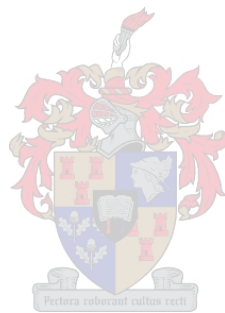


**A MOBILITY STUDY TO DETERMINE THE POTENTIAL FOR NON
MOTORISED TRANSPORT AS PART OF STELLENBOSCH
UNIVERSITY FUTURE URBAN CAMPUS PLAN.**

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Research assignment presented in partial fulfilment of the requirements for
the degree Master in Urban Regional Planning
at the Stellenbosch University.

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April 2019

DECLARATION

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Date: 30 October 2018.

SUMMARY

Traffic congestion is a problem in Stellenbosch and continue to grow per year. One of the reasons is that the university is located in the town of Stellenbosch and students make use of private vehicles. Universities have experienced an increase in student numbers. As the numbers of students increase, so does the automobile numbers, which brings urban issues such as traffic congestion and the shortage of parking. To address the issue of congestion during peak hours, pedestrian and cycling infrastructure can be implemented. This will reduce the number of private vehicles. Automobile dependency is a reality of the twenty-first century and can be addressed by providing people with sustainable transportation options and automobile-free lifestyle options.

The research study proposes that many students live close to campus and do not have to make use of automobiles if proper alternative infrastructure is implemented. A solution would be to adjust the infrastructure to create a more pedestrian and cycle friendly environment where people feel safe to walk and do not have to make use of automobiles. Improvement of the infrastructure will encourage cycling and walking to and on campus and to the different faculties. Another solution would be to develop parking areas on the outskirts of the university and students can travel by shuttles or walk from the parking areas to the campus.

The primary aim of this study is to analyse the mobility of students and staff at Stellenbosch University and to provide alternative sustainable solutions to the conventional mobility modes. To achieve this research aim the following objectives are compiled: Identify and analyse the mobility pattern of students on and around campus. Identify where students travelling by private car, park on campus. Identify the academic buildings that are most visited during the day. Identify where the majority of students live on campus. Based on these mobility patterns, identify potential pedestrian and other non-motorised transport routes.

The research methodology is divided into four phases namely: introduction, data gathering, interpretation and analysing, conclusion and summary of the report. Relevant literature about NMT, cycling and pedestrianisation were studied throughout the research process. The literature will consist of NMT that would consider pedestrian routes and cycling lanes, infrastructure guidelines, location and examples. A meeting was scheduled with Prof Krygsman from the logistics department of SU (coordinator of SUMS), who provided the secondary data about SU staff and students mobility patterns and travel behaviour. The data was obtained through on-line questionnaires and trip dairies that participants filled in for two

consecutive days. The electronic questionnaires focused on students and staff members travel behaviours. It consists of separate questionnaires completed by staff members and students. The data was collected during the second semester of September and October. The target group consists of Stellenbosch University students and staff members. It was the participant's choice to participate volunteering in the survey and they will stay anonymous. The secondary data is in the form of text and numeric values. Therefore, a qualitative and quantitative research strategy was made use of. The data and findings were represented visually in graphs and tables that were created in Microsoft Excel and Microsoft Word. Maps that illustrate the data were created in ArcMap through the spatial statistics tool (Hot spot analysis).

The main findings of this research study comprises of only a small percentage (37%) of the Stellenbosch University staff travel 10 kilometres or less to campus. The majority (92%) of the staff members travel within 40 kilometres to work. Of the total 37% of staff that live within 10 kilometres of campus, only 32% of them utilise private vehicles. While the majority (77%) of SU staff members make use of private vehicles. Of the total records 60% of the students, live within a radius of 1.2 kilometres from Stellenbosch University campus. A further, 15% of the students live within 2.5 kilometre from the campus. Further 45% of the 63% of the students that travel up to 5 kilometres to campus, utilise private vehicles. In addition, students make use of lift clubs (21%) and 6% of the sample make use of ride sharing. Furthermore, more than half of the students live within 1.2 kilometre of campus and thus should be encouraged to make use of NMT that would help contribute the reduction of private vehicles by half.

Parking space is limited on campus and to address this issue, parking bays has to be developed on the periphery of campus with shuttle services from the parking bays to the centre of campus. This will help contribute to the utilisation of the parking areas on the periphery. These outcome links with this research study hypothesis that, the major problem is that there is limited land and space available to develop new car parking lots and it is expensive to build parking structures. A solution would be to develop parking areas on the outskirts of the university and students travel by busses from the parking areas to the campus, which would reduce the traffic flow around campus. The study found that the three major factors that will decrease the utilisation number of private vehicles to campus are: implementation of alternative transport options. Secondly, the increase of parking bay fee at SU. Thirdly, the reduction in parking space will lead to the reduction in utilisation of private vehicles.

OPSOMMING

Vervoer en die opeenhoping van voertuie is 'n probleem veral in Stellenbosch dorp en hou aan met groei elke jaar. Die rede hiervoor is, omdat Stellenbosch is 'n universiteit dorp en studente maak gebruik van private voertuie as vervoer middel. Plus die universiteit se student getalle neem ook toe elke jaar. Met die toename in universiteit studente getalle, neem die gebruik van voertuie ook toe, wat stedelike kwessies soos vervoer opeenhoping en tekort aan parkering veroorsaak. Infrastruktuur vir stap en fiets gebruik kan geïmplementeer word om die bogenoemde stedelike kwessies aan te spreek en die getalle private voertuie te verminder. Individue is afhanklik van voertuie, dit is 'n realiteit van die een en twintigste eeu en kan aangespreek word deur alternatiewe volhoubare vervoer opsies en leefstyl opsies te verskaf aan inwoners.

Die navorsingstudie ondersoek hoe om studente wat naby aan die universiteit woon se gebruik van private vervoer te verminder deur alternatiewe stap roetes na die kampus toe te implementeer. 'n Oplossing is dus om die infrastruktuur aan te pas om voetgangers en fietsryers te akkommodeer. Dit is belangrik om 'n omgewing te skep wat stap vriendelik is sodat studente veilig voel om te stap in plaas van om van private vervoer metodes gebruik te maak kampus toe. Die fiets en stap infrastruktuur na die verskillende fakulteite moet opgegradeer word om die studente te motiveer om te stap op en na kampus. Nog 'n oplossing behels dat parkeer areas op die buite kringe van die universiteit ontwikkel word en studente die opsie gegun word om te stap of van 'n minibus gebruik kan maak om van die parkeer area tot by die universiteit te pendel.

Die hoof doel van die navorsingstudie behels om die mobiliteit van studente en personeel by Stellenbosch Universiteit te analiseer en om alternatiewe volhoubare oplossings vir die huidige gebruik van mobiliteit metodes te verskaf. Om die navorsingstudie doel te bereik is die volgende mikpunte ontwikkel: Identifiseer en analiseer die mobiliteits patrone van studente op en om kampus. Identifiseer waar die studente wat van voertuie gebruik maak, parkeer op kampus. Identifiseer die akademiese geboue wat die meeste besoek word deur die dag. Identifiseer waar die meerderheid van die studente op en om kampus woon. Gebaseer op die mobiliteit patrone, identifiseer potensiale stap en fiets roetes.

Die navorsing metodologie vir die studie is verdeel in vier fases naamlik: Inleiding, data versameling, interpretasie en analisering en samevatting en afhandeling. Relevante literatuur oor fietsry en voetganger roetes is reg deur die navorsing proses bestudeer. 'n Vergadering was

geskeduleer met Prof Krygsman van die logistieke departement van Stellenbosch Universiteit (koördineerder van Universiteit Stellenbosch Mobiliteit studie), wie die sekondêre data oor Stellenbosch Universiteit se personeel en studente se mobiliteit patrone en vervoer gedrag verskaf het. Die data was ingesamel deur middel van aan lyn vraelyste. Die vraelyste fokus op studente en personeel lede se mobiliteit patrone en vervoer gedrag. Die data was ingesamel tydens die tweede semester in September en Oktober. Die teiken groep was studente en personeel van Stellenbosch Universiteit. Dit is die deelnemers se keuse om vrywillig deel te neem in die opname asook dat hulle anoniem sal bly. Daar was van 'n kwalitatiewe en kwantitatiewe navorsing strategie gebruik gemaak. Tabelle was in Microsoft Word ontwerp en grafieke was in Microsoft Excel geskep om 'n visuele oorsig te verkry van die versamelde data en bevindings. Kaarte wat die data voorstel is in die program ArcMap geskep deur gebruik te maak van 'n Hot spot analise.

Die hoof bevindinge van hierdie navorsingstudie bestaan uit, 'n klein persentasie (37%) van Stellenbosch Universiteit se personeel reis 10 kilometer of minder na die kampus. Terwyl die meerderheid (92%) van die personeellede binne 40 kilometer reis na die werk. Van die 37% van die personeel wat binne 10 kilometer van die kampus woon, gebruik slegs 32% van hulle privaat voertuie. Terwyl die meerderheid (77%) van die Stellenbosch Universiteit personeellede van private voertuie gebruik maak. Van die totale steekproef bly 60% van die studente binne 'n radius van 1,2 kilometer van die kampus. Verder, woon 15% van die studente binne 2,5 kilometer van die kampus. Daar is bevind dat 45% van die 63% van die studente wat tot met en met 5 kilometer reis tot by kampus, maak gebruik van privaat voertuie. Daarbenewens maak 21% van die studente gebruik van saamryklub. Verder woon meer as die helfte van die studente binne 1,2 kilometer van die kampus en behoort aangemoedig te word om nie-gemotoriseerde vervoer te gebruik wat die gebruik van privaat voertuie met die helfte sal verminder.

Parkeer ruimtes is beperk op kampus en om hierdie kwessie aan te spreek, moet parkeer areas op die periferie van die kampus ontwikkel word. Vervoer van mense met pendel dienste vanaf die parkeer areas na die middelpunte van die kampus sal bydra tot verhoogte benutting van die parkeerareas aan die periferie. Die bevindings hou verband met die navorsingstudie se hipotese, dat die grootste probleem is dat daar beperkte grond beskikbaar is om nuwe parkeer terreine te ontwikkel en dit is te duur om parkeer strukture te ontwikkel. 'n Oplossing sou wees om parkeer areas op die periferie van die universiteit te ontwikkel en studente met busse vanaf die parkeer

areas na die kampus te vervoer, wat die verkeersvloei rondom die kampus sal verminder. Die studie het bevind dat die drie belangrikste faktore wat die gebruik van private voertuie na die kampus sal verminder is: eerstens, deur alternatiewe vervoer opsies te implementeer. Tweedens, 'n toename in parkeer geld by die universiteit. Derdens, sal die vermindering in parkeer ruimtes sal lei tot die vermindering in die gebruik van private voertuie.

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ABBREVIATIONS AND ACRONYMS

CBD	Central Business District
IDP	Integrated Development Plan
NMT	Non-motorised transportation
NWU	North West University
SDF	Spatial Development Framework
SUMS	Stellenbosch University Mobility Study
STTMP	The Stellenbosch Town Transport Master Plan
SU	Stellenbosch University
UJ	University of Johannesburg
UK	United Kingdom

1. INTRODUCTION

Universities have experienced an increase in student numbers. As the number of students increase, so does the automobile numbers, which brings urban issues such as traffic congestion and a shortage of parking (Miralles-Guasch & Domene 2010). The major problem is that there is limited land and space available to develop new car parking lots and also it is expensive to build parking structures on expensive land. The preferable alternative would be better bicycle and pedestrian facilities for students, which would not only preserve the air quality, but also decrease the carbon footprint, greenhouse gas emissions and thus contribute to a sustainable campus (Bond & Steiner 2006). A solution would be to reduce the number of automobiles around and to and from campus and improve the infrastructure to encourage bicycling and walking to campus and to the different faculties. Another solution would be to develop parking areas on the periphery of the university campus and students travel by certain modes of transport from the parking areas to the campus. This would reduce the traffic flow of vehicles around campus. Many students live near campus and it is possible to implement sustainable mobility alternatives such as bicycle routes and walking paths (Toor & Havlick 2004; Miralles-Guasch & Domene 2010).

Agarwal and North (2012) found that students do not make use of bicycles because they are afraid to share the road with automobiles and because of bicycle theft. Universities can encourage cycling and walking to campus by investing in pedestrian paths and infrastructure for bicycles on campus. A study at Colorado indicated that students using bicycles increased when the university invested in infrastructure for bicycles and the result were that trips made by vehicles decreased from 49% to 36% (Toor & Havlick 2004). The University of California-Santa Barbara have improved the infrastructure to accommodate bicycles and pedestrians that resulted in more than 50% of the students making use of non-motorised transportation. This indicates that campuses can increase cycling and walking, which would reduce the need of students living on and near campus, to make use of motorised transportation options (Wang et al. 2016). University of North Carolina converted their parking lots into bike and pedestrian paths as well as bike parking to decrease the use of automobiles (Havlick 2004).

According to the Stellenbosch University Mobility Study, 2010 (SUMS) there has been a growth in student numbers that contributed to the lack of vehicular parking, illegal parking and traffic congestion in and around the university. The SUMS was compiled in 2010, and proposed the use of non-motorised transportation and an increase in parking charges would increase the

cost of private transport. This could change individual's perspective about using private transport and encourage them to switch to non-motorised transportation or shuttle services. Non-motorised transportation would lower the carbon footprint of the University and cycling and pedestrian routes would help reduce the number of vehicles around campus (VELA VKE 2010).

The parking areas on the periphery of the university campus and cycling routes that the mobility study proposed has not yet been implemented as it is part of the lateral phase of the study. The Spatial Development Framework (SDF) for Stellenbosch and Integrated Development Plan (IDP) indicates that traffic congestion has increased over the years and is a problem during peak hours. To solve this problem non-motorised transport (NMT) modes has to be implemented such as pedestrian routes and cycling lanes to reduce the utilisation of private transport by students (Stellenbosch Municipality 2012). Therefore, there is a need to investigate the mobility of students to identify non-motorised solutions at Stellenbosch University. This study will investigate the mobility patterns of Stellenbosch University's students to identify possible cycling routes, pedestrian paths and possible parking areas that should be developed.

1.1 PROBLEM STATEMENT

Automobile dependency is a reality of the twenty-first century and can be addressed by providing people with sustainable transportation options and automobile-free lifestyle options. Many students live close to campus and do not have to make use of automobiles. A solution would be to adjust the infrastructure to create a more pedestrian and cycle friendly environment where people feel safe to walk and do not have to make use of automobiles (Toor & Havlick 2004; Ziegler 2009; Miralles-Guasch & Domene 2010; Ziegler 2011; Abd-Razak, Utberta & Handryant 2012).

Individuals are always moving from one place to another resulting in an increase in transport (Abd-Razak, Utberta & Handryant 2012). The use of vehicles bring issues such as congestion, limited parking, air pollution and urban sprawl. Spatial planners have tried to solve this problem by adapting the built environment. Concepts such as new urbanism and the compact city try to reduce car use and travel distances through designs that accommodate public transport and non-motorized travel (De Vos 2015). The concept New Urbanism includes walkable neighbourhoods to encourage people to walk rather than to travel by car. A bicycle and pedestrian environment increase safety, reduce greenhouse gas emissions and increase a sustainable environment (Crane & Schweitzer 2003; Sisiopiku & Akin 2003).

The literature prompts the need to investigate the mobility of students to identify sustainable mobility solutions at Stellenbosch University. Stellenbosch University experiences shortage of parking due to the increase of automobiles with the rising student numbers. Stellenbosch University has not implemented measures to restrict the use of cars and to a limited extent addressed the parking issues. This encourages the study to investigate alternative solutions to address these problems. A secondary objective of the study is to identify bicycle nodes and pedestrian paths to indicate the position where it should be ideally located. It will include the parking areas on the outskirts of Stellenbosch University to address the parking issue on Stellenbosch campus.

1.2 STUDY AREA

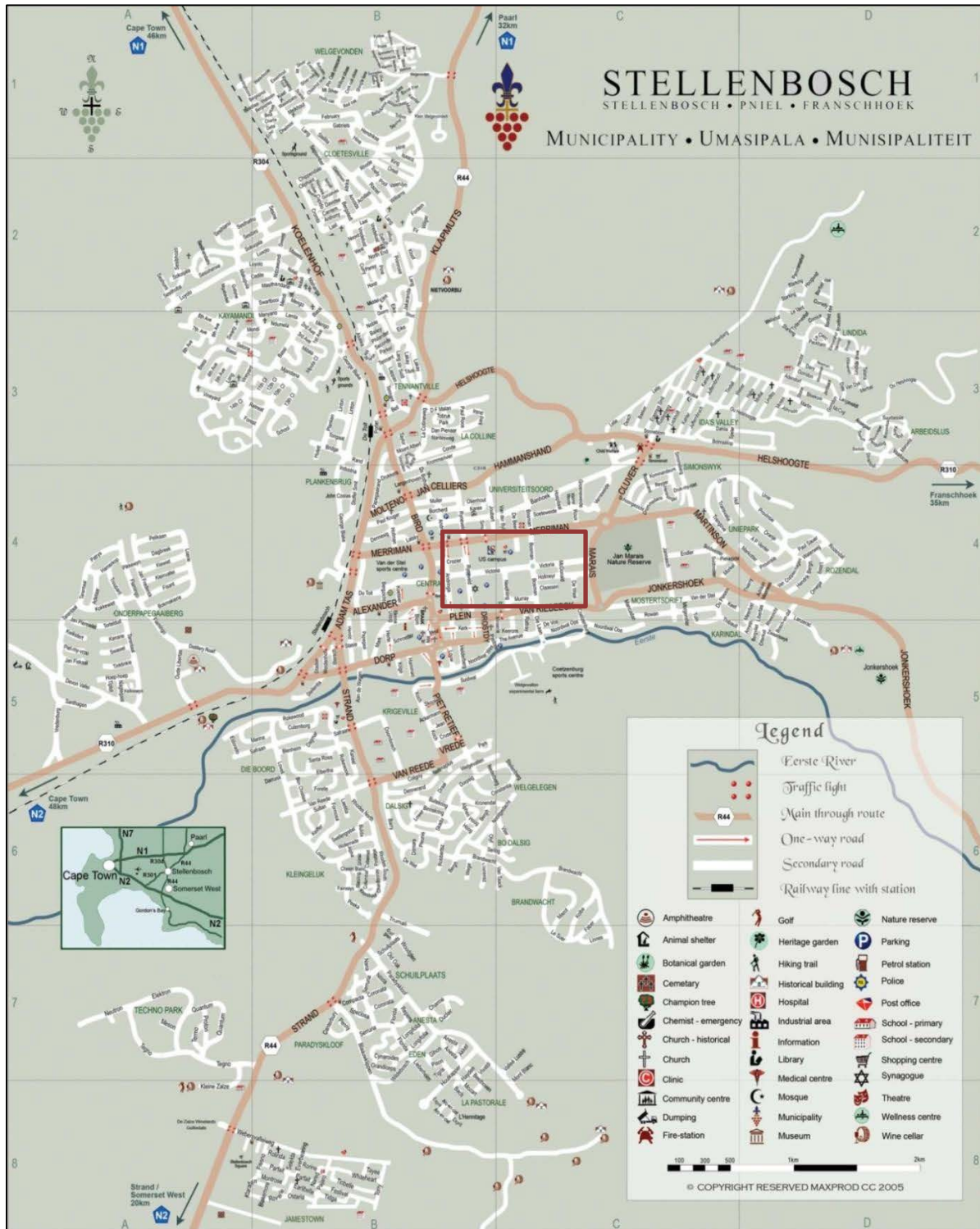
Stellenbosch University is located in Stellenbosch, which is part of the Western Cape Province in South Africa (Figure 1.1). Figure 1.1 illustrates the University's location in the Western Cape Province and circled in red on the map.



Source: One World-Nations Online (2017).

Figure 1.1 Map of South Africa.

This study focus more specifically at Stellenbosch University. Figure 1.2 illustrates the location of the main campus area of the Stellenbosch University in Stellenbosch Town that is squared in red on the map (Figure 1.2).



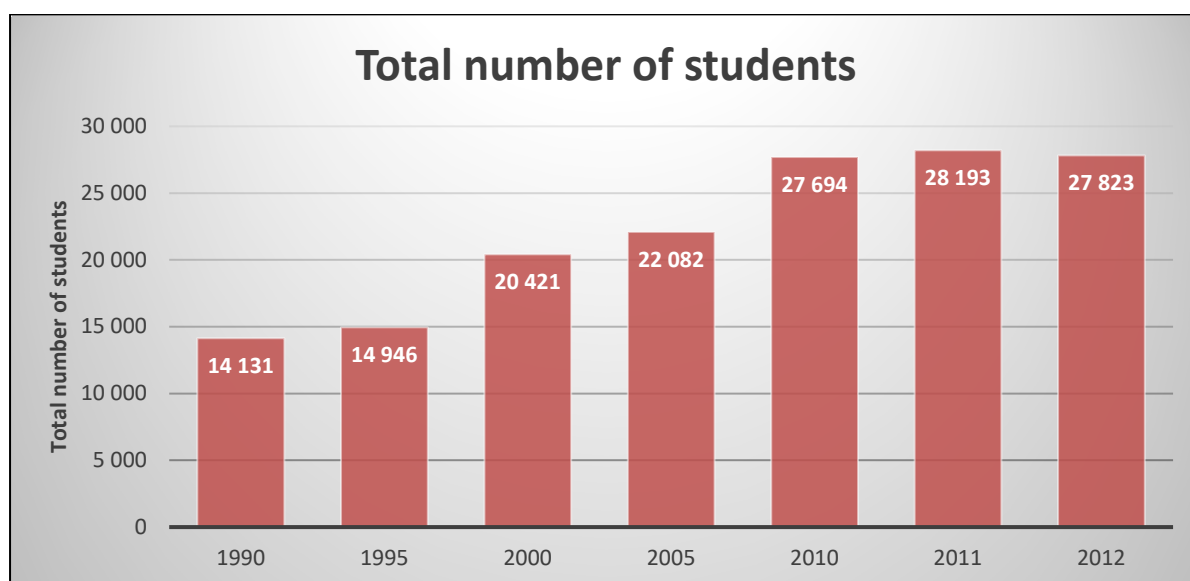
Source: Jong (2008).

Figure 1.2 Map of Stellenbosch Town.

The area on and around the main campus of the Stellenbosch University is the focus area of this study. Stellenbosch centre is compact, has a flat topography and consists of young students in the centre of Stellenbosch. Therefore, the campus is a preferred destination for implementing NMT routes. The growth of Stellenbosch town and the growth of student numbers will be discussed. The growth in traffic and the feeding areas to and from Stellenbosch will also be discussed.

Stellenbosch town is around 831.04 km² and is growing rapidly. The population of Stellenbosch in 2011 was 155 733 and was estimated to be 173 557 in 2017. In 2030 the estimated population number would be 190 677. Therefore, the population growth rate would be around 9.9% from 2017-2030 (Stellenbosch Municipality 2017).

In 2000, the total student population was 20 421 (Figure 1.3). In 2010 the total student population of the University has grown to 27, 694, indicating an increase of 7273 students between 2000 and 2010. When student numbers increase so does vehicle numbers increase and alternative transport modes needs to be implemented to accommodate the growth in individuals (Stellenbosch University 2018).



Source: Stellenbosch University (2018).

Figure 1.3 Total number of students.

The average growth rate of traffic in Stellenbosch is 6.2% per year (Table 1.1). The reasons for the increase in private transport in Stellenbosch is the lack of public transport, students from surrounding areas make use of private transport to travel to campus and individuals who travel

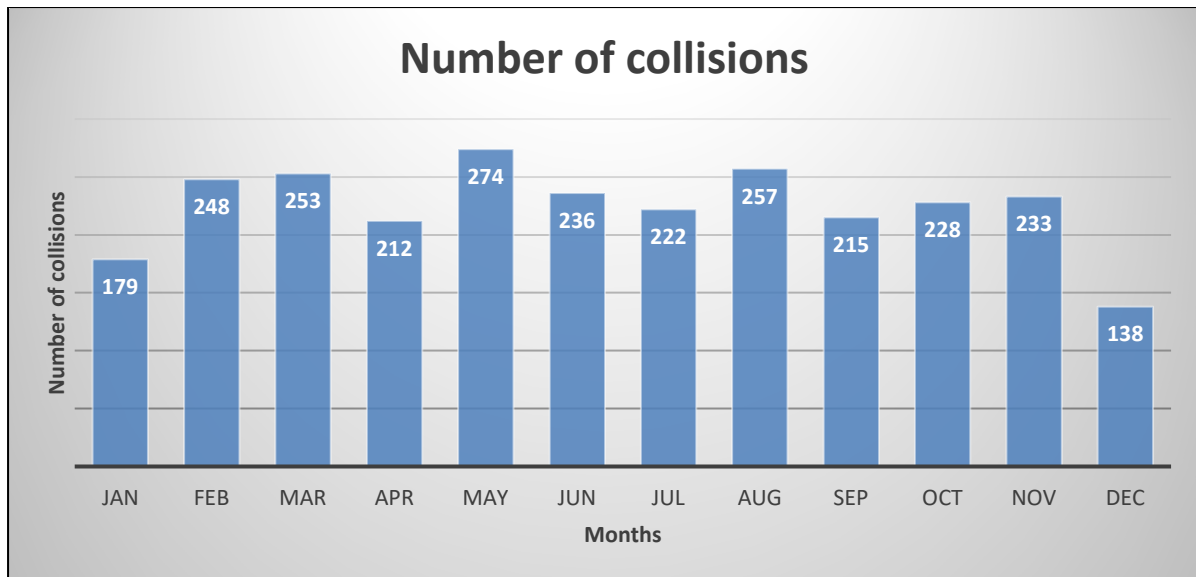
from Stellenbosch to other places and people who travel from other towns through Stellenbosch to the South and North (Swilling, Sebitosi & Loots 2012).

Table 1.1 Increase in traffic.

Counting station	Total vehicles		Heavy vehicles	Total vehicles	Heavy vehicles
	Observed 2000	Observed 2009	Observed 2009	Projected 2030	Projected 2030
R44 Blaauwklippen	20 510	35 406	1 266	73 224	3 213
R44 Cloetesville	12 928	19 339	1 106	39 995	2 824
R304 Kayamandi	14 151	18 247	867	37 737	2 203
Polkadraai	13 641	19 207	1 216	39 722	4 360
Helshoogte	5 358	6 893	373	14 256	1 131

Stellenbosch traffic has increased over the past 9 years. Vehicle numbers has increased by 38% from 2000 to 2009. Traffic congestion contributes to environmental consequences such as air and noise pollution. With the increase in traffic there is a lack of parking space in Stellenbosch that results in illegal parking and on sidewalks. There is a shortage of 4000 to 5000 parking space at Stellenbosch University alone (Swilling, Sebitosi & Loots 2012). To address this problem non-motorised transport options and better infrastructure needs to be implemented.

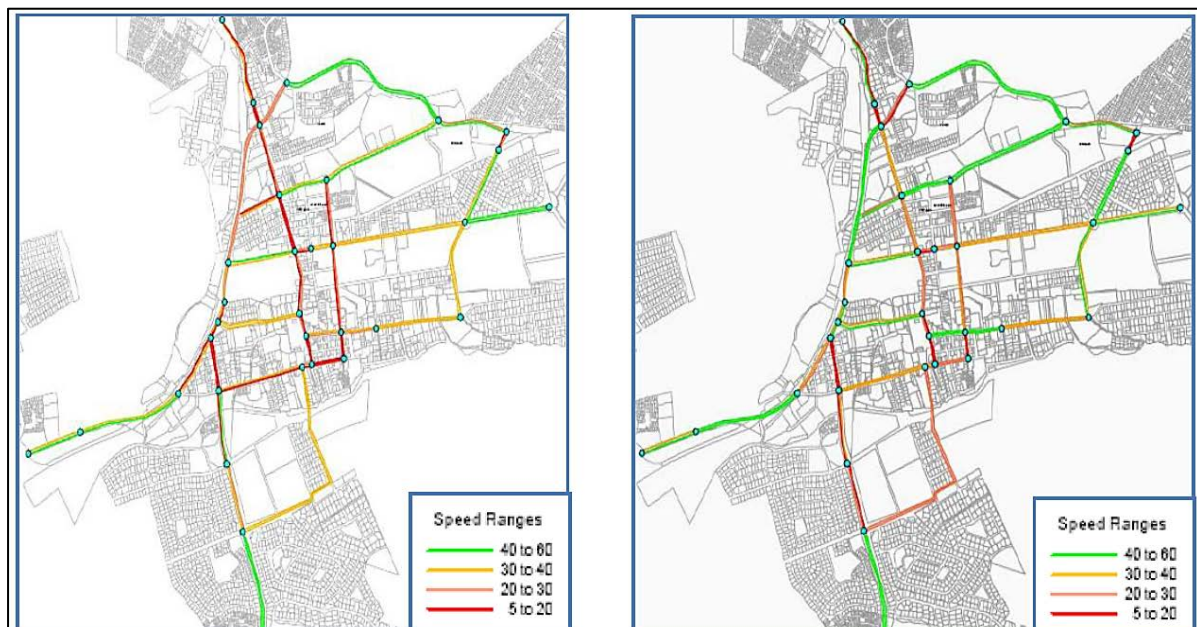
Stellenbosch is a university town and is also one of the factors that contributed to the increase in vehicle numbers. In Figure 1.4 below the accidents are less in January, July and December when the students are with holiday contributing to the aspect that students contribute to traffic congestion in Stellenbosch. This means students contribute to the increase in traffic congestion (Swilling, Sebitosi & Loots 2012).



Source: Swilling, Sebitosi & Loots (2012).

Figure 1.4 Number of accidents in Stellenbosch.

The number of vehicles has increased over the past years. The average growth rate of traffic in Stellenbosch is around 6.2% per year (Stellenbosch Municipality 2016). One of the reasons therefore is because Stellenbosch is a university town and students make use of private vehicles. Around campus, the speed average is 30 to 40 km/h during peak hours (Figure 1.5).



Source: Jong (2008).

Figure 1.5 Illustrates the average speed in the afternoon peak hours on the left and in the morning peak hours on the right.

1.3 RESEARCH AIM AND OBJECTIVES

The purpose of this study is to analyse the mobility of students at Stellenbosch University and to provide alternative sustainable solutions to the conventional mobility methods. To achieve this research aim the following objectives are compiled:

- Identify and analyse the mobility pattern of students on and around campus.
- Identify where students travelling by private car, park on campus.
- Identify the academic buildings that are most visited during the day.
- Identify where the majority of students live on campus.
- Based on these mobility patterns, identify potential pedestrian and other non-motorised transport routes.

1.4 RESEARCH QUESTIONS

What are the trends in mobility patterns of students at Stellenbosch University?

From where do students who make use of private cars travel from?

Where do students who make use of private cars park?

Which academic buildings are the most utilised by students?

Where do the majority of students live on campus?

The reasons why students make use of private vehicles and not alternative modes of transport?

Which features of pedestrian facilities are the most important to Stellenbosch students?

Where would logical pedestrian and non-motorised transport route ideally be located to cater for the largest amount of students travelling on and around campus?

1.5 HYPOTHESIS

The major problem is that there is limited land and space available to develop new car parking lots and it is expensive to build parking structures. The desired outcome would be better bicycle and pedestrian facilities for students, which would not only preserve the air quality, but also decrease the carbon footprint, greenhouse gas emissions and contribute to a sustainable campus. A solution would be to improve the infrastructure along the most utilised routes, to

encourage cycling and walking to campus and to the different faculties. Another solution would be to develop parking areas on the periphery of the university campus and students travel by busses from the parking areas to the campus, which would reduce the traffic flow around campus (Toor & Havlick 2004).

1.6 CHAPTER OUTLINE

The research study is divided into 5 chapters and a summary of each chapters is given here. Each chapter form part of the aim of the research study, to determine the potential for Non-motorised transport at Stellenbosch University campus.

Chapter 1: Introduction

The purpose of this study is to analyse the mobility of students at Stellenbosch University and to provide alternative sustainable solutions to the conventional mobility methods.

Chapter 2: Literature Review

This chapter introduces the concept Non-motorised transport. Relevant literature about NMT, cycling and pedestrianisation are provided. The literature will consist of NMT that would consider pedestrian routes and cycling lanes infrastructure guidelines, location and examples. An overview of NMT in Global South and North cities is provided.

Chapter 3: Methodology

This chapter provides a table of the overall approach from the build-up to the finalisation of the research study. The methods that will be used to analyse the data is also provided in this section. The research consists of qualitative and quantitative data to achieve the research aim and objectives.

Chapter 4: Results

This chapter illustrates the findings of the data and determine potential NMT at Stellenbosch University.

Chapter 5: Conclusion

A conclusion is drawn from the findings of the research on NMT in Stellenbosch. Recommendations are also made for future research in this field.

2. LITERATURE REVIEW

2.1 INTRODUCTION

In this section, literature and theory that is relevant to this study will be discussed. The increase in automobile numbers elevates urban issues such as traffic congestion, air pollution and the shortage of parking. The preferable alternative would be better bicycle and pedestrian facilities for students, which would not only preserve the air quality, but also decrease the carbon footprint, greenhouse gas emissions and thus contribute to a sustainable campus (Bond & Steiner 2006). The reason why students do not make use of non-motorised transport is because NMT infrastructure are absent and individuals are afraid to share the road with vehicles as it increases their chance of accidents (Teschke et al. 2012). A solution would be to reduce the number of automobiles around and to and from campus and improve the NMT infrastructure to encourage bicycling and walking to campus and to the different faculties.

Firstly, the concept mobility is discussed. Secondly, NMT in the global South and North are considered. In cities of the global South NMT routes are rare and mostly absent, because bulk infrastructure is expensive to develop (Wardlaw 2014). In the global South issues such as safety and security is a major problem and factors that contribute to the apprehension for NMT modes. In contrast, global North cities are the opposite, theft rate is low, they have proper NMT routes and separate pedestrian and cycling lanes for individuals that encourages the utilisation of NMT. Cities in the global North have a high utilisation number of bicycle share programs and continue to grow, as individuals prefer to make use bicycle share programmes. Cities of the global North cities and their NMT routes are considered, to see what these NMT infrastructure looks like and how it is implemented. Secondly, the reasons for underutilisation of NMT was considered. Thirdly, how to improve NMT was discussed. Universities can encourage cycling and walking to campus by investing in pedestrian and bicycles routes that include lanes that are specifically used only by bicycles or pedestrians on campus, would contribute to the use of non-motorised transport modes. Providing indoor bicycle rooms or outdoor bicycle shelter that can only be accessed through controlled magnetic strips on student cards would help reduce bicycle theft (Wardlaw 2014; Fishman et al. 2015). Fourthly, NMT and international and local university campuses is discussed. Lastly, planning for NMT in Stellenbosch was considered.

2.2 MOBILITY

Mobility refers to the movement of people also known as physical mobility. Mobility includes one of the different types of modes for example feet, automobile, train, bicycle, wheelchair and

airplane. Mobility means the ability of movement between and among places, this can be on a daily basis or over a longer period. In the 21st century people consume more than before therefore people cannot not move between places without some form of mobility. Mobility gives individuals the opportunity for accessibility and contributes to the independence of individuals and quality of life (Gregory et al. 2009). Therefore, mobility plays an important part of society as people are always moving from one point to a destination (Abd-Razak, Utaberta & Handryant 2012).

2.3 NON-MOTORISED TRANSPORT IN THE GLOBAL SOUTH AND NORTH CITIES

Many cities are car orientated and therefore cycling and walking will be a second choice. However, implementing segregated cycling and pedestrian routes have indicated some encouragement to individuals to make use of non-motorised transportation. Non-motorised transportation modes includes walking, bicycle, skateboards, handcarts and wheelchairs (Yazid, Ismail & Atiq 2011).

In the global South, cities such as Asia and Latin America, only 26% to 32% of the trips are non-motorised transport modes. In contrast, in African cities 41% of the residence make use of walking and cycling due to the majority of the population that falls within the low-income bracket (Kenworthy 2003). In developing countries, residence in the lowest income quintile have poor access to private and public transport. An individual's income determines one's lifestyle. The reason why developing countries NMT rates are higher is because the poor are pushed out to the periphery of the CBD or located in the inner-city ghettos that leads to spatial incoherence and poor access to transport. It is mostly the poorly and social disadvantage residents that experience transport disadvantage. Therefore, the only modes of transport available to them is NMT and the most basic mode of mobility is walking (Gwilliam 2003). While residents in the higher income quintiles are dependent on private vehicles for mobility that contributes to traffic congestion in cities in the global South. Global South cities experience social exclusion and spatial incoherence that may lead to transport disadvantages to lower income groups (Lucas 2012).

Although the majority of individuals walk because it is the most affordable options, there are few developed walking and cycling lanes to accommodate them. The poorer cities in Africa and Latin America have poor public transport services and NMT infrastructure. In the global South, bulk infrastructure is expensive and often absent. In addition, there are no improvements

on the walking paths. Population and cities continue to expand but the transport services and alternative modes are not implemented to accommodate the growth. Adequate transport services could help improve the quality of life of residents by helping them to travel further distances and travel to jobs to make a better living for themselves. People are more cautious about crime and theft therefore, they would not make use of non-motorised transport when it is dark or where the routes are quiet. Non-motorised routes should be developed where the majority of individuals walk to ensure safety. In the global South issues such as safety and security is a major problem and public transport is unaffordable (Kenworthy 2003).

In contrast people, living in cities in the global North earn a higher income and can afford non-motorised transport modes. These cities have the capital to implement NMT routes for individuals. Theft numbers in the global North are lower and these towns can implement bicycle share programs as theft can be controlled. When looking at cities in the South people are afraid to make use of bicycles because of the high theft rate. The University California-Santa Barbara have improved infrastructure to accommodate bicycles and pedestrians only and resulted in more than 50% of the students making use of non-motorised transportation. Good access to non-motorised transport decrease the usage of vehicles by 10-30%. Individuals that live in areas that is pedestrian friendly, walk up to four times more and decrease the usage of private vehicle with up to 15%. In the United Kingdom (UK) towns, the cycling programme consists of implementing safe cycling parking; integration of NMT routes with the parking bays on the outskirts; bike sharing programmes; restrictions on private vehicles usage and ownership; compact development to shorten trip distances and education to cyclist and pedestrians (Wardlaw 2014). Implementing rental and bicycle-share programs in universities may contribute to an increase in usage of bicycles. Bicycle routes that are smoothly paved and off the street would increase the mobility of individuals. In Montreal, Washington D.C., Chicago and New York they make use of bicycle shares and it is a success. In 2009, there has been around 1 million trips and in 2011, there has been over 4 million trips made with the bicycle share program. Cities in the global North have implemented some good NMT modes and infrastructure that can be carried over to global South cities (Vijayakumar & Burda 2015).

Toronto's cycling plan emphasise that bicycle and automobiles have to have separate lanes to ensure safety and combat congestion. There are two different types of on-street cycling routes namely: painted or separated lanes (Pucher, Dill & Handy 2010). The painted lanes are only separated from the vehicular traffic through painted lanes and means there is no barrier to avoid cars from driving into these cycling lanes (Figure 2.1). The separated lanes are adjacent to the

street but are separated from the vehicular traffic by kerbs (Figure 2.1). Separated lanes are more expensive and that is why painted lanes are mostly used in suburbs. In Toronto, cycling routes were implemented in Richmond Street and Adelaide Street that stretched to the university and founded that cycling trips have increased to 4 200 cycle trips daily (Vijayakumar & Burda 2015). The increase in bicycles on the road did not negatively affect the flow and travel time of vehicles. The result of implementing cycling lanes can be effective and bring an increase in bicycle utilisation that would reduce the utilisation of private vehicles (Vijayakumar & Burda 2015).



Source: (Vijayakumar & Burda 2015).

Figure 2.1 The image on the left indicates the painted cycling lanes and the image on the right illustrates the separated bicycle lanes.

In Chicago, the sidewalks were upgraded to bicycle and pedestrian routes. The sidewalks were wide enough to implement both types of lanes (Abd-Razak, Utaberta & Handryant 2012). Individuals did not have a problem with sharing the sidewalk with other NMT as the two routes were separated by kerbs or vegetation. In contrast, more people started to use the bicycle and pedestrian routes that brought a decline in private vehicle usage. The routes were linked to jobs, recreational areas and train stations. People did not have to make use of private vehicles as the routes are safe and linked to the facilities people daily use (Thakuriah et al. 2012). If separate infrastructure is developed and would ensure safety to individuals, more people would make use of non-motorised transportation because parking is a limitation. Figure 2.2 below indicates how segregated cycling routes and pedestrian routes are combined on the sidewalk, in Sydney. The cycling routes can be painted in green or the routes on the right hand side of the figure 2.2 is paved with concrete to clearly distinguish between the two routes. The pedestrian and cycling

routes are separated from each other by trees to ensure safety. Pedestrians are afraid to make use of the same route as cyclist as their speed are much faster and can cause accidents. By separating pedestrian and cycling routes with kerbs or vegetation would contribute to utilisation and individual's safety.



Source: Crane et al. (2016).

Figure 2.2 Design of sidewalk converted into cycling and pedestrian routes.

Ciolek (1978) found that pedestrian routes should be 2 meter width and if trees and benches are included it should stretch to 5 meter wide (Figure 2.3). In Houten in the Netherlands, they provide infrastructure for pedestrians and cyclists and according to their guidelines, the walking routes should at least be 1.8 meters wide. The segregated cycling routes should be a minimum of 2 meter and a maximum of 3.5 meters wide. The cycling routes connect to every location that resulted in the main mode of transportation usage in Houten. In contrast, Houten is a small place but NMT routes can be implemented (Jong 2008).



Source: Ciolek (1978).

Figure 2.3 Illustrates the width of the walking routes.

2.4 REASONS FOR UNDERUTILISATION OF NMT

The location of walking paths, roads and parking areas are important to look at. Weak planning of physical development will reduce the level of accessibility and usage. Abd-Razak et al. (2011) found that students do not make use of parking areas, routes and facilities that are dark because they feel unsafe and there is no one to protect them. Students avoid quiet areas and routes because they feel unsafe and alone. Therefore, location plays an important part in planning other ways students would not utilise walking routes and parking areas. The ideal location would include routes that the majority of students make use of and are the shortest routes. Routes must include security and lighting to improve visibility and safety (Abd-Razak et al. 2011). Helbing et al. (2001) observed student mobility and more specifically the mode of walking. Helbing et al. (2001) and Ciolek (1978) findings agree with Abd-Razak et al. (2011) findings, that students would take the shortest route and also the straightest routes. Students do not like changing direction the whole time in contrast they would change direction as late as possible to get to the faculty that results in taking the direct route. Furthermore, students make use of the same route because they are more comfortable taking the path that is familiar to them and are used frequently by fellow students (Ciolek 1978; Helbing et al. 2001; Gehl 2011; Pucher, Garrard & Greaves 2011; Spooner 2011).

2.5 HOW TO IMPROVE NMT

Agarwal and North (2012) found that universities can encourage cycling and walking to campus by investing in pedestrian routes and infrastructure for bicycles that include lanes that are specifically used only by bicycles or pedestrians on campus. Providing indoor bicycle rooms or outdoor bicycle shelter that can only be accessed through controlled magnetic strips on student cards would help reduce bicycle theft. Separate bicycle lanes mean that cyclists do not have to share the road with vehicles that would ensure more safety and convenience (Wardlaw 2014; Fishman et al. 2015). Rybarczyk & Gallagher (2014) also founded that the reason why few students make use of bicycles was that they are afraid of bicycle theft as well as bicycle lanes are absent near campus. Teschke et al. (2012) finding agrees with the authors above that the reason why few individuals make use of bicycle as transport mode is because of safety reasons. Individuals are afraid to share the road with vehicles as it may increase the risk for accidents. Therefore, there is a need for separate cycling infrastructure to reduce the risk for accidents. Roads and routes that have less traffic creates a more bicycle friendly environment that cyclers prefer and feel safe to use (Dill 2009).

Abd-Razak, Utaberta & Handryant (2012) mentioned that pedestrian routes needs to be linked to the facilities, hostels and main roads. If campuses develop pedestrian routes and cycling lanes that are wide enough and that provides security to students, students would most likely make use of these non-motorised transportation. Walk paths should be implemented along the roads and separately from the vehicle flows. This would ensure pedestrian safety and friendly environment (Abd-Razak, Utaberta & Handryant 2012). Chong et al. (2010) agrees that transport of different speed and flow should be separated to ensure safety and fewer accidents. To ensure pedestrian safety across a main road with dense vehicular traffic a kerb side can be built in the middle of the road and also a zebra strip of 5 meter wide across the road (Tiwari & Jain 2012).

In London, the bicycle share programme has various stations, which give individuals the opportunity to hire a bike from any station and return it to any station. Individuals can pay in the form of their credit card, online or at the station self. The stations are situated plus minus every 300 meter from each other. Individuals that are located near a station make more often use of bicycle share programs than individuals that have to walk a few kilometres to the station (Goodman & Cheshire 2014). According to Campbell et al. (2016) the locality of the end destination stations is more important than to have various stations in the central of a town or

campus. If one knows where the individuals travel to and back, stations can be implemented more effectively that will result in an increase of utilisation of bicycle share programs (Campbell et al. 2016). The ideal location would be to create walking routes on the routes that are frequently used by students. This would result in effective utilisation of pedestrian routes (Abd-Razak et al. 2011).

Lanzendorf & Busch-Geertsema (2014) founded that developing sidewalks into bicycle and pedestrian routes are cheaper than to implement new road infrastructure and other modes of transportation. New cycling and pedestrian infrastructure would not just encourage an increase in non-motorised transportation but also student safety, better health and quality of life (Crane et al. 2016).

2.6 INTERNATIONAL UNIVERSITIES THAT PLANNED FOR STUDENT MOBILITY

In this paragraph, various universities that implemented bicycle infrastructure will be considered as having contributed to the increase in numbers of cyclists. A study at Colorado indicated that students began using bicycles when the university invested in infrastructure for bicycles and the result were that trips made by vehicles decreased from 49% to 36% (Toor & Havlick 2004). The University California-Santa Barbara have improved infrastructure to accommodate bicycles and pedestrians only and resulted in more than 50% of the students making use of non-motorised transportation (Toor & Havlick 2004). Good access to non-motorised transport decrease the usage of vehicles by 10-30%. Individuals that live in area that is pedestrian friendly, walk up to four times more and decrease the usage of private vehicle with up to 15% (Rahul & Verma 2014).

The University of North Carolina improved pedestrian safety by implementing more lighting across pedestrian routes and linking pedestrian routes with one another and to the main routes. Further, they increased parking fees and use the capital to provide bicycle routes, storage and secure parking. The university used the money to convert the parking lots into bike and pedestrian paths to decrease the use of automobiles. Also a parking lot was redeveloped into bicycle parking that is much cheaper than vehicle parking and more bicycle parking can fit into a car parking (Figure 2.4). This helped address the issue of limited parking on campus (Havlick 2004).



Source: Havlick (2004).

Figure 2.4 Indicates a parking lot that was converted into bicycle parking.

The University of Florida experience limited parking and students have to find alternatives modes of transportation to get to campus. The University of Florida have created alternative transportation methods to accommodate their students for example the Campus Circulator Routes, this means the campus implemented busses that travel on fixed routes through the campus. The intention was to accommodate University of Florida students and staff to move around campus and to the different faculties. This method gives students the opportunity to move on campus without a private vehicle. Reducing the vehicular traffic in the core of the campus contributes to a safe pedestrian and cycling environment. Individuals feel more comfortable to walk and cycle where there is less traffic and they can feel free to move without fast moving traffic that may collide with them. Parking areas are found on the outskirts of campus and students are given the choice to make use of bus or bicycle rides to the core of the campus. This University implemented parking prices and-, transit services. In addition, the lack of parking resulted in a mode shift away from private vehicles to NMT modes (Bond & Steiner 2006).

A University located within Trieste's proposed solution was to improve accessibility and mobility movement through the improvement of pedestrian routes that are linked to transit stops, parking areas on the periphery of the university campus and university faculties. The implementation of bicycle lanes between the faculties, residents and parking facilities improve mobility and increase in the utilisation of bicycle and pedestrian routes. The university

implemented transport services during the evenings for residents to ensure safety and combat crime. The university also implemented special fares for students to help reduce public and private transport costs for them and the Fares can be paid through their student cards. NMT modes would help address the issue of congestion and parking at universities (Longo, Medeossi & Padoano 2015).

How bicycle share programmes work at universities is, there are areas that consists of rental bikes on campus that are normally located central to campus and within walking distance for students, where they can use their student card to scan in and hire a bike to use to travel to faculties and hostels. At the hostels there will be a room where you can give the bike back. Residents would have the opportunity at their hostel to rent a bike and do not have to walk far to the nearest station. This will increase the use of the program as well as improve mobility. To increase the safety and reduce bicycle theft a guard and staff can be employed that can manage the share program and scan students in (Pucher, Dill & Handy 2010). Students can make use of their students cards to register for the share program and can pay through their student cards or cash for the share program (Vijayakumar & Burda 2015).

Bicycle sharing programs give students the opportunity to make use of non-motorised transport without having to own a bicycle. Students come from far places and do not have the opportunity to bring their bicycle with them to university or own a bicycle. Another positive aspect is it gives the poorer individuals the opportunity to make use of to the program even if they cannot afford a bicycle (Faghih-Imani & Eluru 2016). Bicycle share programs has grown especially in North America and Europe. Through implementing bicycle share programs, bicycles have been replacing private car usage. For example, in Melbourne the bicycle share program resulted in 19% car reduction. In Brisbane bike share programs contribute to 21% of car substitution. In Minnesota, bike share programs reduced the usage of car by 19% (Fishman, Washington & Haworth 2014; Fishman et al. 2015).

Raised pedestrian crossings, speed humps and cobble paving help contribute to the decrease in vehicular speed. Individuals take notice if a road surface change and slow down to see what is going on around them. Furthermore, a formal sign is placed in these areas of integrated routes so that people can take note that they are sharing the road with other mode of transport. This is also known as the concept “woonerf”. If an area is integrated there still needs to be clear walking and cycling lanes to ensure safety. This concept has been implemented in the Swedish university town where there is a high volume flow of student pedestrians and cyclists. In Figure

2.5 the intersection that the students make use of to the university has been paved with a clear boundary around the paved area to help distinguish the intersection from the rest of the road and slow down the traffic. The paved area has slow down the traffic but it did not create any congestion or delays that can be seen as a good example of integration that was effective. According to Hamilton-Baillie (2008) findings the new paved intersection has increased pedestrian numbers and individuals feel comfortable utilising this intersection to campus. Shared space would be a solution to heavy flow roads and intersections (Hamilton-Baillie 2008; Gehl 2011).



Source: Gehl (2011).

Figure 2.5 Integrated paved intersection.

2.7 LOCAL UNIVERSITY THAT PLANNED FOR STUDENT MOBILITY

At the University of Johannesburg only 33% of the students walk to campus. Students have to travel a long distance to reach the campus and that is the reason for the low number of people walking and cycling to UJ campus. Students of UJ indicated that they would rather make use of buses (25%), minibus (21%) or taxis because it is more convenient and they live far from the campus. Almost none of the students cycle as there are no cycling infrastructure and students are too afraid of sharing the road with vehicles. Students of UJ complained that the walking paths are not interconnected and are not well secured. NMT routes are absent contributing to the increase in vehicles and buses that results in traffic congestion (Mbara &

Celliers 2013). A suggestion would be to implement NMT routes or busses from the residents to campus. Another important factor is that walking paths need to be linked and to main roads and provide lights for students to feel secure to make use of these routes (Mbara & Celliers 2013).

At the University of Pretoria, separate cycling parking and cycling sheds that are indicated with a road sign board are provided. The university has implemented parking regulations to restrict traffic around the campus. There is limited parking available for students and staff in an attempt to regulate parking space. This is done by providing disc to students and staff members and the discs have to be attached to the vehicles so that the guards can see if they have allocated parking. Students who have parking discs have entry through their student card to the parking area. Undergraduate students may only park on campus from 16:30. If students do not obey these rules, fines are permitted to the students. Student bus transport services are implemented to transport students from their residence to the campuses. The buses travel a fixed route and only from 06:00 to 18:00 during weekdays (Ranjit & Mohammed 2014).

North West University (NWU) campus, experience the same problem as the local universities mentioned above. The reason why students do not make use of NMT modes is that the bicycle infrastructures are informal or absent. The reason why students do not walk to campus is that the pedestrian walkways are not integrated. Although the pedestrian routes are accessible, there is a need for improvement. This can be done through integrating pedestrian routes to other pedestrian routes and main roads students utilise often (NWU 2018).

The NWU's solution to control private vehicle usage was to control vehicles by implementing parking discs and restriction of vehicles in certain areas. Certain parking areas are access controlled through student cards to address the issue of limited parking and reduce the use of private vehicles to and around campus. NWU make use of fences, gates, cameras and a guard to regulate traffic access. This could also be implemented to control bicycle parking areas to ensure safety and reduce theft of bicycles. NWU has implemented concrete pedestrian routes in between the academic buildings almost like the "woonerf" concept to ensure safety and accessibility to faculties (NWU 2018).

Tygerberg campus has sufficient parking space for staff members and future growth in staff members. There is limited parking for the day students driving to campus and have to park their car somewhere. Parking space at Tygerberg campus are access controlled to address the issue of limited parking space and reduce the number of private vehicles on campus. According

to the SUMS providing parking on the outskirts of the campus would reduce the traffic flow in the core of campus creating a more pedestrian and cycling friendly environment. To transport the students from the parking areas on the outskirts of campus to the centre of campus, shuttle services has been implemented at Tygerberg campus to increase accessibility (VELA VKE 2010).

Tygerberg campus has implemented shuttle services to transport the students to the hostels that is located further away from the campus to accommodate the students and reduce traffic flow around campus. The shuttles travel a fixed route and has regular schedules to increase accessibility to campus and from campus. Night shuttle services has also been implemented after students last classes that contributes to the safety of students. These shuttles have also addressed the safety concern students have with walking to campus. Just more than fifty percent of the students live on campus or within 1.2 kilometres of campus therefore, Tygerberg campus is looking at broadening the shuttle services to transport students from the hostels to campus to reduce traffic flow around and to campus (VELA VKE 2010).

Tygerberg students live within walking and cycling distance from the campus, but for them to make use of bicycles there has to be separate and painted cycling lanes. Secure lockers and bicycle shed facilities are absent and there are no change rooms available. NMT infrastructure are important to students to ensure safety and for them to make use of alternative transport modes. If private vehicles costs increase and alternative mode of transport were provided, students would make a mind shift and utilise NMT.

2.8 POLICIES FOR NMT IN STELLENBOSCH

In this section, various local guidelines and policies to implement NMT infrastructure were considered. These document and policies are established to give guidelines on NMT but it is still vague and people in institutions cannot seem to come to a conclusion how these routes should look, from what material it must consist of and how it should be implemented.

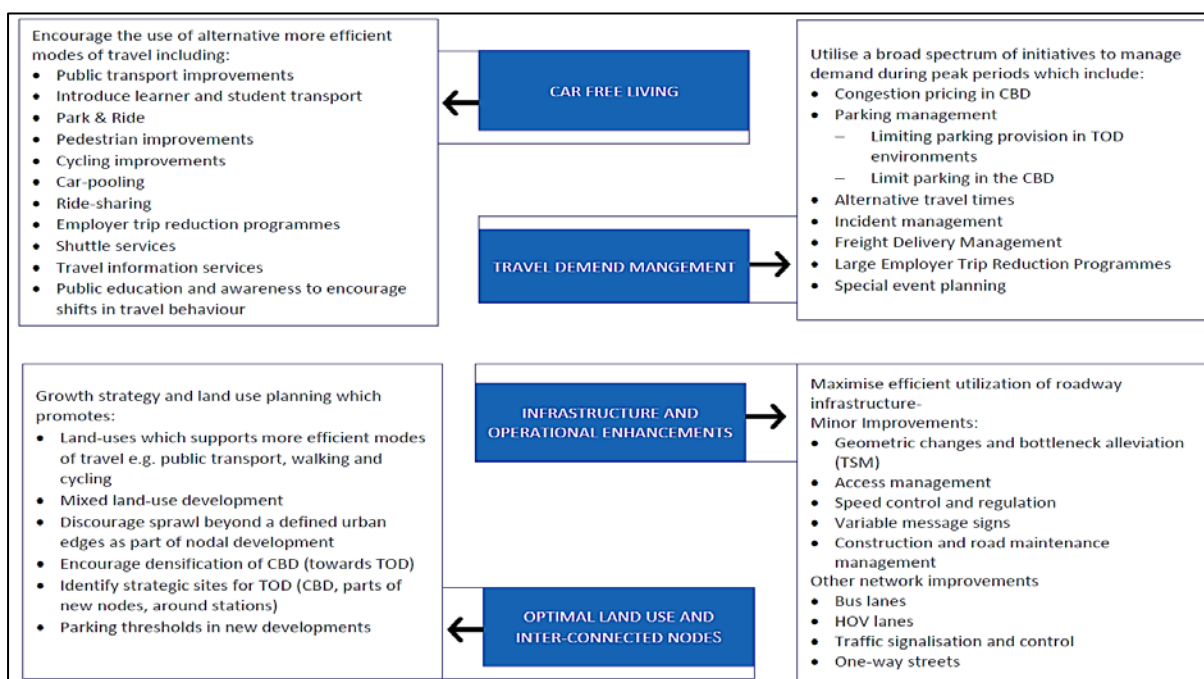
Of the total sample, 75% of the students live within 2.5 kilometres of campus that creates an opportunity to improve pedestrian and cycling routes to reduce private vehicle usage but these documents and policies has not kept up with the rapid student growth around campus. All the policies that speak to the potential use of NMT in Stellenbosch will be considered.

First, the IDP will be looked at. Secondly, the urban design policy and the width of infrastructures was discussed. There after there will be looked at the Stellenbosch Town

Transport Master Plan, the comprehensive integrated transport plan, Transport Draft Policy Document on NMT, NMT Policy and NMT facility guidelines. Lastly, there will be looked at the Spatial Development Framework.

2.8.1 The Stellenbosch Integrated Development Plan (IDP 2017)

The Stellenbosch Integrated Development Plan (IDP) suggest that Stellenbosch implements alternative modes of transport such as public transport and NMT. With the increasing congestion in Stellenbosch there is a need to implement strategies to reduce congestion such as congestion and parking costs (Figure 2.6). Stellenbosch should improve NMT infrastructure and develop interconnected nodes. The reason why the IDP is considered are because the IDP suggestions can be implemented at SU for example parking costs could be implemented at Stellenbosch University. If the tariffs for private car usage increase students would change their mind about using private cars as it will become unaffordable to pay parking costs and they would have to find an alternative transportation mode. The IDP suggest that pedestrian and cycling infrastructure needs to be improved if a car free living wants to be created (Stellenbosch Municipality 2017).



Source: Stellenbosch Municipality (2017).

Figure 2.6 Illustrates the suggestions made by the IDP.

2.8.2 Spatial Development Framework (2012)

This document agrees with this research study problem statement and suggests a solution to the problem. In the Spatial Development Framework of Stellenbosch, it was evident that traffic congestion is a major problem in Stellenbosch and has increased over the years. A solution to this problem would be to look at non-motorised transportation. Further pedestrian and cycling routes could be implemented to reduce the use of private transport. If activities and services that are within in 1 kilometre of the residential areas individuals would most likely walk or cycle that would reduce the utilisation of vehicles. The municipality experience challenges with infrastructure capacity and would be better to upgrade current infrastructure to reduce commuting. The SDF does not look specifically at the University campus, but sustainable solutions to address the transport issue should be co-developed with the University (Stellenbosch Municipality 2012).

The reason why the SDF is considered is, because the SDF suggestion can be implemented at SU. By looking at the secondary data, 60% of the students live within 1.2 kilometres of the campus, if NMT routes are implemented from the residence to campus, students would more likely walk or cycle instead of making use of private cars to campus. This links with the principles of creating walkable neighbourhoods through developing urban design that includes streets that are safe for walking. Providing public transport for everyone and that is affordable for the low income as well. Conserve, reserve and regenerate resources through upgrading infrastructure rather than to implement new infrastructure (Stellenbosch Municipality 2012).

2.8.3 NMT facility guidelines (2014)

NMT facility guidelines are a broad guideline for the whole of South Africa and indicates that pedestrian routes and cycling routes can be next to each other. The pedestrian route should be 1.2 to 2.5 meter wide. The cycling route should be at least 1.5 meter wide and maximum of 2.5 meter wide. The reason for considering the NMT facility guidelines is because this guidelines suggestions can be implemented at SU, through dividing sidewalks into pedestrian and cycling routes would help safe space and money that can be implemented at campus. Implementing speed bumps help reduce the speed of vehicles. Another aspect to take in consideration is to pave the street between education buildings, as this can help reduce car speed and contribute to a bicycle and pedestrian friendly environment at SU. By making streets one ways there is more space to implement bicycle and pedestrian routes and facilities (Figure 2.7). This could

be a solution to take in consideration when planning for pedestrian and cycling routes where there is little space for implementing NMT infrastructure (South Africa 2014).



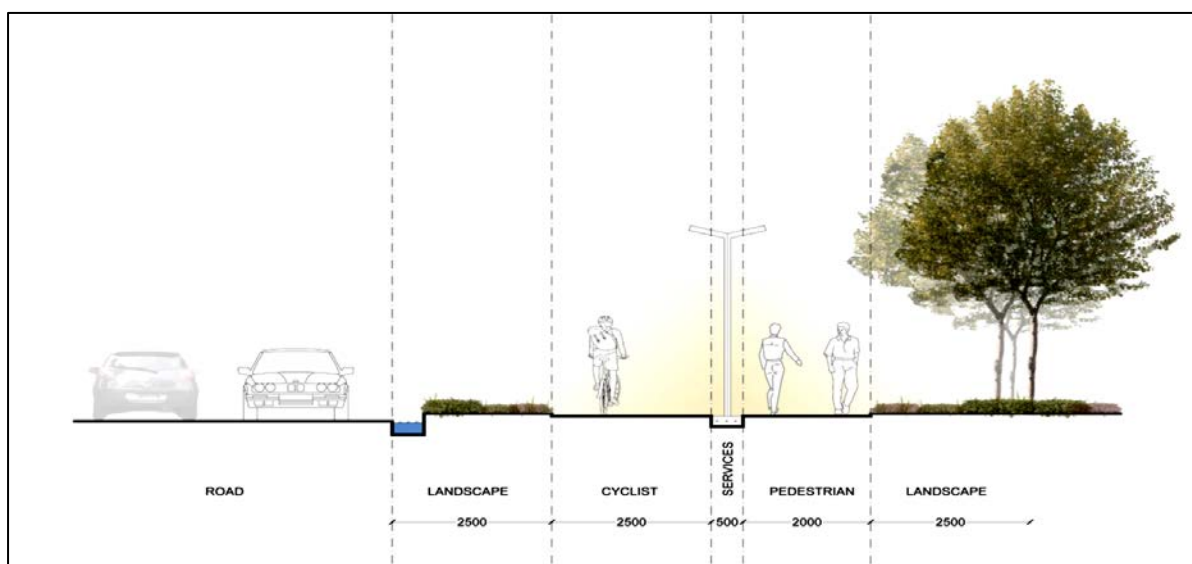
Source: South Africa (2014).

Figure 2.7 One way streets that are paved with speed bumps and signs.

2.8.4 Urban Design Policy (2013)

According to Cape Town Urban Design Policy (2013) non-motorised transport facilities must cater for the different needs and users such as students, staff and visitors. This may include cycle parking, change rooms and storage facilities after individuals have made use of NMT. The facilities must ensure safe and convenient access. The bicycle routes should be 2.5 meters wide and can be a minimum of 1.2 meters wide (Figure 2.8). Findings by Tiwari & Jain (2012) also suggest that the cycling routes should be 2.5 meter wide and segregated from the vehicular traffic. Vegetation along the routes would help separate the different types of routes. Pedestrian lanes should be linked to one another and to facilities. The routes should access all buildings, transport routes and be along the popular pedestrian routes. Car parking facilities must not negatively affect pedestrian safety and convenience. Therefore, developing parking areas on the outskirts of the campus would help reduce traffic in the centre of the campus resulting in a pedestrian friendly environment. NMT routes should be developed between the car parking areas and the end destination (City of Cape Town 2013). The reason why this policy is

considered is because Stellenbosch University make use of this guideline. Another reason for considering this policy is the fact is it states clearly the width of the routes that would be make use of and taking in consideration that planting vegetation between the pedestrian routes and the road could help reduce crime. Often pedestrians are an easy target for theft and cars would stop in the road next to the pedestrian route and target pedestrians. Planting trees between the road and the pedestrian route would create a barrier and cars would not have the opportunity to spot pedestrians as easy and stop and grab their belongings as they would have to get by the vegetation barrier first. Another solution would be to develop cycling lanes next to the road and then the pedestrian routes to ensure safety (Figure 2.8), this could be implemented at Stellenbosch University.



Source: City of Cape Town (2013).

Figure 2.8 Illustrates the guidelines for pedestrian and cycling routes.

The above policies assist practitioners in the planning and design of NMT facilities and infrastructure. Nevertheless, the policies are not significant to Stellenbosch University or taken into consideration. The NMT policies that are more focused on Stellenbosch town NMT planning and where chosen from the many policies that are compiled are: The Stellenbosch Town Transport Master Plan (2016); The comprehensive integrated transport plan (2016); Transport Draft Policy Document on NMT (2008) and Non-Motorised Transport Policy (2015). These are the policies that speak to the potential use of NMT in Stellenbosch.

2.8.5 The Stellenbosch Town Transport Master Plan (2016)

The purpose of the Stellenbosch Town Transport Master Plan (STTMP) was to identify routes that are mostly used in the main areas of Stellenbosch. These areas included: Kayamandi to the Central Business District (CBD), Plankburg and Cloeteville; pedestrian routes in Church and Adringa Street; the Stellenbosch station to the CBD and from the University to the CBD. This plan indicates that there should be a choice of mode for mobility, develop streets that are safe, protect historical and cultural aspects and to achieve sustainability through the maintenance of infrastructure and preserving the natural environment (Stellenbosch Municipality 2016). The reason for considering this document is the suggestion that people should have the choice of mode of transport and this contribute to the increase in usage of NMT modes. Improving NMT routes around the University would give individuals the opportunity to make use of alternative transportation modes that this study aims for. NMT routes should be safe otherwise, individuals would not make use of these routes this can be done by adding lights and developing the most popular routes into NMT routes.

2.8.6 The comprehensive integrated transport plan (2016)

The comprehensive integrated transport plan, states that NMT are not used by high income groups of Stellenbosch. In the centre of Stellenbosch and around the University Campus pedestrian numbers increases. The reason for considering this document is it suggests that individuals that are within 5 kilometre of their work or education would make use of NMT. As mentioned before 75% of the students live within 2.5 kilometres of the campus that is why it seems logical to implement NMT routes to reduce private vehicles to and around campus. The solution to vehicle congestion is non-motorised transport especially over shorter trips. NMT would not only reduce traffic congestion but also help improve road safety through the reduction in vehicle transport. This could be done by implementing bicycle parking and change rooms for employees and individuals. The private sector can help fund these NMT projects. Implementing bicycle hire at companies would help raise awareness of bicycle share projects can help increase cyclists. Developing pedestrian routes that are signalised and have good lightning would increase safety and utilisation. The master plan suggests that the parking issue needs to be address in Stellenbosch through providing parking on the outskirts. Further people would have the choice to walk or make use of a bus to campus, this could be considered to be implemented at Stellenbosch University. Pedestrian and cycling routes needs to be developed within the core of Stellenbosch (Stellenbosch Municipality 2016).

2.8.7 Transport Draft Policy Document on NMT (2008)

When planning for NMT routes it should always be direct and linked to facilities. The facilities should be safe, secure, comfortable that means not sharing the road with vehicles and straight gradient, convenient, shortest route and pleasing route that may include plants (Stellenbosch Municipality 2016). The reason for looking at this document as it also suggests to implement routes that are separate from the road to ensure safety for students and vegetation is important to separate routes clearly to ensure safety. The routes that would be considered are the routes that are utilised by the majority of students and the shortest routes from the residence or parking areas to the campus this would contribute that individuals would utilise these routes.

2.8.8 Non-Motorised Transport Policy (2015)

The reason for considering this policy is NMT Policy (2015) looked at NMT and that it would help reduce carbon emissions, air and noise pollution. NMT is an alternative, safe and cheaper mode of transport than private vehicles. Stellenbosch centre is mostly flat that contributes to the easy implementation of NMT routes in the centre (Stellenbosch Municipality 2016). This policy strengthens the hypothesis of this research study that NMT is safer and cheaper mode than private vehicles. Furthermore, Stellenbosch centre is already even and NMT routes can be easy implemented for less capital that contributes to that Stellenbosch is a preferred destination for implementing NMT routes. Stellenbosch consists of a young population (university students) and a compact university centre that contributes to the implementation of NMT and a perfect destination. This policy suggest that walkways should consists of lightning and the routes should be integrated that would be take in consideration when planning for these routes in the next chapter.

2.9 STUDENTIFICATION

In this section, studentification will be briefly considered as this term has an impact on university towns. Studentification is when neighbourhoods current residents are being replaced by students (Munro & Livingston 2012). It also refers to the concentration of students in a city or area located near a university (Garmendia, Corondo & Ureña 2012).

Students want to live close to campus and within walking distance to campus. Students would move into neighbourhoods that are close to campus when accommodation becomes limited on campus. In Nottingham high-quality middle-class neighbourhoods was being occupied by students as student numbers grow and accommodation became scarce. This leads to a wide

variety of culture and class in a town. This brings changes in neighbourhoods as well as communities (Table 2.1). Students are flexible tenants and rent for short term. The housing market cater for the students need, as they are willing to pay high rent for a poor quality housing and is seen as profitable tenants. Residents becomes pushed out of their own communities while students occupy their residents, churches and facilities (Munro & Livingston 2012).

Table 2.1 Evidence of local change (Smith, Sage & Balsdon 2014).

Changes in	Effects on a neighbourhood
Local population	<ul style="list-style-type: none"> High proportion of student residents High levels of annual in and out-migration of students Replacement and/or displacement of established residential population High levels of population density High levels of population transience Depopulation between July and September
Local housing market	<ul style="list-style-type: none"> Reduction inn owner-occupied family housing Increase in shared private-rented housing Increase in short-term rented tenancies Changed fabric and internal structure of housing Escalation of property prices
Residential environments	<ul style="list-style-type: none"> Increase in domestic refuse and litter Lack of parking spaces for private vehicles Changing visual appearance of streetscape and residential environs Proliferation of “to-let” boards Unkempt gardens and yards
Local services and culture	<ul style="list-style-type: none"> Reorientation of retail, leisure and recreational services for student market Closure of public and private services between July and September Relatively high level of burglary and crime Reception of “student” sense of place

Studentification are reshaping the urban space through displacing current residents in neighbourhoods that are located near campuses. This leads to the spatial restructuring and re-organisation of an area in a city. It further results in providing in the needs for students and suburbs developing into student housing as the demand for student housing is high (Munro & Livingston 2012). Students prefer to live in the central part of the city close to campus and

spread out to suburbs around campus when accommodation becomes limited. Suburbs often undergo rezoning to accommodate student housing in university cities. Studentification thus leads to spatial transformation of suburbs (Donaldson et al. 2014).

Studentification results in higher population density and high mobility of students. The increase in the mobility of students results in limited parking (Smith, Sage & Balsdon 2014). Therefore, there is a need to implement NMT to reduce the mobility of students by private vehicles.

3. RESEARCH METHODOLOGY

This section focusses on the data processing and analysis techniques that were used to achieve the research aim and objectives. The research methodology is divided into four phases namely: introduction, data gathering, interpretation and analysing and conclude and summarise the report (Figure 3.1). Relevant literature about NMT, cycling and pedestrianisation were studied throughout the research process. The literature will consist of NMT that would consider pedestrian routes and cycling lanes infrastructure guidelines, location and examples.

Phase one, consisted of the review of international and South African literature to get a better understanding of the concepts and topic. The literature contributed to formulating a problem statement, aim and objectives as well as the research questions of this research study.

Phase two, included, getting hold of the secondary data from SUMS. The SUMS was conducted by making use of a survey. A meeting was scheduled with Prof Krygsman from the logistics department of SU (coordinator of SUMS), who provided the secondary data about SU staff and students mobility patterns and travel behaviour. The target group consists of Stellenbosch University students and staff members. The data was obtained through on-line questionnaire and trip diary that participants filled in for two consecutive days. The electronic questionnaires focused on students and staff members travel behaviour and consists of separate questionnaires for the staff members and students. The questionnaire for students is divided in to four sections namely: about yourself; about private transport usage; public transport and non-motorised modes of transport. The staff member's questionnaire consists of the same sections as the students' questionnaire except it includes sections about their household and SU shuttle services. The data was collected during the second semester during September and October. It was the participant's choice to participate volunteering in the survey and they will stay anonymous. The secondary data is in the form of text and numeric values. Therefore, a qualitative and quantitative research strategy was made use of.

According to SUMS there has been a growth in student numbers that contributed to the lack of vehicular parking, illegal parking and traffic congestion in and around Stellenbosch university. The SUMS was compiled in 2010, and proposed the use of non-motorised transportation and an increase in parking charges would increase the cost of private transport. This could change individual's perspective about using private transport and encourage them to switch to non-motorised transportation or shuttle services (VELA VKE 2010). Therefore, this research study identifies and analyse the mobility pattern of students on and around Stellenbosch campus and

the routes that are the most utilised by students for potential future implementation of non-motorised transportation and potential pedestrian routes. Non-motorised transportation would lower the carbon footprint of the University and cycling and pedestrian routes would help reduce the number of vehicles around campus.

Phase three, consisted of the analyses of the data where the data and findings were represented visually in graphs and tables that was created in Microsoft Excel and Microsoft Word. Maps that illustrate the data were created in ArcMap through the spatial statistics tool (Hot spot analysis). Lastly, phase four, is the concluding phase where the findings and literature will be studied together to formulate a conclusion, to finalise the research report as well as to mention the limitations and recommendations of this research study.

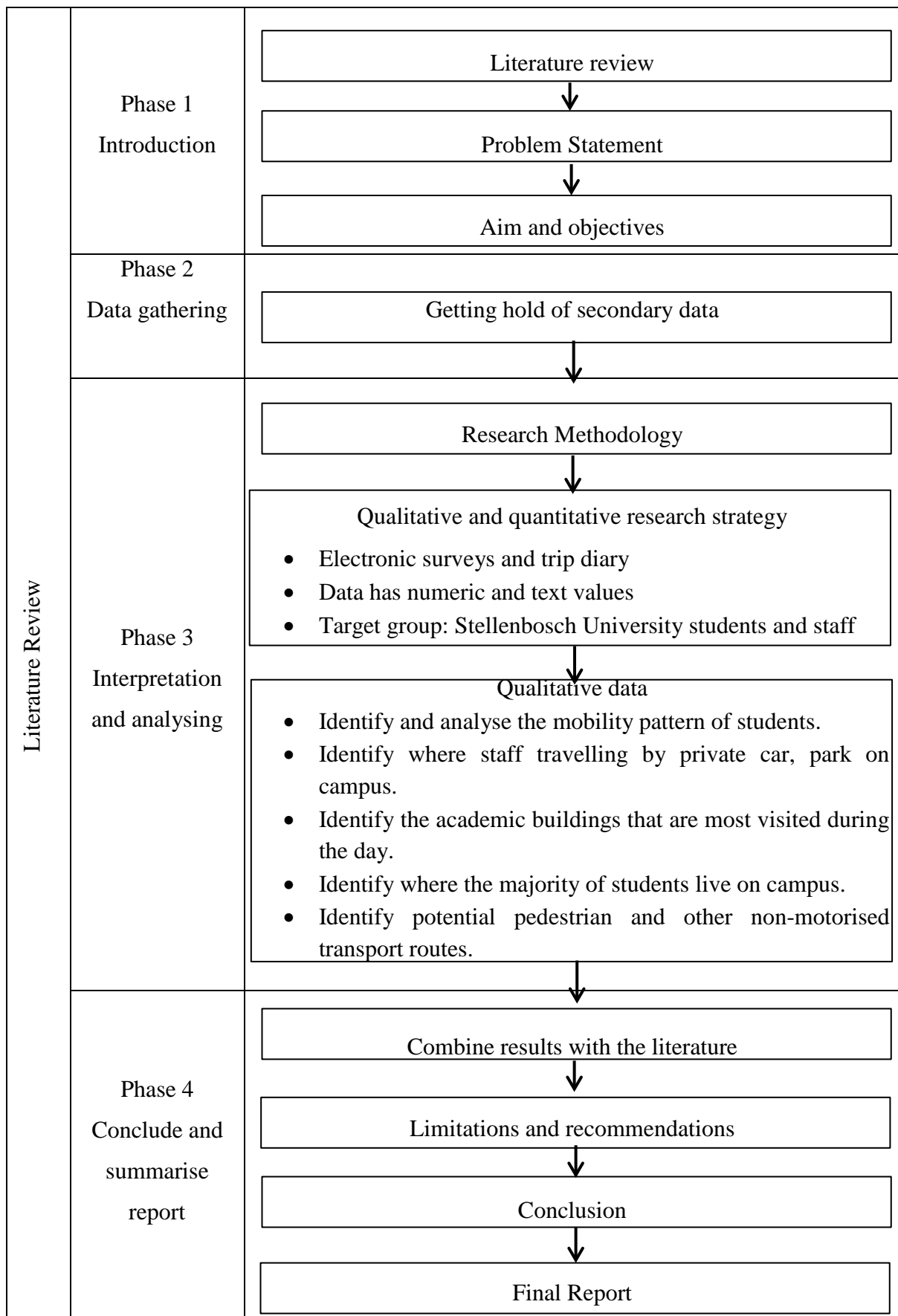


Figure 3.1 Research design

4. DATA ANALYSIS AND RESULTS

In this section, secondary data about the mobility patterns of Stellenbosch University staff members and students are discussed to identify whether they make use of alternative transportation modes like walking and cycling. The main aim of this study is to analyse the mobility patterns and distances of students and staff members around Stellenbosch University using the Neelsie as the centre point of SU. Firstly, where the majority of students live on campus was identified. Secondly, look at the type of transport modes staff members make use of. Thirdly, look at the type of transport modes students make use of. Fourthly, identify where students traveling by car, park on campus and identify whether students make use of the shuttle services. Lastly, the non-motorised transport modes students and staff members make use of and what would encourage them to make use of alternative transport modes was discussed. Looking at the mobility patterns of students on and around campus would help contribute to effective implementation of infrastructure and non-motorised transport routes.

4.1 RESIDENCE OF THE MAJORITY STUDENTS

Of the total records 60% of the students, live within a radius of 1.2 kilometres from Stellenbosch University campus (Figure 4.1). A further, 15% of the students live within 2.5 kilometre from the campus. While only 8% live within 5 kilometre of the campus and 15% of the students live between 20 and 40 kilometre from the campus. Looking at the outcome, NMT routes should be extended to the accommodation within 1.2 kilometres of campus to reduce the number of private vehicles.

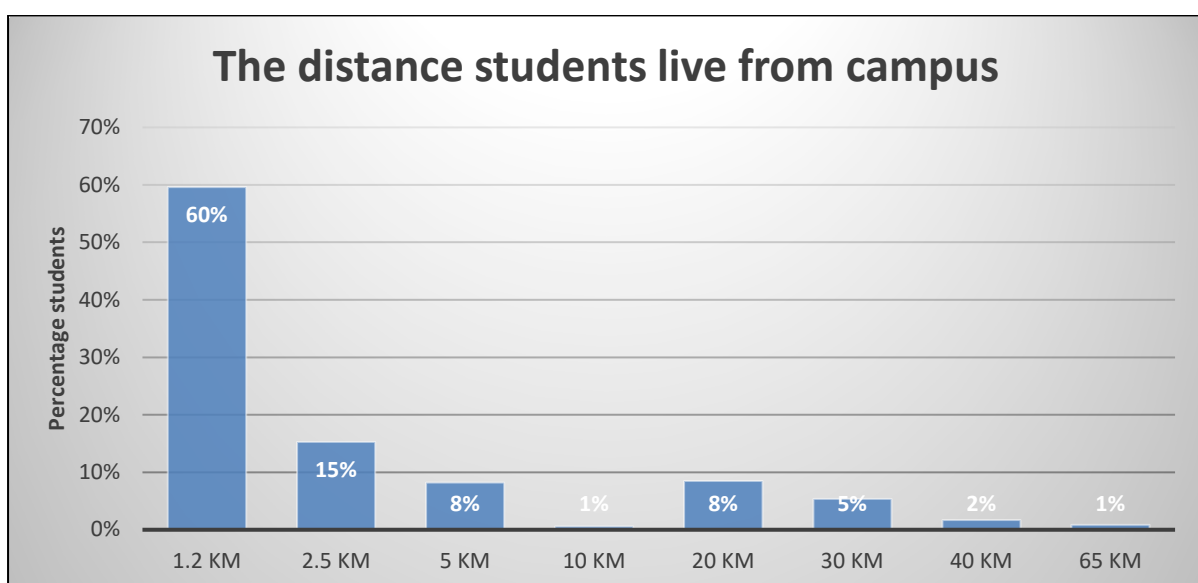


Figure 4.1 The distance students live from campus.

Figure 4.2 below indicates where the majority of students live, and it creates the opportunity to implement non-motorised transport routes from their residence to campus academic buildings. This map spatially represents where the NMT routes could work. The majority of students live in university housing and stay in private housing within 5 kilometres from the Neelsie (Figure 4.2). This could result in 75% of the students living within 2.5 kilometres can have access to NMT routes.

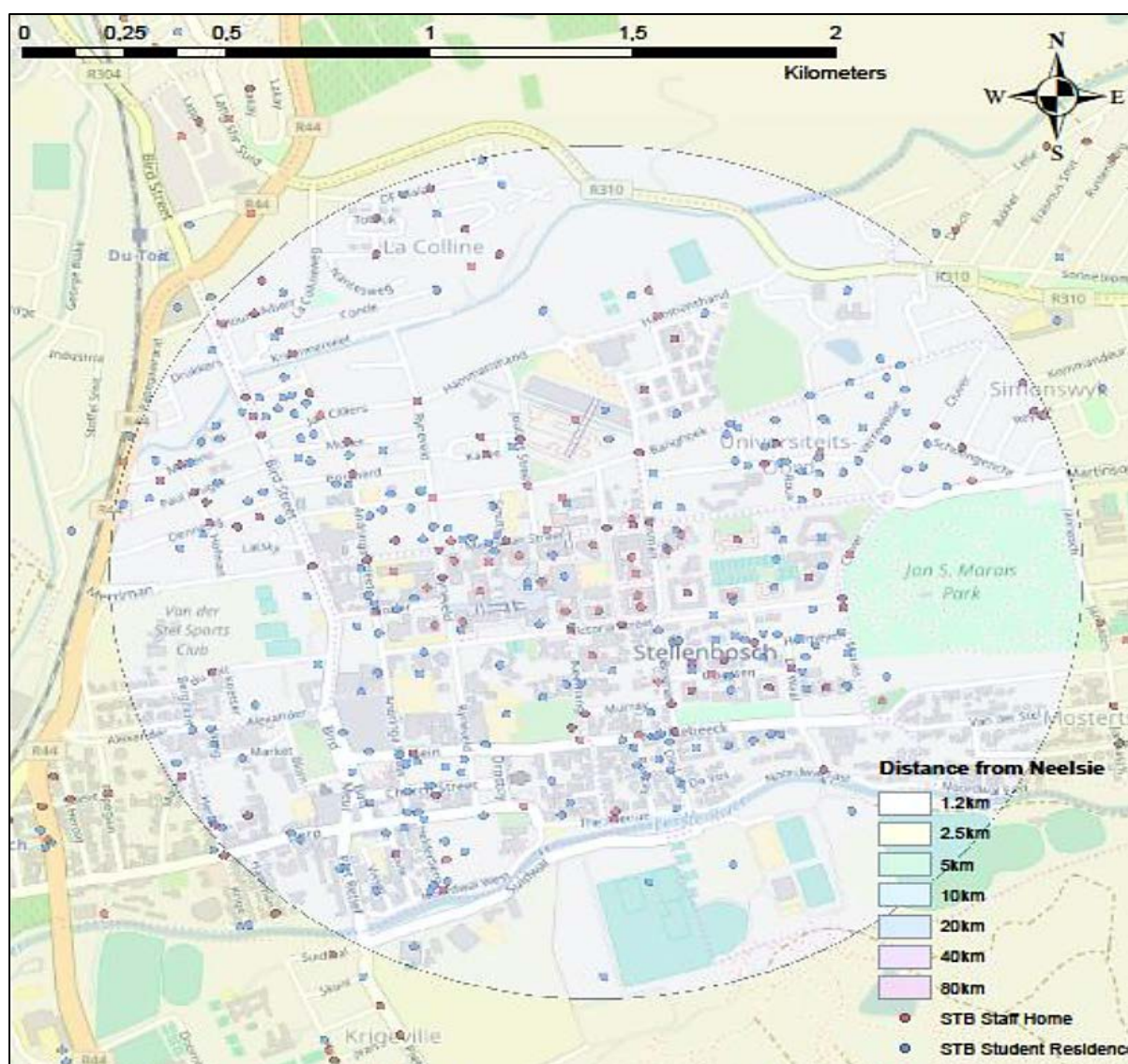


Figure 4.2 Where the majority of student live.

In contrast looking at the residence of Stellenbosch University staff members, only 37% of the staff live within 10 kilometres of the campus (Figure 4.3). Three fifths of the staff members live within 20 kilometres from the campus and the majority (92%) of the staff live within 40 kilometres of campus. By looking at the figures of the distance staff members have to travel, it

is more difficult to implement NMT routes within 40 kilometres of the campus. The positive aspect is that there is enough parking space within the centre of the campus to accommodate the current staff members and for the future growth of staff members. Allocated central campus parking space are on average 70% occupied. Allocated parking is well managed and can accommodate future staff growth (Venter et al. 2018).

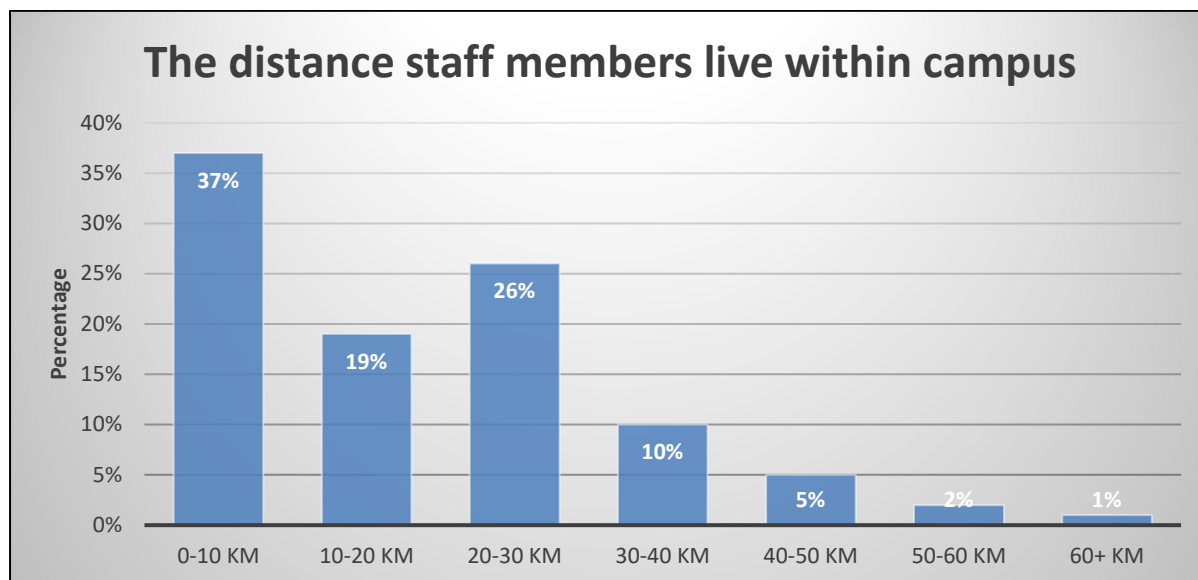


Figure 4.3 The distance that staff members live from campus.

As mentioned above the central allocated parking areas can accommodate the staff members and future growth, but the main issue is there is limited parking for the amount of students that make use of private vehicles to campus. But from the outcomes above students are the ones that live close to campus and they are the ones that need to be encouraged to make a mind shift to switch from private vehicles to alternative transport methods if it is accessible. To encourage students to make use of NMT, functional pedestrian and cycling routes need to be implemented to link the accommodation that are within 1.2 kilometres of campus to Stellenbosch University campus. This can be done by upgrading the existing infrastructure of Stellenbosch to improve NMT routes. This will be discussed in more depth later in the chapter.

4.2 TRANSPORT MODE FOR STELLENBOSCH STAFF MEMBERS

Looking at the distance that staff members travel to campus aids in better understanding that NMT routes would be difficult to implement for staff members. Only a small percentage (37%) of the Stellenbosch University staff travel 10 kilometres or less to campus (Figure 4.4). While the majority (92%) of the staff members travel within 40 kilometres to work (Figure 4.4).

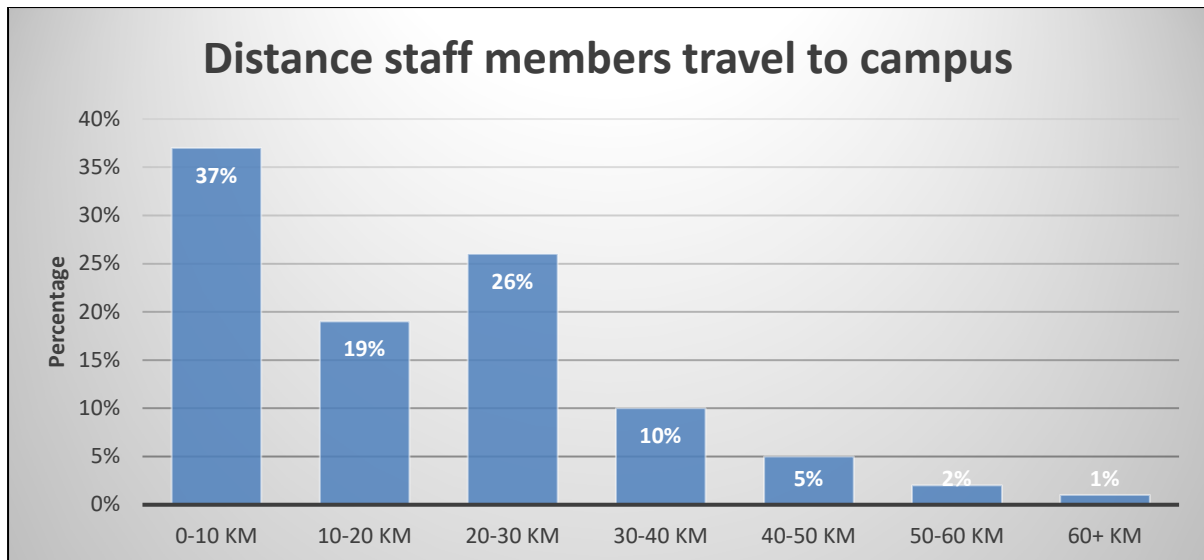


Figure 4.4 The distance staff members travel to campus.

Of the total 37% of staff that live within 10 kilometres of campus, only 32% of them utilise private vehicles (Figure 4.5). Therefore, the staff members that travel within 10 kilometres to campus, will be the main target group of the research study.

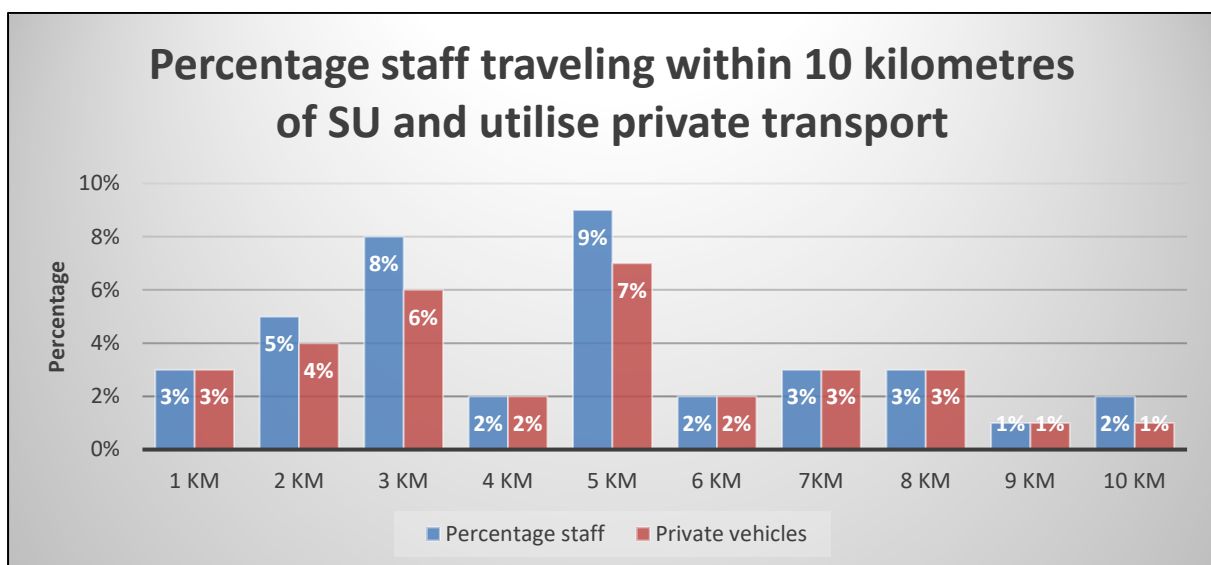


Figure 4.5 Percentage staff members within 10 kilometre of SU that utilise private vehicles.

By analysing the secondary data, the reason that Stellenbosch staff members make use of private vehicles is, because it is the most convenient option (63%), it is the quickest option (61%) and it is the safest option (33%). Also 35% of the staff requires their private vehicle for work. This finding links with Toor & Havlick (2004) found that automobile dependency is a reality of the twenty-first century. According to 61% of the staff members, they make use of private vehicles because there is lack of alternative transport options. Toor & Havlick (2004)

found that automobile dependency can be addressed by providing people with sustainable transportation options and automobile-free lifestyle options. By looking at the results, alternative transport options are limited and there is a need for alternative transport options to reduce the numbers of private vehicles.

A high number of staff members make use of private transport, but there are factors that will help contribute to the decrease in utilisation of private vehicles. The reasons for staff members specifically that would contribute to the decrease in utilisation of private vehicles are affordable alternatives (53%), reduction in monthly transport costs (46%) and to avoid peak hour congestion (35%) as illustrated in Figure 4.6 below. Individuals would make use of alternative transportation modes if it is reliable and on time. The results links with De Vos (2015) findings that the use of vehicles brings issues such as congestion, limited parking and air pollution that people would try to avoid. If alternative transport modes existed that are reliable and transport them directly to their work, individuals would avoid congestion by making use of alternative transport modes. Staff members would decrease the utilisation of private vehicles if the cost of parking increases and the number of parking space decreases (Figure 4.6).

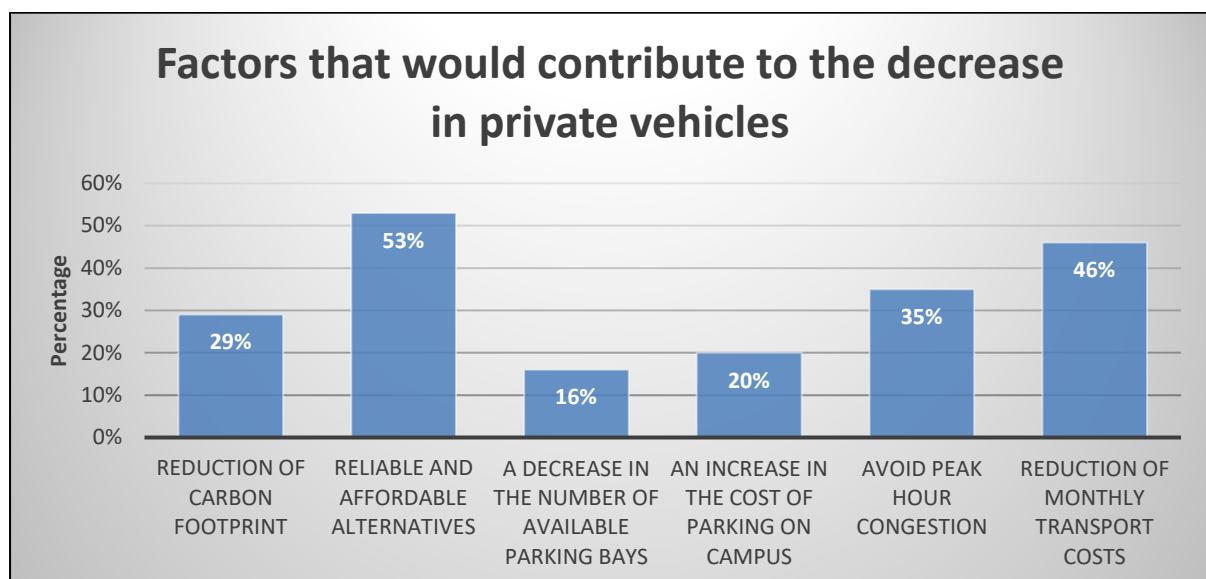


Figure 4.6 Factors that would decrease the utilisation of private vehicles.

4.3 TRANSPORT MODE FOR STELLENBOSCH STUDENTS

First, by looking at the distance students travel to campus would determine the transport mode they make use of. The majority of students travel within 10 kilometres or less to campus (Figure 4.7).

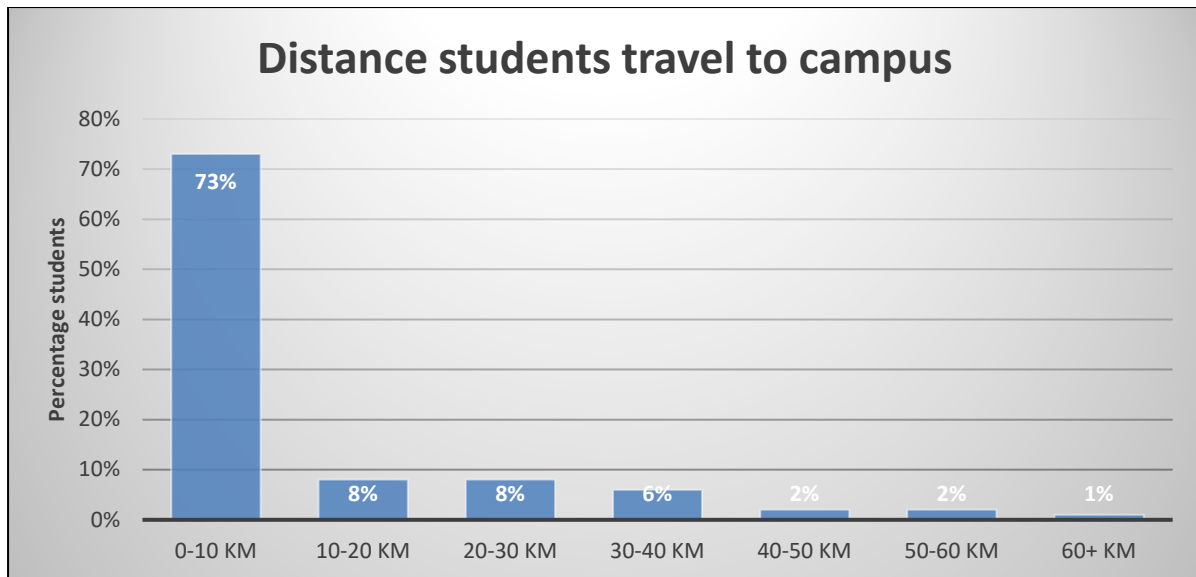


Figure 4.7 The distance students travel to campus.

The majority of students travel 10 kilometres or less to campus therefore in Figure 4.8 below it was important to break down the 10 kilometres from 500 metres to 5 kilometres to illustrate the percentage of students that travel only up to 5 kilometres to campus.

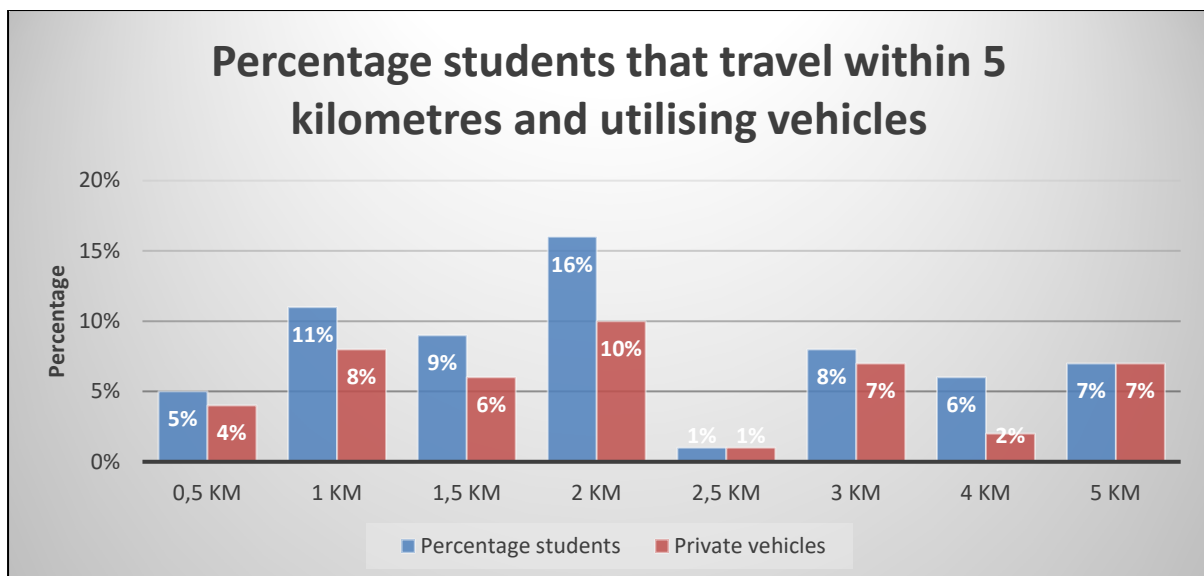


Figure 4.8 The percentage students within 5 kilometres of SU and utilise private vehicles.

As mentioned above students prefer to live close to campus to be within walking distance to campus. By looking at the results, students prefer to live close to campus as the majority of students travel up to 5 kilometres to campus. This outcome links with the comprehensive integrated transport plan (2016) suggestion that individuals that are within 5 kilometre of their education institution, they would most likely make use of NMT. By breaking the results further

down 45% of the 63% of the students that travel up to 5 kilometres to campus, utilise private vehicles. Thus, the students that travel up to 5 kilometres to campus, will be the target group for the research study and needs to be encourage to utilise NMT.

By looking at the type of private transport mode students within 5 kilometre from Neelsie make use of, is private vehicles the most utilised (Figure 4.9). Students make use of lift clubs as 18% of the total students sample are only passengers and 6% of the sample make use of ride sharing (Figure 4.9). An interesting result was that 25% of the total student sample do not make use of private transport to travel to campus. It is thus, a lower percentage individual that needs to be encourage to decrease the utilisation of private vehicles and increase the utilisation of alternative sustainable transportation. This would be discussed next.

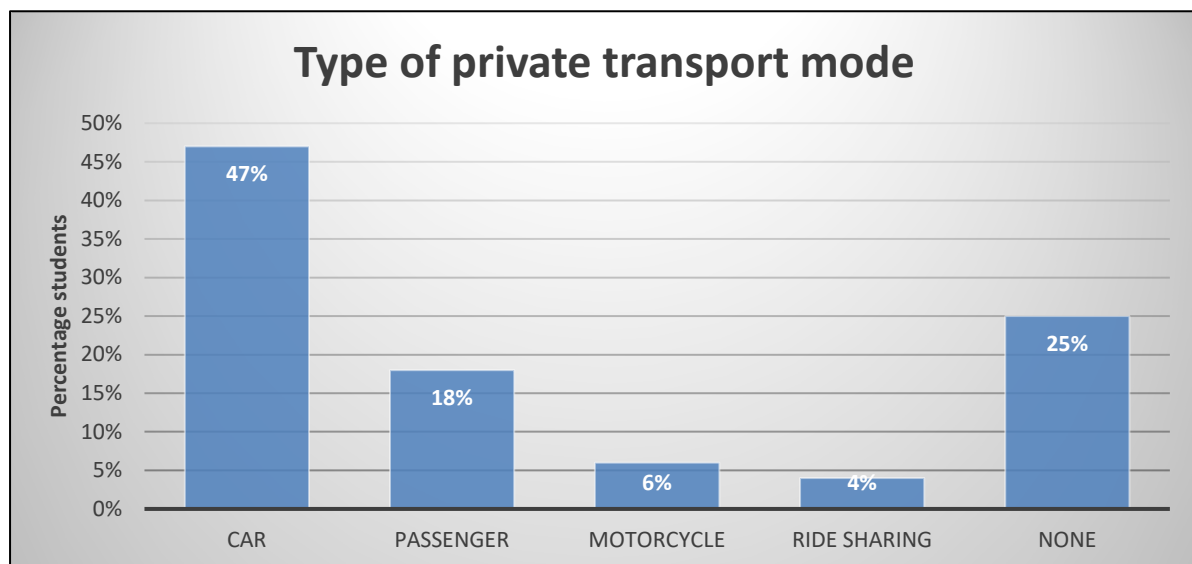


Figure 4.9 Type of private transport mode students within 5 kilometres radius utilise.

By analysing the secondary data, the reason that Stellenbosch students use private vehicles is because it is the quickest option (48%), it is the most convenient option (46%) and it is safer to use (36%). By looking at the results, alternative transport options are absent and there is a need for alternative transport options to help reduce the numbers of private vehicles.

Figure 4.10 illustrates that 45% of the students indicated that if there were alternative non-motorised transportation options it would decrease their usage of private vehicles. The reduction in monthly transport costs would decrease the usage of private vehicles under students. Students would reduce the usage of private vehicles to avoid peak hour congestion (31%), to reduce their carbon footprint (26%) and the reduction in parking bays would help

contribute to the decrease in utilisation of vehicles (24%). Another interesting factor that would reduce the usage of private vehicles are if the cost of parking on campus increases (figure 4.10). This links with the IDP car free living suggestion, to address the increasing congestion in Stellenbosch, there is a need to implement strategies to reduce congestion such as congestion fees and parking costs (Stellenbosch Municipality 2017). Looking at the outcome, there was found that the reduction in parking bays would result in people finding an alternative choice of transport. Furthermore, students would reduce the usage of private vehicles if parking costs increases.

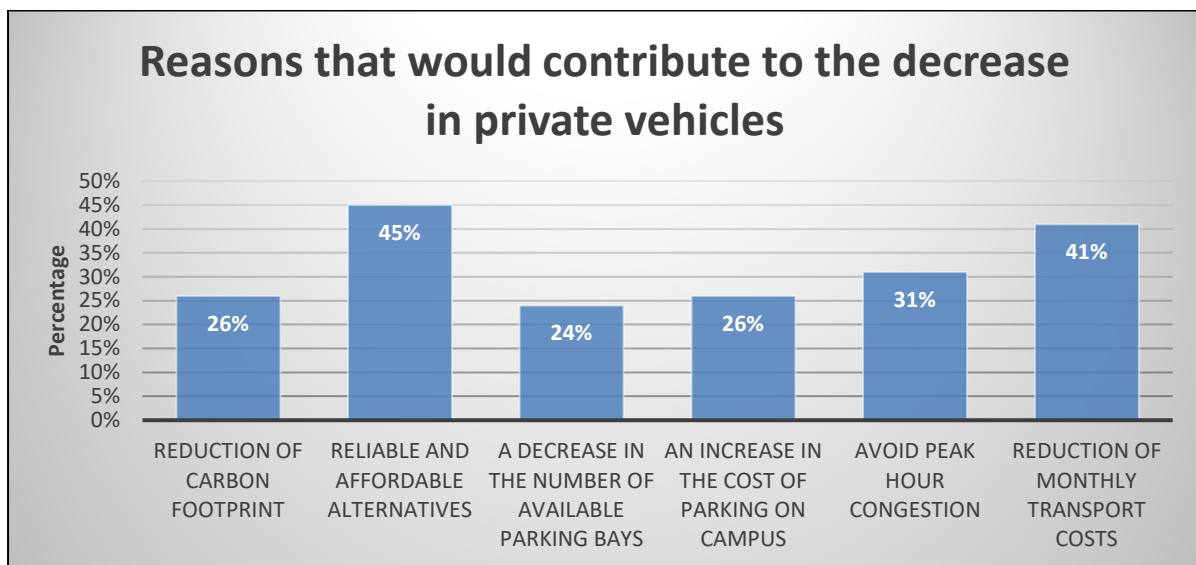


Figure 4.10 Factors that would contribute to the decrease in private vehicles.

In summary the three major factors that will decrease the utilisation number of private vehicles to campus is: firstly, by implementing alternative transport options. Secondly, the increase in parking bay fee at SU. Thirdly, the reduction in parking space will lead to the reduction in utilisation of private vehicles. Therefore, the preferable outcome would be to identify parking space on the periphery of campus and implement shuttle services to transport students from the parking areas to the academic buildings as alternative transport options and help reduce the amount of private vehicles on campus. Implementing shuttle services would help reduce the distance students have to walk to campus but also help increase the utilisation of parking areas on the outskirts of campus.

4.4 PARKING AREAS

Looking at Stellenbosch University current parking bays, the majority of the central parking on campus is unreserved (Figure 4.11). The parking bays at the hostels (green coloured) are

reserved for the residents only. There are also visitors parking available on the outskirts and central of campus. The blue coloured parking areas in the centre of campus are unreserved parking and are on average the most utilised by student and staff members. While parking areas at the North of campus, at the Engineering building are on average more than half utilised by students and less than half, utilised by staff members. In contrast, the parking area at Coetzenburg (South of campus) is the least utilised. Therefore, this will be considered the future peripheral parking area.

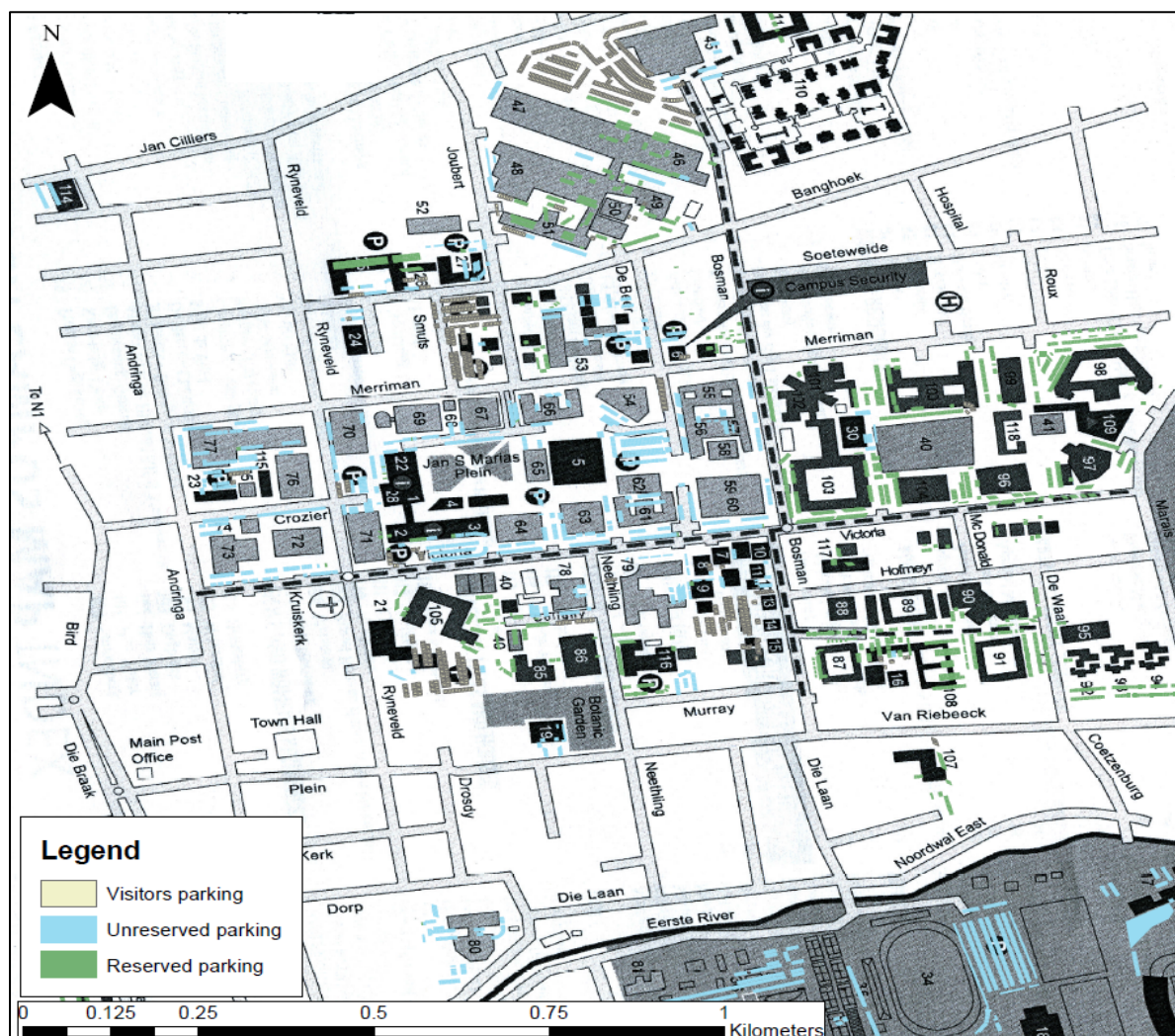


Figure 4.11 Current allocated parking bays on campus.

The blue coloured parking areas in the centre of campus are unreserved parking and researches an average of 70-80% utilisation (Table 4.1) While parking areas at the North of campus, at the Engineering building are on average 50-60% utilised during week days. In contrast, the parking area at Coetzenburg (South of campus) is the least utilised. Therefore, this will be considered the future peripheral parking area.

Table 4.1 The average utilisation of parking areas.

Allocated parking areas	Percentage average utilisation by staff members	Percentage average utilisation by students
Central campus	70%-80%	70%-80%
South campus	50%-60%	30%-50%
Northern campus	50%-60%	60%-70%

Looking at the Stellenbosch staff members the majority of them travel far distances to work and therefore allocated parking are given to staff members. Only a small percentage staff members have reserved parking but if staff members had a choice more of them would prefer to have reserved parking (Figure 4.12).

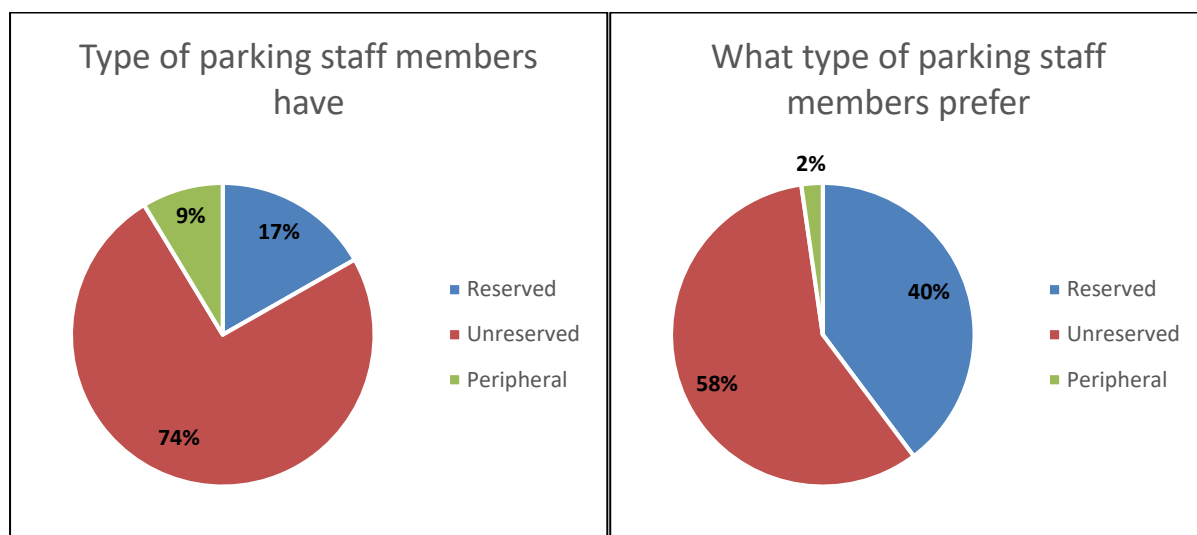


Figure 4.12 Type of parking staff members have and would prefer.

Parking space is limited on campus and with the increasing academic buildings, land availability to develop more parking space is limited. To address the parking limitation on campus staff members and students were asked whether they would choose to park on campus at a higher fee or at the periphery of campus for a lower fee and make use of the shuttle service to their office. There was found that, staff members and students would prefer parking at the peripheral of campus at a lower cost than parking at the centre of campus for a very high fee (Figure 4.13). Further, staff members and students would make use of the Matie shuttle services to travel to the academic buildings from the peripheral parking areas. When parking bays'

prices increases students would find an alternative mode of transport because not everyone can afford the increase in cost of private transport.

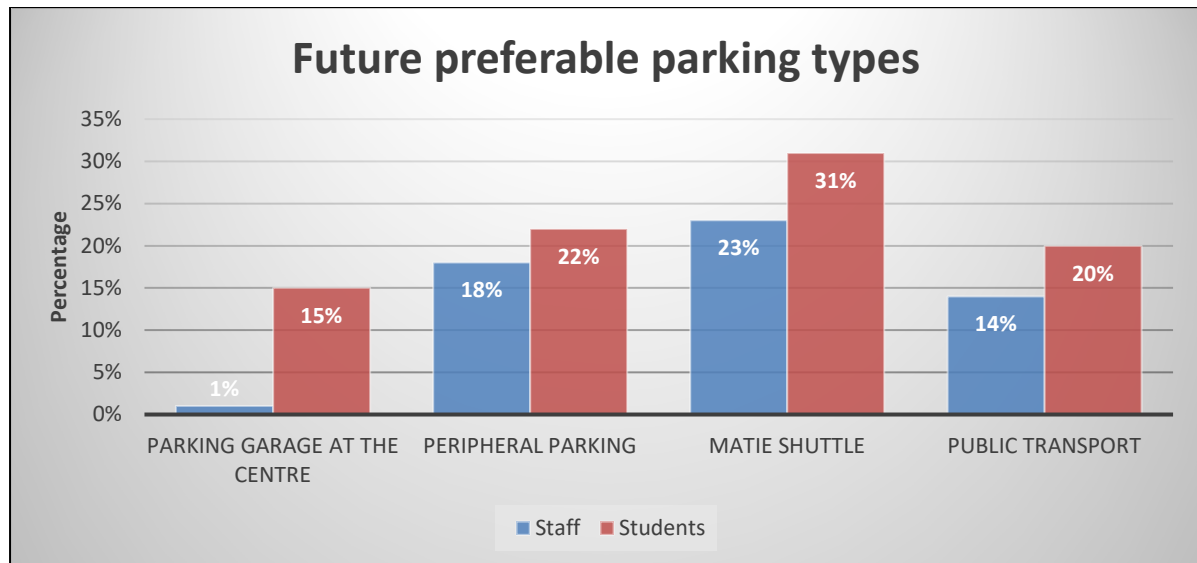


Figure 4.13 Future parking preference.

Looking at the results the solution would be to shift parking areas to the periphery of the campus. The parking area should be shifted to the South of campus at Coetzenburg as this parking area is the least utilised and has the capacity to accommodate future vehicle growth. If students have to walk further to campus they would less likely make use of the parking space and find an alternative transport mode. The outcome links with this research study hypothesis that, the major problem is that there is limited land and space available to develop new car parking lots and it is expensive to build parking structures. A solution would be to develop parking areas on the periphery of the university and students travel by busses from the parking areas to the campus that would reduce the traffic flow on campus.

4.4.1 Shuttle services

Creating parking on the periphery would reduce the traffic on and around campus that would contribute to a more pedestrian and cycling friendly environment. To make this work, shuttle services could be extended so that the peripheral parking areas are linked to the centre of campus and academic buildings. Another suggestion is to extend NMT routes, to link the peripheral parking areas with the centre of campus so that students have a choice of transport mode. Stellenbosch University has a day and night shuttle services. The day services run between 07:00 and 17:30 during the week. These shuttles have specific drop off and pick up points so that students can know where to wait. The number of students utilising the day

services has increased from 2013 to 2016 (Table 4.2). The night services are between 18:00 and 02:00 that pick up students that work late and drop them off at their residence as long as it is within 6 kilometre of the centre campus. The majority of students live within 5 kilometres of campus and thus can they rather make use of the shuttle services than vehicles.

Table 4.2 Number of students utilising the shuttle service.

	2013	2014	2015	2016
Average number of passengers transported daily	400	480	550	670
Average number of students transported nightly	200	220	150	186

The reason for providing parking on the outskirts of the campus is because central campus parking on average reaches 70%-80% utilisation during the weekdays. But, when parking bays become too far from the campus, students would find an alternative mode of transport. That brings us to another question for staff members and students whether they would make use of the shuttle service if parking areas are shifted to the periphery of campus to address the parking issue. There was found that, 73% of the staff members would make use of the shuttle services from the parking areas to their office (Figure 4.14). While more students (77%) would make use of the shuttle services to campus (Figure 4.14).

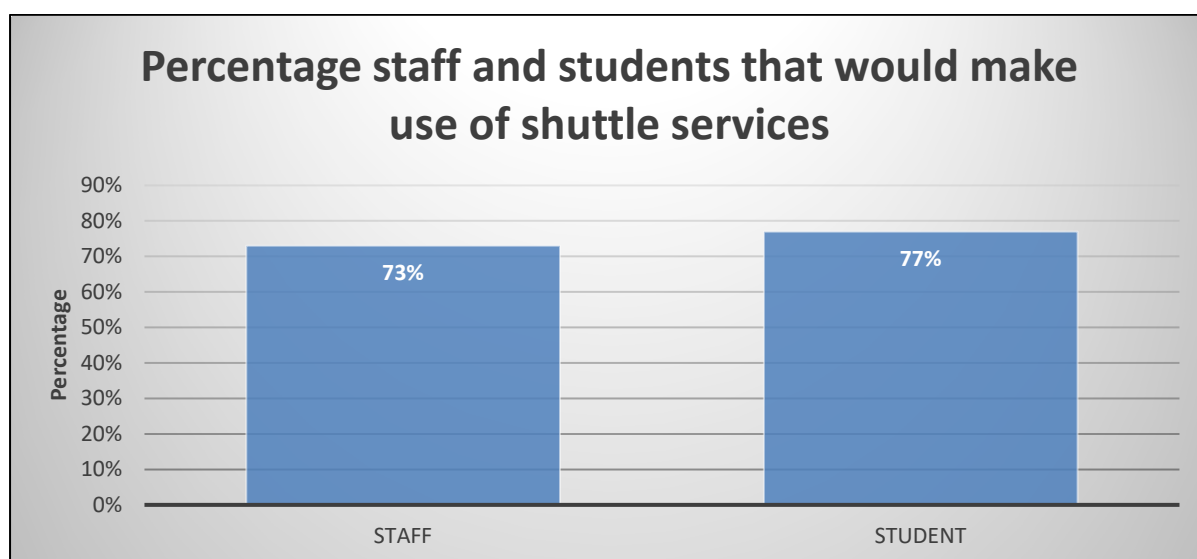


Figure 4.14 Illustrates the percentage staff members that would make use of the shuttle services if it is properly implemented.

Looking at the important factors that would increase the number of individuals to make use of the shuttle services was it should include reliable services (20%). Individuals want to be

ensured that they would have a transport mode from their car to the campus and a lift back if they work late or if students have practical's later than normal. Individuals are safety concerned and they want their minds at ease that they would have a guaranteed ride back to the parking bays. Safe pick and drop off points have to be available for individuals where they can feel safe to wait for a shuttle. Location is important and therefore safe waiting posts have to be develop at the centre of campus where there is many people and people can feel safe to wait for a shuttle. This links with the literature review in section two, that weak planning of physical development will reduce the level of accessibility and usage. The ideal location would include routes that the majority of students make use of and are the shortest routes. It is also important that there is various drop off and pick up points to reduce the distance people have to walk from the waiting point to the academic buildings.

4.5 NON-MOTORISED TRANSPORTATION FOR STAFF MEMBERS

Staff members travel further distances to campus than students, but looking at the reasons why staff members do not make use of alternative transport options are mainly because of the overcrowding conditions on minibus taxis (72%); public transport are unreliable (62%) and the poor safety conditions of public transport, scare people to make use of public transport (57%) as illustrated in Figure 4.15 below. In Figure 4.15, staff members indicated that because there are no bicycle lanes people do not make use of cycling to campus.

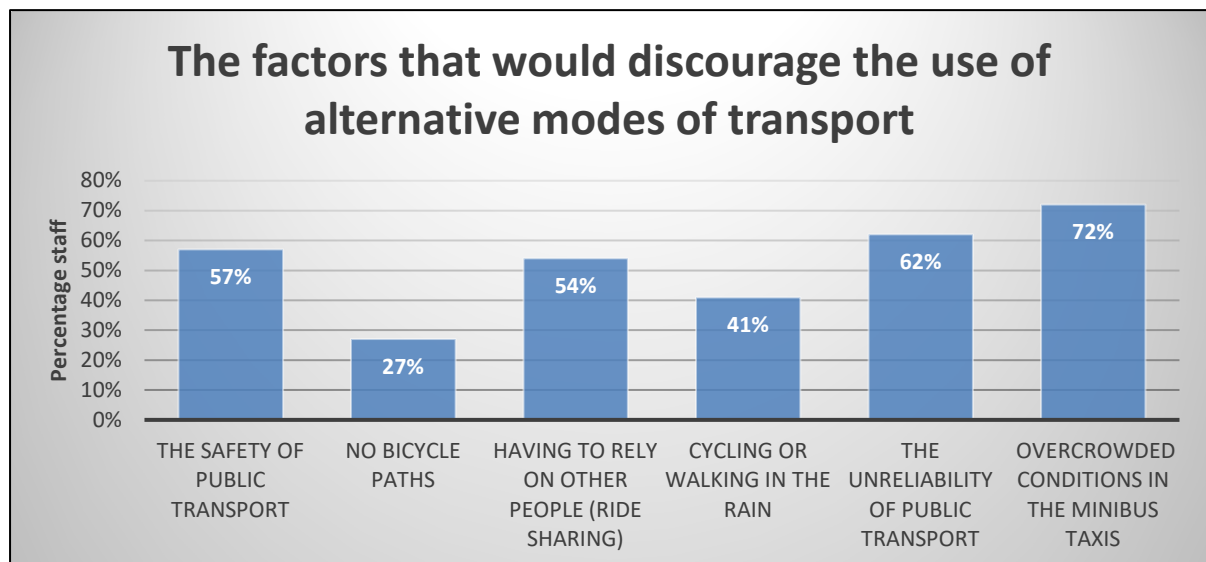


Figure 4.15 The reasons that would discourage staff members to make use of alternative transport modes.

Staff members live too far from work to consider making use of alternative sustainable options (Figure 4.16). A few (15%) of the staff members would consider cycling to work and therefore the factors that would contribute to the increase in cycling under staff members would be discussed next.

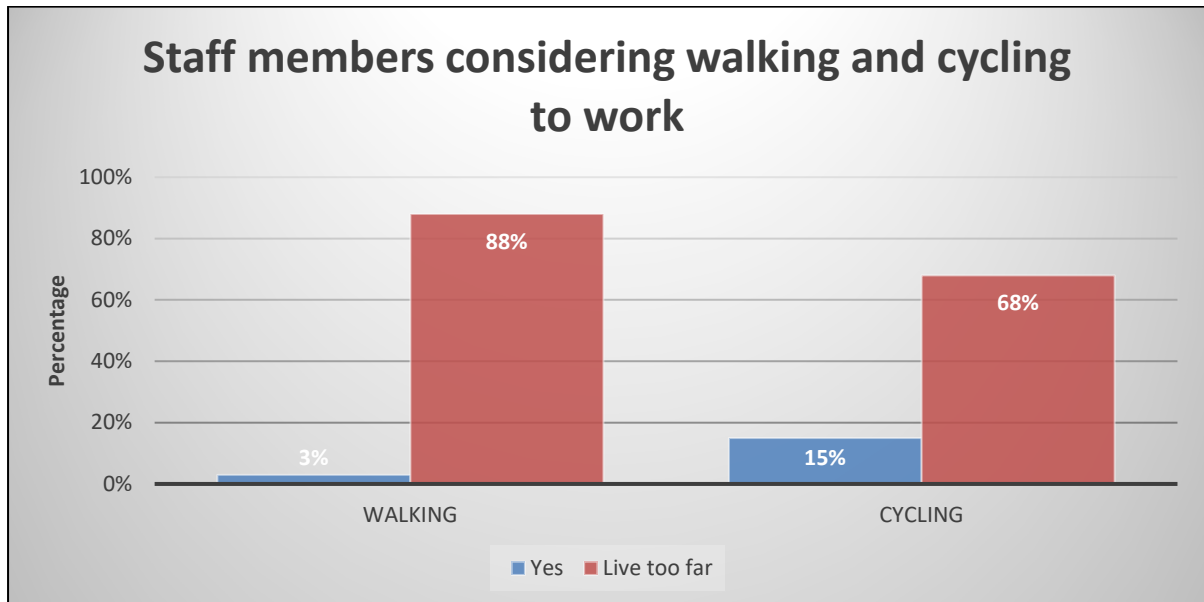


Figure 4.16 Percentage staff considering alternative transport modes.

Secure bicycle sheds are important to staff members before considering cycling to work (32%) as illustrated in Figure 4.17 below. In the global South issues such as safety and security is a major problem and factors that contribute to the discouraging of NMT modes (Wardlaw 2014). Individuals are afraid that their bicycle will be stolen and therefore there is a need for secure bicycle sheds and lockers to lock their bicycle away for the day. A solution would be to provide indoor bicycle rooms or outdoor bicycle shelter that can only be accessed through controlled magnetic strips on student and staff member's cards at the centre of campus, would help reduce bicycle theft. In Figure 4.17 below the second most important factor that needs to be addressed before staff members consider cycling to work is safe and clearly marked bicycle lanes. People are afraid to share the road with fast moving vehicles. This could be addressed by upgrading the current pedestrian sidewalk in Stellenbosch by adding clear marked cycling lanes. The sidewalks will consist of a pedestrian lane and clearly marked cycling lane to encourage the utilisation of NMT.

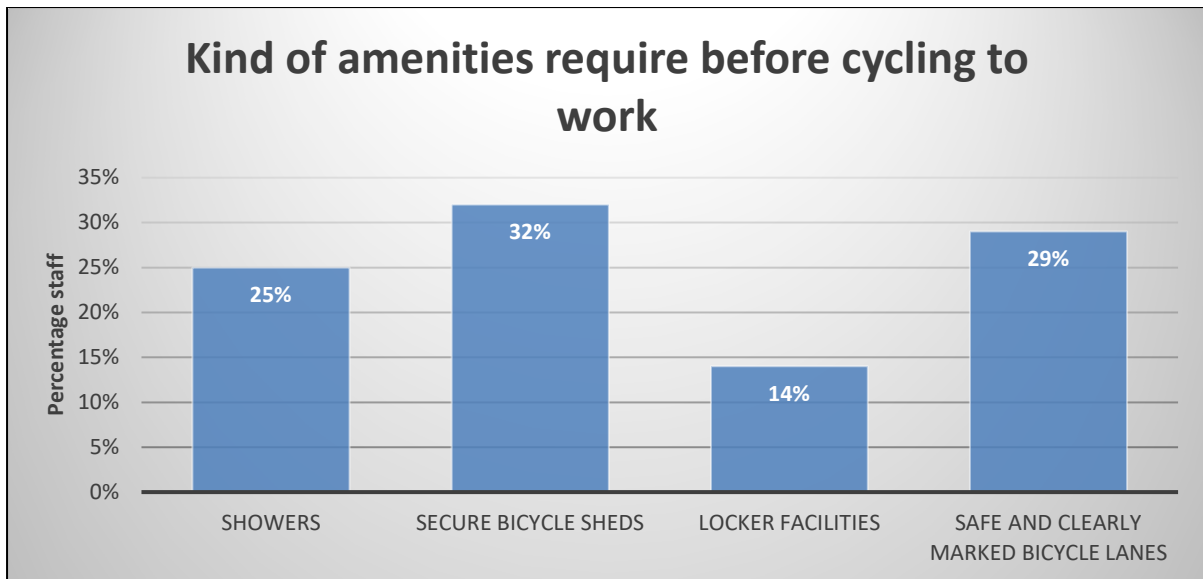


Figure 4.17 Type of amenities staff members required before cycling to work.

4.6 NON-MOTORISED TRANSPORTATION UNDER STUDENTS

Students live closer to campus and therefore have to travel a shorter distance to academic buildings and are their usage of alternative sustainable transport higher than for staff members. More than half of the students live within 5 kilometres to campus and 40% of the students walk to campus daily (Figure 4.18). Many cities are car orientated and therefore cycling and walking will be a second choice (Crane et al. 2016).

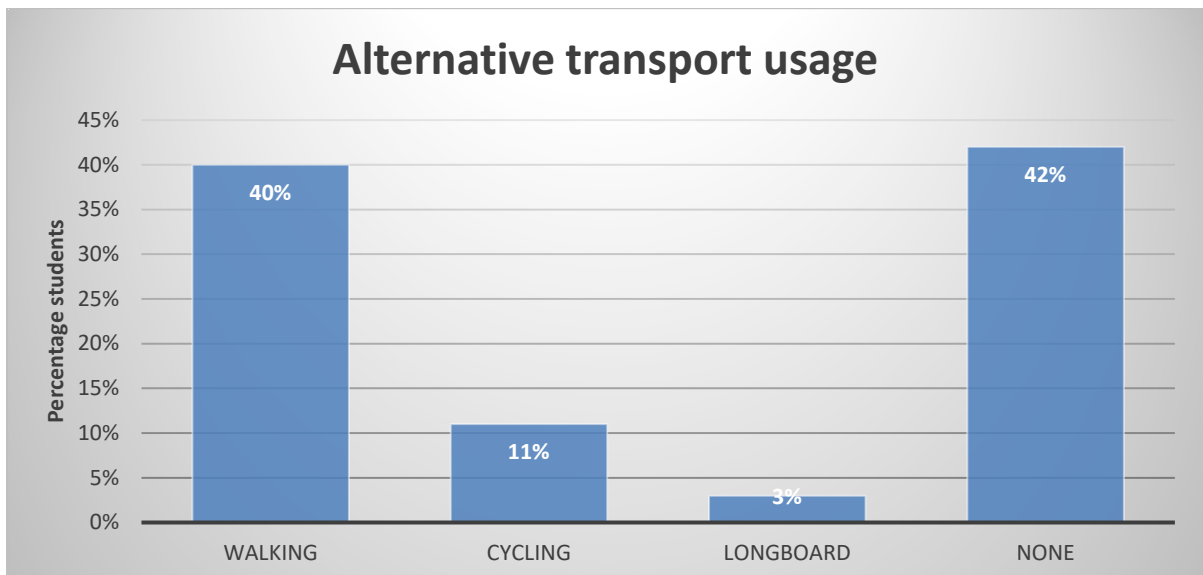


Figure 4.18 Alternative transport mode utilisation by students.

As mentioned above the majority of students walk to campus, but cycling under students are still low and therefore there is a need to identify how can cycling under students be increased.

Only a few (25%) of the students consider cycling to campus while the majority of the students think they live too far to cycle to campus (Figure 4.19). The implementation of bicycle lanes between the faculties, residents and parking facilities would help improve mobility and increase in the utilisation of bicycle and pedestrian routes.

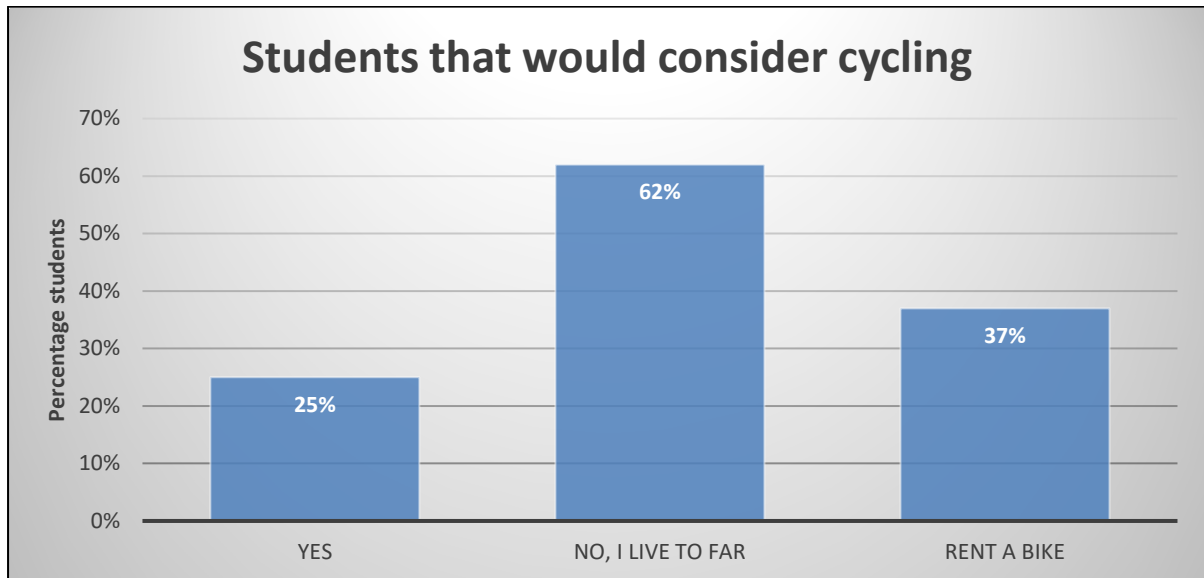


Figure 4.19 Percentage students that consider cycling to campus.

Looking at the factors why so few students would consider cycling to campus is because there are no clear bicycle lanes (Figure 4.20). By implementing segregated cycling and pedestrian routes will help encourage individuals to make use of non-motorised transportation. If separate infrastructure is developed and would ensure safety to individuals, more people would make use of non-motorised transportation because parking space is a limitation. For example, a study at Colorado indicated that students using bicycles increased when the university invested in infrastructure for bicycles and the result were that trips made by vehicles decreased from 49% to 36% (Toor & Havlick 2004). The second most important factor that would increase the utilisation of bicycles are the implementation of secure bicycle sheds and locker facilities. Providing indoor bicycle rooms or outdoor bicycle shelter that can only be accessed through controlled magnetic strips on student cards at the centre of campus would help reduce bicycle theft. Looking at the outcome there was found that, the reason why few students make use of bicycles was that they are afraid of bicycle theft as well as bicycle lanes are absent near campus.

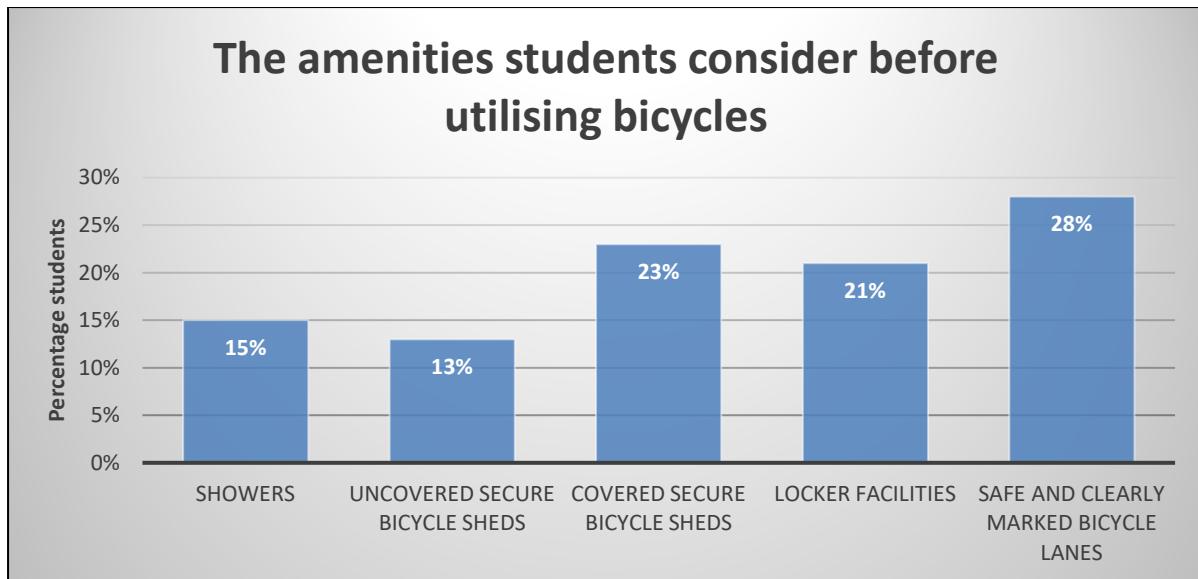


Figure 4.20 The factors that will contribute in the utilisation of bicycles under students.

The research study found that, bicycles under students are underutilised because they are afraid of bicycle theft as well as bicycle lanes are absent near campus. Secure bicycle parking needs to be implemented for students before they would utilise bicycles to commute to campus. Further, implementing bicycles lanes that are paved next to the pedestrian walkways to separate the NMT routes from each other and the roads would ensure safety. This will be discussed next.

4.7 FUTURE NON-MOTORISED TRANSPORTATION PLAN FOR STUDENTS

The research study found that cycling lanes should be implemented to increase the utilisation of NMT. Secure bicycle sheds and lockers should be provided on central campus to combat theft before individuals will consider cycling to campus. Furthermore, parking on the periphery of campus at a lower cost would be utilised above expensive central parking and individuals would make use of shuttle services to travel from the peripheral parking areas to the centre of campus. This research study findings links with the United Kingdom towns, cycling programme that consists of implementing safe cycling parking; integration of NMT routes with the parking bays on the outskirts; bike sharing programmes; restrictions on private vehicles usage and ownership and education to cyclist and pedestrians (Wardlaw 2014).

4.7.1 Most utilised buildings and routes at SU

The academic buildings of US that are the most utilised by students during the day are indicated in the analysis in Figure 4.21 (i.e. coloured in dark red). The most utilised buildings during the day are located close to each other, contributing to the argument that private vehicles among

students on campus can be reduced by creating peripheral parking together with implementing shuttle services from the parking areas to the centre of campus. This will create a more pedestrian friendly campus and by addressing the limited parking issue US experience.

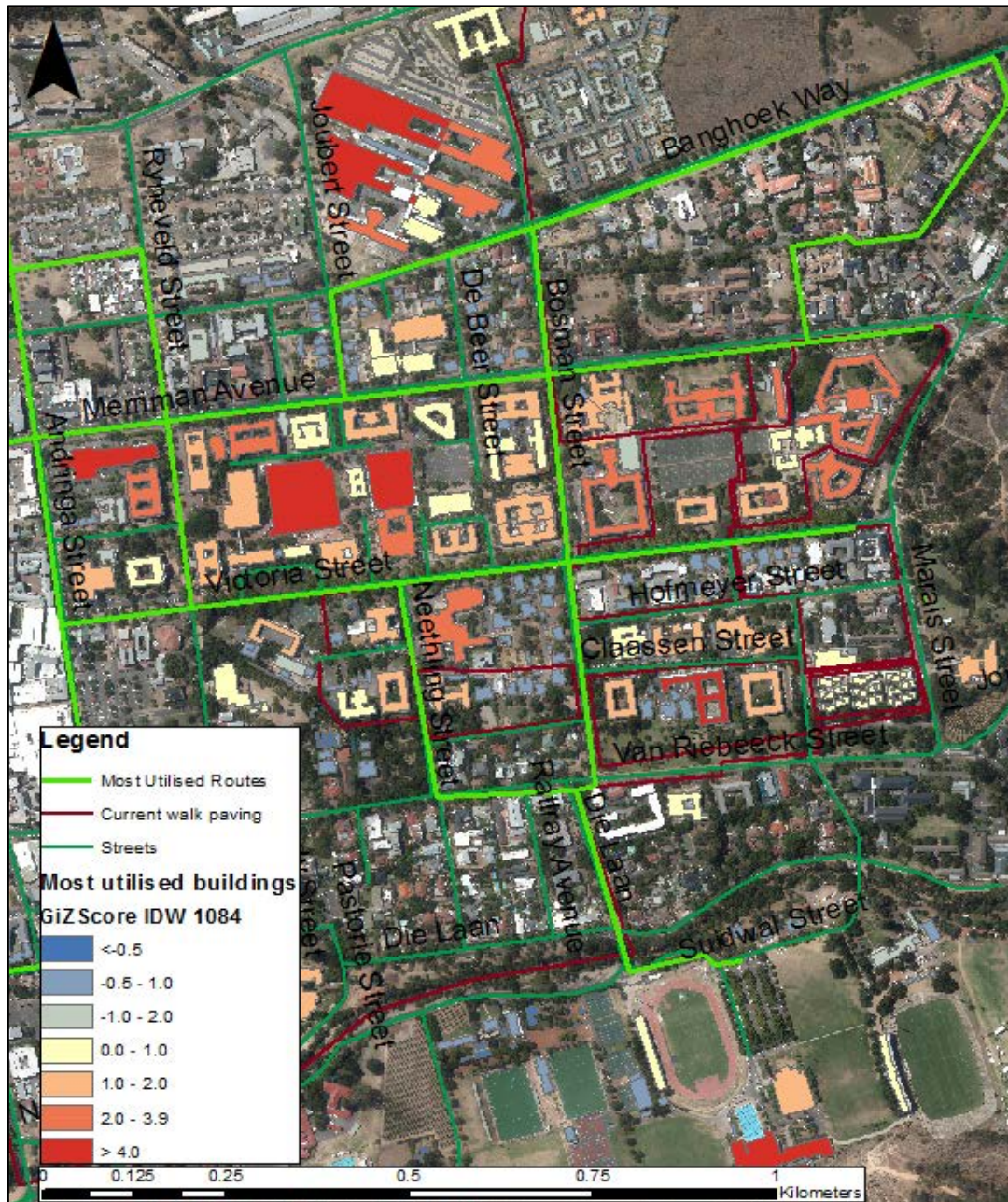


Figure 4.21 Most utilised academic buildings at SU.

By analysing the data, it was found that, the most used routes correlates with the buildings that are the most utilised. Individuals that live at SU hostels more likely make use of Victoria Street to get to campus. While students living in private accommodation near campus make use of Merriman Street and Ryneveld Street to commute to campus. Individuals prefer to make use

of Victoria Street and turn into Bosman Street to get to CGW Schumann and Accounting and Statistics buildings. Individuals make use of Victoria Street and turn into Ryneveld Street to get to RW Wilcocks, Education, Old Main and Arts and Social Science building. Further, students that utilise the academic buildings in Neethling Street and in Victoria Street make use of mentioned streets to commute to these buildings. It was found that individuals make use of Victoria Street and turn into Bosman Street or Joubert Street to travel to the Engineering building, while fewer individuals make use of Merriman Street and turn into Bosman Street to commute to the Engineering building. The academic buildings situated in Bosman Street, Merriman Street, Ryneveld Street and Victoria Street are the most utilised as well as these routes.

4.7.2 Suggested shuttle route and waiting points

Creating parking on the periphery of campus would reduce the traffic on and around campus that would result in a more pedestrian and cycling friendly environment. Coetzenburg has a big parking area that is not utilised at full during the day contributing to the choice as periphery parking space. Another reason for choosing Coetzenburg parking area is it can be converted into a multi-level parking area in the future, if it becomes more utilised. The suggestion would be to expand the parking area and implementing more shuttle services from Coetzenburg parking area to the centre of campus (Figure 4.22). There are current pick up and drop off points on campus but there should be another one added opposite the Arts and Social Science building and between CGW Schumann and Accounting and Statistics, as it is the buildings that are most utilised after the Engineering building (Figure 4.22). Students wish to be covered from rain during the winters and direct heat in the summer season. Waiting areas that include a roof and benches with possible Wi-Fi and mobile application to indicate the location of shuttle from pick up point, will result in more students utilising the shuttle services. The academic buildings situated on Bosman Street, Merriman Street, Ryneveld Street and Victoria Street are the most utilised as well as these routes and that is why this route are chosen for the shuttle services. Another reason for choosing this route is because students traveling between Coetzenburg and campus utilise Die Laan and Bosman Street to commute to campus.



Figure 4.22 Proposed peripheral parking and shuttle services at SU.

4.7.3 NMT route

If the parking areas are moved to the periphery of campus, NMT routes can also be extended to link the peripheral parking areas with the centre of campus. This will provide students with a choice of transport mode. There are already walkways linking the centre of campus to the peripheral parking thus it will be possible to upgrade the infrastructure to functional NMT routes. In figure 4.23 the suggested NMT routes linking the periphery parking space to the centre of campus are illustrated. In Figure 4.23 were the students live on and around campus was created in ArcMap with the spatial statistics tool (Hot Spot Analysis) and the Gi_Bin field classifies the data into a range from -3 to 3, to identify where the majority of students live. Also most of the individuals make use of Ryneveld Street from their residents to get to campus therefore there is a need to upgrade the infrastructure to NMT routes along these routes. Figure 4.23 was created in ArcMap with the spatial statistics tool (Hot Spot Analysis) to identify the buildings that are the most utilised and less utilised by students. The academic buildings situated in Bosman Street, Merriman Street, Ryneveld Street and Victoria Street are the most utilised as well as these routes. Therefore, there is a need to upgrade the sidewalk to

accommodate cyclers and pedestrians to increase the utilisation of NMT to campus and decrease the utilisation of private vehicles.

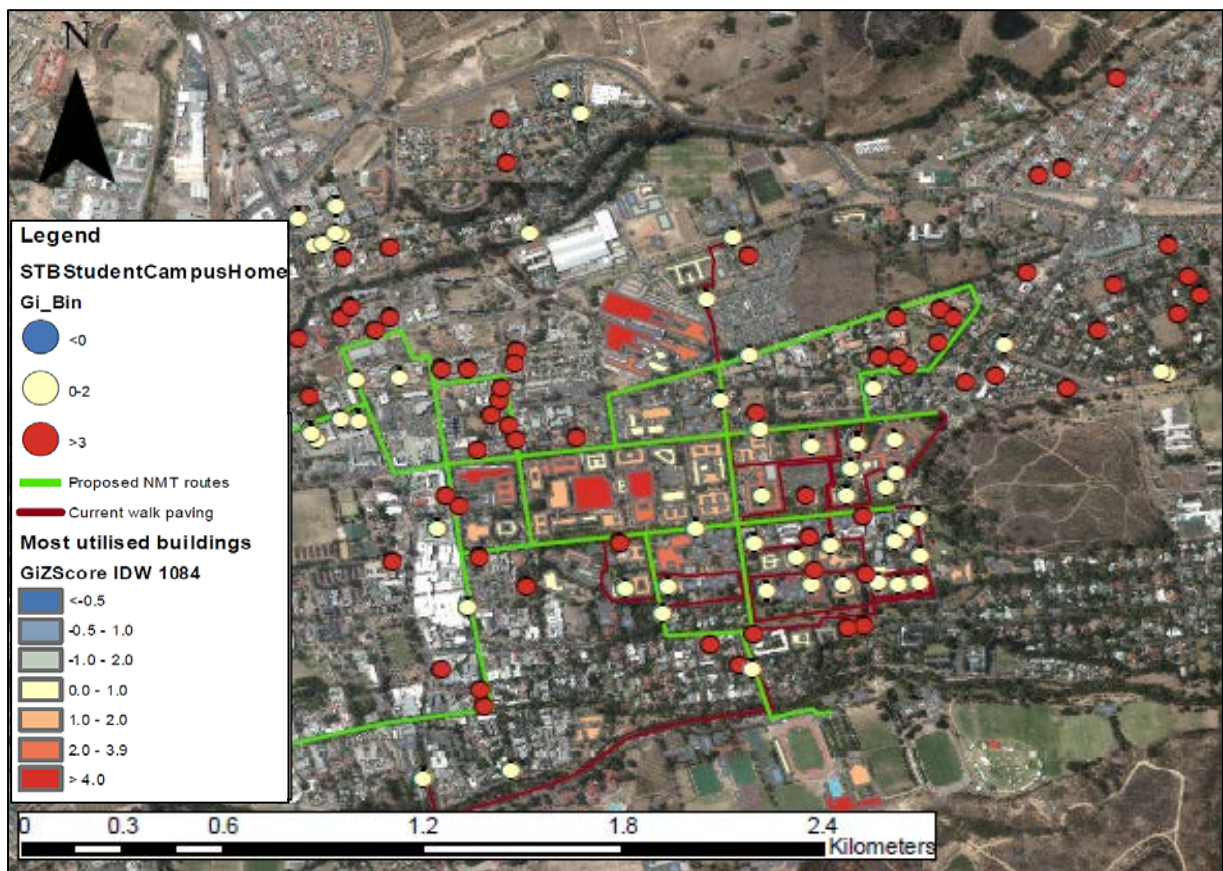


Figure 4.23 Suggested NMT routes.

Looking at the results, cycling lanes are absent near campus and needs to be implemented before students would consider cycling to campus and making use of Matie rent a bike. To address the issue of underutilisation of NMT by SU students a solution would be to, divide the current pathways into pedestrian and cycling lanes to accommodate pedestrians and cyclers on campus. The research study suggests to implement cycling paved lanes as part of the pedestrian walkways to separate NMT routes from each other and from the roads that would ensure safety. The pedestrian routes should be 2 meter wide, the vegetation stroke should be 2 meter wide and the cycling lane should be 1.5-2.5 meter wide. Figure 4.24 illustrates an example of how the pedestrian walkways around campus should be upgraded. The pedestrian route should be the closest to the academic buildings with a vegetation kerb separating the pedestrian and cycling lane. The cycling lane would be implemented closer to the road. Further clearly marked cross overs (Figure 4.24) need to be implemented to link NMT routes with each other and create a safe walking and cycling environment on and around campus. Stellenbosch pedestrian

routes are wide enough to divide it into pedestrian and cycling lanes especially in Merriman Street and Victoria Street. Merriman Street is problematic in terms of safety reasons and to address this issue the walkway can be upgraded to look like the NMT route in Figure 4.24 below.



Source: Crane et al. (2016).

Figure 4.24 Suggested pedestrian and cycling lanes.

5. CONCLUSION AND RECOMMENDATIONS

The primary aim of this study was to analyse the mobility of students at Stellenbosch University and to provide alternative sustainable solutions to the conventional mobility methods and was achieved. To achieve the research aim, the following objectives were compiled and achieved: Identify and analyse the mobility pattern of students on and around campus. Identify where students travel by private car and park on campus. Identify the academic buildings that are most visited during the day. Identify where the majority of students live on campus. Based on these mobility patterns, identify potential pedestrian and other non-motorised transport routes.

The main findings of this research study comprises of only a small percentage (37%) of the Stellenbosch University staff travel 10 kilometres or less to campus. While the majority (92%) of the staff members travel within 40 kilometres to work. Of the total 37% of staff that live within 10 kilometres of campus, 32% of them utilise private vehicles to commute to campus. This is a high percentage and can be severely reduced. Of the total records 60% of the students, live within a radius of 1.2 kilometres from Stellenbosch University campus. A further, 15% of the students live within 2.5 kilometre from the campus. Further, 45% of the 63% of the students that travel up to 5 kilometres to campus, utilise private vehicles this is a high percentage and can be severely reduced. In addition, students make use of lift clubs (21%) and 6% of the sample make use of ride sharing. Many cities are car orientated and therefore cycling and walking will be a second choice (Crane et al. 2016). Furthermore, more than half of the students live within 1.2 kilometre of campus and thus should be encouraged to make use of NMT that would help contribute the reduction of private vehicles by half.

Of the total student sample, 59% of the students walk to campus but few of them cycle to campus because there is no clear bicycle lanes and bicycle sheds. In addition, individuals would reduce the usage of private vehicles if the cost of parking on campus increases. This outcome links with the IDP car free living suggestion by addressing the increasing congestion in Stellenbosch. There is a need to implement strategies to reduce congestion such as congestion fees and parking costs (Stellenbosch Municipality 2017). The research study found that students would reduce the usage of private vehicles if there is a decrease in parking space on campus and if parking costs increases. Parking space is limited on campus and to address this issue, parking bays has to be developed on the periphery of campus with shuttle services from the parking bays to the centre of campus that would help contribute to the utilisation of the parking areas on the periphery. This outcome links with this research study hypothesis that, the

major problem is that there is limited land and space available to develop new car parking lots and it is expensive to build parking structures. A solution would be to develop parking areas on the outskirts of the university and students travel by buses from the parking areas to the campus, which would reduce the traffic flow around campus.

The research study indicates that many students live nearby campus and do not have to make use of automobiles if functional alternative infrastructure is constructed. A solution would be to adjust the infrastructure to create a more pedestrian and cycle friendly environment where people feel safe to walk and do not have to make use of automobiles. Also to improve the infrastructure to encourage bicycling and walking to campus and to the different faculties. Another solution would be to develop parking areas on the outskirts of the university and students travel by shuttles or walk from the parking areas to the campus. The study found that the major factors, that will decrease the utilisation number of private vehicles to campus is: firstly, by implementing alternative transport options. Secondly, the increase in parking bay fee at SU. Thirdly, the reduction in parking space will lead to the reduction in utilisation of private vehicles.

5.1 LIMITATIONS

Relatively new data and theories on NMT was difficult to find and therefore old data and theories was made use of in the literature review as it is relevant to this research topic. Also to explain the concepts of non-motorised transportation and mobility. The data of SUMS was compiled in 2010, but they still make use of the data today as it is still relevant and updated through the years.

5.2 RECOMMENDATIONS

The research study highlight that not many people make use of NMT especially cycling because of the absence of clear cycling lanes. A suggestion would be to look at where separated cycling lanes could be implemented to increase the usage of NMT under students.

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APPENDICES

Appendix A: Institutional permission65

APPENDIX A: INSTITUTIONAL PERMISSION

UNIVERSITEIT • STELLENBOSCH • UNIVERSITY
jou kennisvennoot • your knowledge partner

INSTITUTIONAL PERMISSION:**AGREEMENT ON USE OF PERSONAL INFORMATION IN RESEARCH**

Name of Researcher: Leane De Wet

Name of Research Project: A mobility study to determine the potential for non motorised transport as part of the future urban campus plan

Service Desk ID: IRPSD 1175

Date of Issue: 21 December 2018

You have received institutional permission to proceed with this project as stipulated in the institutional permission application and within the conditions set out in this agreement.

1 WHAT THIS AGREEMENT IS ABOUT	
What is POPI?	<p>1.1 POPI is the Protection of Personal Information Act 4 of 2013.</p> <p>1.2 POPI regulates the entire information life cycle from collection, through use and storage and even the destruction of personal information.</p>
Why is this important to us?	<p>1.3 Even though POPI is important, it is not the primary motivation for this agreement. The privacy of our students and employees are important to us. We want to ensure that no research project poses any risks to their privacy.</p> <p>1.4 However, you are required to familiarise yourself with, and comply with POPI in its entirety.</p>
What is considered to be personal information?	<p>1.5 'Personal information' means information relating to an identifiable, living, individual or company, including, but not limited to:</p> <p>1.5.1 information relating to the race, gender, sex, pregnancy, marital status, national, ethnic or social origin, colour, sexual orientation, age, physical or mental health, well-being, disability, religion, conscience, belief, culture, language and birth of the person;</p> <p>1.5.2 information relating to the education or the medical, financial, criminal or employment history of the person;</p>