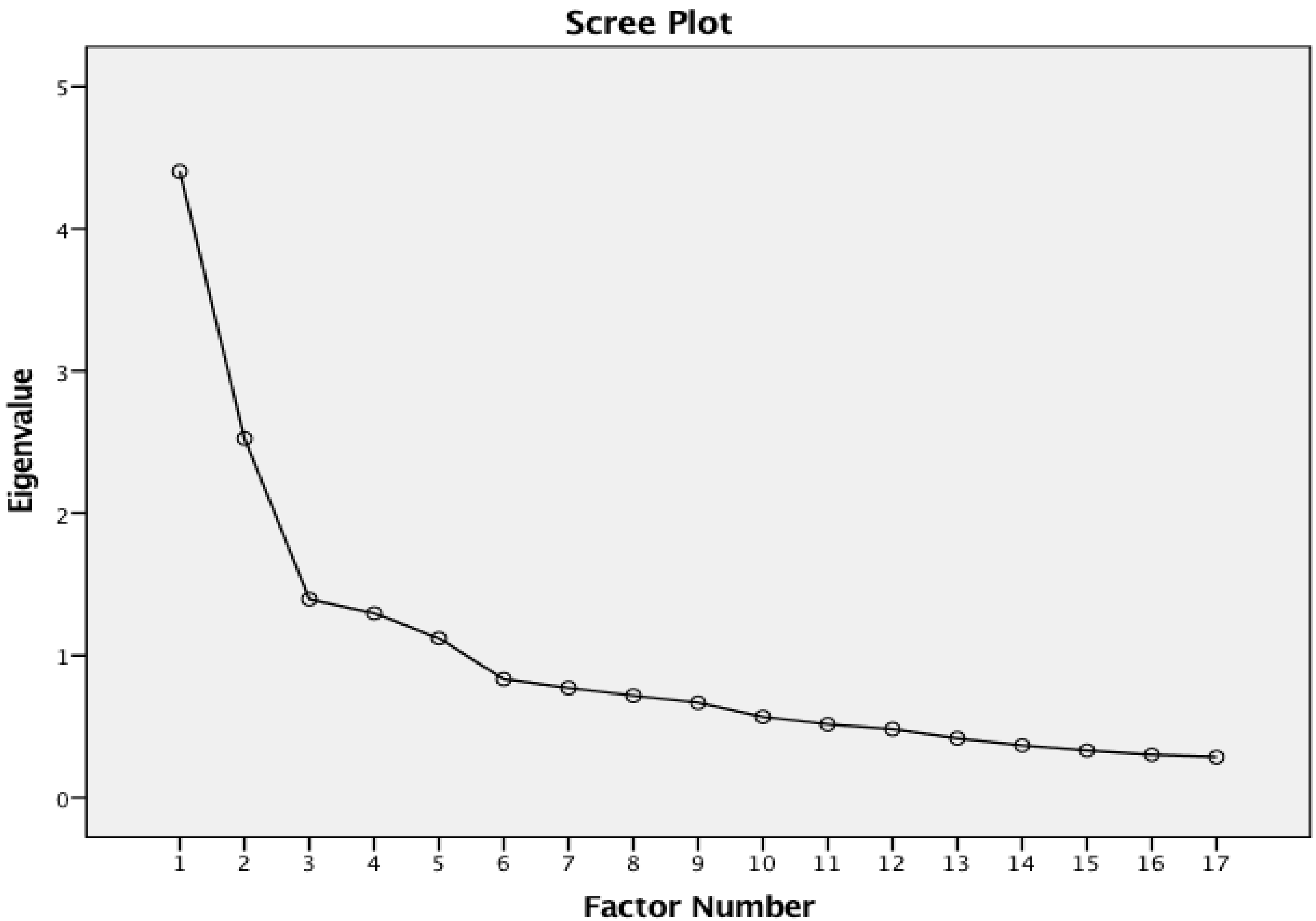
Extraction Method: Principal Axis Factoring.

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.404	25.906	25.906	3.954	23.260	23.260
2	2.525	14.854	40.760	2.024	11.907	35.167
3	1.396	8.213	48.973	.907	5.334	40.501
4	1.296	7.622	56.596	.745	4.385	44.885
5	1.121	6.596	63.192	.614	3.614	48.499
6	0.833	4.901	68.093			
7	.772	4.539	72.632			
8	.717	4.219	76.851			
9	.668	3.928	80.778			
10	.568	3.339	84.118			
11	.515	3.032	87.150			
12	.482	2.833	89.983			

13	.418	2.458	92.441			
14	.368	2.163	94.604			
15	.332	1.952	96.556			
16	.301	1.771	98.328			
17	.284	1.672	100.000			

Extraction Method: Principal Axis Factoring.



Pattern Matrix[a]

	Factor				
	1	2	3	4	5
D2.2 Vehicles cause noise pollution	.836				
D2.3 Vehicle emissions are a threat to the environment	.709				
D2.1 Vehicle related air pollution is dangerous to our health	.672				
D2.4 The more vehicles on the road, the more road accidents resulting in injuries and deaths	.645				
D4.3 Public transport is convenient		.790			
D4.1 Public transport service is reliable for me		.721			
D4.4 There is good information about public transport		.674			
D4.2 Public transport is expensive for me		.413			
D3.1 Cycling is a safer transport option for me					
D1.1 From an environment point of view, it is important that we reduce car use			.712		
D1.2 Public transport is a more environmentally friendly option than driving a car			.561		
D1.6 Being environmentally responsible is important to me			.390		
D3.3 A car is essential to satisfy my needs				.650	
D3.2 I feel more comfortable in private cars than in other transport modes				.600	
D1.5 Walking and cycling can help me keep fit and healthy					.710

D1.4 If more people walked and cycled, this would have a positive effect on our environment					.668
D1.3 Cycling and walking are more environmentally friendly option than driving a car					.584

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.[a]
a. Rotation converged in 12 iterations.

Factor Correlation Matrix

Factor	1	2	3	4	5
1	1.000	0.110	0.344	0.228	0.393
2	0.110	1.000	0.237	-0.084	-0.151
3	0.344	0.237	1.000	0.135	0.254
4	0.228	-0.084	0.135	1.000	0.253
5	0.393	-0.151	0.254	0.253	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

2. Factor Analysis: Transport initiatives

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.882
Bartlett's Test of Sphericity	Approx. Chi-Square	4337.617
	df	231
	Sig.	.000

Communalities

	Initial	Extraction
E1.1 Cheaper fares for public transport	.364	.344
E1.2 More reliable public transport service	.529	.624
E1.3 More bus routes	.557	.685
E1.4 Car-free days	.461	.406
E1.5 Supermarkets shuttle bus	.409	.333
E1.6 Car sharing schemes	.337	.303
E1.7 Financial incentive to use public transport	.334	.336
E1.8 Less parking space	.432	.443
E1.9 Higher parking fees	.437	.497
E2.1 Space for the bike on public buses	.557	.555
E2.2 Bicycle rental facilities	.642	.613
E2.3 Provision of bicycle parking	.697	.698
E2.4 Dedicated cycling lanes	.676	.657
E2.5 Improved security and safety of bicycles	.726	.671
E2.6 Reduced bicycle price	.560	.554
E2.7 Improved path network for bikes	.747	.721
E2.8 Bathrooms and locker facilities available for bicycle users	.615	.614
E3.1 Improved existing walking routes	.413	.340
E3.2 Provision of bathrooms at work place	.441	.357
E3.3 Car-free days	.484	.534
E3.4 Walking groups	.536	.641
E3.5 Walking challenges for health and fitness	.500	.541

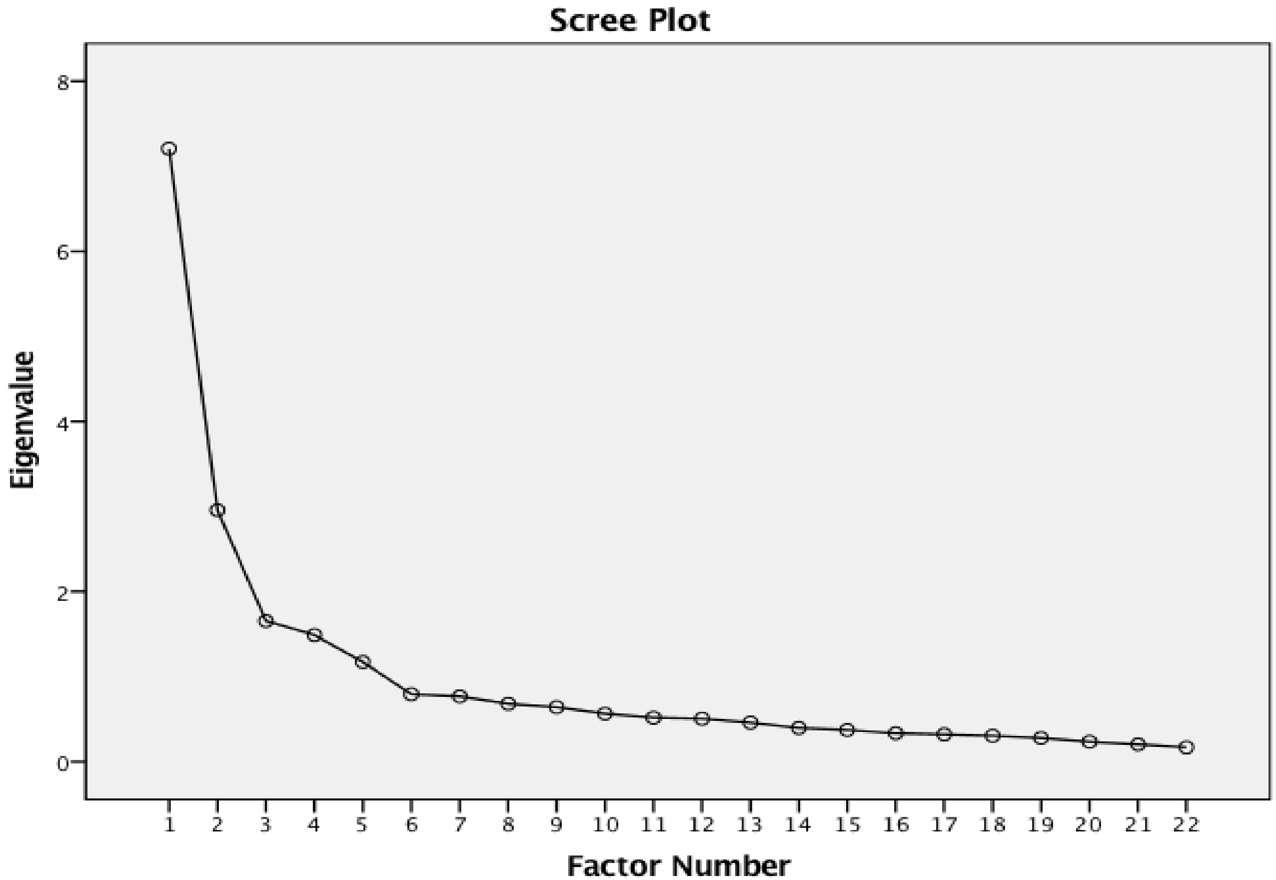
Extraction Method: Principal Axis Factoring.

Total Variance Explained

Factor	Initial Eigenvalues Total	Initial Eigenvalues % of Variance	Initial Eigenvalues Cumulative %	Extraction Sums of Squared Loadings Total	Extraction Sums of Squared Loadings % of Variance	Extraction Sums of Squared Loadings Cumulative %	Rotation Sums of Squared Loadings[a] Total
1	7.207	32.759	32.759	6.773	30.788	30.788	5.994
2	2.957	13.439	46.199	2.486	11.301	42.090	3.483
3	1.654	7.517	53.715	1.217	5.532	47.622	3.802
4	1.488	6.765	60.480	.989	4.497	52.119	2.215
5	1.171	5.321	65.801				
6	.792	3.599	69.400				
7	.766	3.484	72.884				
8	.680	3.091	75.976				
9	.640	2.910	78.886				
10	.563	2.559	81.444				
11	.516	2.345	83.789				
12	.504	2.292	86.081				
13	.458	2.083	88.165				
14	.396	1.799	89.964				
15	.372	1.690	91.654				
16	.333	1.515	93.169				
17	.320	1.454	94.623				
18	.304	1.380	96.003				
19	.278	1.262	97.265				
20	.233	1.058	98.323				
21	.201	.916	99.239				
22	.167	.761	100.000				

Extraction Method: Principal Axis Factoring.

a. When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.



Pattern Matrix[a]

	Factor			
	1	2	3	4
E2.7 Improved path network for bikes	.844			
E2.3 Provision of bicycle parking	.817			
E2.4 Dedicated cycling lanes	.802			
E2.5 Improved security and safety of bicycles	.795			
E2.2 Bicycle rental facilities	.793			
E2.8 Bathrooms and locker facilities available for bicycle users	.768			
E2.6 Reduced bicycle price	.719			
E2.1 Space for the bike on public buses	.707			

E3.2 Provision of bathrooms at work place	.433			
E3.4 Walking groups		.811		
E3.5 Walking challenges for health and fitness		.747		
E3.3 Car-free days		.661		
E3.1 Improved existing walking routes		.392		
E1.4 Car-free days		.352		
E1.3 More bus routes			.856	
E1.2 More reliable public transport service			.826	
E1.1 Cheaper fares for public transport			.566	
E1.7 Financial incentive to use public transport			.460	
E1.5 Supermarkets shuttle bus				
E1.9 Higher parking fees				.706
E1.8 Less parking space				.653
E1.6 Car sharing schemes				

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.[a]
a. Rotation converged in 7 iterations.

Factor Correlation Matrix

Factor	1	2	3	4
1	1.000	0.288	0.369	0.165
2	0.288	1.000	0.400	0.304
3	0.369	0.400	1.000	0.304
4	0.165	0.304	0.304	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

Appendix H: Factor analysis – Reliability of constructs

H.1: Reliability- Traffic problem awareness

Section D (Public attitudes towards sustainable transport)

Scale: ALL VARIABLES

Case Processing Summary			
		N	%
Cases	Valid	411	98.3
	Excluded[a]	7	1.7
	Total	418	100.0

a. List wise deletion based on all variables in the procedure.

Reliability Statistics	
Cronbach's Alpha	N of Items
.833	4

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
D2.2 Vehicles cause noise pollution	12.71	7.006	0.702	.770
D2.3 Vehicle emissions are a threat to the environment	12.70	7.200	0.689	.777
D2.1 Vehicle related air pollution is dangerous to our health	12.59	7.248	0.674	.784
D2.4 The more vehicles on the road, the more road accidents resulting in injuries and deaths	12.75	7.282	0.588	.823

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
16.91	12.098	3.478	4

H.2 Reliability- Public transport

Scale: ALL VARIABLES

Case Processing Summary			
		N	%
Cases	Valid	413	98.8
	Excluded[a]	5	1.2
	Total	418	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics	
Cronbach's Alpha	N of Items
0.722	4

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
D4.3 Public transport is convenient	8.41	9.413	0.625	0.592
D4.1 Public transport service is reliable for me	8.29	9.328	0.586	0.613
D4.4 There is good information about public transport	8.65	9.875	0.504	0.664
D4.2 Public transport is expensive for me	8.39	11.220	0.343	0.754

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
11.25	16.201	4.025	4

H.3: Reliability- Environmental awareness

Scale: ALL VARIABLES

Case Processing Summary			
		N	%
Cases	Valid	409	97.8
	Excluded[a]	9	2.2
	Total	418	100.0

a. List wise deletion based on all variables in the procedure

Reliability Statistics	
Cronbach's Alpha	N of Items
.633	3

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
D1.1 From an environment point of view, it is important that we reduce car use	7.63	3.963	0.470	0.499
D1.2 Public transport is a more environmentally friendly option than driving a car	7.66	4.427	0.460	0.509
D1.6 Being environmentally responsible is important to me	7.14	5.321	0.410	0.583

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
11.22	8.689	2.948	3

H.4: Reliability-Private car

Scale: ALL VARIABLES

Case Processing Summary			
		N	%
Cases	Valid	410	98.1
	Excluded[a]	8	1.9
	Total	418	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.601	2

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
D3.3 A car is essential to satisfy my needs	3.93	1.491	0.435	.
D3.2 I feel more comfortable in private cars than in other transport modes	4.10	1.091	0.435	.

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
8.02	3.691	1.921	2

H.5: Reliability- Cycling and walking

Scale: ALL VARIABLES

Case Processing Summary			
		N	%
Cases	Valid	414	99.0
	Excluded[a]	4	1.0
	Total	418	100.0
a. Listwise deletion based on all variables in the procedure.			

Reliability Statistics	
Cronbach's Alpha	N of Items
.777	3

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
D1.5 Walking and cycling can help me keep fit and healthy	8.20	4.017	0.593	0.726
D1.4 If more people walked and cycled, this would have a positive effect on our environment	8.51	3.437	0.666	0.640
D1.3 Cycling and walking are moreæenvironmentally friendly option than driving a car	8.63	3.281	0.596	0.728

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
12.67	7.243	2.691	3

H.6: Reliability- Cycling

Scale: ALL VARIABLE

Case Processing Summary			
		N	%
Cases	Valid	402	96.2
	Excluded[a]	16	3.8
	Total	418	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability statistics	
Cronbach's Alpha	N of Items
.921	9

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
E2.7 Improved path network for bikes	31.05	59.447	0.795	0.907
E2.3 Provision of bicycle parking	31.39	57.614	0.799	0.906
E2.4 Dedicated cycling lanes	31.07	59.294	0.766	0.909
E2.5 Improved security and safety of bicycles	31.00	60.132	0.748	0.910
E2.2 Bicycle rental facilities	31.47	58.609	0.725	0.911
E2.8 Bathrooms and locker facilities available for bicycle users	31.24	59.033	0.750	0.909
E2.6 Reduced bicycle price	31.23	59.424	.719	0.912
E2.1 Space for the bike on public buses	31.46	58.822	.683	0.914
E3.2 Provision of bathrooms at work place	31.03	65.213	.479	0.926

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
35.12	74.857	8.652	9

H.7: Reliability- Walking
Scale: ALL VARIABLES

Case Processing Summary			
		N	%
Cases	Valid	414	99.0
	Excluded[a]	4	1.0
	Total	418	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics	
Cronbach's Alpha	N of Items
.780	4

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
E3.4 Walking groups	11.57	7.727	0.658	0.687
E3.5 Walking challenges for health and fitness	11.35	8.004	0.640	0.698
E3.3 Car-free days	11.84	7.644	0.583	0.730
E3.1 Improved existing walking routes	11.25	9.283	0.468	0.781

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
15.34	13.522	3.677	4

H.8: Reliability- Public transport
Scale: ALL VARIABLES

Case Processing Summary			
		N	%
Cases	Valid	411	98.3
	Excluded[a]	7	1.7
	Total	418	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics	
Cronbach's Alpha	N of Items
.776	4

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
E1.3 More bus routes	12.07	7.961	0.668	0.681
E1.2 More reliable public transport service	12.09	7.785	0.670	0.677
E1.1 Cheaper fares for public transport	12.40	7.504	0.544	0.746
E1.7 Financial incentive to use public transport	12.40	8.464	0.465	0.780

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
16.32	13.115	3.621	4

H.9: Reliability- Parking management
Scale: ALL VARIABLES

Case Processing Summary			
		N	%
Cases	Valid	414	99.0
	Excluded[a]	4	1.0
	Total	418	100.0

a. Listwise deletion based on all variables in the procedure.

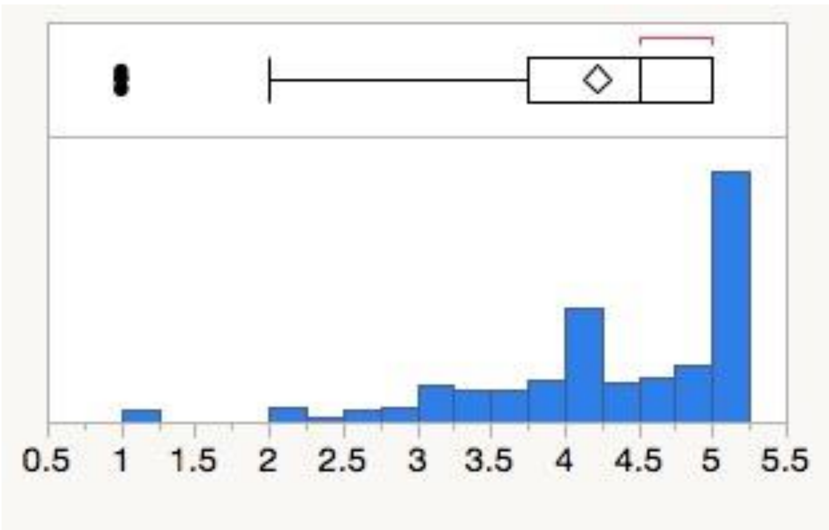
Reliability Statistics	
Cronbach's Alpha	N of Items
.755	2

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
E1.9 Higher parking fees	3.11	2.043	0.606	.
E1.8 Less parking space	2.96	1.998	0.606	.

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
6.07	6.491	2.548	2

Appendix I: Distributions

I.1: Traffic problem awareness



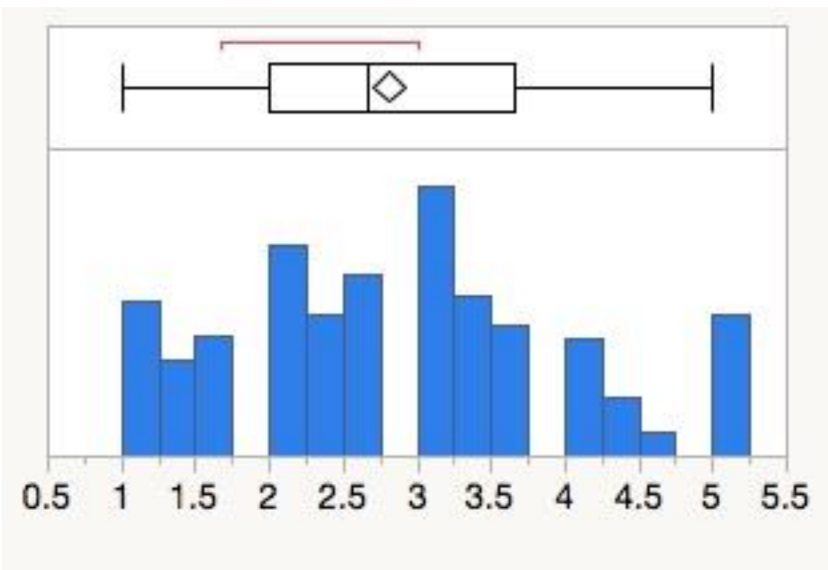
Quantiles

100.0%	maximum	5
99.5%		5
97.5%		5
90.0%		5
75.0%	quartile	5
50.0%	median	4.5
25.0%	quartile	3.75
10.0%		3
2.5%		2
0.5%		1
0.0%	minimum	1

Summary Statistics

Mean	4.2219551
Std Dev	0.868311
Std Err Mean	0.0425724
Upper 95% Mean	4.3056396
Lower 95% Mean	4.1382706
N	416
Skewness	-1.26795
Kurtosis	1.6340178

I.2: Public transport



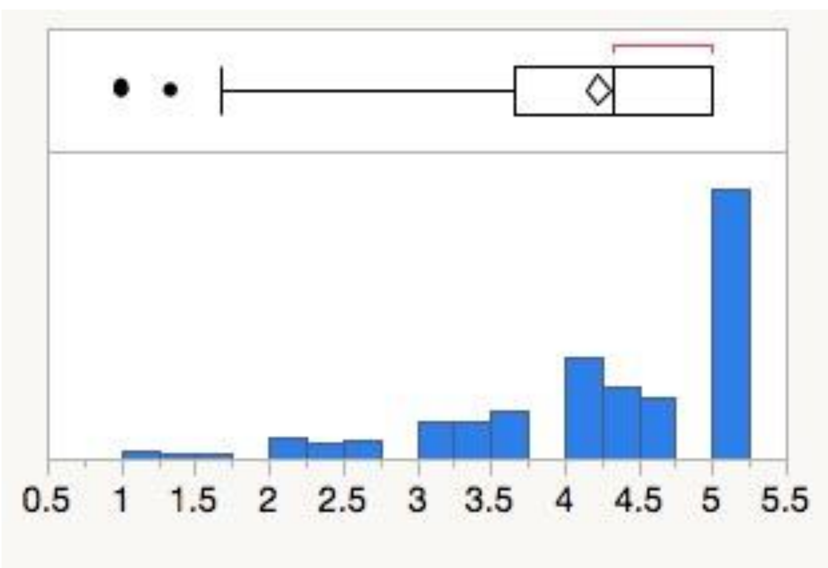
Quantiles

100.0%	maximum	5
99.5%		5
97.5%		5
90.0%		4.3333333333
75.0%	quartile	3.6666666667
50.0%	median	2.6666666667
25.0%	quartile	2
10.0%		1.3333333333
2.5%		1
0.5%		1
0.0%	minimum	1

Summary Statistics

Mean	2.8082137
Std Dev	1.1182278
Std Err Mean	0.0546943
Upper 95% Mean	2.9157246
Lower 95% Mean	2.7007028
N	418
Skewness	0.2439083
Kurtosis	-0.649957

I.3: Cycling and walking



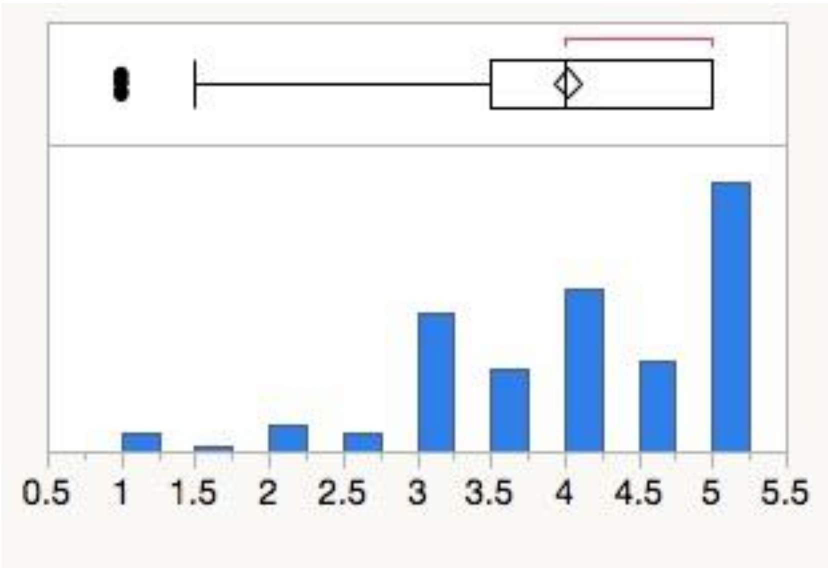
Quantiles

100.0%	maximum	5
99.5%		5
97.5%		5
90.0%		5
75.0%	quartile	5
50.0%	median	4.3333333333
25.0%	quartile	3.6666666667
10.0%		3
2.5%		2
0.5%		1
0.0%	minimum	1

Summary Statistics

Mean	4.2257028
Std Dev	0.8968144
Std Err Mean	0.0440229
Upper 95% Mean	4.3122391
Lower 95% Mean	4.1391666
N	415
Skewness	-1.207821
Kurtosis	0.9647283

I.4: Private car



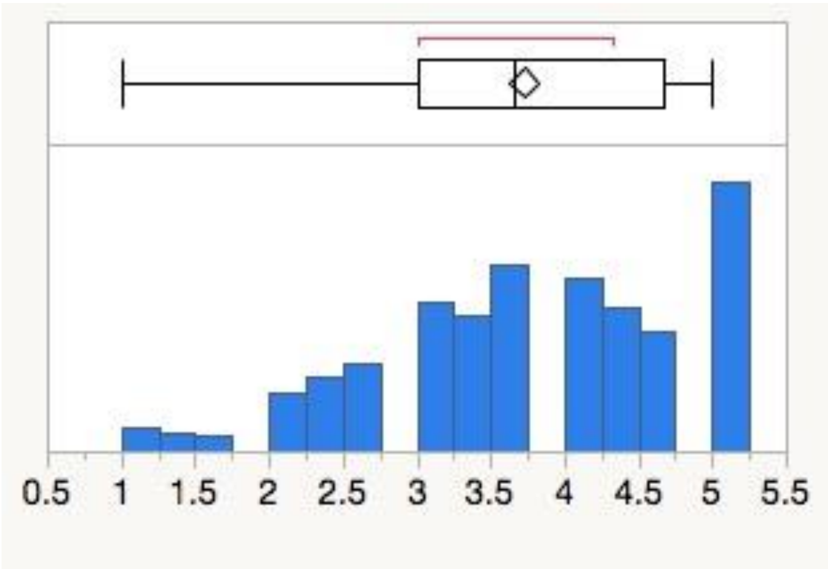
Quantiles

100.0%	maximum	5
99.5%		5
97.5%		5
90.0%		5
75.0%	quartile	5
50.0%	median	4
25.0%	quartile	3.5
10.0%		3
2.5%		2
0.5%		1
0.0%	minimum	1

Summary Statistics

Mean	4.0145631
Std Dev	0.9595374
Std Err Mean	0.047273
Upper 95% Mean	4.1074902
Lower 95% Mean	3.9216361
N	412
Skewness	-0.846945
Kurtosis	0.3489923

I.5: Environmental awareness



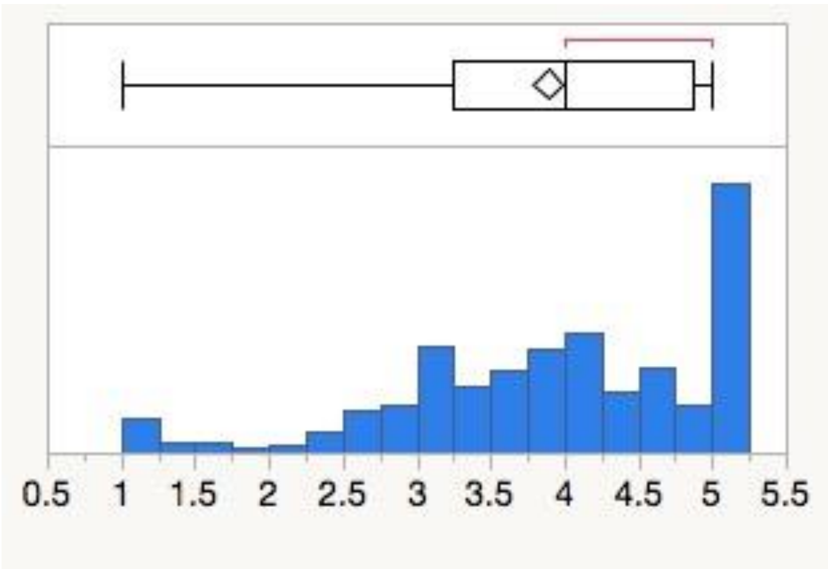
Quantiles

100.0%	maximum	5
99.5%		5
97.5%		5
90.0%		5
75.0%	quartile	4.6666666667
50.0%	median	3.6666666667
25.0%	quartile	3
10.0%		2.3333333333
2.5%		1.3333333333
0.5%		1
0.0%	minimum	1

Summary Statistics

Mean	3.7259615
Std Dev	0.9953488
Std Err Mean	0.048801
Upper 95% Mean	3.8218895
Lower 95% Mean	3.6300336
N	416
Skewness	-0.52466
Kurtosis	-0.354242

I.6: Cycling



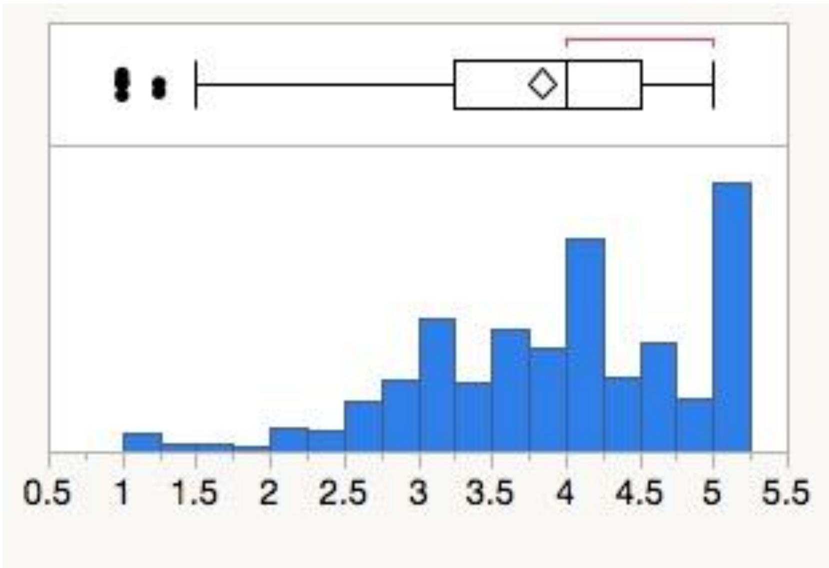
Quantiles

100.0%	maximum	5
99.5%		5
97.5%		5
90.0%		5
75.0%	quartile	4.875
50.0%	median	4
25.0%	quartile	3.25
10.0%		2.625
2.5%		1
0.5%		1
0.0%	minimum	1

Summary Statistics

Mean	3.8892943
Std Dev	1.0003175
Std Err Mean	0.0490446
Upper 95% Mean	3.9857011
Lower 95% Mean	3.7928875
N	416
Skewness	-0.85438
Kurtosis	0.4432172

I.7: Walking



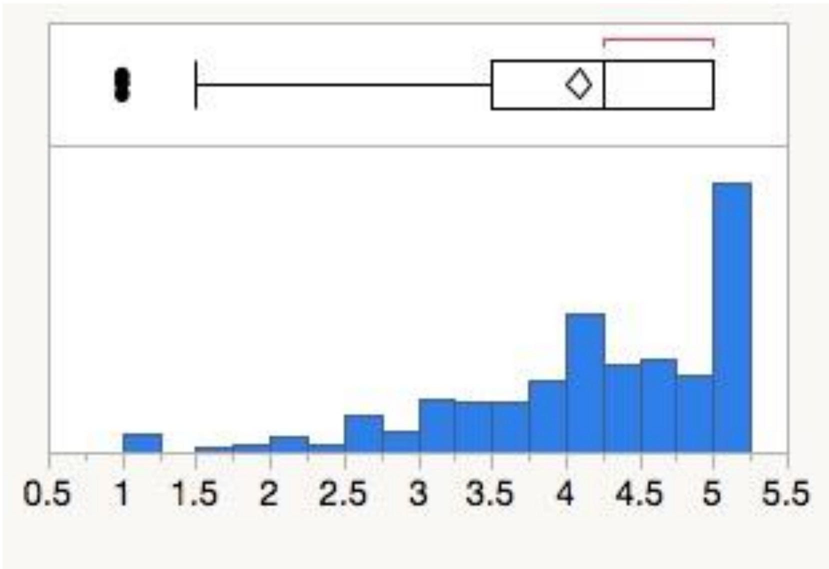
Quantiles

100.0%	maximum	5
99.5%		5
97.5%		5
90.0%		5
75.0%	quartile	4.5
50.0%	median	4
25.0%	quartile	3.25
10.0%		2.75
2.5%		1.86875
0.5%		1
0.0%	minimum	1

Summary Statistics

Mean	3.8393142
Std Dev	0.9170558
Std Err Mean	0.0448547
Upper 95% Mean	3.9274836
Lower 95% Mean	3.7511448
N	418
Skewness	-0.59339
Kurtosis	0.0321552

I.8: Public transport



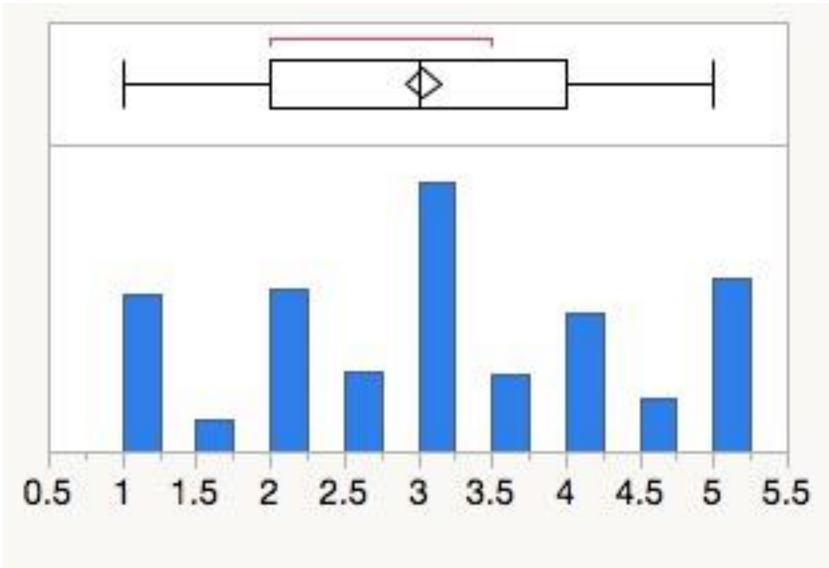
Quantiles

100.0%	maximum	5
99.5%		5
97.5%		5
90.0%		5
75.0%	quartile	5
50.0%	median	4.25
25.0%	quartile	3.5
10.0%		2.9
2.5%		1.85
0.5%		1
0.0%	minimum	1

Summary Statistics

Mean	4.0845382
Std Dev	0.9033389
Std Err Mean	0.0443432
Upper 95% Mean	4.171704
Lower 95% Mean	3.9973723
N	415
Skewness	-1.117142
Kurtosis	1.1169256

I.9: Parking management



Quantiles

100.0%	maximum	5
99.5%		5
97.5%		5
90.0%		5
75.0%	quartile	4
50.0%	median	3
25.0%	quartile	2
10.0%		1
2.5%		1
0.5%		1
0.0%	minimum	1

Summary Statistics

Mean	3.0349398
Std Dev	1.2723778
Std Err Mean	0.0624586
Upper 95% Mean	3.1577152
Lower 95% Mean	2.9121643
N	415
Skewness	-0.005181
Kurtosis	-0.983346

Appendix J: Inferential statistics

J.1: Traffic problem awareness

Non-parametric comparisons for each pair using Wilcoxon method

LEVEL	-LEVEL	SCORE MEAN DIF	STD ERR DIF	Z	P-VALUE	HODGES-LEHMAN N	LOWER CL	UPPER CL
REGION 6	Region 5	18.3429	6.51815	2.81412	0.0049*	0.7500	0.000	1.250
REGION 7	Region 5	9.4333	4.44483	2.12232	0.0338*	0.5000	0.000	1.250
REGION 6	Region 4	7.1633	6.51970	1.09871	0.2719	0.0000	0.000	0.500
REGION 6	Region 3	6.3271	7.01944	0.90136	0.3674	0.0000	0.000	0.250
REGION 6	Region 2	0.9376	6.42900	0.14584	0.8840	0.0000	0.000	0.250
REGION 7	Region 4	-0.5912	5.23373	-0.1130	0.9101	0.0000	0.500	0.250
REGION 4	Region 3	-2.9538	6.53174	-0.4522	0.6511	0.0000	0.250	0.250
REGION 7	Region 2	-3.6899	5.04583	-0.7313	0.4646	0.0000	0.500	0.250
REGION 7	Region 3	-3.8123	6.53005	-0.5838	0.5594	0.0000	0.500	0.250
REGION 3	Region 2	-3.8736	6.46884	-0.5988	0.5493	0.0000	0.250	0.000
REGION 4	Region 2	-4.3412	5.51893	-0.7866	0.4315	0.0000	0.500	0.000
REGION 7	Region 6	-7.0870	6.51972	-1.0870	0.2770	0.0000	0.500	0.000
REGION 2	Region 1	-8.6416	7.34584	-1.1764	0.2394	0.0000	0.250	0.000
REGION 6	Region 1	-10.228	7.56113	-1.3528	0.1761	0.0000	0.250	0.000
REGION 5	Region 2	-11.373	5.04277	-2.2552	0.0241*	-0.7500	1.250	0.000
REGION 5	Region 4	-11.528	5.24173	-2.1992	0.0279*	-0.7500	1.000	0.000
REGION 7	Region 3	-16.239	7.77129	-2.0897	0.0366*	-0.2500	0.500	0.000
REGION 7	Region 3	-16.342	6.54214	-2.4979	0.0125*	-0.7500	1.250	0.000
REGION 4	Region 1	-16.930	7.42446	-2.2803	0.0226*	-0.2500	0.500	0.000
REGION 3	Region 1	-17.530	7.63949	-2.2947	0.0218*	0.0000	0.250	0.000
REGION 5	Region 1	-28.2109	7.77085	-3.6304	0.0003*	-0.7500	1.500	0.250

J.2: Public transport

Multiple Comparisons							
Games-Howell							
Dependent Variable	(I) B4Area	(J) B4Area	Mean Dif (I-J)	Std. Err	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
D Public transport	Winterveld	Region 2	-.7536*	.2151	.0130	-1.405	-.1023
		Region 3	-.4327	.1707	.1541	-.9426	.0771
		Region 4	.4618	.1675	.0936	-.0407	.9643
		Region 5	-.4226	.1525	.0929	-.8825	.0372
		Region 6	.0326	.1602	1.000	-.4453	.5106
		Region 7	.1663	.2194	.9878	-.5080	.8405
	Hammanskraal	Region 1	.7536*	.2151	.0130	.1023	1.4048
		Region 3	.3208	.2281	.7970	-.3675	1.0091
		Region 4	1.2154*	.2257	.0000	.5329	1.8978
		Region 5	.3309	.2148	.7197	-.3217	.9836
		Region 6	.7862*	.2203	.0105	.1199	1.4525
		Region 7	.9198*	.2665	.0158	.1107	1.7289
	Atteridgeville to CBD	Region 1	.4327	.1707	.1541	-.0771	.9426
		Region 2	-.3208	.2281	.7970	-1.0091	.3675
		Region 4	.8945*	.184	.0001	.3430	1.4461
		Region 5	.0101	.170	1.000	-.5030	.5232
		Region 6	.4654	.177	.1260	-.0646	.9953
		Region 7	.5990	.232	.1512	-.1100	1.3080
	Centurion to R21	Region 1	-.4618	.1675	.0936	-.9643	.0407
		Region 2	-1.2154*	.2257	.0000	-1.8978	-.5329
		Region 3	-.8945*	.184	.0001	-1.446	-.3430
		Region 5	-.8844*	.167	.0000	-1.3905	-.3784
		Region 6	-.4292	.174	.1826	-.9520	.0937
		Region 7	-.2956	.230	.8553	-.9991	.4080
	Roodeplaat dam to Cullinan	Region 1	.4226	.153	.0929	-.0372	.8825
		Region 2	-.3309	.215	.7197	-.9836	.3217
		Region 3	-.0101	.170	1.000	-.5232	.5030
		Region 4	.8844*	.1672	.0000	.3784	1.3905
		Region 6	.4553	.1599	.0770	-.0268	.9373
		Region 7	.5889	.2191	.1248	-.0868	1.2646
	Mamelodi to	Region 1	-.0326	.160	1.000	-.5106	.4453

	South-East border	Region 2	-.7862*	.220	.0105	-1.453	-.1199
		Region 3	-.4654	.177	.1260	-.9953	.0646
		Region 4	.4292	.1742	.1826	-.0937	.9520
		Region 5	-.4553	.1599	.0770	-.9373	.0268
		Region 7	.1336	.2246	.9967	-.5547	.8219
	Bronkhorstspruit to Eastern border	Region 1	-.1663	.2194	.9878	-.8405	.5080
		Region 2	-.9198*	.2665	.0158	-1.7289	-.1107
		Region 3	-.5990	.2322	.1512	-1.3080	.1100
		Region 4	.2956	.2298	.8553	-.4080	.9991
		Region 5	-.5889	.2191	.1248	-1.2646	.0868
		Region 6	-.1336	.2246	.9967	-.8219	.5547

J.3: Cycling

Non-parametric comparisons for each pair using Wilcoxon method

LEVEL	-LEVEL	SCORE MEAN DIF	STD ERR DIF	Z	P-VALUE	HODGES-LEHMANN	LOWER CL	UPPER CL
REGION 6	Region 5	40.4706	6.405989	6.31762	<.0001*	1.33333	1.000	1.667
REGION 6	Region 2	16.5761	6.278128	2.64029	0.0083*	0.33333	0.000	0.667
REGION 7	Region 5	16.2667	4.471820	3.63759	0.0003*	1.00000	0.667	1.667
REGION 6	Region 1	16.1576	7.500223	2.15429	0.0312*	0.00000	0.000	0.333
REGION 3	Region 2	13.0340	6.330292	2.05899	0.0395*	0.33333	0.000	0.667
REGION 6	Region 4	7.9719	6.237633	1.27804	0.2012	0.00000	0.000	0.333
REGION 4	Region 2	7.8394	5.515517	1.42133	0.1552	0.00000	0.000	0.667
REGION 3	Region 1	6.7286	7.539173	0.89249	0.3721	0.00000	0.000	0.000
REGION 6	Region 3	5.8158	6.606898	0.88026	0.3787	0.00000	0.000	0.000
REGION 4	Region 1	4.4482	7.485047	0.59428	0.5523	0.00000	0.000	0.333
REGION 7	Region 2	1.4870	5.071085	0.29322	0.7694	0.00000	0.333	0.333
REGION 4	Region 3	-3.2727	6.298139	-0.5196	0.6033	0.00000	0.333	0.333
REGION 7	Region 4	-4.9442	5.152003	-0.9597	0.3372	0.00000	0.667	0.000
REGION 7	Region 1	-6.0818	7.884029	-0.7714	0.4405	0.00000	0.333	0.000
REGION 2	Region 1	-8.6416	7.551394	-1.1444	0.2525	0.00000	0.667	0.000
REGION 7	Region 3	-9.6237	6.278969	-1.5327	0.1254	0.00000	0.667	0.000
REGION 7	Region 6	-12.227	6.209085	-1.9692	0.0489*	0.00000	1.333	0.000
REGION 5	Region 2	-19.90	5.142334	-3.8715	0.0001*	-1.0000	1.667	0.667
REGION 5	Region 4	-28.537	5.260161	-5.4251	<.0001*	-1.3333	1.667	1.000
REGION 5	Region 3	-39.029	6.442535	-6.0581	<.0001*	-1.3333	1.333	1.000
REGION 5	Region 1	-47.182	7.982	-5.9113	<.0001*	-1.333	1.333	1.000

J.4: Private car

Non-parametric comparisons for each pair using Wilcoxon method

LEVEL	-LEVEL	SCORE MEAN DIF	STD ERR DIF	Z	P-VALUE	HODGES-LEHMANN	LOWER CL	UPPER CL
REGION 1	Region 5	23.240	6.42263	3.61845	0.0003*	0.500	0.500	1.000
REGION 4	Region 3	18.119	6.44155	2.81286	0.0049*	0.500	0.000	1.000
REGION 6	Region 3	14.467	6.92291	2.08968	0.0366*	0.500	0.000	0.500
REGION 7	Region 5	11.936	4.38740	2.72044	0.0065*	0.500	0.000	1.000
REGION 4	Region 1	11.247	7.50222	1.49916	0.1338	0.000	0.000	0.500
REGION 7	Region 3	7.603	6.46194	1.17654	0.2394	0.000	0.000	0.500
REGION 2	Region 1	5.114	7.52480	0.67955	0.4968	0.000	0.000	0.500
REGION 6	Region 1	5.092	7.65778	0.66487	0.5061	0.000	0.000	0.000
REGION 4	Region 2	2.803	5.38427	0.52055	0.6027	0.000	0.000	0.500
REGION 7	Region 1	0.614	7.97143	0.07697	0.9386	0.000	0.500	0.500
REGION 6	Region 2	-0.561	6.29888	-0.08909	0.9290	0.000	0.000	0.000
REGION 7	Region 6	-2.271	6.36478	-0.35685	0.7212	0.000	0.500	0.000
REGION 7	Region 2	-2.333	4.95725	-0.47067	0.6379	0.000	0.500	0.000
REGION 7	Region 4	-5.297	5.09120	-1.04042	0.2981	0.000	0.500	0.000
REGION 6	Region 4	-5.669	6.33229	-0.89518	0.3707	0.000	0.500	0.000
REGION 3	Region 2	-10.609	6.40863	-1.65549	0.0978	0.000	0.500	0.000
REGION 3	Region 1	-11.623	7.73157	-1.50332	0.1328	0.000	0.500	0.000
REGION 5	Region 2	-12.970	5.04419	-2.57119	0.0101*	-1.000	1.500	0.000
REGION 5	Region 3	-13.417	6.45347	-2.07898	0.0376*	-0.5000	1.000	0.000
REGION 5	Region 4	-21.765	5.19469	-4.18992	<.0001*	-1.000	1.500	0.500
REGION 5	Region 1	-24.967	8.00446	3.1191	0.0018	5.000	1.000	0.000

J.5.1: Environmental awareness

Non-parametric comparison for each pair using Wilcoxon

LEVEL	-LEVEL	SCORE MEAN DIF	STD ERR DIF	Z	P-VALUE	HODGES-LEHMANN	LOWER CL	UPPER CL
REGION 3	Region 1	26.1155	7.86918	3.31871	0.0009*	0.66667	0.000	0.667
REGION 6	Region 5	19.6193	6.57817	2.98249	0.0029*	0.66667	0.333	1.000
REGION 3	Region 2	15.6688	6.52185	2.40250	0.0163*	0.33333	0.000	0.667
REGION 6	Region 1	12.6246	7.87975	1.60215	0.1091	0.33333	0.000	0.667
REGION 4	Region 1	7.0723	7.73819	0.91395	0.3607	0.00000	0.333	0.667
REGION 6	Region 2	5.8976	6.53379	0.90263	0.3667	0.00000	0.000	0.667
REGION 6	Region 4	4.3603	6.59524	0.66112	0.5085	0.00000	0.333	0.333
REGION 2	Region 1	3.5748	7.75521	0.46095	0.6448	0.00000	0.333	0.333
REGION 4	Region 2	2.8591	5.65245	0.50582	0.6130	0.00000	0.333	0.667
REGION 7	Region 5	1.0667	4.46752	0.23876	0.8113	0.00000	0.333	0.333
REGION 7	Region 2	-8.9493	5.14462	-1.7395	0.0819	-0.3333	1.000	0.000
REGION 5	Region 2	-9.7754	5.14572	-1.8997	0.0575	-0.3333	1.000	0.000
REGION 6	Region 3	-10.303	7.04170	-1.4630	0.1434	0.00000	0.333	0.000
REGION 7	Region 1	-13.999	8.14576	-1.7185	0.0857	-0.3333	0.333	0.000
REGION 7	Region 4	-14.080	5.32628	-2.6435	0.0082*	-0.6667	0.333	0.000
REGION 4	Region 3	-14.623	6.56179	-2.2285	0.0259*	-0.3333	0.667	0.000
REGION 5	Region 1	-14.810	8.15019	-1.8171	0.0692	-0.3333	1.000	0.333
REGION 5	Region 4	-15.653	5.32362	-2.9404	0.0033*	-0.6667	0.667	0.000

REGION 7	Region 6	-18.387	6.57576	-2.7962	0.0052*	-0.6667	1.000	0.000
REGION 7	Region 3	-29.359	6.55781	-4.4770	<.0001*	-1.0000	1.000	0.333
REGION 7	Region 3	-31.428	6.56086	-4.7902	<.0001*	-1.0000	1.000	0.333

J.5.2: Environmental awareness

Multiple Comparisons							
Games-Howell							
Dependent Variable	(I) B4Area	(J) B4Area	Mean Diff (I-J)	Std. Err	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Environmental awareness	Winterveld	Region 2	-.0763	.1854	.9996	-.6360	.4835
		Region 3	-.5326*	.1330	.0017	-.9291	-.1361
		Region 4	-.1912	.1563	.8838	-.6600	.2777
		Region 5	.3788	.1862	.4055	-.1906	.9482
		Region 6	-.2212	.1619	.8190	-.7049	.2625
		Region 7	.3677	.1993	.5252	-.2439	.9793
	Hammanskraal	Region 1	.0763	.1854	.9996	-.4835	.6360
		Region 3	-.4563	.1769	.1475	-.9927	.0801
		Region 4	-.1149	.1950	.9970	-.7038	.4739
		Region 5	.4551	.2197	.3811	-.2119	1.122
		Region 6	-.1449	.1996	.9907	-.7457	.4558
		Region 7	.4440	.2310	.4732	-.2581	1.146
	Atteridgeville to CBD	Region 1	.5326*	.1330	.0017	.1361	.9291
		Region 2	.4563	.1769	.1475	-.0801	.9927
		Region 4	.3414	.1461	.2379	-.0987	.7815
		Region 5	.9114*	.1778	.0001	.3641	1.459
		Region 6	.3114	.1522	.3908	-.1442	.7670
		Region 7	.9003*	.1915	.0005	.3090	1.492
	Centurion to R21	Region 1	.1912	.1563	.8838	-.2777	.6600
		Region 2	.1149	.1950	.9970	-.4739	.7038
		Region 3	-.3414	.1461	.2379	-.7815	.0987
		Region 5	.5700	.1958	.0709	-.0273	1.167
		Region 6	-.0300	.1729	1.000	-.5485	.4885
		Region 7	.5589	.2083	.1219	-.0783	1.196
	Roodeplaat dam	Region 1	-.3788	.1862	.4055	-.9482	.1906

	to Cullinan	Region 2	-.4551	.2197	.3811	-1.122	.2119
		Region 3	-.9114*	.1778	.0001	-1.459	-.3641
		Region 4	-.5700	.1958	.0709	-1.167	.0273
		Region 6	-.6000	.2004	.0560	-1.209	.0088
		Region 7	-.0111	.2316	1.000	-.7188	.6966
	Mamelodi to South-East border	Region 1	.2212	.1619	.8190	-.2625	.7049
		Region 2	.1449	.1996	.9907	-.4558	.7457
		Region 3	-.3114	.1522	.3908	-.7670	.1442
		Region 4	.0300	.1729	1.000	-.4885	.5485
		Region 5	.6000	.2004	.0560	-.0088	1.209
		Region 7	.5889	.2126	.0985	-.0591	1.237
	Bronkhorstspruit to Eastern border	Region 1	-.3677	.1993	.5252	-.9793	.2439
		Region 2	-.4440	.2310	.4732	-1.146	.2581
		Region 3	-.9003*	.1915	.0005	-1.492	-.3090
		Region 4	-.5589	.2083	.1219	-1.196	.0783
		Region 5	.0111	.2316	1.000	-.6966	.7188
		Region 6	-.5889	.2126	.0985	-1.237	.0591

*. The mean difference is significant at the 0.05 level.

J.6: Cycling

Non-parametric comparisons for each pair using Wilcoxon method

LEVEL	-LEVEL	SCORE MEAN DIF	STD ERR DIF	Z	P-VALUE	HODGES-LEHMANN	LOWER CL	UPPER CL
REGION 7	Region 5	10.033	4.47460	2.24229	0.0249*	0.62500	0.000	1.250
REGION 7	Region 6	9.4377	6.57470	1.43546	0.1512	0.25000	0.000	0.750
REGION 6	Region 5	8.6241	6.59737	1.30721	0.1911	0.25000	0.125	0.750
REGION 7	Region 4	8.4533	5.34299	1.58214	0.1136	0.25000	0.000	0.750
REGION 3	Region 2	6.3338	6.57433	0.96342	0.3353	0.12500	0.125	0.500
REGION 7	Region 2	4.6812	5.13851	0.91100	0.3623	0.12500	0.250	0.625
REGION 7	Region 3	3.3939	6.58425	0.51545	0.6062	0.00000	0.250	0.500
REGION 6	Region 4	0.4311	6.623625	0.06508	0.9481	0.00000	0.375	0.375
REGION 4	Region 2	-3.068	5.67292	-0.5408	0.5887	-0.1250	0.500	0.250
REGION 6	Region 2	-4.5366	6.56671	-0.6909	0.4897	0.00000	0.500	0.250
REGION 5	Region 4	-8.5600	5.35208	-1.5994	0.1097	-0.3750	0.750	0.125
REGION 7	Region 1	-8.7279	7.93330	-1.1002	0.2713	0.00000	0.500	0.000
REGION 6	Region 3	-10.040	7.10412	-1.4132	0.1576	-0.2500	0.625	0.000
REGION 4	Region 3	-10.942	6.62746	-1.6510	0.0987	-0.2500	0.625	0.000
REGION 5	Region 2	-11.097	5.15268	-2.1537	0.0313*	-0.3750	0.875	0.000
REGION 3	Region 1	-19.050	7.80192	-2.4416	0.0146*	-0.2500	0.500	0.000
REGION 2	Region 1	-19.413	7.63067	-2.5440	0.0110*	-0.3750	0.7500	0.000
REGION 5	Region 3	-20.015	6.60249	-3.0314	0.0024*	-0.6250	1.000	0.250
REGION 6	Region 1	-25.553	7.78270	-3.2833	0.0010*	-0.3750	0.875	0.000
REGION 4	Region 1	-26.998	7.64775	-3.5302	0.0004*	-0.5000	1.000	0.125
REGION 5	Region 1	-30.473	7.99860	-3.8098	0.0001*	-1.0000	1.375	0.500

J.7: Walking

Non-parametric comparisons for each pair using Wilcoxon method

LEVEL	-LEVEL	SCORE MEAN DIF	STD ERR DIF	Z	P-VALUE	HODGES-LEHMANN	LOWER CL	UPPER CL
REGION 6	Region 5	21.2379	6.63952	3.1987	0.0014*	0.50000	0.250	1.000
REGION 2	Region 1	13.8483	7.68418	1.8022	0.0715	0.25000	0.000	0.750
REGION 7	Region 5	10.3667	4.48475	2.3115	0.0208*	0.50000	0.000	1.000
REGION 3	Region 1	9.7818	7.88466	1.2406	0.2148	0.00000	0.000	0.500
REGION 4	Region 1	7.8940	7.71039	1.0238	0.3059	0.00000	0.000	0.500
REGION 4	Region 3	-0.1979	6.62802	-0.0299	0.9762	0.00000	0.250	0.250
REGION 7	Region 6	-2.7561	6.63856	-0.4152	0.6780	0.00000	0.500	0.250
REGION 6	Region 1	-3.9864	7.89235	-0.5051	0.6135	0.00000	0.250	0.250
REGION 7	Region 1	-5.8044	8.12167	-0.7147	0.4748	0.00000	0.500	0.250
REGION 4	Region 2	-6.7200	5.59601	-1.2009	0.2298	-0.2500	0.500	0.000
REGION 3	Region 2	-7.0841	6.53732	-1.0837	0.2785	0.00000	0.500	0.000
REGION 7	Region 4	-8.7467	5.32460	-1.6427	0.1004	-0.2500	0.750	0.000
REGION 6	Region 4	-10.012	6.63143	-1.5097	0.1311	-0.2500	0.500	0.000
REGION 7	Region 2	-10.326	5.08850	-2.0293	0.0424*	-0.5000	1.000	0.000
REGION 7	Region 3	-11.279	6.62783	-1.7018	0.0888	-0.2500	0.750	0.000
REGION 6	Region 3	-12.195	7.14174	-1.7075	0.0877	-0.2500	0.500	0.000
REGION 6	Region 2	-14.880	6.57076	-2.2646	0.0235*	-0.5000	0.750	0.000
REGION 5	Region 2	-19.936	5.10665	-3.9040	<.0001*	-1.0000	1.500	0.500
REGION 5	Region 4	-22.347	5.32847	-4.1938	<.0001*	-1.0000	1.250	0.500
REGION 5	Region 1	-27.507	8.13242	-3.3824	0.0007*	-0.7500	1.000	0.250
REGION 5	Region 3	-29.112	6.64011	-4.3843	<.0001*	-1.0000	1.250	0.500

J.8.1 E Public transport

Multiple Comparisons							
Games-Howell							
Dependent Variable	(I) B4Area	(J) B4Area	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
E Public transport	Winterveld	Region 2	.1527	.1738	.9749	-.3705	.6760
		Region 3	-.0109	.1468	1.000	-.4488	.4270
		Region 4	.1851	.1695	.9292	-.3245	.6947
		Region 5	.5966*	.1627	.0080	.1033	1.0898
		Region 6	.0067	.1266	1.000	-.3710	.3845
		Region 7	.1966	.1810	.9298	-.3551	.7483
	Hammanskraal	Region 1	-.1527	.1738	.9749	-.6760	.3705
		Region 3	-.1636	.1729	.9638	-.6850	.3578
		Region 4	.0324	.1926	1.000	-.5482	.6130
		Region 5	.4438	.1867	.2229	-.1221	1.0098
		Region 6	-.1460	.1562	.9655	-.6203	.3283
		Region 7	.0438	.2027	1.000	-.5721	.6597
	Atteridgeville to CBD	Region 1	.0109	.1468	1.000	-.4270	.4488
		Region 2	.1636	.1729	.9638	-.3578	.6850
		Region 4	.1960	.1687	.9065	-.3117	.7037
		Region 5	.6075*	.1619	.0063	.1160	1.0989
		Region 6	.0176	.1255	1.000	-.3580	.3933
		Region 7	.2075	.1802	.9090	-.3426	.7575
	Centurion to R21	Region 1	-.1851	.1695	.9292	-.6947	.3245
		Region 2	-.0324	.1926	1.000	-.6130	.5482
		Region 3	-.1960	.1687	.9065	-.7037	.3117
		Region 5	.4115	.1827	.2813	-.1423	.9653
		Region 6	-.1784	.1514	.9002	-.6373	.2806
		Region 7	.0115	.1991	1.000	-.5935	.6165
	Roodeplaat dam to Cullinan	Region 1	-.5966*	.1627	.0080	-1.090	-.1033
		Region 2	-.4438	.1867	.2229	-1.010	.1221
		Region 3	-.6075*	.1619	.0063	-1.099	-.1160
		Region 4	-.4115	.1827	.2813	-.9653	.1423
		Region 6	-.5898*	.1438	.0028	-1.032	-.1478
		Region 7	-.4000	.1934	.3851	-.9912	.1912
	Mamelodi to	Region 1	-.0067	.1266	1.000	-.3845	.3710

	South-East border	Region 2	.1460	.1562	.9655	-.3283	.6203
		Region 3	-.0176	.1255	1.000	-.3933	.3580
		Region 4	.1784	.1514	.9002	-.2806	.6373
		Region 5	.5898*	.1438	.0028	.1478	1.0318
		Region 7	.1898	.1641	.9063	-.3176	.6972
	Bronkhorstspruit to Eastern border	Region 1	-.1966	.1810	.9298	-.7483	.3551
		Region 2	-.0438	.2027	1.000	-.6597	.5721
		Region 3	-.2075	.1802	.9090	-.7575	.3426
		Region 4	-.0115	.1991	1.000	-.6165	.5935
		Region 5	.4000	.1934	.3851	-.1912	.9912
		Region 6	-.1898	.1641	.9063	-.6972	.3176

*. The mean difference is significant at the 0.05 level.

J.8.2 Public transport

Non-parametric comparisons for each pair using Wilcoxon method

LEVEL	-LEVEL	SCORE MEAN DIF	STD ERR DIF	Z	P-VALUE	HODGES-LEHMANN	LOWER CL	UPPER CL
REGION 6	Region 5	24.8740	6.61578	3.75980	0.0002*	0.50000	0.250	1.000
REGION 7	Region 5	9.7333	4.47750	2.17383	0.0297*	0.50000	0.000	0.750
REGION 3	Region 2	5.3218	6.48734	0.82034	0.4120	0.00000	0.000	0.500
REGION 6	Region 4	3.0777	6.60246	0.46614	0.6411	0.00000	0.250	0.250
REGION 6	Region 2	2.7955	6.54384	0.42719	0.6692	0.00000	0.250	0.250
REGION 7	Region 4	-1.5708	5.23496	-0.3001	0.7641	0.0000	0.500	0.250
REGION 4	Region 2	-1.7880	5.56911	-0.3211	0.7482	0.00000	0.500	0.250
REGION 7	Region 2	-1.8725	5.11014	-0.3664	0.7141	0.00000	0.500	0.250
REGION 7	Region 6	-6.2069	6.60405	-0.9399	0.3473	0.00000	0.500	0.250
REGION 3	Region 1	-6.3348	7.74274	-0.8182	0.4133	0.00000	0.250	0.000
REGION 6	Region 3	-7.1245	7.06742	-1.0081	0.3134	0.00000	0.250	0.000
REGION 4	Region 3	-9.6025	6.55168	-1.4657	0.1427	-0.2500	0.500	0.000
REGION 7	Region 3	-9.7399	6.54791	-1.4875	0.1369	-0.2500	0.750	0.000
REGION 2	Region 1	-10.771	7.58303	-1.4204	0.1555	0.00000	0.500	0.000
REGION 5	Region 2	-12.088	5.12230	-2.3600	0.0183*	-0.5000	1.000	0.000
REGION 6	Region 1	-13.679	7.78562	-1.7569	0.0789	-0.1667	0.500	0.000
REGION 5	Region 4	-14.110	5.24208	-2.6918	0.0071*	-0.5000	1.000	0.250
REGION 7	Region 1	-16.560	8.00327	-2.0691	0.0385*	-0.2500	0.750	0.000
REGION 4	Region 1	-17.006	7.64477	-2.224	0.0261*	-0.2500	0.500	0.000
REGION 5	Region 3	-25.105	6.56567	-3.8237	0.0001*	-0.7500	1.000	0.500
REGION 5	Region 1	-32.714	8.03802	-4.0699	<.0001*	-0.7500	1.000	0.500