EVALUATION OF PEDESTRIAN SIDEWALK UTILISATION IN RESIDENTIAL AREAS OF BLOEMFONTEIN CITY, SOUTH AFRICA.

By

HEINRICH PRETORIUS

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Promoter: Mr. J. E. Honiball
Co-Promoter: Prof. M. Mostafa

ABSTRACT

The necessity of pedestrian-friendly environments is evident when looking at the multitude of benefits that it offers. These benefits include improved social integration, stimulating economic growth, and accessibility.

The safety of pedestrians is not guaranteed, with a third of all road fatalities on South African roads being pedestrian fatalities. With the increased urbanisation among people from rural areas, there is a need for the development of safer non-motorised transport, especially because two-thirds of the population rely on walking as a mode of transport. In central areas of cities, effort has been done to enhance the walkability of the area, however, residential areas are often last on the list when it comes to the implementation of appropriate sidewalk infrastructure. It is observed that, although dangerous, pedestrians in residential areas increasingly use the roadway for walking. Sidewalks form an integral part of efforts to facilitate pedestrian access, which, in turn, support an effective and successful transportation network. This study examined the most essential attributes that contribute to the walkability of residential areas. More specifically, this study evaluated the factors contributing to the use or avoidance of sidewalks in residential areas.

For this purpose, a case-study was performed in a residential area where the problem of pedestrians using the roadway was identified to be quite severe. To this end, the residential area of Universitas in Bloemfontein, Free State, South Africa was selected. A survey research methodology was followed, where data was collected through questionnaires and physical surveys. This study also employed a Conjoint Analysis technique, which is a multivariate technique used to understand an individual's preference, in order to identify the levels of importance with regards to sidewalk attributes. The Conjoint Analysis was used to objectively identify and categorise sidewalk attributes (walkable width, number of obstacles, walking surface, and changes in elevation) that contribute to the use or avoidance of sidewalks.

The findings revealed that attributes such as walkable width and the number of obstacles are significant parameters which influence the use of sidewalks in residential areas. Furthermore, the results revealed the relative importance of each evaluated attribute, which provided valuable insight into the prioritisation and possible budget allocation towards these

attributes when it comes to the development of walkability. Finally, the Conjoint Analysis results were evaluated against pedestrians' genuine willingness to make use of selected sidewalks within the study area. The evaluation revealed that the utility values produced by the Conjoint Analysis could be used to predict how likely it is that a pedestrian would use a specific sidewalk. Additionally, other significant concerns influencing neighbourhood walkability, such as personal safety and conflict with motorised traffic, were also identified by respondents.

The results and findings of this study were used to recommend alternative planning and design guidelines that contribute to the development of walkability in residential areas. It is envisaged that, if the plausible recommended planning and design guidelines are implemented, the walkability of the study area will improve substantially.

Keywords: sidewalk utilisation; conjoint analysis; walkability; pedestrian infrastructure; residential areas; sidewalk assessment.

DECLARATION

I, HEINRICH PRETORIUS, identity number and student number , do hereby declare that this research project submitted to the Central University of Technology, Free State for the Degree MASTER OF ENGINEERING IN CIVIL ENGINEERING, is my own independent work; and complies with the Code of Academic Integrity, as well as other relevant policies, procedures, rules and regulations of the Central University of Technology, Free State; and has not been submitted before to any institution by myself of any other person in fulfilment (or partial fulfilment) of the requirements for the attainment of any qualification.

SIGNATURE

26/11/2018

DATE

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LIST OF ABBREVIATIONS

American Association of Retired Persons .... AARP
Central University of Technology .... CUT
Conjoint Analysis .... CA
Council for Scientific and Industrial Research .... CSIR
Geographic Information Systems .... GIS
Highway Capacity Manual .... HCM
International Business Machines (Company) .... IBM
Irvine-Minnesota Inventory .... IMI
Microscale Audit of Pedestrian Streetscapes .... MAPS
Neighbourhood Environment Walkability Survey .... NEWS
Neighbourhood Sidewalk Assessment Tool .... NSAT
Non-Motorised Transport .... NMT
Part-worth Utility .... PWU
Path Environment Audit Tool .... PEAT
Pedestrian Environmental Quality Index .... PEQI
Pedestrian Environmental Scan .... PEDS
Pedestrians' Preference Score .... PPS
Scottish Walkability Assessment Tool .... SWAT
Statistical Package for the Social Sciences .... SPSS
Systematic Pedestrian and Cycling Environmental Scan .... SPACES
Technical Recommendations for Highways .... TRH
Total Utility Value .... TUV
Urban Transport Guidelines .... UTG
Walking Suitability Assessment Form .... WSAF

CHAPTER 1: INTRODUCTION AND RESEARCH DESIGN

1.1 INTRODUCTION

The importance of pedestrian-friendly environments are on the rise in various fields of urban planning, transportation planning, and medicine, be it for reasons of health, safety, sustainability or economic growth (Ewing & Cervero, 2001; Gilderbloom, Riggs & Meares, 2015). The reduction of emissions if a person decides to walk instead of using motorised transport or walking to improve health is an example of this. The pedestrian environment, however, plays a much more significant role and has an influence on a micro as well as a macro scale. The pedestrian environment has a significant impact on the accessibility and mobility of residents, and, in turn, the overall quality and efficiency of a transport network. For example, accessibility is one of the primary determinants of the success of public parks and open spaces (Crabill, 2009; Das & Honiball, 2016). Furthermore, a walkable environment produces advantages such as an increase in property values, decreased air pollution, and improved social integration (Kim & Woo, 2016). A developing country such as South Africa, can benefit considerably from the effective implementation of non-motorised transport.

Since the establishment of its democratic political system in 1994, South Africa has been undergoing many transformations in regard to land use and urbanisation. Urbanisation is the primary driver behind the physical growth of cities and the demand for services and infrastructure (Todes, Kok, Wentzel, van Zyl & Cross, 2010). Consequently, there has been a significant increase in pedestrians in and around cities that warrant the need for pedestrian infrastructure. Sidewalks are at the heart of a safe and effective walkable environment. The importance of sidewalks is evident throughout walkability research (Saelens & Handy, 2008). Sidewalks provide safety, better street connectivity, and improved level of service. These benefits also influence travel time, route selection and, ultimately, the choice to walk (Tribby, Miller, Brown, Werner & Smith, 2016).

According to the literature, the majority of South Africans rely on walking as a mode of transport. This is evident not only in central business districts, but also in and around local urban residential areas. More specifically, it has been observed that pedestrians in local residential areas often jaywalk or travel directly on the carriageway. Despite the danger, it is common behaviour. In some instances, pedestrians even obstruct the normal flow of traffic. This poses a hindrance to motorists and, as Brysiewicz (2001) points out, it is also a significant concern in terms of pedestrian road traffic collisions. Looking closer into the matter, it is evident that, even though the sidewalk areas are sufficient in width, they are littered with inappropriate urban furniture, poor maintenance, and low-quality materials. Typical examples are built up gardens, uneven driveways, vegetation, and unmaintained surface water inlets.

A wide range of factors can contribute to the inefficiency and avoidance of using sidewalks. The lack of pedestrian infrastructure is often due to neglected municipal planning and budgets (Krambeck, 2006). Insufficient planning for pedestrians has many negative consequences. Economic and social mobility are negatively affected if more travel time and energy is needed to get to work, attend schools, and shop. Beyond economic implications, Krambeck (2006) indicates that pedestrians in developing countries are much more likely to be injured or killed by vehicles in comparison to developed countries. Similarly, Albers, Wright, and Olwoch (2010) note that the pedestrian environment in South Africa is insufficient and contributes to pedestrian fatalities. Using a residential area in Bloemfontein, the study assesses which aspects of the built environment influence pedestrians' choice to use or avoid sidewalks at a neighbourhood level in cities in South Africa.

1.2 PROBLEM STATEMENT

In South Africa, approximately 60% of the population relies on walking as a mode of transport (Albers *et al.*, 2010), whilst 21% of the population walks all the way to their place of work (Vanderschuren & Sekadi, 2015). Even motorised trips start and end with walking.

A third of all fatalities on South African roads are pedestrian fatalities (South African National Department of Transport, 2011). The need for governmental policies and projects that develop non-motorised transport is clear. The Non-Motorised Transport Facility Guidelines (Vanderschuren, Phayane, Taute, Ribbens, Dingle, Pillay, Zuidgeest, Enicker, Baufeldt & Jennings, 2014) were introduced in 2014 to re-balance the way that South African roads were thought about and designed, and to address their safety and sustainability (Vanderschuren & Sekadi, 2015). It has been observed that residential areas, however, seem to be last on the list when it comes to implementation. It is increasingly observed that pedestrians use the roadway for walking in residential areas. Pedestrians within residential areas include residents going about their daily activities, attending schools and universities, exercising, and doing their daily shopping, as well as workers using residential areas as thoroughfares. Sidewalks form an integral part of facilitating pedestrian access, which, in turn, supports an effective and successful transportation network (Southworth, 2005). Figure 1.1 is a typical example of pedestrians using the roadway for walking in neighbourhoods in South African cities.

Figure 1.1 Pedestrians using the roadway for walking in the Universitas suburb of Bloemfontein (Source: Author).

The lack of adequate walkways is the result of insufficient and neglected municipal planning and budgets (Krambeck, 2006), and the spatial development transformations that occurred post-1995 (Toba, Campell, Schoeman & Lesia, 2012). Literature indicates that the walkable environment is receiving increasingly more attention due to the range of benefits related to health, social life, the economy, and sustainability (Choi, 2012). The pedestrian environment can impact the overall efficiency and quality of a transport network, as well as the mobility and accessibility for residents and visitors (Krambeck, 2006). While individual preferences and socioeconomic characteristics influence walkability, the built environment has a significant influence on the decision to walk (Tribby *et al.*, 2016). In addition, the South African-based literature indicates that the built environment plays an influential role in physical activity participation (Dhurup & Grobler, 2012) and pedestrian safety (Albers *et al.*, 2010). Thus, it is essential to assess the conduciveness of the built environment for walking in South Africa. This study attempted to identify built environment attributes as well as to what extent these attributes contribute to the walkability of residential areas in South Africa. The study used Bloemfontein as a case study to achieve this goal.

The study was conducted by evaluating the built environment attributes that influence pedestrians' choices to make use of or avoid sidewalks. Its purpose is to provide guidance to municipalities and planning authorities to effectively plan and allocate their limited resources and budgets by (1) prioritising the most essential attributes, (2) reducing expenditure by limiting or excluding the least essential attributes, and (3) providing effective solutions on a larger scale with the same available resources and budgets.

1.3 PURPOSE OF STUDY

1.3.1 Research Aims of the Study

The main research aim of this study is to:

- Analyse sidewalk attributes that contribute to the walkability of residential areas in order to evolve urban planning design solutions for planned and existing pedestrian infrastructure.

1.3.2 Objectives of the Study

For the purpose mentioned above (section 1.3.1), a set of specific objectives were identified. The objectives of this investigation are to:

- Explore the contributing sidewalk attributes in the pedestrian environment within the selected study area and categorise their importance.
- Identify any additional factors contributing to the pedestrian built environment which is specific to the residential areas of South Africa.
- Analyse and define engineering infrastructure, social, and environmental attributes that will contribute to the successful creation of a walkable environment in residential areas of South African cities.
- Develop guidelines for promoting walkability in planned and existing residential areas in Bloemfontein, which can be applied to other South African cities.

1.4 SCOPE OF THE STUDY

The scope of this investigation is limited to developing a set of transportation planning and design guidelines that will improve the walkability of the residential neighbourhoods in Bloemfontein, Free State, South Africa. A case-study approach was adopted to provide a deeper insight into the effect of the built environment on the behaviour of pedestrians in residential areas. This was done by evaluating the built environment attributes of the sidewalks in the case-study area and their conduciveness to walking. The investigation was conducted by identifying and evaluating a case-study neighbourhood that sufficiently represents the identified problem. The neighbourhood, Universitas, was selected for three reasons: (1) the overwhelming presence of pedestrians using the roadway instead of sidewalks; (2) its diversity in trip generating destinations and (3) its size as the largest residential neighbourhood in the city. Physical and questionnaire surveys were used to collect data for the evaluation. The methodology described in the next section was deployed to evaluate existing conditions and pedestrian behaviour in the case-study neighbourhood.

1.5 RESEARCH DESIGN

1.5.1 Methodology of the Study

The investigation uses Conjoint Analysis; a multivariate technique initially developed for marketing research with the goal of understanding an individual's preference (Green & Srinivasan, 1978). Conjoint Analysis is based on the idea that an individual will trade-off between attributes that make up a specific product before making a final decision. For this study, it was assumed that pedestrians' behaviour with regard to sidewalks can be presented in terms of sidewalk attributes. Recent research by Wicramasinghe and Dissanayake (2017), where they applied the Conjoint Analysis technique as an unbiased method to evaluate pedestrians' preference, was used as a basis for this dissertation. This evaluation, therefore, (1) validates the use of the Conjoint Analysis technique for pedestrian and walkability research, (2) evaluates the method in different geographical, land use, and unique cultural setting, and (3) possibly contribute to research with regard to pedestrian perception and walkability development in South Africa.

This study's methodology therefore makes use of the Conjoint Analysis technique. The steps followed, and the application of Conjoint Analysis in the study is presented in Figure 1.2. These steps are as follows:

1. Problem identification, literature review, setting objectives and research design
2. Identification and evaluation of the study area within Bloemfontein City
    a) Identify a neighbourhood that sufficiently represents the identified problem
    b) Investigate the selected neighbourhood
    c) Evaluate and compare other neighbourhoods to the selected neighbourhood
    d) Physical surveys (site observations, GIS information, and aerial photography)
3. Data collection using questionnaires
    a) Socio-demographic data
    b) Conjoint Analysis data
    c) Pedestrian preference data
4. Conjoint Analysis
    a) Attributes and mutually independent attribute level generation
    b) Generation of conjoint profiles
    c) Compilation, analysis, and synthesis of Conjoint Analysis results.
5. Evaluate and validate
    a) Identify selected locations in the study area for evaluation
    b) Calculate the Total Utility Value of each location from Conjoint Analysis results.
    c) Calculate the Pedestrians' Preference Score of selected locations
    d) Evaluate variation between Total Utility Value and Pedestrians' Preference Score
6. Formulation of guidelines for improving sidewalks in residential areas

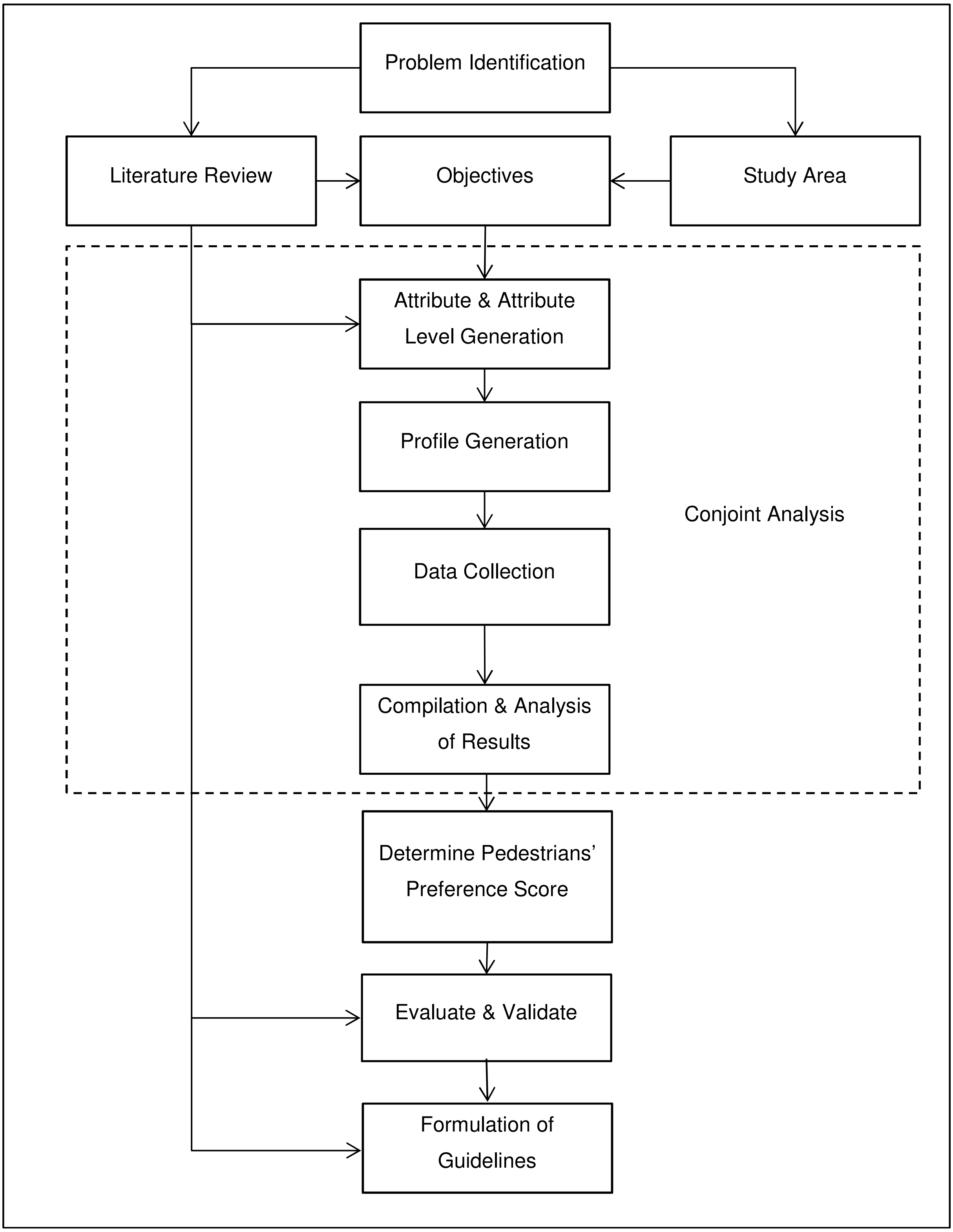

Figure 1.2 Research design flow chart.

1.5.2 Study Area

The Universitas neighbourhood of Bloemfontein was identified as a suburb where pedestrians using the roadway for walking is quite prominent. It was found that, in some instances, pedestrians even obstruct the normal flow of motorised traffic. From site observations and measurements, it is evident that little to no facilities exist to accommodate pedestrians. Since there is seldom a dedicated sidewalk, or proper development of the verge to serve the purpose of a sidewalk, people are forced to walk on the side of the road, where they are vulnerable to traffic. For the purpose of this study, sidewalk and verge are used interchangeably, as it investigates user preferences in terms of sidewalks (based on what currently exists - i.e. a mixture of undeveloped and developed verges for the purpose of accommodating pedestrians).

To further investigate the issue, other residential suburbs in Bloemfontein were evaluated and compared to Universitas. Trip generating destinations were identified and compared. These destinations are schools, universities, shopping centres, churches, retirement villages, residential homes, and public parks. Additionally, other factors affecting pedestrians were considered, namely population, size, type of accessibility, and thoroughfares for pedestrians.

After evaluating the 35 neighbourhoods in Bloemfontein, Universitas was found to be ideal for this investigation. Universitas shows diversity in trip generating destinations; is the largest residential neighbourhood in the city; and consists of a large number of pedestrians using the road instead of sidewalks.

Universitas, with an area of 9.66 square kilometres and located on the south-western side of Bloemfontein (see Figure 1.3), holds major sub-arterial roads connecting adjacent neighbourhoods to each other, as well as to the business district. Consequently, Universitas acts as a thoroughfare for motorists and pedestrians.

Residents mostly stay in stand-alone houses, apartments, and townhouses. The University of the Free State, with 37 000 enrolled students (University of the Free State, 2016), is also located in this suburb, and, with its growing number of students, has been a significant contributor to the increase in residents over the past few years (Ackermann & Visser, 2016). Many houses have been converted to student housing to accommodate this increase. Along with students, the overall income level of Universitas is medium to high. Schools within and directly adjacent to the suburb are Universitas Primary School, Grey College Primary and

Secondary School, Eunice Primary and Secondary School, and Dr Bohmer Secondary School. Other trip generating destinations making Universitas pedestrian-rich are two retirement villages, five churches, two shopping centres, twelve public parks, and two hospitals (see section 3.3 for more detail).

Figure 1.3 City of Bloemfontein (© OpenStreetMap contributors, 2018)

1.5.3 Conjoint Analysis

a) Attribute and Attribute Level Generation

The selection of attributes was done by conducting a comprehensive literature study, evaluating existing conditions using physical surveys, and with the guidance of experts.

According to previous studies, the most appropriate attributes contributing to the avoidance of sidewalks were sidewalk width, availability of obstacles, pedestrian flow rate, and safety regarding separation from vehicles (Muraleetharan, Adachi, Hagiwara & Kagaya, 2005; Wicramasinghe et al., 2017). However, these attributes are not necessarily the most appropriate attributes for South African conditions.

Along the same vein, Wicramasinghe et al. (2017) indicated that the accuracy of the Conjoint Analysis technique could be improved by selecting appropriate attributes and attribute levels that more accurately describe the scenario. Thus, through synthesizing South African literature, evaluating physical conditions, and following the guidance of experts, the following attributes were selected for the study: walkable width, number of obstacles, walking surface, and number of changes in elevation. These pre-selected attributes and their mutually independent levels are listed in Table 1.1. Furthermore, the levels for each attribute were derived from examining literature and existing design standards (see section 4.5.1).

Table 1.1 Pre-selected sidewalk attributes and mutually independent levels

Sidewalk Attributes	**Attribute Levels**		
	Level 1	**Level 2**	**Level 3**
Walkable Width (m)	>2m	1m - 2m	<1m
Number of Obstacles per 50m	No Obstacles	1 to 5 Obstacles	> 5 Obstacles
Walking Surface	Paved	Gravel	Vegetation
Changes in Elevation	No Change	1 to 3 Changes	>3 Changes

b) Conjoint Profile Generation

To assess the selected attributes, hypothetical profiles had to be compiled with various combinations thereof. However, generating all possible combinations would result in 81 hypothetical profiles, which would be tedious for respondents to the extent that it could compromise the collection of data. To solve this issue, the use of orthogonal fractional design was employed. Orthogonal fractional design refers to a method of reducing product configurations, while all attributes are arranged to be represented equally and on an uncorrelated basis. The 81 hypothetical profiles were then reduced to nine profiles.
Table 1.2 lists these nine hypothetical profiles and attribute combinations.

Table 1.2 Nine hypothetical profiles generated using orthogonal fractional design.

Card	Walkable Width	Number of Obstacles	Walking Surface	Changes in Elevation
1	<1m	1 - 5 Obstacles	Vegetation	No Change
2	<1m	> 5 Obstacles	Paved	1 to 3 Changes
3	1m-2m	No Obstacles	Vegetation	1 to 3 Changes
4	1m-2m	> 5 Obstacles	Gravel	No Change
5	1m-2m	1 - 5 Obstacles	Paved	>3 Changes
6	>2m	> 5 Obstacles	Vegetation	>3 Changes
7	>2m	No Obstacles	Paved	No Change
8	<1m	No Obstacles	Gravel	>3 Changes
9	>2m	1 - 5 Obstacles	Gravel	1 to 3 Changes

c) Data Collection

Primary and secondary data was collected and has been employed in this investigation.

Primary Data

Primary data was collected through pedestrian questionnaires, as well as physical surveys of sidewalks. Physical surveys of sidewalks were essential to ensure that the existing conditions correlates with the Conjoint Analysis' generated profiles.
The questionnaire consisted of three main sections:

Section 1 – Socio-demographic and walking experience data.

Section 2 – Nine profiles developed by the Conjoint Analysis technique. The respondents had to sort the profiles form the most to the least preferred. Figure 1.4 shows a sample of a hypothetical conjoint profile (Card 1) which has a walking width of less than 1 meter, 1 to 5 obstacles, vegetation as walking surface, and no changes in elevation.

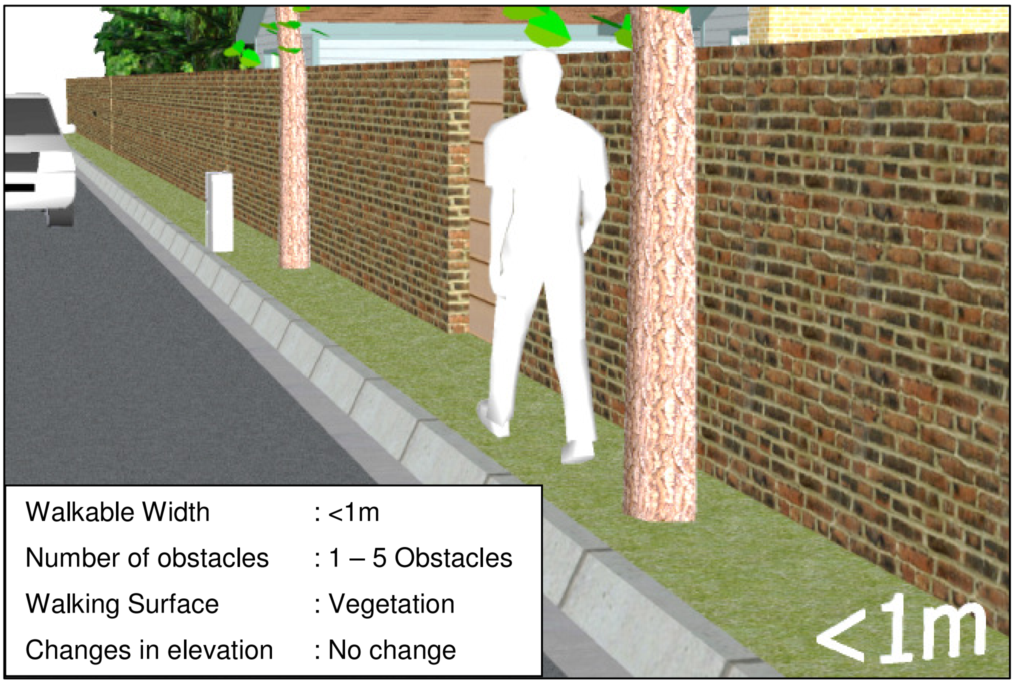

Figure 1.4 Example of a hypothetical conjoint profile.

Section 3 – To measure a pedestrian's preference score, photographs of pre-selected locations with a five-point Likert-scale were employed. The respondent had to indicate how likely it is that they would walk on the sidewalk at the specific location. Figure 1.5 shows a sample of a pre-selected location.

Figure 1.5 Example of the question used to measure a pedestrians' preference at a pre-selected location (Source: Author).

The collected survey data did not only provide information for the implementation of the analysis, but also provided insight into the development of formulated guidelines.

Pedestrian Questionnaires

The pedestrian survey was conducted in and around the selected suburb. To conduct the survey, all of the key access points were first identified. This includes neighbourhood access points as well as access points to trip generating destinations. Thereafter, 400 surveys were deployed, of which only 326 were returned. A total number of 154 pedestrian surveys were conducted at the identified access points. Furthermore, an additional 172 random sampling surveys were done with pedestrians throughout the suburb.

Physical Survey

The physical condition of sidewalks and the sidewalk network was obtained by conducting physical surveys and obtaining GIS information from the local municipality. The physical surveys included land use and conditions, the traffic network, sidewalk presence, and sidewalk attributes. Moreover, the survey included the identification and verification of trip generating destinations.

Every street in the suburb, along with their adjacent sidewalks, were evaluated in terms of possible pedestrian use. With the help of GIS data and aerial photography, the streets were divided into different pedestrian use categories, namely: suburb entry points, residential collector streets, thoroughfare streets, and residential streets (Committee of Urban Transport Authorities, 1988; CSIR Building and Construction Technology, 2000). There are 138 streets, of which 11 are suburb access points, 13 are residential collector streets, 7 are thoroughfare streets, and 107 are residential streets.

Significance of Data Collected

The pedestrian surveys primarily provided the data for the Conjoint Analysis technique. Secondarily, these surveys provided insight into the daily activities, demographic composition, and perceptions of pedestrians. They also provided insight into the perceptions of residents that make use of motorised transport within the neighbourhood and how pedestrians affect them.

A physical survey of the neighbourhood aided in assessing the transport network, land use, visibility, pedestrian facilities, safety, and, most importantly, pedestrian trip generating destinations.

The sidewalk survey assisted in evaluating the physical condition of the existing sidewalks. Existing sidewalks' attributes influenced conjoint profile generation by providing valuable insights into existing conditions as well as possible improvements.

Secondary Sources of Data

Data input from various other sources was gathered. This included aerial photography, statistics and maps from the local municipality, current and historical street photography, and GIS data. Furthermore, the review of current and past literature, as well as expert consultation contributed to the development of conjoint profiles.

d) Data Analysis

The collected data was evaluated and analysed in 5 steps. Step 1 was the evaluation of the first section of the survey; socio-demographic and travel behaviour was summarised to verify the distribution of respondents. In Step 2, the part-worth utility value and attribute importance were evaluated according to the Conjoint Analysis profiles. Step 3 was the evaluation of the third section of the survey; the Pedestrians' Preference Score was calculated at the selected locations. During Step 4, the Total Utility Value was calculated at each selected location using the part-worth utility values from Step 2. The last step, Step 5, was the comparative evaluation of the results from Step 3 (Pedestrian' Preference Score) and Step 4 (Total Utility Value).

All data was captured digitally for analysis. After a thorough evaluation of the data collected, errors and incomplete surveys were removed. The analysis was completed by making use of various tools and techniques as described in the sections that follow.

Analytical Tools

Analytical software tools, such as Microsoft Excel (Microsoft Corp., 2010) and IBM SPSS Statistics (IBM Corp., 2015), were used for data processing and analysis.

Analytical Techniques

<u>Conjoint Analysis</u>

The Conjoint Analysis produced two indices: (1) the part-worth utility value of each attribute level and (2) the relative importance of each attribute. The part-worth utility value and relative importance were calculated by making use of the IBM SPSS Statistics (IBM Corp., 2015) software. With the results of the part-worth utility values and relative importance values, the Total Utility Value of each hypothetical profile was calculated with the use of equation 1 below. The Conjoint Analysis theory states that the product/attribute that receives a higher Total Utility Value than other products/attributes will be considered more valuable (Green & Srinivasan, 1978).

Total Utility Value $U(Xij) = Constant + \sum_{i=1}^{m} \sum_{j=1}^{k_i} u_{ij} X_{ij}$ (1)

U(Xij)	=	Total utility of an alternative
m	=	Number of attributes
k_i	=	Number of levels in i^{th} attribute
u_{ij}	=	Utility associated with j^{th} level of the i^{th} attribute
X_{ij}	=	Dummy variable that takes on 1 if the j^{th} level of the i^{th} attribute is present or 0 other

Pedestrians' Preference Score

To measure the Pedestrians' Preference Score on how likely it is that a pedestrian would use a portion of a sidewalk, the third section of the survey was employed. This entailed a photograph of 11 selected locations alongside a 5-point Likert scale. After the data was collected and captured, the Pedestrians' Preference Score for each location was calculated with equation 2 below.

Pedestrian Preference Score $(PPS_j) = \frac{1}{n} \sum_{i=1}^{n} (WTC)_{ij}$ (2)

$(WTC)_{ij}$	=	Willingness to use at the j^{th} sidewalk by i^{th} respondent
N	=	Number of respondents

1.5.4 Evaluation and Validation

Validation of the Total Utility Value

To validate the index developed by the Conjoint Analysis technique, the Total Utility Value was plotted against the Pedestrians' Preference Score for each location. A linear relationship was found which strongly indicates a correlation.

Application of the Index

Based on the validation, the index developed by the Conjoint Analysis technique can be used to determine and categorise sidewalk utility. Furthermore, the index can be used to map sidewalks to provide a graphical representation of utility. The results of the index were used to inform the development of feasible planning and design guidelines.

1.6 RESULTS AND DISCUSSION

Plausible findings were drawn after a detailed discussion comprising of literature, pedestrian surveys, physical surveys, and the results from the Conjoint Analysis.

1.7 INFERENCES

From the evaluation, probable inferences were drawn for developing a set of feasible planning and design guidelines.

1.8 GUIDELINES AND RECOMMENDATIONS

Planning and design guidelines, as well as recommendations, were prepared based on the results, discussions, and inferences of this evaluation. These recommendations can be used for developing walkability in the residential areas of South Africa.

It is believed that, if the recommendations developed by this study are implemented within the study area, accessibility, pedestrian safety, and convenience will be significantly improved. Additionally, the overall transportation network in the area will be improved by reducing travel times and increasing level of service.

1.9 LIMITATIONS

The limited time (time-based Masters' program), limited availability of manpower and limited funding available contributed to the relatively limited but adequate sample size.

Only one neighbourhood, which had the best heterogeneous representation of pedestrians, was selected within the city of Bloemfontein. Although a seemingly good distribution of trip generating destinations was evaluated, different neighbourhoods with a majority of a specific type of destination could produce different results.

1.10 ETHICS IN PEDESTRIAN SURVEYS.

Ethical concerns can be found in any research. Survey research should be conducted in an ethical manner and according to the best research practice (Kelley, Clark, Brown & Sitzia, 2003). The awareness and use of established ethical principles can lessen research difficulties.

Orb, Eisenhauer, and Wynaden (2001) state that well-established ethical principles are autonomy, beneficence, and justice. Participants have the right to be informed about the study, as well as the right to freely decide to participate without any consequence. Beneficence, which is closely related to autonomy, should be adhered to with confidentiality, informing participants how the results will be published, and what information is excluded from confidentiality. Confidentiality should always be respected (Fink, 2012).

The principle of justice and fairness encompasses the fair recognition of participants and their contribution, without abuse or exploitation. The investigator was strictly made aware of the established ethical principles to be followed. The potential respondents were duly informed about the purpose, use, and implications of the study and given the option to participate freely. Accordingly, anonymity and confidentiality were emphasised. Reasonable care was taken to prevent any form of risk or exploitation that could cause any harm.

1.11 CHAPTER SCHEME

Chapter 1:	The chapter consists of an introduction, problem statement, and discussion of the objectives, scope, research methods and limitations of the research.
Chapter 2:	This chapter comprises of a review of the literature.
Chapter 3:	In this chapter the study area profile concerning the background of the study area, demographic profile, social functions, infrastructure, transportation, amenities, pedestrian accommodation, and sidewalk conditions and attributes are discussed.
Chapter 4:	The chapter focuses on the data analyses, results, and discussions.
Chapter 5:	This chapter contains findings, guidelines, recommendations, and conclusions.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Non-motorised transport (walking and cycling) not only speaks to environmental concerns related to motorised transportation emissions, but also has numerous health benefits - as various studies have shown (Adkins, Dill, Luhr & Neal, 2012; Ewing & Cervero, 2010; Gilderbloom *et al.*, 2015). The International World Health Organization has recently called for changes to the built environment to improve human health (Zuniga-Teran, Orr, Gimblett, Chalfoun, Marsh, Guertin & Going, 2017). In addition to promoting health benefits, walkable neighbourhoods have critical economic value, as they boost real estate property values and encourage social exchanges and economic transactions (Gilderbloom *et al.*, 2015). Lo (2009) outlines that walkability is an essential component of accessible, equitable, efficient, sustainable, and liveable communities.

The purpose of this literature review is to investigate the most vital attributes influencing walkability, and, more specifically for this study, the attributes influencing the use of sidewalks. Throughout the review; approaches to assess walkability, methods to investigate and measure walkability, as well as sidewalk walkability will be examined. The findings of this review will inform and contribute to the methods and design methodology within this dissertation.

2.2 WALKABLE ENVIRONMENT

Pedestrian transportation, or walkability, refers to the attractiveness and suitability of the built environment for walking (Tribby *et al.*, 2016). In essence, walkability is about the route in an area which connects an origin and a destination (Moudon, Lee, Cheadle, Garvin, Johnson, Schmid, Weathers & Lin, 2006, cited in Adkins *et al.*, 2012). Southworth (2005) ascertains that connectivity, links to other modes, land-use patterns, safety, quality of path, and path context are the six crucial attributes of walkability.

In recent years, there has been an increasing amount of literature that investigates the correlation between walkability and the built environment (Babb & Curtis, 2015; Ewing &

Cervero, 2001; Saelens & Handy, 2008; Tribby *et al.*, 2016). Research focusing on the walkability of the built environment – which was instigated by the field of medicine (Heath, Brownson, Kruger, Miles, Powell & Ramsey, 2006; Leslie, Saelens, Frank, Owen, Bauman, Coffee & Hugo, 2005) – is a multi-disciplinary and growing field. One of the main reasons walkability research was initiated was the startling increase in obesity (Saelens, Sallis & Frank, 2003).

Although research on walkability analyses of the built environment has expanded considerably in the past decade in fields related to urban planning, geography, psychology, and public health (Brownson, Hoehner, Day, Forsyth & Sallis, 2009), walkability is still addressed with far less intensity as compared to other modes of transport (Brown, Morris & Taylor, 2009; Lo, 2009; Southworth, 2005).

There is a need to objectively quantify how roadways accommodate pedestrians (Saelens & Handy, 2008). Satisfying this need would greatly aid in prioritising the sidewalk upgrades as well as roadway design (Landis, Vattikuti, Ottenberg, McLeod & Guttenplan, 2001). From research, it can be seen that pedestrian level of service is the most common approach to assessing walkability (Tanvir, Hossain & Idris, 2016). Most methodologies identify factors and attributes affecting pedestrians and the environment, but many factors are not included in the computation of level of service. Also, many of these factors are qualitative and can be difficult to measure. As an example, the Highway Capacity Manual (Transportation Research Board, 2010) provides analysis for factors affecting pedestrian level of service, but little guidance on compiling level of service for each factor contributing to the overall level of service (Muraleetharan, Adachi, Hagiwara, Kagaya & Member, 2000).

To assist researchers with walkability research related to environmental perceptions, Ewing and Handy (2009) did a comprehensive study to measure subjective qualities objectively. The study identified and evaluated five qualities of importance, namely; imageability, enclosure, human scale, transparency, and complexity.

Imageability refers to the value of a place that makes it dissimilar and memorable. The features that contribute to the formation of this image is very much personalised to the sociocultural environmental background of an individual. Ewing and Handy (2009) further describe enclosure as the space perceived from the physical environment. This perception is influenced by the elements that interrupt the line of sight. Human scale refers to the proportion of the human body to building elements or space. For example, as Ewing and Handy (2009) illustrate, larger road signs designed for higher vehicle speeds can cause disorientation and discomfort for pedestrians. Transparency as a quality refers to what physical elements and human activity are perceived by pedestrians to be beyond the edge of the street. Elements that contribute to this perception include signs to off-street elements, walls, windows, landscaping, and openings between buildings. The quality of complexity refers to the combination of various elements of the physical environment. These elements, listed by Ewing and Handy (2009), in order of significance, are the number of people, number of dominant building colours, number of buildings, the presence of outdoor dining, number of accent colours, and number of pieces of public art. The scope of their study, however, was limited to commercial streets, and the results might not necessarily apply to other settings.

2.3 APPROACHES FOR ASSESSMENT OF WALKABILITY

If one were to categorise previous walkability research, it can be said that it focused on urban design qualities that influence walkability – or, as Ewing and Cervero (2010) have grouped it: travel and the built environment on the one hand, and perceptions of walking environment attractiveness and consequent walking behaviour (or physical activity and the built environment) (Ewing & Cervero, 2010) on the other hand. All of the studies that were reviewed by Ewing and Cervero (2010 :267) related to some, or all, of the “D variables”, i.e. (1) density, (2) diversity, (3) design, (4) destination to accessibility, (5) distance to transit, (6) demand management, and (7) demographics.

Similarly, Sauter, Hogerts, Tight, Thomas, and Zaidel (2010) outlined the different concepts used to measure walking and pedestrian activity, as can be seen in Table 2.1. A wide range of concepts exist, and the terminology is often confusing. Sauter et al. (2010) attempted to summarise approaches into qualitative versus quantitative and subjective versus objective assessments.

Subjective measurement (based on personal opinions) combined with qualitative measurement (based on approximations, judgments, and descriptions) can be used to determine, for example, how members of a community judge the safety of a crossing. Subjective measurement combined with quantitative measurement can be used to do a population survey about attributes that are conducive to walking.

On the other hand, objective measurement (based on unbiased reality), combined with qualitative measurement, can be used to determine how well a street fulfils official safety requirements. Objective measurement combined with quantitative measurement can be used to determine, for example, how many people were killed or injured.

Each approach is valid in its own right, and should be used depending on the objectives and needs, which should complement each other (Sauter *et al.*, 2010).

Table 2.1 Classification of assessment methods (Sauter *et al.*, 2010).

	"qualitative" results usually based on small numbers, approximations, judgments, descriptions (verbal data)	**"quantitative"** results usually based on larger (representative) figures.
"subjective" results usually based on personal perceptions and opinions	Example: Community street audit (How community members judge safety of a crossing)	Example: Population survey about attitudes towards walking (How safe people feel generally)
"objective" results usually based on 'immediate reality' ('objectivised' judgments)	Example: Expert street audit based on norm checklist (How well a street fulfils official safety requirements)	Example: Counts and 'hard' data collection (How many people got killed and seriously injured)

2.4 MEASURING WALKABILITY

Several systematic reviews of walkability and the measuring thereof have been undertaken.

Saelens and Handy (2008) reviewed the literature from the period of 2002 up to 2006 and found consistent positive relations between walking for transportation and density, distance to non-residential destinations, and land use mix. Sidewalks for pedestrians and connectivity were found to be highly correlated with walking (Saelens & Handy, 2008).

In their review of existing pedestrian indices, Maghelal and Capp (2011) aimed to identify built environment variables associated with walking that can be objectively measured using GIS. Only 13 of the 25 pedestrian indices used variables that were found to allow for objective measurement through GIS. Maghelal and Capp (2011) indicated that the various indices quantified the same built environment variables using different measures to quantify walking. Thus, they set out to compile a standardised list of objectively measured variables that can be measured with GIS.

Together, these studies indicate that, due to the lack of available technology, most of the methods either conducted audits or used self-measured environmental correlates to measure and analyse the effect of the built environment on walking.

With recent improvements in technology to collect, create, store, simulate and evaluate data at a separate component level, the use of GIS and other technologies to assess the walking and the built environment is encouraged (Lee & Moudon, 2006; Leslie *et al.*, 2005; Moudon, Hess, Snyder & Stanilov, 1997; Rodríguez, Khattak & Evenson, 2006).

Two fundamental approaches in the assessment of the pedestrian environment are macro and micro design factors. Macro design factors are commonly evaluated within boundaries and include origin, destination, distance, density, and land use (Kim, Park & Lee, 2014). On the other hand, micro design factors are commonly assessed at street level and range from sidewalk width to amenities (Kim *et al.*, 2014).

The body of literature that has evaluated the tools available to measure the categories above is not to be ignored, however. Aghaabbasi, Moeinaddini, Zaly Shah, and Asadi-Shekari (2017), for instance, undertook a comprehensive study on existing sidewalk assessment and walkability assessment tools to improve the evaluation of the microscale factors that influence walkability at a neighbourhood level, whilst Giles-Corti, Macaulay, Middleton, Boruff, Bull, Butterworth, Badland, Mavoa, Roberts and Christian (2014) focused on both intra- and inter-neighbourhood walkability to develop an automated geospatial tool in Australia. Frackelton, Grossman, Palinginis, Castrillon, Enlago and Guensler (2013) deployed an Android application to automatically generate spatial sidewalk inventories, assessing sidewalk quality, and prioritising repairs. Smith, Malik, and Culler (2013) further leverage techniques from computer vision and machine learning to gather information regarding the presence and quality of sidewalks in street view images. Numerous studies have reported on (1) the use of Walk Score™ – an online tool which measures neighbourhood walkability and evaluates the accessibility within neighbourhoods based on network distance and connectivity metrics, (2) its validity for assessing walkability based on GIS indicators, and (3) the subjective and objective measures of the physical activity environment (see Frackelton *et al.*, 2013).

2.5 MEASURING SIDEWALK WALKABILITY

Research regarding walkability assessment is ample, and sidewalk assessment forms an integral part thereof. Existing sidewalk assessment tools have been developed in various forms, such as level of service methods (Asadi-Shekari, Moeinaddini & Zaly Shah, 2014; Dandan, Wei, Jian & Yang, 2007; Muraleetharan et al., 2005), audits (Clifton, Smith, Rodriguez, Livi Smith & Rodriguez, 2007; Lee & Talen, 2014), and questionnaires (Kihl, Brennan, Gabhawala, List & Mittal, 2005; Saelens, Sallis, Black & Chen, 2003). From the literature, it is clear that audits are used to measure the quantity of the built environment related to walking, while indices and levels of service rank the segments of areas according to how suitable they are for walking. Indices and levels of service make use of a collective value consisting of measures of the built environment evaluated through audits, subjective and objective assessments, as well as GIS indicators. These approaches and tools are further discussed in the following sections.

Pedestrian Level of Service Methods

Level of service methods are the most common approaches used to assess transportation facilities (Tanvir *et al.*, 2016). Pedestrian level of service permits us to qualify and better understand the street design elements that are conducive to the needs of pedestrians (Muraleetharan, Adachi, Uchida, Hagiwara & Kagaya, 2003).

The existing level of service methods regarding sidewalk assessments consider several attributes. Most studies examine built environment attributes, such as sidewalk width, slope, surface material, and obstacles (Asadi-Shekari, Moeinaddini & Zaly Shah, 2013; Asadi-Shekari *et al.*, 2014; Christopoulou & Pitsiava-Latinopoulou, 2012; Dandan *et al.*, 2007; Dowling, Flannery, Rouphail, Ruys, Reinke, Landis, Petritsch, Vandehey & Bonneson, 2009; Kang, Xiong & Mannering, 2013; Kim, Choi & Kim, 2011). Several methods consider the presence and continuity of sidewalks (Landis *et al.*, 2001; Moudon, 2001; Sarkar, 1993). However, only a few of the existing methods take into account sidewalk amenities like public toilets, drinking fountains, and benches (Asadi-Shekari *et al.*, 2013, 2014). Equally so, there is a lack of methods that consider the presence of pedestrians with disabilities (Asadi-Shekari *et al.*, 2013, 2014; Christopoulou & Pitsiava-Latinopoulou, 2012). Some methods considered a separation between pedestrians and vehicles (Asadi-Shekari *et al.*, 2014; Kang *et al.*, 2013; Landis *et al.*, 2001).

Although existing pedestrian level of service methods take into account some attributes, none of them cover the full range of pedestrian level of service (Muraleetharan *et al.*, 2003). For example, the pedestrian level of service in the Highway Capacity Manual (Transportation

Research Board, 2010) is mostly based on space and capacity. This view is supported by Aghaabbasi *et al.* (2017), who writes that the pedestrian level of service studies that assess microscale factors have been neglected. Furthermore, Asadi-Shekari *et al.* (2014) highlight that a significant weakness of existing pedestrian level of service methods is the lack of reliable measures of data collection.

Audits

Audits are also a pervasive form of walkability assessment. Walkability audits measure the quantity of the built environment associated with walking (Maghelal & Capp, 2011). This review draws from Aghaabbasi et al.'s (2017) evaluation of 11 audit tools that are intended to assess walkability with regard to sidewalks, as well as Lee and Talen's (2014) review of audit tools that consider sidewalks. Moreover, the audit tools reviewed by Albers *et al.* (2010) to develop an audit tool specific to South Africa are included as well. Table 2.2 summarises the sidewalk indicators of these assessment tools.

Included in multiple reviews (Aghaabbasi *et al.*, 2017; Albers *et al.*, 2010; Lee & Talen, 2014) is the Systematic Pedestrian And Cycling Environmental Scan (SPACES) method (Pikora, Bull, Jamrozik, Knuiman, Giles-Corti, Donovan & Pikora, 2002). Developed within the urban context of Australia, SPACES evaluates several elements, which are categorised into four groups: (1) functional; (2) safety; (3) aesthetics; and (4) travel destination (Pikora *et al.*, 2002). Sidewalk indicators include sidewalk obstructions, the number of trees, driveway cuts, sidewalk material, surface condition, cleanliness, and lighting (Pikora *et al.*, 2002).

Furthermore, several tools were reviewed separately by Aghaabbasi et al. (2017) and Lee and Talen (2014). The well-known Irvine-Minnesota Inventory (IMI) (Boarnet, Day, Alfonzo, Forsyth & Oakes, 2006) was designed to assess objective and subjective built environment features, consider sidewalk design factors such as the presence of sidewalks, the continuity of sidewalks, as well as their condition, maintenance, and buffering. The walking suitability assessment form (WSAF) assesses fewer design factors and does not consider amenities for convenience (Emery, Crump & Bors, 2003). The Pedestrian Environmental Scan (PEDS) is based on the SPACES tool and thus considers similar factors. Additionally, PEDS includes a section that determines the degree of attractiveness of the environment in terms of walking and cycling (Clifton *et al.*, 2007).

The Analytical Audit Tool was initially developed to understand the relationship between physical activity and street scale environments (Brownson, Hoehner, Brennan, Cook, Elliott & Mcmullen, 2004). Moreover, this tool is used to obtain detailed information about street segments. The Analytical Audit Tool considers sidewalk factors such as presence, continuity, location, condition, width, levelness, and obstructions (Brownson *et al*., 2004).

Additionally, Aghaabbasi *et al.* (2017) evaluated two more tools. The first is the Microscale Audit of Pedestrian Streetscapes (MAPS) (Millstein, Cain, Sallis, Conway, Geremia, Frank, Chapman, Van Dyck, Dipzinski, Kerr, Glanz & Saelens, 2013), which was primarily adapted from the Analytical Audit Tool (Brownson *et al*., 2004). The MAPS tool evaluates sidewalks under positive and negative subscales. Positive subscales include the presence and width of sidewalks, buffers, shaded sidewalks, the presence of shortcuts, trees, street-level windows, and building attributes. However, negative subscales include trip hazards, obstructions, slopes, and cross-slopes.

Another tool is the Path Environment Audit Tool (PEAT), which includes sidewalk design factors, disability issues, and amenities such as benches and drinking fountains (Troped, Cromley, Fragala, Melly, Hasbrouck, Gortmaker & Brownson, 2006).

Albers *et al.* (2010) developed the first South African pedestrian environment audit tool. To develop this pedestrian environment audit tool, Albers *et al.* (2010) evaluated three existing audit tools developed for issues and conditions similar to South Africa, which are: the Australian Systematic Pedestrian And Cycling Environmental Scan (SPACES) (Pikora *et al*., 2002); the Scottish Walkability Assessment Tool (SWAT) (Millington, Ward Thompson, Rowe, Aspinall, Fitzsimons, Nelson & Mutrie, 2009); and the Pedestrian Environmental Quality Index (PEQI) (San Francisco Department of Health, 2008). Each of these tools assesses the walking environment according to the purpose of the tool, but also includes a section to assess sidewalk factors. The type of sidewalk, sidewalk width, sidewalk obstructions, driveway cuts, the presence of curbs, and trees/vegetation are common factors (Millington *et al*., 2009; San Francisco Department of Health, 2008; Pikora *et al*., 2002).

However, only two of these tools take into consideration sidewalk location, sidewalk slope, sidewalk condition, tree/vegetation height, parking, continuity of path, lighting, and sidewalk material (Millington *et al*., 2009; Pikora *et al*., 2002). Other factors included in each tool were public seating, the presence of a buffer (San Francisco Department of Health, 2008), and road signs (Pikora *et al*., 2002). Subsequently, these factors were used for the development of the tool which was tested on five sites in the Tshwane Metropolitan Area. It was found that, although the tool provided relevant information, measures needed to be implemented that would ensure the security of fieldworkers – a telling result in itself.

Table 2.2 Summary of audit assessment tools, adapted from Aghaabbasi *et al.* (2017), and modified with data from Lee and Talen (2014), and Albers *et al.* (2010).

Tool Name	Authors	Sidewalk Indicators	Limitations
Analytic Audit Tool—St Louis University	(Brownson *et al.*, 2004)	(1) Availability of comfort features (shade trees, benches, or other types of amenities), (2) Availability of path obstructions (3) Availability/visibility of service amenities in the segment, (4) Presence of street amenities, (5) Availability/visibility of destinations in the segments(driveways) ,(6) Sidewalk width, (7) Sidewalk presence, (8) Street support for walking (crosswalks, traffic lights), (9) Lighting, (10) Aesthetics	Limited number of microscale sidewalk design factors assessed.
Irvine Minnesota Inventory(IMI)	(Boarnet *et al.*, 2006)	(1) Number of seating areas, (2) Number of trees, (3) Sidewalk shaded by trees, (4) Number of visible driveways on the segment, (5) Steepness of the segment, (6) Availability of pedestrian signals, (7) Availability of lighting on the segment	Sidewalk amenities such as trash cans, bollards, and drinking fountains are overlooked. Disability is overlooked.
Microscale Audit of Pedestrian Streetscapes (MAPS)	(Millstein *et al.*, 2013)	(1) Availability of street amenities (benches and seating area, drinking fountain), (2) Presence of path obstruction (trees), (3) Number of trees on either side of the sidewalk, (4) The order of planting the trees, (5) Coverage of trees along the sidewalk (percentage), (6) Number of driveways on the segments, (7) The degree of steepest cross slope, (8) Sidewalk width, (9) Availability of pedestrian signal	Sidewalk facilities overlooked, such as benches, drinking fountains, tactile pavement for people with disability. Surveillance of sidewalk not assessed.
Path Environment Audit Tool (PEAT)	(Troped *et al.*, 2006)	(1) Seating areas and benches, (2) Wheelchair accessible benches and seating areas, (3) Bollards on the segments, (4) Wheelchair	Can consider more types of disabilities, safety, crime not

		accessible bollards (5) Drinking fountains, (6) Function of drinking fountains, (7) Cleanliness of drinking fountains, (8) Wheelchair-accessible drinking fountains, (9) Toilets along the sidewalk, (10) Function of existing toilets along the sidewalks, (11) Cleanliness of existing toilets, (12) Wheelchair-accessible toilets, (13) Slope of the segment, (14) Path condition, (15) Availability of pedestrian signal, (16) Availability of signage, (17) Availability of lighting	assessed, visibility elements like surveillance and window into sidewalk not assessed.
Pedestrian Environment Data Scan (PEDS)	(Clifton *et al.*, 2007)	(1) Availability of street amenities (benches), (2) Number of trees shading the walking area, (3) Availability of medium-/high-volume driveways, (4) Path material, (5) Sidewalk width, (6) Availability of crossing aids (pedestrian signal, signage), (7) Obstruction of path (signs), (8) Overall cleanliness of sidewalk, (9) Roadway/path lighting	Disability issues overlooked. Insufficient inclusion of microscale factors.
Pedestrian Environmental Quality Index (PEQI)	(San Francisco Department of Health, 2008)	(1) Sidewalk width, (2) Sidewalk Obstructions, (3) Presence of curb, (4) Driveway Cuts, (5) Trees, (6) Gardens, (7) Seating, (8) Buffer	Narrow scope, No applied evidence available
PIN3 Neighbourhood Audit Instrument	(Evenson, Sotres-Alvarez, Herring, Messer, Laraia & Rodríguez, 2009; Kelly Evenson, 2009)	(1) Availability of trees shading the walking area, (2) Availability of public lighting	Limited number disability and microscale design factors assessed.
Scottish Walkability	(Millington *et al.*, 2009)	(1) Path location, (2) Type of Path, (3) Material, (4) Sidewalk	Limited study area, Recreation focus,

Assessment Tool (SWAT)		Width, (5) Slope, (6) Condition, (7) Obstructions, (8) Driveway Cuts, (9) Presence of vegetation, (10) Vegetation height, (11) Parking, (12) Street Lighting	
South African Pedestrian Environment Assessment Tool	(Albers *et al.*, 2010)	(1) Sidewalk Presence/Location, (2) Material, (3) Obstructions, (4) Condition, (5) Slope, (6) Drop Off, (7) Curb, (8) Driveway Cuts, (9) Trees, (10) Hedges, (11) Fences, (12) Public Seating, (13) Parking Restrictions, (14) Lighting, (15) Public Transport	Design factors, such as sidewalk width and distance to nearest crossings were not included. Lighting could not be assessed due to fieldworker security.
Systematic Pedestrian and Cycling Environmental Scan (SPACES)	(Pikora *et al.*, 2002)	(1) Availability of path obstructions (trees, sign poles), (2) Number of trees, (3) Average height of trees, (4) Driveway crossovers,(5) Path material, (6) Path surface condition, (7) Cleanliness, (8) Availability of lighting	Disability issued overlooked. Insufficient inclusion of microscale factors. Limited results for subjective factors, Neighbourhood not clearly defined, Poor variability of sites.
Walking Suitability Assessment Form (WSAF)	(Emery *et al.*, 2003)	(1) Material, (2) Surface Condition, (3) Sidewalk width, (4) Necessity of installation of pedestrian signals at busy intersection, (5) Availability of curb ramps, (6) Availability of adequate lighting	Limited number of sidewalk design factors assessed, such as continuity of sidewalks, material, width, and surface condition. Disability issues not considered like tactile pavement and accessible drinking fountains.

In addition to the limitations mentioned in Table 2.2 above, audit assessment tools are also expensive and time-consuming (McMillan, Cubbin, Parmenter, Medina & Lee, 2010). Another significant drawback is the reliability of the audit that mostly depends on the auditors' interpretation (Brownson *et al*., 2009; Clifton *et al*., 2007).

Questionnaires (Surveys)

Questionnaires are the most popular approach to capture and evaluate people's perceptions (Peterson, 2000), and are an essential instrument for data collection. Depending on the objective of the study, scholars make use of questionnaires in various forms, such as to study perceptions as a method (Forsyth, Oakes & Schmitz, 2009; Kihl *et al*., 2005; Saelens, Sallis & Frank, 2003), combine perceptions with objective measurements as a method (Brownson *et al*., 2009), and compare measured results to perceptions (Coughenour, 2013; Zuniga-Teran *et al*., 2017).

Several studies have been conducted to assess perceptions about the walking environment and sidewalks (Kang *et al*., 2013; Kihl *et al*., 2005; Leather, Fabian, Gota & Mejia, 2011; Saelens, Sallis, Black, *et al*., 2003). A well-known questionnaire instrument developed to assess the walking environment is the Neighbourhood Environment Walkability Survey (NEWS) (Saelens, Sallis, Black, *et al*., 2003). This tool considers sidewalk factors by asking about the presence of sidewalks, availability of trees, shade, pedestrian signals, crosswalks, lighting, and a buffer between pedestrians and vehicles.

Liveable communities is a tool initially developed by Pollak (1999) and later updated by Kihl *et al.* (2005), which evaluates sidewalks in terms of maintenance, sidewalk width, the presence of bicycles, traffic signals, amenities, and curb cuts.

Aghaabbasi *et al.* (2017) made use of two questionnaires to develop and evaluate the Neighbourhood Sidewalk Assessment Tool (NSAT). The first questionnaire evaluates the importance of sidewalk facilities to generate a relative weight for each indicator. The second questionnaire is used to assess the selected factors using pedestrians' perception of sidewalk conditions. Among the sidewalk factors included were seating areas, signage, bollards, driveways, tactile pavement, ramps, slope, landscaping, surface, and lighting.

Addressing Shortcomings

In an attempt to address some of the shortcomings mentioned in the previous methods, for example bias of auditors when doing audits (Clifton *et al*., 2007), and the lack of reliable methods to collect data for level of service methods (Asadi-Shekari *et al*., 2014), some researchers are looking at a technique known as Conjoint Analysis (CA). For example, Muraleetharan et al. (2003) used the Conjoint Analysis technique to determine the level of service of a pedestrian path as well as the factors contributing to high or low level of service.

Of particular interest to this study is the recent research done by Wicramasinghe and Dissanayake (2017) to develop an unbiased methodology that can evaluate vital attributes influencing pedestrians in city centres in Sri-Lanka. This was done by using the multivariate technique called Conjoint Analysis. This is a marketing research method based on the principle that customers make a decision for a product or service by comparing its relevant attributes or attribute levels (Green & Srinivasan, 1978). In more detail, Wicramasinghe and Dissanayake (2017) selected relevant attributes and attribute levels, which were used to generate (with the assistance of orthogonal fractional factorial design) hypothetical conjoint profiles. These profiles were then given to pedestrians as a questionnaire to rank the profiles from most to least desired. The results from this were used to evaluate the attribute importance and part-worth utility value of each attribute level. Finally, by matching attributes to locations it was possible to classify locations according to a Total Utility Value. Despite this method being successfully applied, Wicramasinghe and Dissanayake (2017) indicated that its accuracy could be further improved by choosing more attributes and attribute levels that better describe a particular environment.

In conclusion, their research found that Conjoint Analysis is a suitable methodology for representing the qualitative judgments of pedestrians as a reliable information source. In particular, this methodology was found suitable to cluster sidewalks based on pedestrian's preferences and sidewalk attributes.

Conjoint Analysis

The concept of Conjoint Analysis is described by Green and Srinivasan (1978) as a multivariate technique used to understand an individual's preference for a product or service. In principle, this technique is based on the idea that an individual will make their final decision regarding a product or service by trading-off between its attributes or attribute levels (Green & Srinivasan, 1978). Hair, Black, Babin, and Anderson (2010) describe Conjoint Analysis as a method to derive utility values that individuals attach to varying levels of attributes of products or services. The method comprises of presenting customers or users with a set of hypothetical profiles compiled with relevant attributes and collecting their preferences in the form of rankings (Agarwal, DeSarbo, Malhotra & Rao, 2014).

Historical (Green & Srinivasan, 1978), as well as current (Agarwal *et al.*, 2014) research illustrates the effectiveness of Conjoint Analysis in determining consumer preferences. For walkability, in particular, previous research has established that Conjoint Analysis is a useful tool for accurately measuring and evaluating pedestrian preferences with minimum bias (Van Cauwenberg, De Bourdeaudhuij, Clarys, Nasar, Salmon, Goubert & Deforche, 2016; Muraleetharan *et al.*, 2005; Wickramasinghe & Priyankara, 2011; Wicramasinghe & Dissanayake, 2017).

Muraleetharan *et al.* (2005) evaluated the overall pedestrian level-of-service at intersections and along sidewalks using Conjoint Analysis. By comparing total utility value calculated from field measurement data and scores given by users, the results showed that the total utility values have a linear relationship with the overall level of service.

Van Cauwenberg *et al.* (2016) applied Conjoint Analysis to investigate the relationships between microscale environmental factors and walking for transport among older adults. Sidewalk evenness was found to far outweigh other attributes for transportation walking. Similarly, Wickramasinghe (2011) applied Conjoint Analysis to evaluate the most influencing attributes contributing to illegal road crossings. Familiarity was found to be the most influencing attribute under psychological characteristics and traffic condition for physical environmental factors.

Accordingly, this study makes use of the Conjoint Analysis technique to evaluate the preference of pedestrians toward sidewalks in the study area. Furthermore, Conjoint Analysis is applied to evaluate and emphasise the attributes that influence pedestrians to use the roadway for walking instead of the sidewalks.

2.6 SYNTHESIS, DISCUSSION, AND CONCLUSION

Given that nearly 60% of the South African population relies on walking as their primary mode of transport (Albers et al. 2010), and that a third of all road fatalities in the country are pedestrian fatalities (South African National Department of Transport, 2011, with similar results reported by Olukoga, 2003), the importance of greater attention to and the construction of safe, usable walkways cannot be over-emphasised. Walkways and sidewalks in neighbourhoods that are effective in their purpose will ensure that the residents of the neighbourhood enjoy a range of benefits; from safe access to amenities (Crabill, 2009), to increased social integration (Kim & Woo, 2016), and even the economic growth of an area (Gilderbloom *et al.*, 2015).

Therefore, safe and effective pathways and sidewalks require careful planning, not only for new neighbourhood developments, but also for existing neighbourhoods where the demand for services is continually growing (Todes *et al.*, 2010); especially where budgetary constraints play a role in infrastructure upgrades and maintenance (Krambeck, 2006).

With the rezoning of land use, socioeconomic transformations and an increase in pedestrians within residential areas, the need for usable walkways and sidewalks is rapidly increasing. In order to aid municipal and urban planners to effectively plan and allocate budgets, various options should be available. These options should consist of the most effective solutions for the available budget. Thus, it is essential to investigate the influence of various sidewalk attributes along with their level of importance with regard to the use of sidewalks or the avoidance thereof, particularly in the residential areas of a city.

A number of methods exist and are used to measure sidewalk walkability. These methods include, but are not limited to, level of service methods, audits, and questionnaires (surveys). However, as Clifton *et al.* (2007) and Asadi-Shekari *et al.* (2014) point out, each of these methods has its shortcomings. In an attempt to address these shortcomings, new methods and innovations are being explored.

Although literature for evaluating walkability is ample on the international front, it is less so for South Africa. This is further evidenced in the Pedestrian and Bicycle Facility Guidelines (CSIR Transportek, 2003), developed by the South African National Department of Transport, where the sources used to compile these guidelines are overwhelmingly based on international research. Furthermore, the first pedestrian environment assessment tool for South Africa was only developed as recently as 2010 by Albers *et al.* (2010). A number of studies have focused on road fatalities, particularly in terms of pedestrians (Hobday & Knight, 2010; see Olukoga, 2003; Sukhai, 2013), with Moeketsi (2002) and Ribbens and Raborifi (2002) exploring safe road environments and a pedestrian strategy for the country. In another study, by Das and Honiball (2016), investigating the utilisation of public parks in residential areas, accessibility for pedestrians was found to be a significant variable influencing the under-utilisation of public parks. Moreover, local (Mokitimi & Vanderschuren, 2017) and international (Servaas, 2000) studies evaluated the significance of non-motorised transport in South Africa and other developing countries.

It is promising, however, that the South African National Department of Transport recently updated their Non-Motorised Transport (NMT) Facility Guidelines (Vanderschuren *et al.*, 2014), in order to provide guidance for a more balanced approach to the design of cities for the benefit of non-motorised transport, which would improve the quality of life of South Africans (Vanderschuren & Sekadi, 2015).

It is evident that fully accessible and walkable neighbourhoods have a positive effect on a city, its neighbourhoods, and its users. It is also apparent that research in this regard within South Africa is reasonably limited. Thus, this study intends to explore sidewalk attributes and their importance, in order to contribute to the development of a safe, useful, and effective walkable environment in residential areas. The findings from the literature will form the basic framework for this investigation.

CHAPTER 3: PROFILE OF STUDY AREA

3.1 INTRODUCTION

To provide insight into this investigation and the results contributing to the formulation of sidewalk planning and design guidelines, a good understanding of the study area is required. Numerous geographical, infrastructural, socio-economic, and physical parameters contribute to the accessibility of a city. Sidewalks form an integral part of facilitating pedestrian access.

The residential neighbourhood, Universitas, was selected for this investigation. The selection was based on a range of criteria which is discussed in more detail in section 3.3.1. This chapter presents the state of the parameters that discourage pedestrians from using the current sidewalks, offers a background of the study area, its demographic and socio-economic profile, and an investigation of its land use, transportation, and sidewalk network.

3.2 WALKABLE BLOEMFONTEIN?

The first part of this section provides an overview of Bloemfontein by giving a summary of its history and demographic profile. In the second part, the walkability aspects of the city are discussed.

3.2.1 General Overview

Geographically, Bloemfontein is located in central South Africa at 29°06′S and 26°13′E with an average elevation of 1400m above sea level (see Figure 3.1). Bloemfontein is accessible via the N1, N6, and N8 national roads. Furthermore, Bloemfontein is serviced by a national airport and a north/south and east/west railway line.

Figure 3.1 Map of South Africa (Department of Peacekeeping Operations Cartographic Section, 2007)

The collective Mangaung Metropolitan municipal area has an estimated total population of 826 979. This municipal area consists of Bloemfontein, Botshabelo, and Thaba Nchu (Mangaung Metropolitan Municipality, 2017). Bloemfontein has an estimated population of 569 558, which is an increase of 31% per year from the 2011 Census, which estimated a population of 256 534 people (Statistics South Africa, 2011). This growth is mainly due to the migration from surrounding areas and nearby smaller towns (Mangaung Metropolitan Municipality, 2017). Figure 3.2 illustrates the expected growth for Bloemfontein by 2030.

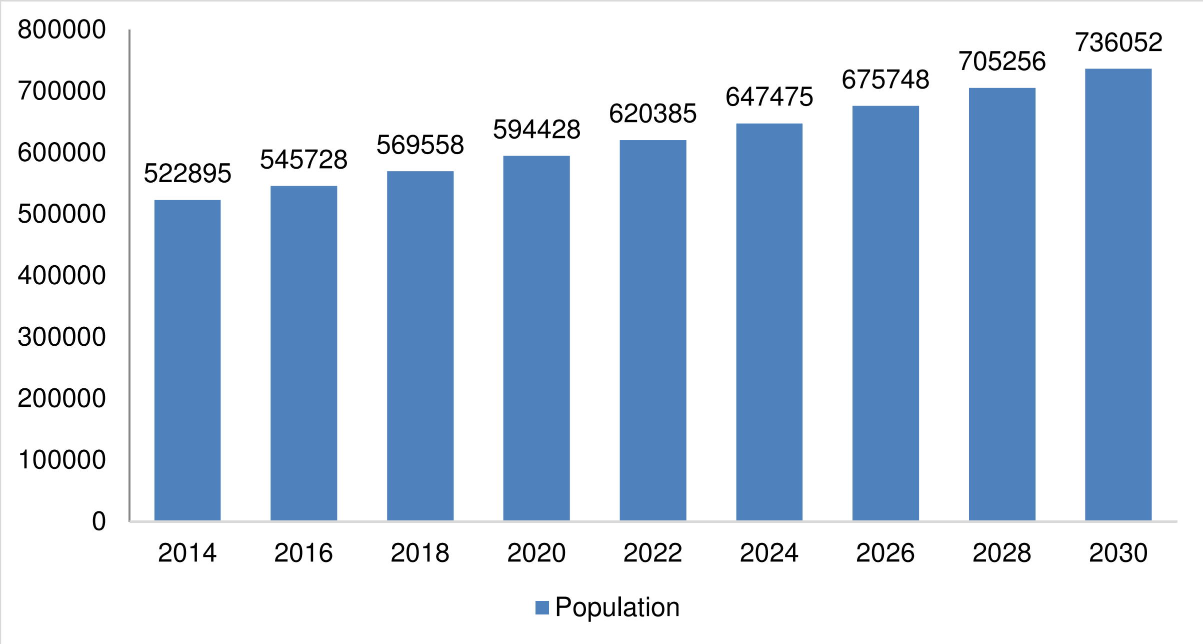

Figure 3.2 Expected population growth for Bloemfontein City. (Mangaung Metropolitan Municipality, 2017)

Bloemfontein is the capital city of the Free State province; therefore, it is the most significant economic contributor to the province (Mangaung Metropolitan Municipality, 2017). The economy in Bloemfontein is mostly driven by financial, trade, transport, and community services.

With regards to employment, 39% of the population in Mangaung is economically active, whereas 27.2% are unemployed (Mangaung Metropolitan Municipality, 2017). Spatial income classification and distribution is shown in Figure 3.3. Higher income areas are located to the northern side of the city, and middle to higher income areas – including Universitas – are mostly located on the western side of the city, whereas the middle to low-income areas are located on the south-western side of the city.

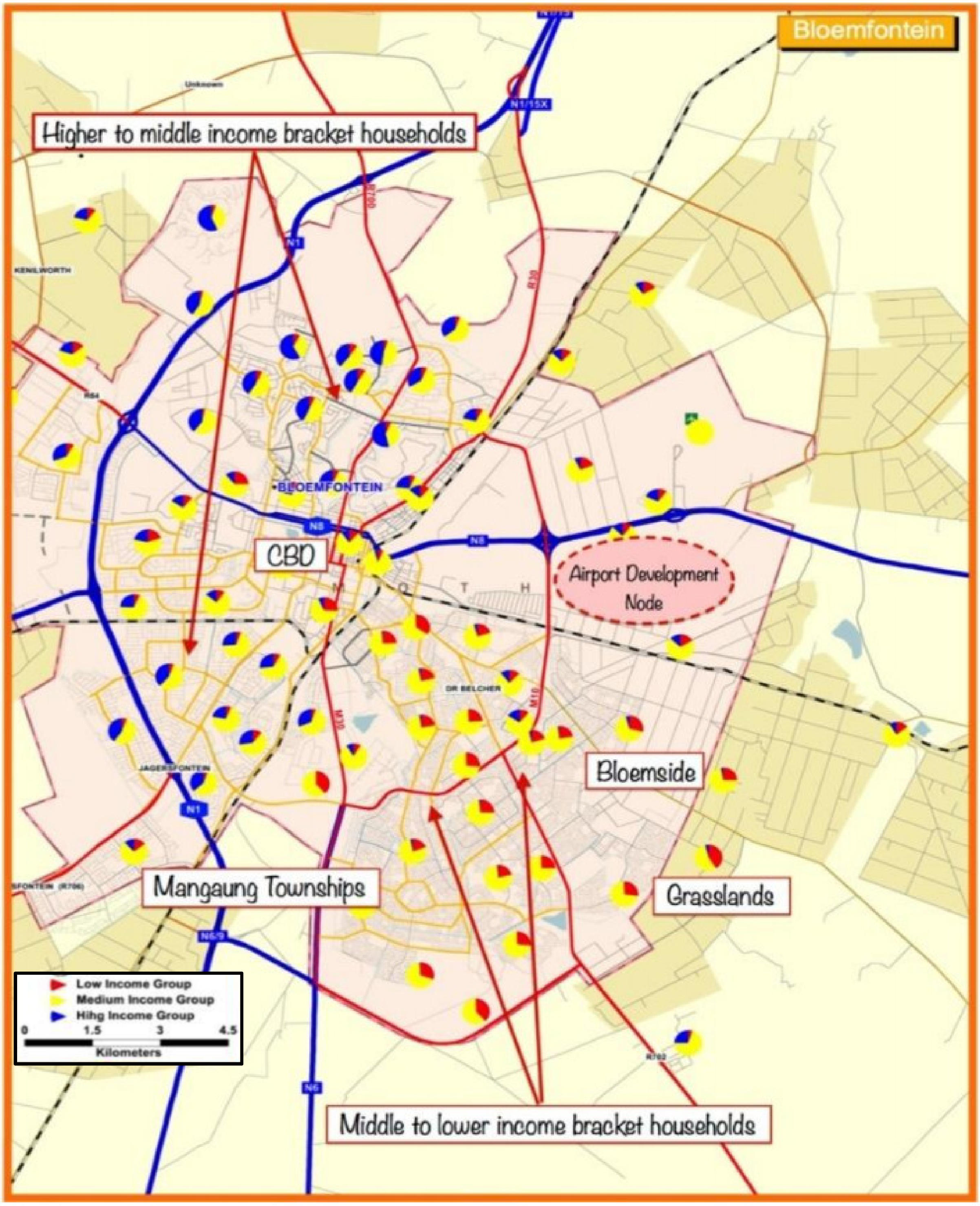

Figure 3.3 Spatial income classification (Mangaung Metropolitan Municipality, 2017).

Figure 3.4 illustrates the age and gender structure of Bloemfontein. It is important to notice that the largest two age groups are young adults, which refers to individuals between 20-24 years of age, making up 12% of the population, and those 25-29 years of age, which make up 10.3% of the estimated population (Statistics South Africa, 2011). A possible contributor to these statistics are the two universities in Bloemfontein. After that, there is also a noticeable decline in population up to the age of 85+.

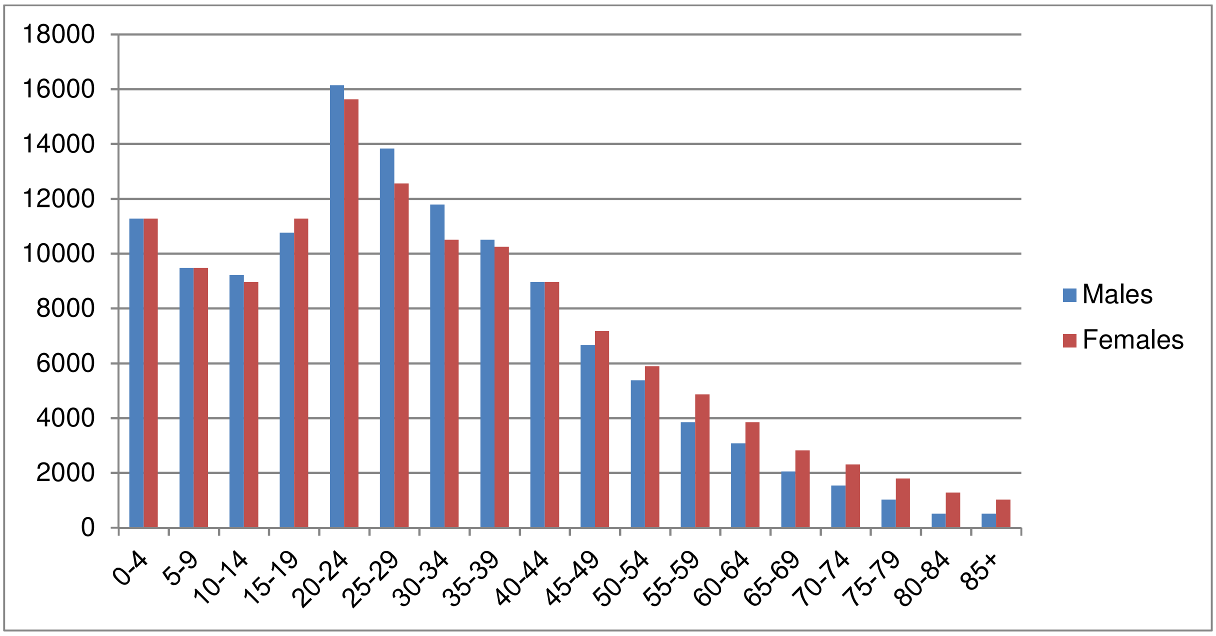

Figure 3.4 Gender and age profile of residents in Bloemfontein by age group.

3.2.2 Transportation Overview

Typical to South African cities, Bloemfontein is mostly planned and designed to accommodate motorised transport (CSIR Transportek, 2003). Nevertheless, according to the Mangaung Metropolitan Municipality Integrated Development Plan of 2017 (2017), Bloemfontein is known as the “walking city”, which is verified by the National Household Travel Survey (2014) - showing that 17% of all work-related trips are made by walking all the way to and from the workplace. Furthermore, approximately 190 000 work-related personal trips are made during the same period (Statistics South Africa, 2014). This mode split is 32.56% by taxi, 10.55% by bus, 8.44% through ridesharing, and 29.3% with private vehicles (Statistics South Africa, 2014).

Bloemfontein has a road network comprising of all six types of roads as classified in TRH 26 South African Road Classification and Access Management Manual (2012), namely: principal, major and minor arterials; collector and local streets; and walkways. Figure 3.5 below shows the road network of Bloemfontein City. The surrounding suburbs are connected to the city centre through a network of major arterials. Some of the residential neighbourhoods are used as thoroughfares to other residential neighbourhoods as well as commercial areas.

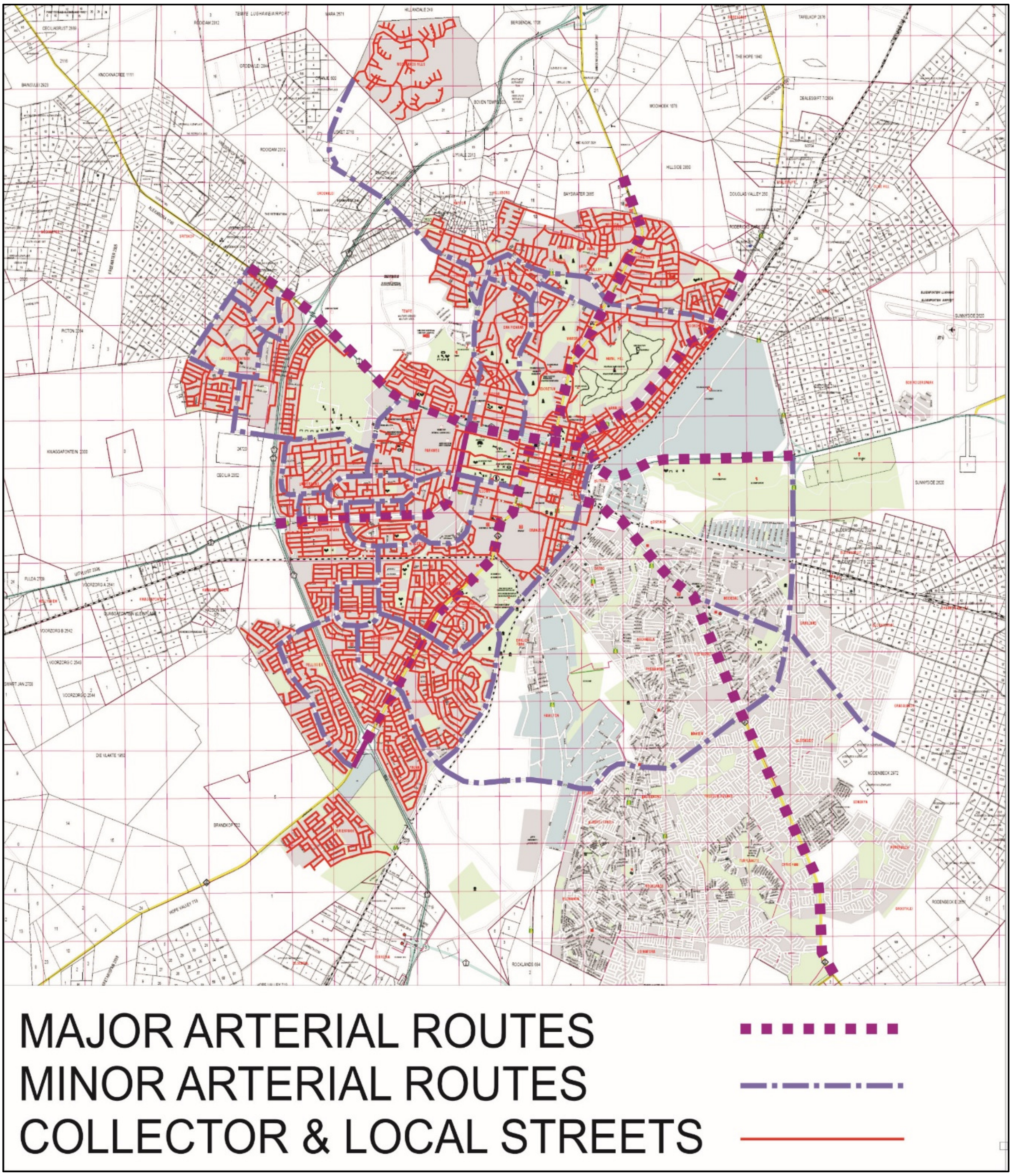

Figure 3.5 Road network of Bloemfontein City (Burger, 2013)

Regarding public transportation, the city of Bloemfontein is mainly serviced by an interstate bus system and minibus taxis. A small number of commuters make use of private taxis. The bus system operates on predetermined routes with various stops located along all the primary and minor arterial roads of the city. Unlike the interstate bus system, the minibuses do not drive according to schedules and operate mostly in an informal fashion. The minibuses do not only stop at designated stops, but also wherever a commuter is waiting along the road to be picked up. Most of the commuters that make use of public transport travel from the eastern part of the city to the central and western parts of the city in the mornings and back in the afternoons. Commuters making use of public transport are expected to walk to the designated pickup points and minor and major arterial routes serviced by the minibuses. The facilities and infrastructure to accommodate these pedestrians seem to be little to none. So, how walkable is the "walking city"?

3.2.3 Walkability Aspects

As mentioned in the previous section, Bloemfontein is known as the "walking city." However, the infrastructure to support the "walking city" is observed to be lacking and is confirmed by the community needs and inputs collected to compile the Mangaung Integrated Development Plan (Mangaung Metropolitan Municipality, 2017).

The local municipality has, however, undertaken projects in the past to improve walkability. Some of these projects include, but are not limited to: the upgraded Hoffman Square (see Figure 3.6) in the city centre; the pedestrianisation of Selbourne (see Figure 3.7) and Elizabeth Street for the 2010 Soccer World Cup, and ongoing sidewalk upgrades (see Figure 3.8) in the central business district of the city.

Figure 3.6 Upgraded Hoffman Square in Bloemfontein City (Source: Author).

Figure 3.7 Pedestrianisation of Selbourne Avenue in Bloemfontein City (Source: Author).

Figure 3.8 Historical imagery form Google Maps Street View showing the sidewalk upgrade in Henry Street, Bloemfontein (Google LLC, 2017).

Although efforts by the municipality to improve walkability in Bloemfontein can be observed in the central business area, residential areas which are also in desperate need (Mangaung Metropolitan Municipality, 2017, Own survey), are not a priority. Additionally, with the population growth discussed in section 3.2.1, the lack of infrastructure could become even more problematic in the near future.

In residential areas, some examples of small-scale private sidewalk and pathway developments can be observed, for example, (1) the pathway around Striata Retirement Village (see Figure 3.9), (2) the sidewalk upgrade at Campus Key Student Accommodation (see Figure 3.10) in Universitas, and (3) isolated cases where homeowners develop the sidewalk in front of their homes (see Figure 3.11).

Figure 3.9 Sidewalk around Striata Retirement Village, Universitas (Source: Author).

Figure 3.10 Sidewalk at the Campus Key Student Accommodation, Universitas (Source: Author).

Figure 3.11 Example of a sidewalk upgraded by a homeowner in Lyle Street, Universitas (Source: Author).

3.3 UNIVERSITAS – DIVERSITY OF PEDESTRIANS

3.3.1 Why Universitas?

Surveys have confirmed that pedestrians in Universitas tend to use the roadway instead of sidewalks for walking. To further investigate the severity of this issue in Universitas, the other residential suburbs in Bloemfontein were evaluated and compared to Universitas. This was done by evaluating different neighbourhoods through field observations and the determination of trip generators form GIS data and aerial photography.

Pedestrian network and route planning are mainly based on the origins and destinations of pedestrian trips (Keshkamat, Looijen & Zuidgeest, 2009). The most useful sources of primary data to determine this are local planning documents and maps that indicate land use, roads, major residential subdivisions, developments, etc. (Vanderschuren *et al.*, 2014). Furthermore, the Non-Motorised Transport Facility Guidelines (Vanderschuren *et al.*, 2014) indicate that a higher concentration of pedestrians can be expected near popular destinations, also known as trip generators. These include schools and universities, shopping areas, gathering facilities (leisure, entertainment, and so on), and natural areas like public parks.

There are 35 residential areas in Bloemfontein (Figure 3.12 and 3.13). Main destinations and trip generators were identified for each suburb, namely schools, universities, shopping centres, churches, retirement villages, residential homes, and public parks. Table 3.2 lists all of these residential areas with their trip generators. Additionally, other applicable factors affecting pedestrians were also evaluated, namely: population, size, type of accessibility, and thoroughfares for pedestrians (Pikora, Giles-Corti & Donovan, 2001).

Figure 3.12 City of Bloemfontein (© OpenStreetMap contributors, 2018).

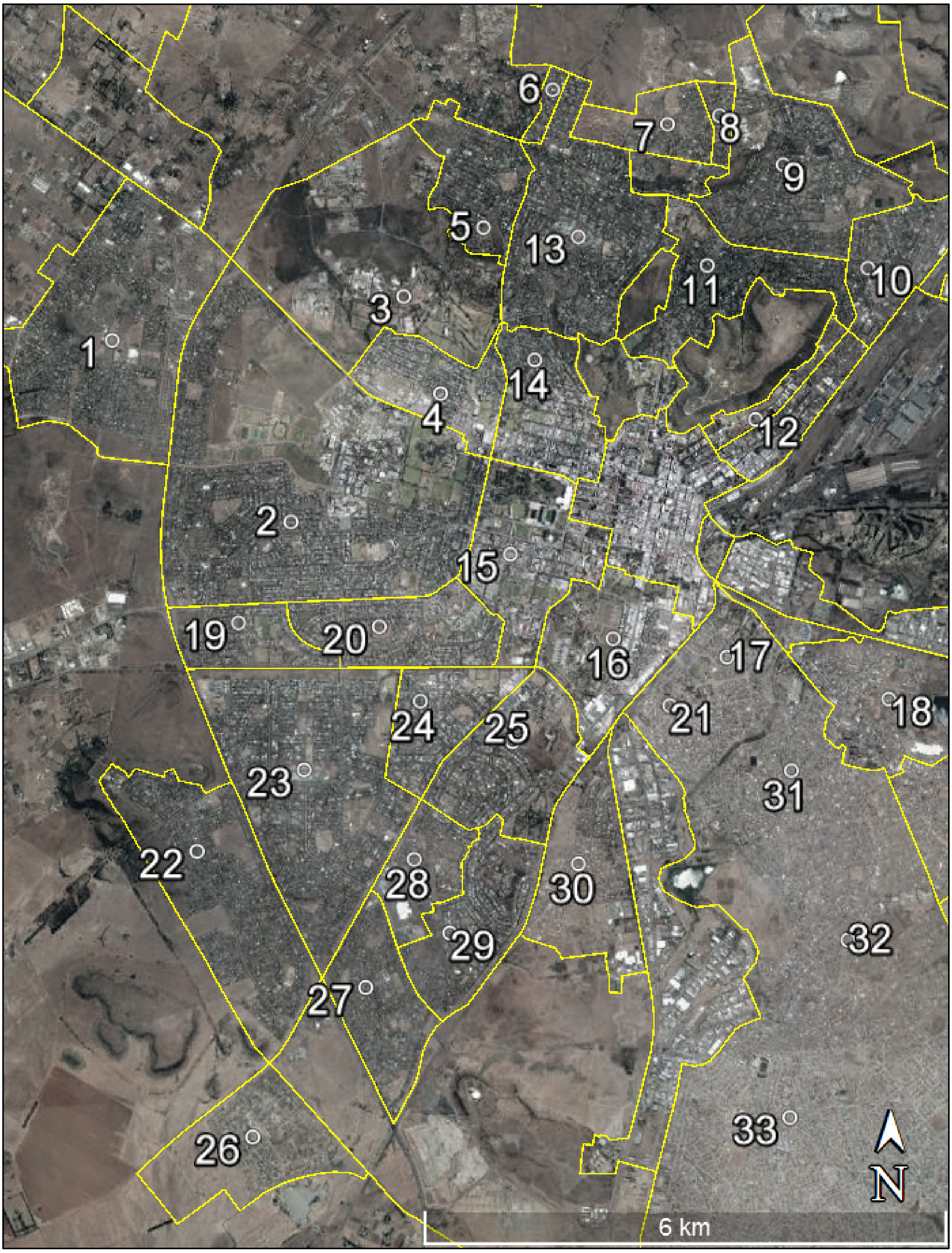

Figure 3.13 Suburban residential areas in Bloemfontein City (Google LLC, 2018a).

Table 3.1 Trip generating destinations in residential suburbs of Bloemfontein (Own survey).

Bloemfontein Suburbs	Reference number in Figure 3.13	Area (km^2)	Residential	Public Parks	Thoroughfare	Schools	Shopping Centres	Religious Gatherings (Churches)	Higher Education Institutions	Retirement Village
Batho	17	1	x	x	x	x	-	x	-	-
Bayswater	9	1.3	x	x	x	x	x	-	-	x
Blomanda	35	0.73	x	x	x	x	-	-	-	-
Bochabello	31	2.35	x	x	x	x	x	x	-	-
Brandwag	4	1.5	x	x	x	x	x	x	-	-
Dan Pienaar	13	3.8	x	x	x	x	x	x	-	x
Ehlrichpark	30	0.47	x	x	-	x	x	-	-	-
Fauna	27	1.54	x	x	x	x	x	x	-	-
Fichardtpark	23	4.04	x	x	x	x	x	x	-	x
Fleurdal	28	1.48	x	x	x	-	x	x	-	-
Gardenia Park	19	1.4	x	x	x	x	x	x	-	-
Generaal De Wet	25	1.5	x	x	x	x	x	x	-	-
Hamilton	21	0.63	x	x	x	-	-	-	x (UFS South	-

									Campus)	
Heidedal	18	0.8	x	x	x	x	x	x	-	-
Helicon Heights	8	1.2	x	x	x	-	-	x	-	-
Heuwelsig	5	2.4	x	x	-	-	x	x	-	-
Hillsboro	6	1	x	x	-	-	-	-	-	-
Hilton	12	1.25	x	x	-	x	x	x	-	-
Hospital Park	24	1.2	x	x	x	x	x	x	-	-
Kagisanong	34	4.54	x	x	x	x	-	x	-	-
Langenhovenpark	1	4.5	x	x	-	-	x	x	-	-
Lourier Park	26	1.5	x	x	-	x	x	x	-	-
Noordhoek	10	0.5	x	x	-	x	x	x	-	-
Oranjesig	16	0.5	x	x	x	-	x	x	-	-
Pellisier	22	3	x	x	-	x	x	x	-	-
Pentagon Park	7	1.3	x	x	-	x	-	-	-	x
Phamaneng	32	2.44	x	x	x	x	-	-	-	-
Rocklands	33	3.05	x	x	x	x	x	x	-	-
Tempe	3	1.3	x	x	-		-	x	-	-

Uitsig	29	0.79	x	x	x	x	x	x	-	-
Universitas	2	9.66	x	x	x	x	x	x	x (UFS Main Campus)	x
Waverley	11	1.3	x	x	x	x	x	x	-	-
Westdene	14	1.6	x	x	x	x	x	x	-	-
Wilgehof	20	1.6	x	x	x	x	x	x	-	-
Willows	15	1.14	x	x	x	x	x	x	x	-

In Table 3.1, 35 residential neighbourhoods in Bloemfontein are listed in alphabetical order; with examples of trip generating destinations shown in columns in addition to the size of a particular neighbourhood. The fact that a neighbourhood is residential in nature, is in itself a source of trip generation; whilst amenities such as a public park, shopping centre, church, and school, also serve as reasons for people to move around within their own neighbourhood, as well as between different neighbourhoods. With the exception of ten neighbourhoods (due to their location – such as being on the peripheral areas of Bloemfontein – or their purpose - as is the case of the Military that is located in Tempe), most neighbourhoods serve as thoroughfares for people moving between their homes and workplaces. The role of two higher education institutions as trip generating amenities are seen directly in the three neighbourhoods that they are located: (1) The main campus of the University of the Free State in the neighbourhood of Universitas, (2) its South Campus in Hamilton, and (3) the Central University of Technology in Willows.

From Table 3.1, it is seen that, not only is Universitas the largest suburb, but it is also the only neighbourhood in which every trip generating amenity can be found, including a retirement village. Due to its location, Universitas connects several neighbourhoods to central business areas, resulting in it being used as a thoroughfare by commuters. In addition to the diversity of trip generators and its large size, the studentification of the neighbourhood, which has been described by Ackermann and Visser (2016), has undeniably contributed to the observed (and growing) overflow of pedestrians from the sidewalk into the roadway. Based on the aforementioned, Universitas is ideal for the suggested investigation.

3.3.2 Background and Overview

Universitas is situated on the western side of Bloemfontein (see Figure 3.14) and is approximately 9.66 square kilometres in size. Historically, Universitas was used for agriculture, and the Bloemfontein racecourse was located where Paul Kruger Avenue is today. This suburb is a single residential suburb and residents mostly stay in stand-alone houses, apartments, and townhouses. Universitas holds major sub-arterial roads, connecting adjacent neighbourhoods to each other and to the business district. Consequently, the neighbourhood acts as a thoroughfare for motorists and pedestrians.

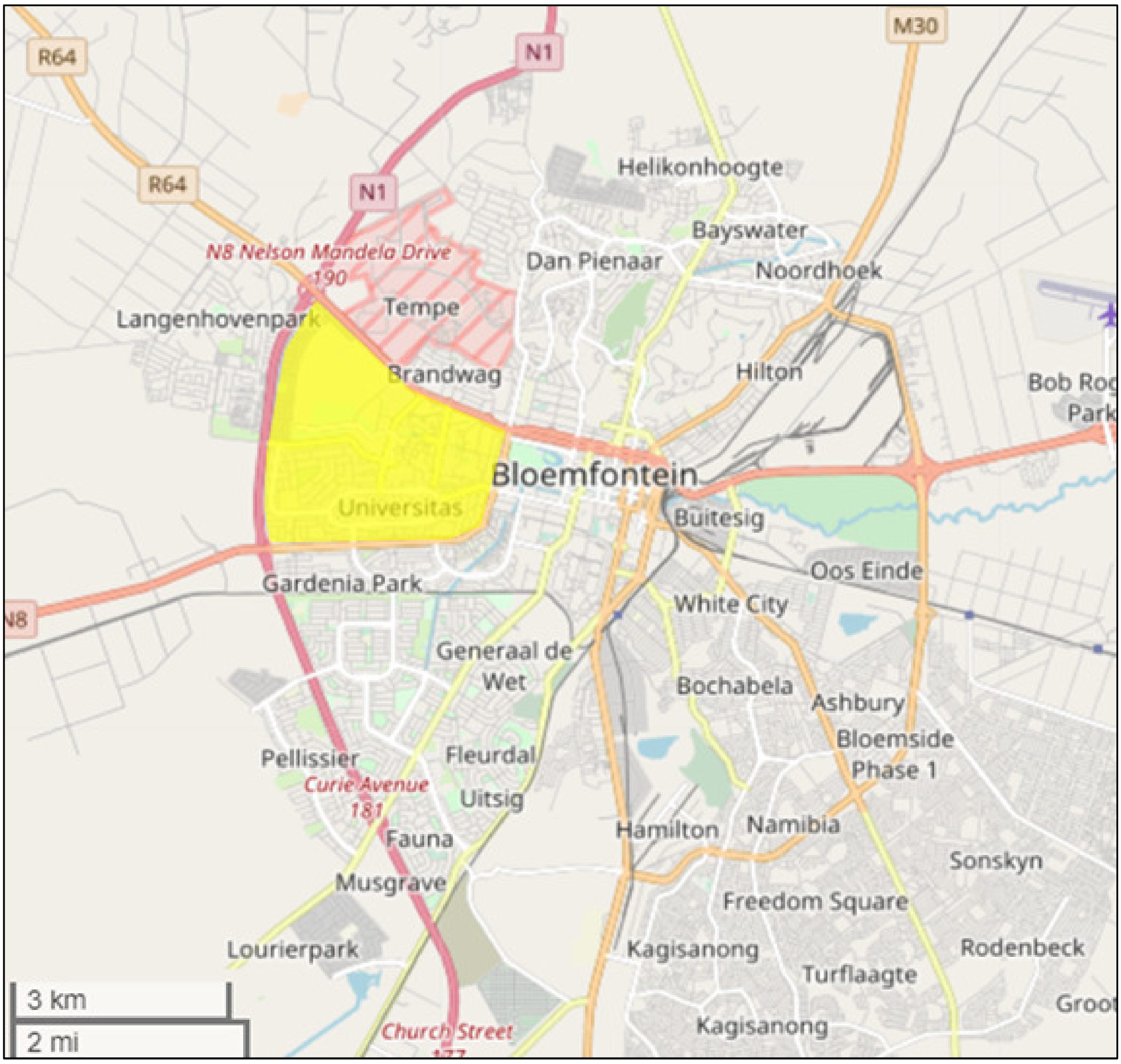

Figure 3.14 The neighbourhood of Universitas in Bloemfontein City (© OpenStreetMap contributors, 2018)

Land Use

The suburb of Universitas is zoned as a single residential suburb (as shown in Figure 3.15), which is defined as a building designed for a single family with 1 to 1.5 parking spaces for every four bedrooms. However, due to the influence of the University, many of these houses have been converted to communal student accommodation (see Figure 3.16). Furthermore, it is also evident that Universitas is a diverse neighbourhood with various types of land use, such as religious, education, business, and sectional titles. The business land use reflected in Figure 3.15 includes not only local shops, but also guesthouses. A large number of sectional titles, guesthouses, and student houses reflects an increase in the number of residents, for which it was not originally designed. Therefore, it is safe to assume that there has been a substantial increase in pedestrians as well.

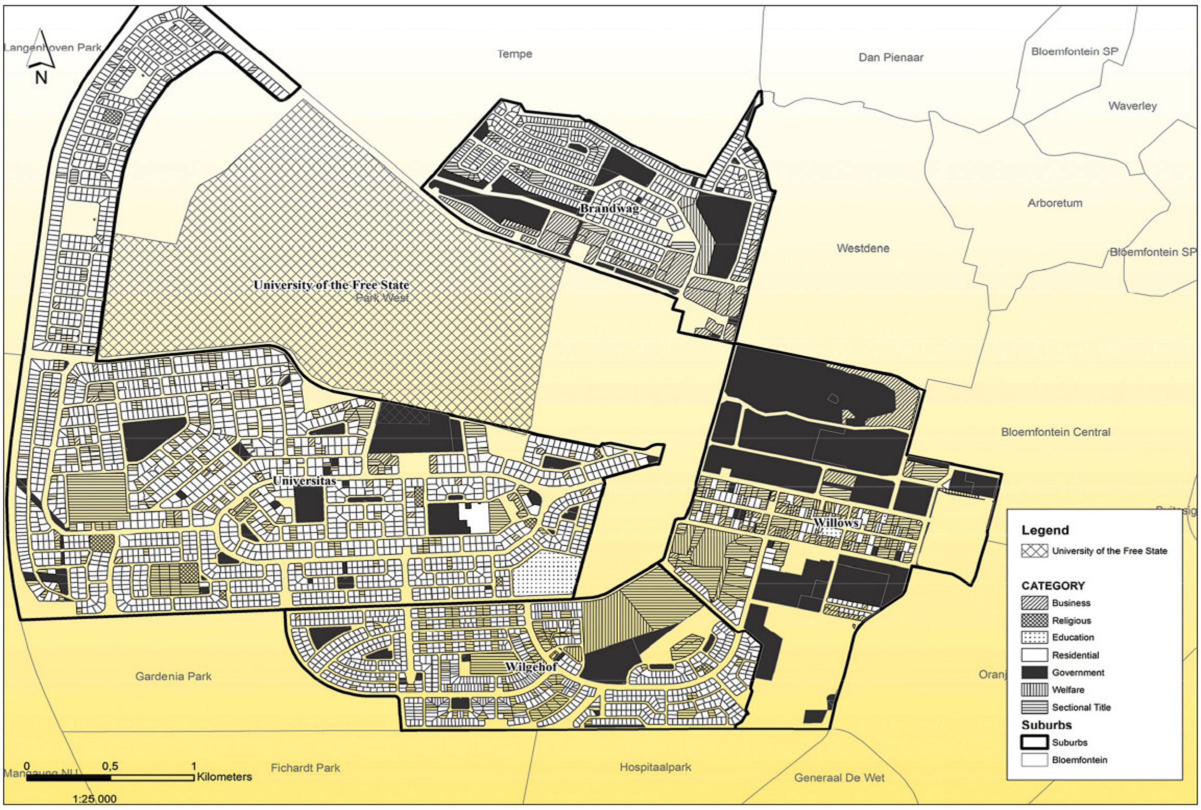

Figure 3.15 Land use of Universitas and the other neighbourhoods surrounding the University of the Free State (Ackermann & Visser, 2016).

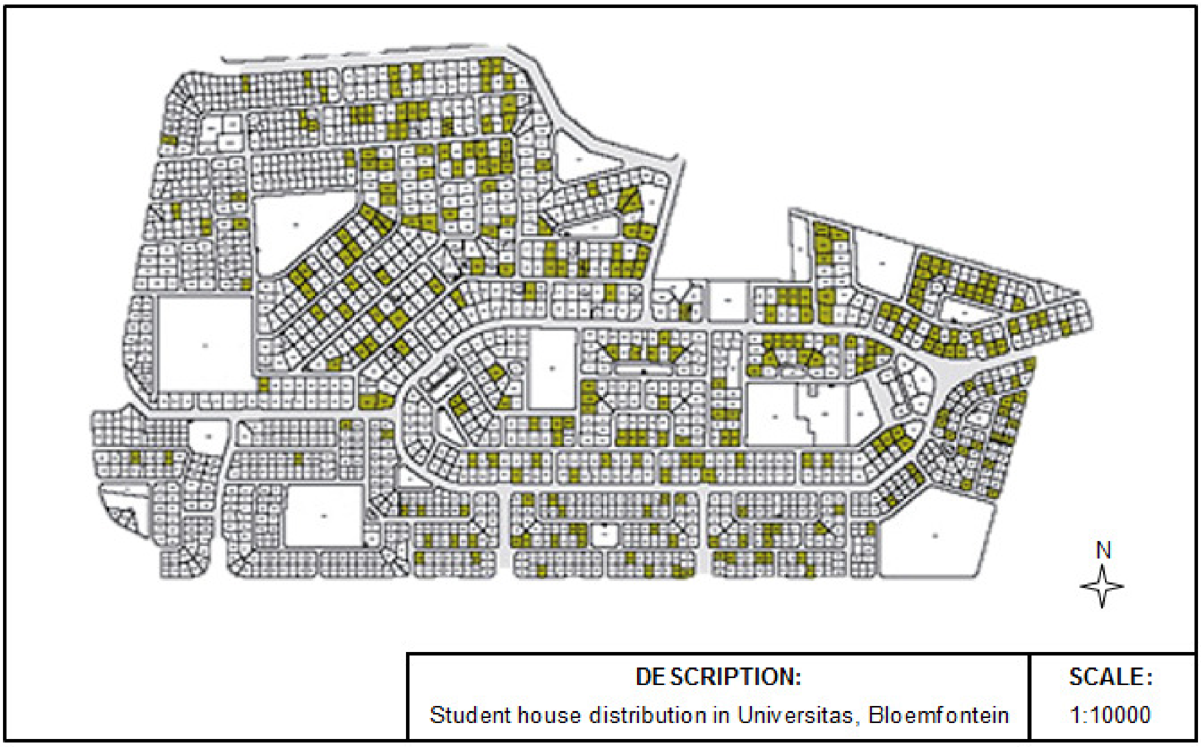

Figure 3.16 Distribution of student houses in Universitas, Bloemfontein (Donaldson, Benn, Campbell & De Jager, 2014).

Population and Density

Universitas has approximately 5304 households with a population of 13929, resulting in a population density of 1510 persons per square kilometre (Statistics South Africa, 2011). A major contributor, as identified by Donaldson *et al.* (2014), is the growing student population of the University of the Free State, with approximately 37 000 students currently enrolled. Many houses have been converted to student housing to accommodate these students. As Donaldson *et al.* (2014) indicate, Universitas has 330 student houses with an average of 9 residents per house, resulting in a total of 2970 residents.

The gender distribution is relatively equal, with 52% female and 48% male residents (Statistics South Africa, 2011). Furthermore, the population groups, in descending order, are White with 49%, Black African with 44%, Coloured with 5%, Indian or Asian with 1%, and Other with 1% (see Figure 3.17).

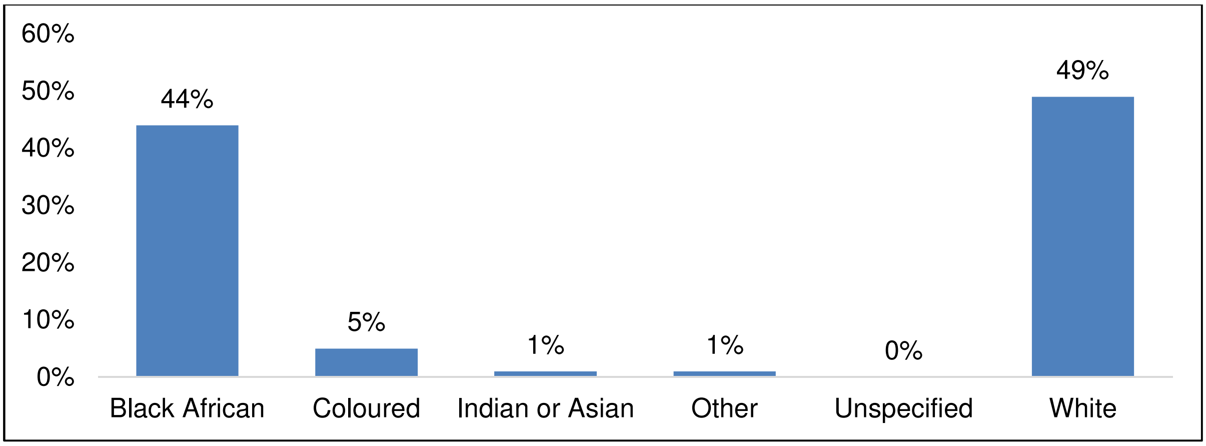

Figure 3.17 Population groups in Universitas (Statistics South Africa, 2011).

Economy

Universitas is located near the central business districts of Bloemfontein and is also a thoroughfare connecting other neighbourhoods. Within the neighbourhood, there are two main shopping centres servicing residents.

Ackermann and Visser (2016) establish that there are significant economic impacts related to the studentification of an area, as students bring capital inflow to local businesses as well as surrounding areas. The presence of hospitals, and the central location of this suburb in relation to other services in the city, contribute to the ample overnight accommodation offerings: There are nearly 50 guest houses located in the neighbourhood (LekkeSlaap.co.za, 2018).

The overall income level of Universitas' residents is medium to high (see Figure 3.4 in the previous section), with an average annual income of R117 000.00 (Statistics South Africa, 2011). The employment rate, however, is only 31.5%, with 66% of residents not being economically active (Statistics South Africa, 2011).

Trip Generating Destinations

As mentioned in section 3.3.1, trip generating destinations are used for pedestrian network and route planning. Using field surveys and GIS information, the destinations shown in Figure 3.18 were identified.

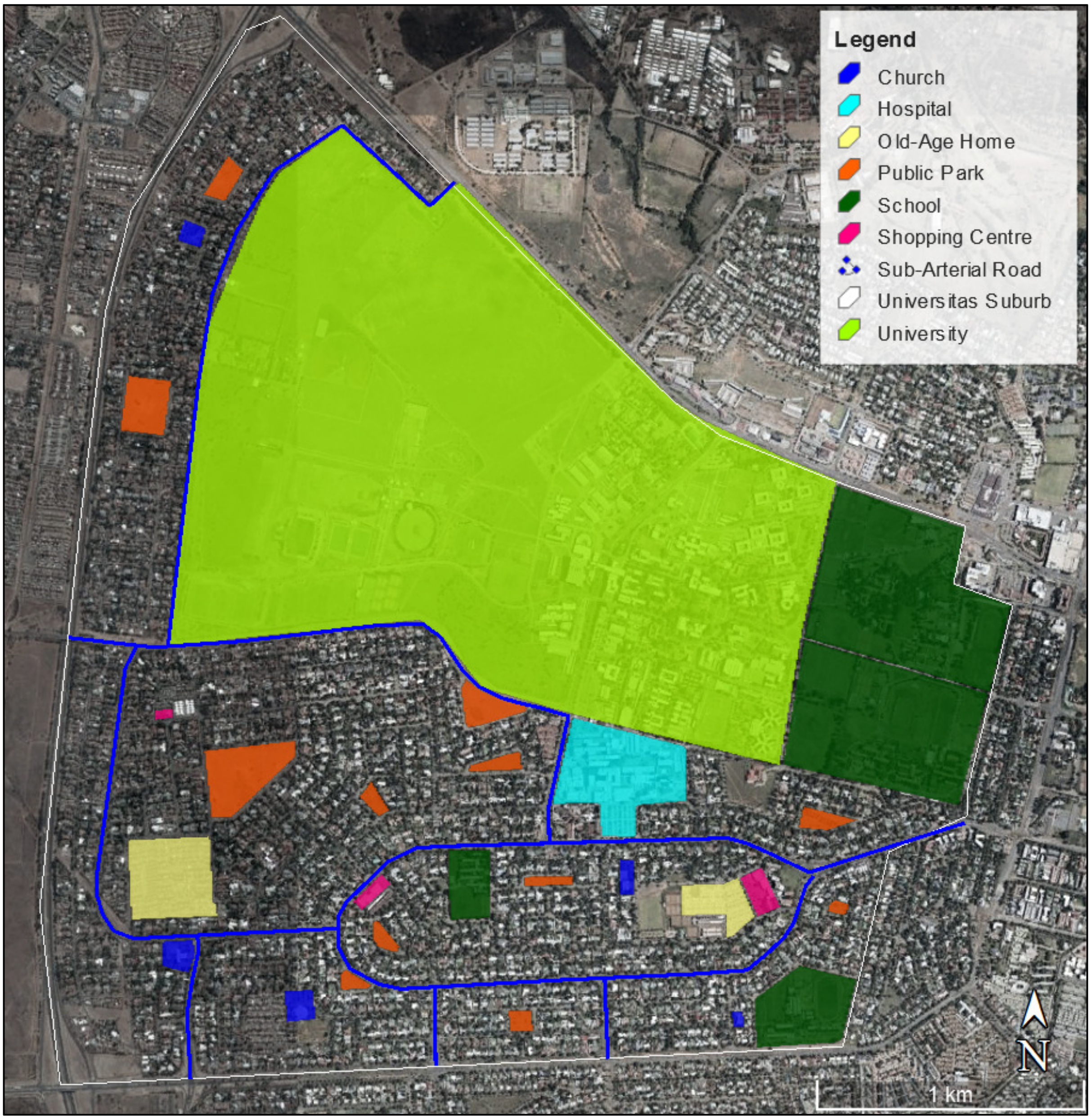

Figure 3.18 Pedestrian generating destinations in Universitas (Google LLC, 2018b).

The University of the Free State, with 37 000 students enrolled, is the most significant trip generating destination. The university, however, can only accommodate around 4000 students on-campus (University of the Free State, 2016). Students, unable to find on-campus accommodation, are compelled to find accommodation in neighbourhoods surrounding the campus.

Directly south of the University of The Free State, two hospitals are located: Universitas Private Hospital and Universitas Academic Hospital. Both hospitals employ staff who must travel to and from work daily. The field surveys indicated that many of these employees make use of public transport up to the designated pickup and drop off areas and must finish and start their trips by means of walking.

Schools within and directly adjacent to the suburb are Universitas Primary School with 890 learners, Grey College (Pre-primary, Primary, and Secondary School) with approximately 1900 learners, Eunice (Primary and Secondary School) with approximately 1600 learners and Dr. Bohmer Secondary School with 810 learners.

Two retirement homes are also present within Universitas. In an anonymous interview, an official representing one of the retirement homes indicated that they regularly receive complaints from residents regarding the conditions of the sidewalks and the safety concerns related to walking in the roadway.

Furthermore, other important destinations are the two shopping centres servicing Universitas, the eleven public parks, and the five churches used for religious gatherings.

Transportation

Major arterials routes surround Universitas and are connected internally with minor arterial routes to the collector and local streets as shown in Figure 3.5. The minor arterial routes connect several adjacent neighbourhoods to central business areas. These thoroughfares are popular routes for public transport as well as pedestrians.

Furthermore, apart from its many pedestrians, Universitas is mostly in line with the rest of Bloemfontein as discussed in section 3.2.3. The number of pedestrians observed making use of the roadway makes it evident that there is a lack of infrastructure and facilities for pedestrians.

3.3.3 Where do people walk in Universitas?

Since there are a large number of pedestrians observed in Universitas, a valid question to ask is “where do people walk in Universitas?”.

Sidewalks and Pathways

From GIS data, aerial photography, and physical surveys, it was found that no pedestrian network exists in Universitas. From the physical surveys, although sufficient in width, most verges and sidewalks are inadequate for walking, due to inappropriate urban furniture, poor maintenance, built up gardens, unmaintained stormwater inlets, uneven driveways, and vegetation (see Figure 3.19).

Figure 3.19 Examples of verges and sidewalks that are unsuitable for walking, in Universitas, Bloemfontein City (Source: Author).

Moreover, it is also evident that pedestrians do, in some instances, make use of the sidewalks where possible, even though there are no designated pathways (See Figures 3.20 & 3.21).

Figure 3.20 Informal pedestrian path navigating trees and vegetation in President Paul Kruger Avenue, Universitas (Source: Author).

Figure 3.21 Informal pedestrian path on vegetation surface in Stofberg Street, Universitas (Source: Author).

Similar to section 3.2.3, there are, however, small-scale private sidewalk and pathway developments present. These developments are mostly in front of the owner's property and thus not continuous (see Figure 3.22).

Figure 3.22 Privately developed paved sidewalk sections on Scholtz Street, Universitas (Source: Author).

Roadway

Since there are little to no walkable sidewalks, the only option left for pedestrians is to walk in the roadway. This is overwhelmingly confirmed by multiple field observations as shown in Figure 3.23. In some instances, pedestrians obstruct the normal flow of traffic.

Figure 3.23 Pedestrians using the roadway for walking in Universitas (Source: Author).

As shown in Figure 3.23, several observations were photographed at various times. These streets (all in Universitas) were: A - Stofberg Street, where 11 pedestrians are shown; B – Scholtz Street, where 7 pedestrians are shown; C – Osborne Street, where 4 pedestrians are shown; and Sergeant Street, where 3 pedestrians are shown.

3.4 SUMMARY

In summary, the analysis of the study area indicated the following:

- Bloemfontein is known as the “walking city”, due to the number of pedestrians commuting daily.
- The population of Bloemfontein is increasing at a rapid pace, mainly due to migration from the surrounding areas and smaller towns in the province.
- The largest age group in Bloemfontein, representing 12% of its total population, is between the ages of 20 to 24 years old. A significant contributor can be the two universities in Bloemfontein.
- There have been upgrades to accommodate pedestrians within the city, but the efforts are not nearly enough to keep up with the city’s growth. These upgrades were mostly done within the city centre, with little to no attention to residential areas.
- The neighbourhood Universitas in Bloemfontein was chosen as the study area. Universitas has a high number of pedestrians with no defined sidewalk network. Although verges and sidewalks are present, they are not adequately developed and,

as a result, they are not walkable. Evaluating and comparing Universitas to other suburbs in Bloemfontein revealed that Universitas is the most suitable suburb to study the identified problem of pedestrians avoiding sidewalks. The comparative evaluation also indicates that to an extent, Universitas, seemingly sufficiently represent conditions present in other residential neighbourhoods in Bloemfontein.

- Universitas is the largest residential neighbourhood in Bloemfontein and has a relatively diverse land use with several trip generating destinations.
- The largest of these trip generating destinations is the University of the Free State. The university has a significant influence on the surrounding areas, due to a large number of students that need off-campus accommodation, and this has a major impact on the local economy.
- Universitas (similar to other residential neighbourhoods in Bloemfontein) has inconsistently developed sidewalks and verges throughout. This space, although seemingly sufficient in width, is unsuitable for walking, due to inappropriate urban furniture, poor maintenance, built up gardens, unmaintained storm water inlets, uneven driveways, and vegetation.
- Since the sidewalks in the suburb are not pedestrian friendly, the only option left for pedestrians is the roadway.

Due to its unique characteristics and evident growth, Universitas presents a setting to investigate and identify possible solutions to better accommodate pedestrians and improve pedestrian access.

CHAPTER 4: DATA ANALYSIS, RESULTS AND DISCUSSION

4.1 INTRODUCTION

In this chapter, an attempt was made to analyse sidewalk attributes that influence the walkability of residential areas in Bloemfontein City. The four objectives identified (see section 1.3.2) to reach this goal were pursued as follows:

Firstly, to explore essential sidewalk attributes and to categorise the importance thereof, the Conjoint Analysis and Pedestrian Preference Score methodologies were deployed. As previously mentioned, the Conjoint Analysis technique was used in an attempt to delineate the most influential sidewalk factors. By evaluating respondents' preferences, a part worth utility value was assigned to the identified attributes. The Total Utility Value was then calculated for selected sidewalks within the study area by assigning the appropriate attribute levels and substituting the part worth utility values determined by the Conjoint Analysis. To further evaluate the results of the Conjoint Analysis, they were related to the actual willingness of pedestrians to use the sidewalk. Thus, a Pedestrians' Preference Score was determined for the selected locations within the study area.

Secondly, to identify additional sidewalk walkability factors unique to residential areas in South Africa, a socio-demographic and walking experience survey was done.

Thirdly, to analyse and define infrastructure, social and environmental attributes that contribute to the successful creation of a walkable environment in residential areas, the literature review as well as the results of the previous objectives were evaluated.

Finally, the results in this chapter provided an essential insight into the use of residential sidewalks and the avoidance thereof. The next chapter (Chapter 5), therefore, will move on to the formulation of transportation planning and design guidelines to improve the walkability of residential areas in Bloemfontein City.

The various implementation and analyses that had been done, include:

- Data Collection
- Location selection for evaluation
- Socio-demographic and walking experience
- Conjoint Analysis
    - Attributes and mutual independent attributes
    - Conjoint Profiles
    - Compilation, analysis, and synthesis of results
    - Calculate Total Utility Value at selected locations
- Pedestrians' Preference Score
    - Calculate Pedestrians' Preference Score at selected locations
- Evaluate and validate
- Summary and Discussion

4.2 DATA COLLECTION

Physical surveys, as well as pedestrian questionnaires, were employed to collect primary data.

Physical Surveys

The evaluation of the sidewalks and verge elements was done using physical surveys, evaluating GIS information, and aerial photography. The physical surveys of the existing sidewalks contributed to the selection of attributes and the profile generation for Conjoint Analysis (discussed later in the chapter).

All of the streets in the study area were divided into different pedestrian use categories, namely: suburb entry points, residential collector streets, thoroughfare streets, and residential streets (Committee of Urban Transport Authorities, 1988; CSIR Building and Construction Technology, 2000). There are 138 streets, of which 11 are suburb access points, 13 are residential collector streets, 7 are thoroughfare streets, and 107 are residential streets. Furthermore, the physical survey assisted with the identification and verification of pedestrian generating destinations in and around the neighbourhood (see section 3.3.2).

Together with random sampling throughout the neighbourhood, pedestrian surveys in the form of questionnaires were done at the identified main destinations and access points.

Pedestrian Questionnaires

The questionnaire was compiled after careful evaluation of the study requirements, and by following the guidelines recommended by Peterson (2000). Valuable input was derived from methodology literature (Green et al.) and studies evaluating similar aspects and conditions (Agarwal *et al.*, 2014; Van Cauwenberg *et al.* (2016); Muraleetharan *et al.*, 2005; Wicramasinghe *et al.*, 2017).

The pedestrian questionnaires were used to collect socio-demographic and walking experience information, the Conjoint Analysis profile data, and the pedestrians' preference for the selected sidewalk locations. A sample of this questionnaire is attached in Annexure A. The questionnaire was designed to measure the following constructs:

Section 1: Socio-demographic and walking experience data

Section 2: Conjoint Analysis profile data

Section 3: Pedestrians' Preference data for selected sidewalk locations

To relate the results of the Conjoint Analysis (Section 2) to the actual willingness of pedestrians to use a sidewalk (from Section 3), several sidewalk trial locations were identified within the neighbourhood. These locations are discussed in the next section.

Four investigators were used to conduct the questionnaire surveys. These investigators were given training in terms of the purpose and type of data being collected. After that, investigators were strictly made aware of the ethical principles to be followed as discussed in section 1.10.

Random pedestrian questionnaire surveys were done throughout the neighbourhood by walking in the neighbourhood. Of the 400 surveys deployed, only 326 returned. A total of 172 random pedestrian questionnaire surveys were conducted. Additionally, questionnaire surveys were done at the neighbourhood's main destinations and access points, namely: (1) Graniet Street, one of pedestrians' favourite roads to access the western shopping centre, (2) Stofberg Street, a main collector/access road towards the university, (3) Magneet Street, a primary access road leading towards the shopping centre on the eastern side, (4) Paul Kruger Avenue, a minor arterial used as a thoroughfare and thus also an access point to the neighbourhood, and (5) De Bruyn Street, which is, similarly to Paul Kruger Avenue, a minor arterial and thoroughfare. Surveys ranged from 25 to 35 surveys per access point, totalling 154 surveys.

Once all of the survey data was collected, all surveys were vetted for completeness and correctness. From the total of 326 surveys collected, the following number of responses per section proved to be suitable for analysis:

Section 1 – 300 responses

Section 2 - 284 responses

Section 3 - 287 responses

Thereafter, this data was transferred to Microsoft Excel (Microsoft Corp., 2010) sheets, and the relevant statistical analysis was done.

4.3 LOCATIONS SELECTED FOR EVALUATION

To evaluate the results of the Conjoint Analysis, they were correlated to the actual willingness of pedestrians to use the sidewalks in the neighbourhood of Universitas. This was done by carefully selecting and analysing 11 sidewalk locations that represent the majority of attributes, and variations thereof, identified from the physical surveys and observations discussed in section 4.2. The selected locations are shown in Figure 4.1 and discussed in more detail hereafter.

Figure 4.1 Selected sidewalk locations in Universitas.

Location 1

This sidewalk is situated at 1 Stofberg Street, Universitas, Bloemfontein. Stofberg Street is a collector street, providing access from a large area of households west of the university to the university. This sidewalk's attributes are 6 obstacles, 2 changes in elevation, vegetation surface, a driveway, and total width of 3.6m. Only 1.2m of this width is walkable, due to encroaching bushes and shrubs (see Figure 4.2).

Figure 4.2 Sidewalk location 1: Stofberg Street, Universitas (Source: Author).

Location 2

Figure 4.3 shows the sidewalk at 8 Stofberg Street. As in Location 1, this street is a collector street. The sidewalk attributes present are two obstacles, no changes in elevation, vegetation surface, with a width of 3m. Of this, 2.5m is walkable, due to encroaching bushes and shrubs.

Figure 4.3 Sidewalk location 2; Stofberg Street, Universitas.

Location 3

A popular access point from the suburb to the local shopping centre, this sidewalk is situated at 1 Graniet Street (see Figure 4.4). This sidewalk comprises of 11 objects, a driveway causing two changes in elevation, a gravel walking surface, and a walkable width of 5.5m.

Figure 4.4 Sidewalk location 3; Graniet Street, Universitas (Source: Author).

Location 4

This sidewalk is situated at 202 Paul Kruger Avenue (see Figure 4.5). This is a minor arterial road and facilitates thoroughfare between suburbs. This sidewalk's attributes include one obstacle, no changes in elevation, paved surfacing, and a walkable width of 4.1m.

Figure 4.5 Sidewalk location 4; Paul Kruger Avenue, Universitas (Source: Author).

Location 5

Figure 4.6 shows the sidewalk at 5 Tommy Border Street. This street is a local street within the suburb of Universitas. This sidewalk comprises of four obstacles, four changes in elevation, vegetation as its surface, a paved driveway, and a walkable width of 3.6m.

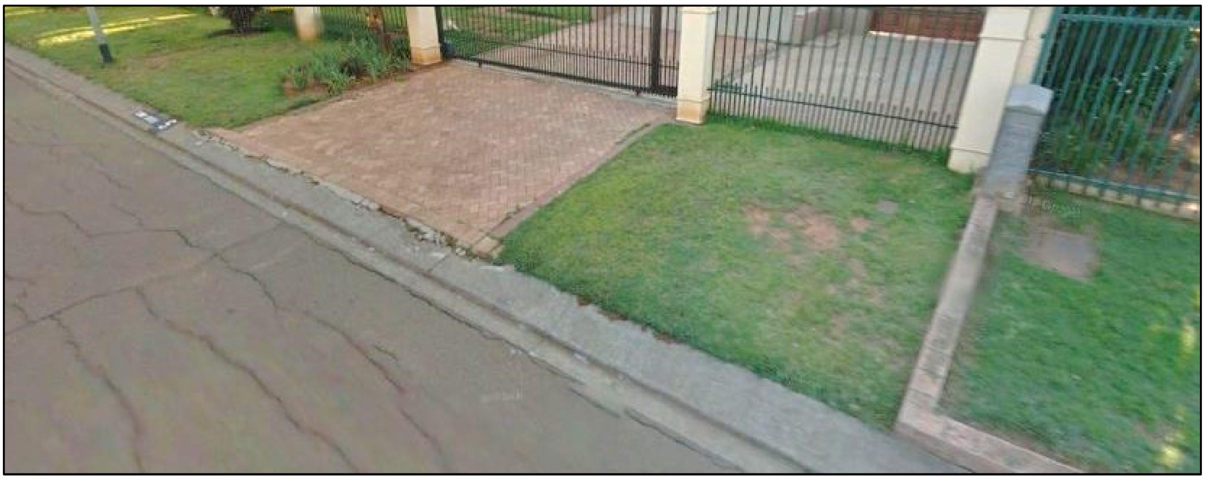

Figure 4.6 Sidewalk location 5; Tommy Border Street, Universitas (Source: Author).

Location 6

The sidewalk at this location is situated at 72 De Bruyn Street (see Figure 4.7). De Bruyn Street is a minor arterial and is used as a thoroughfare. This sidewalk's attributes consist of three obstacles, two changes in elevation, a combination of paved and gravel surfacing, and a walkable width of 4.6m.

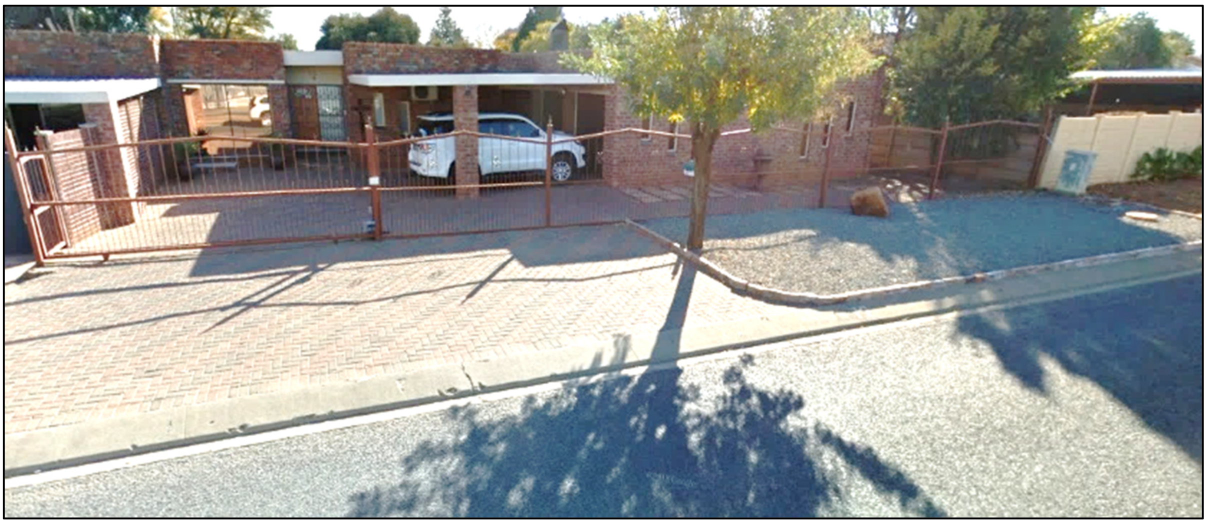

Figure 4.7 Sidewalk location 6; De Bruyn Street, Universitas (Source: Author).

Location 7

This sidewalk is located at 55 Walter Sisulu Road (see Figure 4.8). Walter Sisulu Road (formerly known as Haldon Road) is a minor arterial road at the southern boundary of the suburb. The sidewalk attributes present are three obstacles, no changes in elevation, and a gravel walking surface that is mostly covered with vegetation, thus resulting in a walkable width of 0m.

Figure 4.8 Sidewalk location 7, Walter Sisulu Road, Universitas (Source: Author).

Location 8

Figure 4.9 shows the sidewalk at 8 Christoffel Du Plessis Street. This street is a local street within the suburb. The sidewalk attributes at this location are 0 obstacles, no changes in elevation, paved surfacing, and a walkable width of 2.9m.

Figure 4.9 Sidewalk location 8, Christoffel Du Plessis Street, Universitas (Source: Author).

Location 9

The sidewalk at this location is situated at 64 Scholtz Street (see Figure 4.10). Scholtz Street is a popular collector street in the neighbourhood. The sidewalk features are two obstacles (dense trees), no change in elevation, a gravel and stepping stone surface combination, and a width of 3.7m, of which 0.8m is walkable due to the dense trees.

Figure 4.10 Sidewalk location 9; Scholtz Street, Universitas (Source: Author).

Location 10

This sidewalk is located next to the retirement village Striata at 7 Weitz Street (see Figure 4.11). This is an access road. Its sidewalk attributes consist of 1 obstacle, no changes in elevation, a combination of gravel and paved surfacing, with a walkable width of 4.8m, of which 1m is a paved walkway.

Figure 4.11 Sidewalk location 10; 7 Weitz Street, Universitas (Source: Author).

Location 11

Figure 4.12 shows the sidewalk at 3 Magneet Street. This street is also a local access road, which connects the nearby shops and old retirement village to the minor arterial Paul Kruger Avenue. This sidewalk comprises of four obstacles, two changes in elevation due to a paved driveway, short vegetation walking surface, and a walkable width of 3m.

Figure 4.12 Sidewalk location 11; Magneet Street, Universitas (Source: Author).

4.4 SOCIO-DEMOGRAPHIC AND WALKING EXPERIENCE ANALYSIS

The socio-economic conditions of the study area were analysed to understand the economic status, social behaviour, and walking experience of pedestrians. The analysis was conducted based on a range of variables, including age, gender, education, employment, vehicle ownership, walking purpose and frequency, and concerns when walking.

Age and Gender

The gender distribution is relatively equal, with 53% female and 47% male. Figure 4.13 shows their age distribution which was clustered into six groups. The age group of those younger than 20 represents 33% of the population, which is the second highest percentage. However, what stands out from this table is the age group consisting of those aged 20 to 29, which represents 59% of the respondents. This is most likely due to the influence of the university. Thereafter, the age groups of 30 to 39, 40 to 49, 50 to 60, and over 60 are represented with 3%, 1%, 1%, and 2% respectively. The incline shown at the over 60 age group is most likely due to the presence of the retirement homes within the study area.

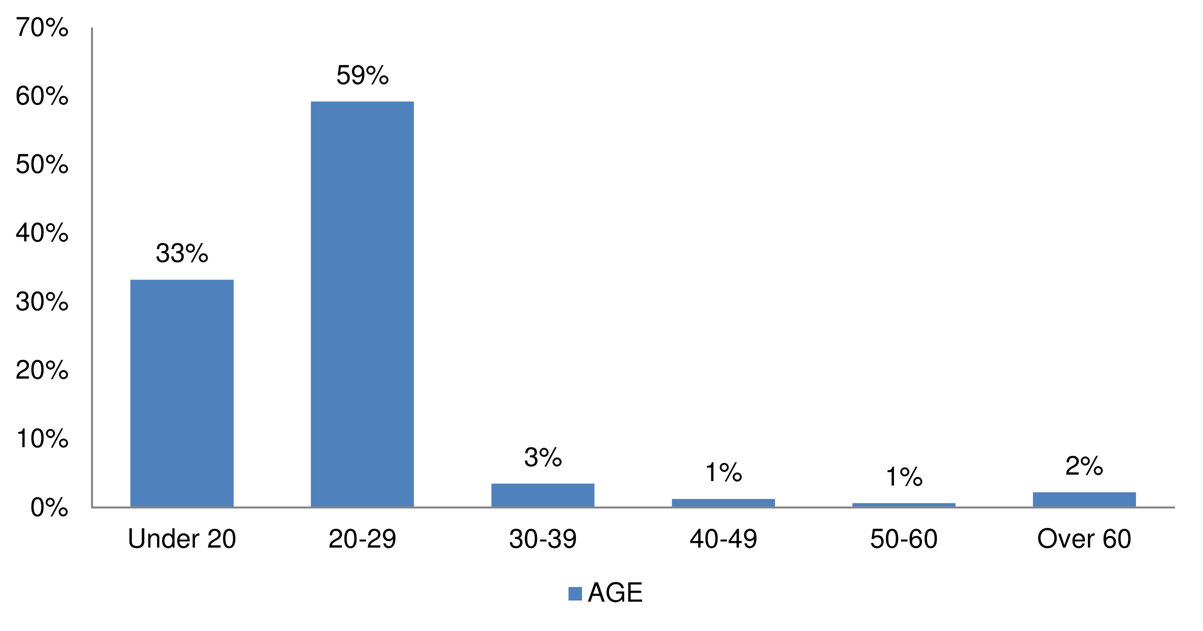

Figure 4.13 Age distribution of surveyed respondents.

Education and Employment

The highest level of education was included in the questionnaire. The results are shown in Figure 4.14. The majority (45%) of the respondents are educated up to high school or less, followed by 44% of respondents, who obtained an undergraduate degree. On the other hand, 8% of respondents have completed a graduate degree. This is most likely an indication that, once students complete their studies, they relocate due to employment prospects.

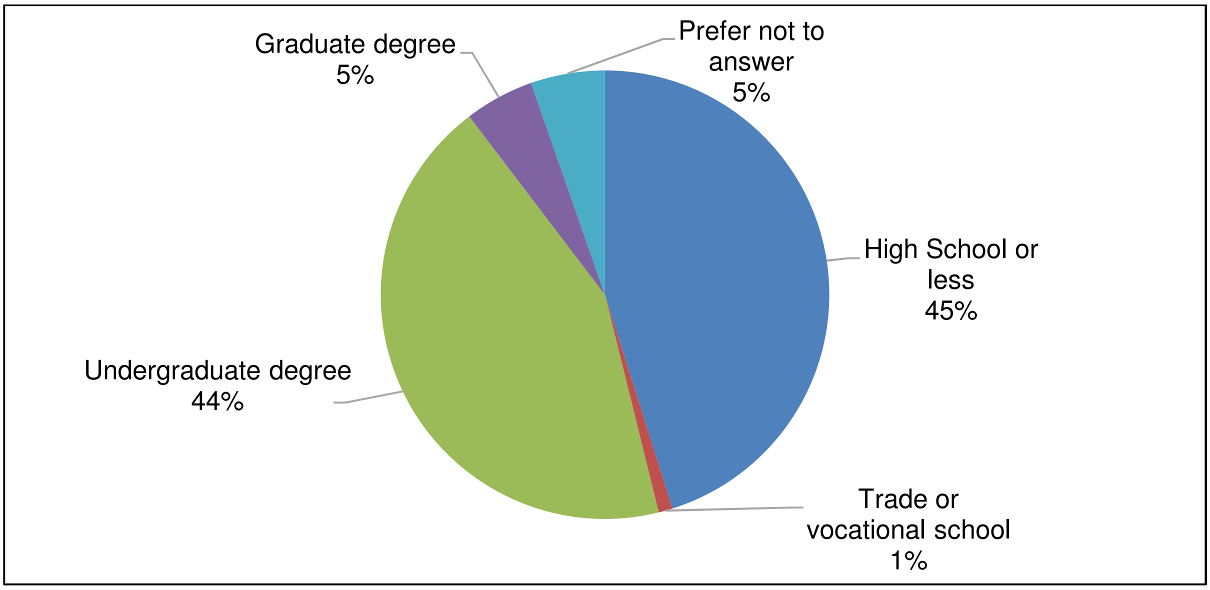

Figure 4.14 Education level of surveyed respondents.

Figure 4.15 provides the employment status of the surveyed respondents. Similar to the results of the age distribution, 84.8% of the respondents are students or scholars. This is also supportive of the 66% of the population of Universitas that is economically inactive (Statistics South Africa, 2011). Hereafter, full-time (5.1%) and part-time (3.4%) employment are below the neighbourhood average of 31.5% (Statistics South Africa, 2011).

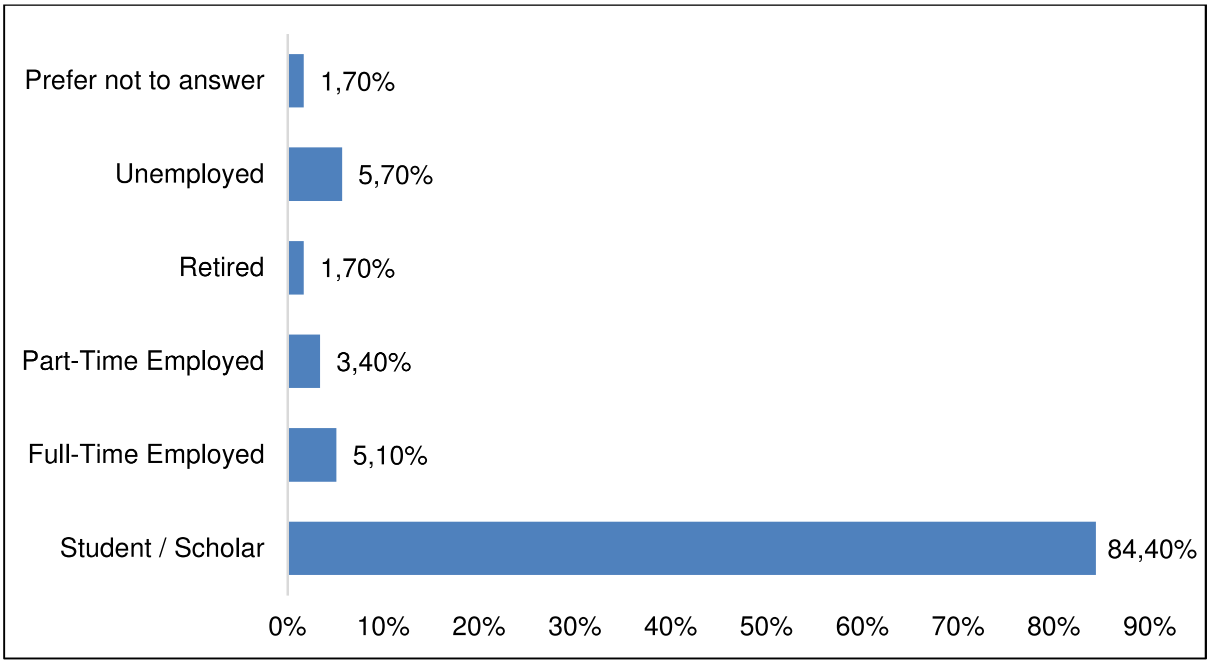

Figure 4.15 Employment status of surveyed respondents.

Neighbourhood Walking Experience

To further provide context and explore the walking experience of pedestrians in the study area, a range of walkability questions were included.

The first question elicited information on where the respondents reside. As shown in Figure 4.16, 64% of respondents live in Universitas. The other areas mentioned are neighbourhoods adjacent to the study area, and most likely indicates that Universitas attracts pedestrians due to its destinations or that it is used as a thoroughfare to other areas.

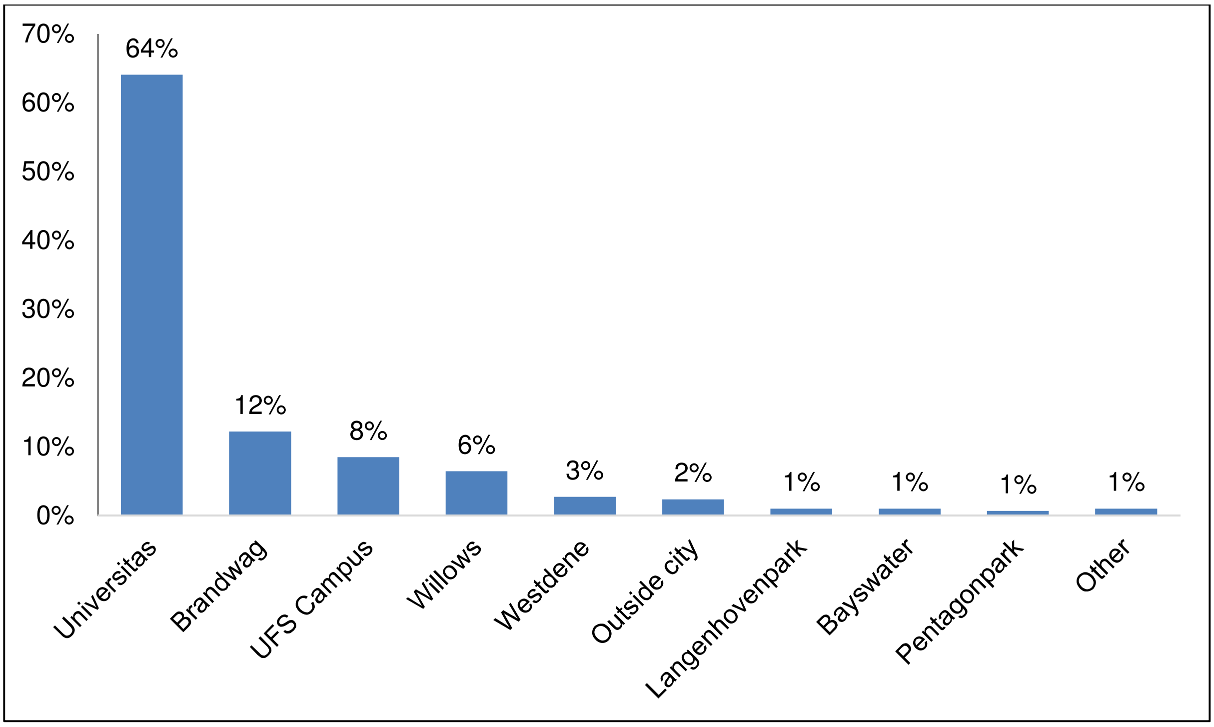

Figure 4.16 Areas where respondents reside.

Respondents were asked about vehicle ownership, whether in a personal capacity or through their households. 18.2% of respondents indicated that they own a vehicle, whereas, 46.3% of respondents indicated that they do not own a vehicle. Of these, 27% have a vehicle in their household. Finally, 13.9% specified that there is no vehicle in their household.

The previous question was then followed by a question to determine if motorists are obstructed by pedestrians. Respondents were asked whether, if or when they drive in the neighbourhood, they find that pedestrians obstruct the driveway. The results are shown in Figure 4.17. 50% of the respondents specified not applicable, mostly due to not owning a vehicle. This was followed by 23% of respondents indicating that they encounter pedestrians obstructing the roadway once per day or more. Furthermore, 10% of respondents said that pedestrians obstruct the roadway several times per week.

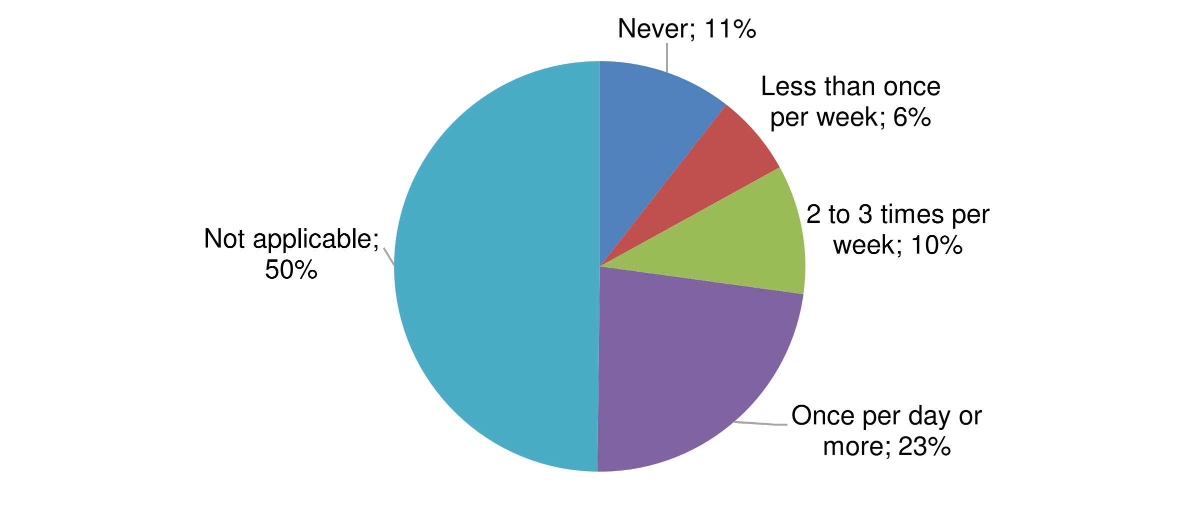

Figure 4.17 Frequency of how often pedestrians obstruct the roadway.

With regard to walking frequency, the majority (68%) of respondents reported that they walk every day. Moreover, in descending order, 15% indicated that they walk in the neighbourhood once per week, 7% walk 2 to 3 times per month, 5% walk less than once a month, and 6% said that they never walk (see Figure 4.18).

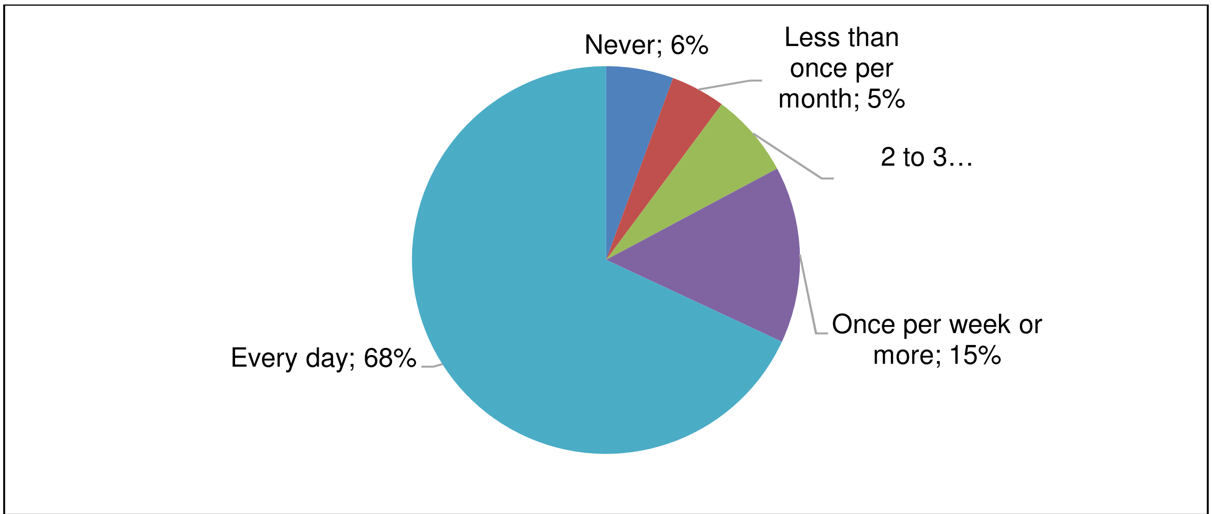

Figure 4.18 Frequency of respondents walking in the neighbourhood.

Participants were asked to rate their walking experience on a scale from 1 (very unsatisfied) to 5 (very satisfied). Interestingly, the majority (52.7%) of the respondents indicated that they had an acceptable walking experience in the neighbourhood (see Figure 4.19). The remaining respondents are distributed in descending order on both sides with an inclination towards reasonably satisfied and reasonably unsatisfied.

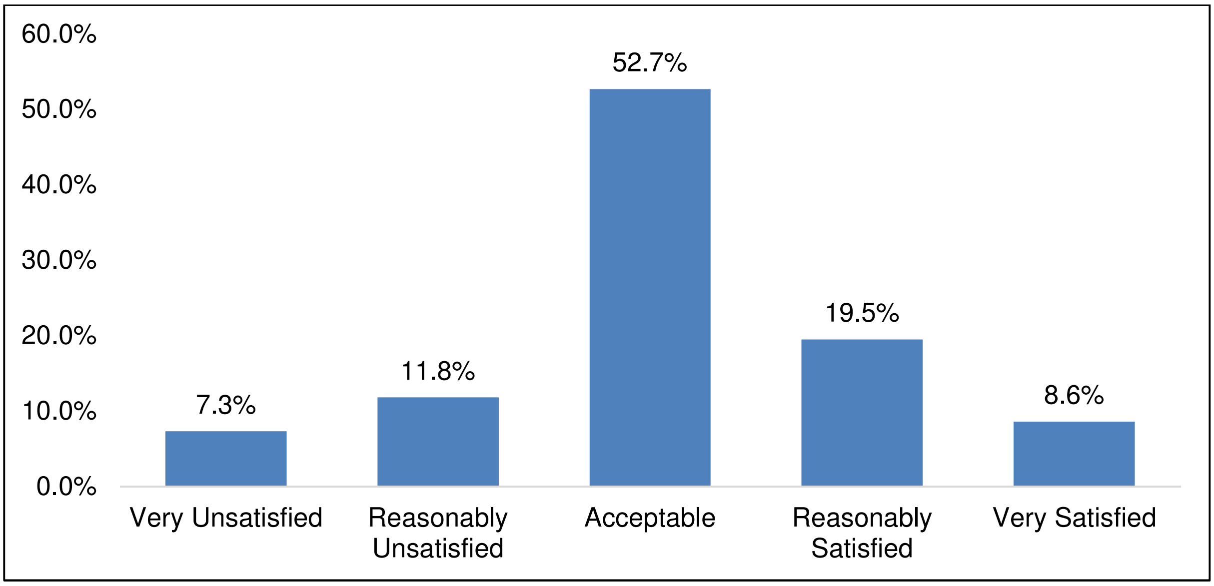

Figure 4.19 Walking experience of surveyed respondents.

Respondents were asked to indicate (multi-selection) what was/is their purpose when walking in the neighbourhood. As shown in Figure 4.20, 46% walk to attend school or university. This is then followed by 19% of respondents who indicated that they partake in walking to do shopping.

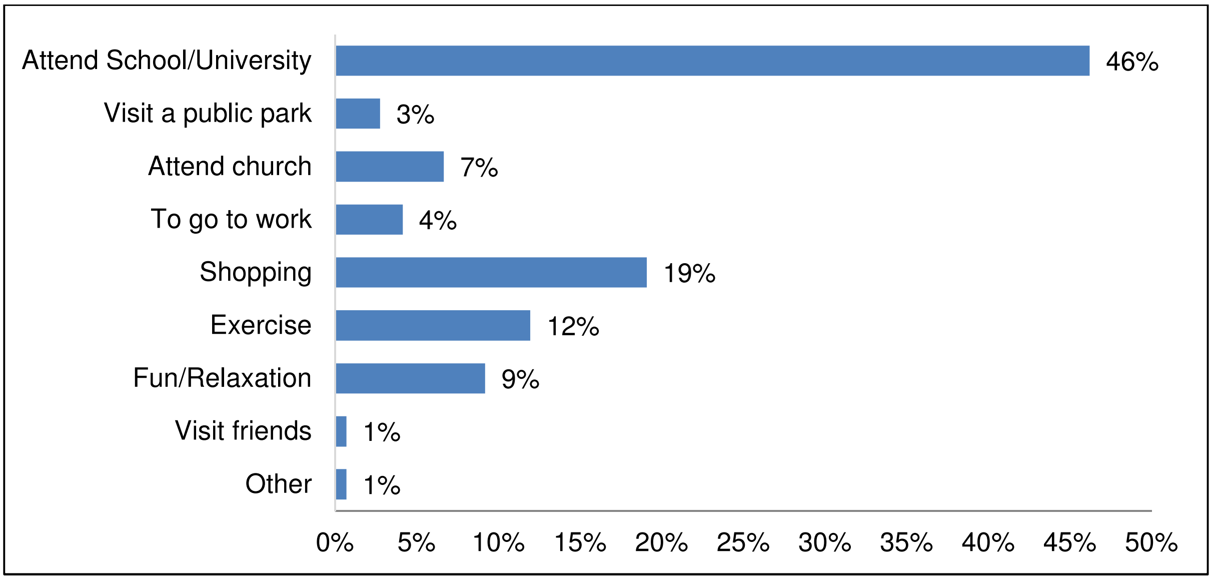

Figure 4.20 Reasons for walking in the neighbourhood.

When asked about the distance that respondents were willing to walk to their points of interest, 27% indicated that they would walk 5 to 10km followed by 32% that would walk 2 to 5km, 22% would walk 1 to 2km, and 19% would walk less than 1km.

Respondents were then asked if they would walk more often if it was safer and more comfortable. The overall response to this question was very positive, with 49.3% stating that they would definitely walk more often. This result also relates to concerns mentioned in the following question.

The questionnaire asked participants to complete an open-ended question that asked about the major concerns that they have while walking in the neighbourhood. Similar to the findings from Albers *et al.* (2010), an overwhelming (65%) concern was personal safety (see Figure 4.21). This was followed by 19% of respondents, who were concerned about conflict with vehicles and 5% were concerned about the lack of walking facilities. Surprisingly, 4% of the respondents were concerned about unattended dogs.

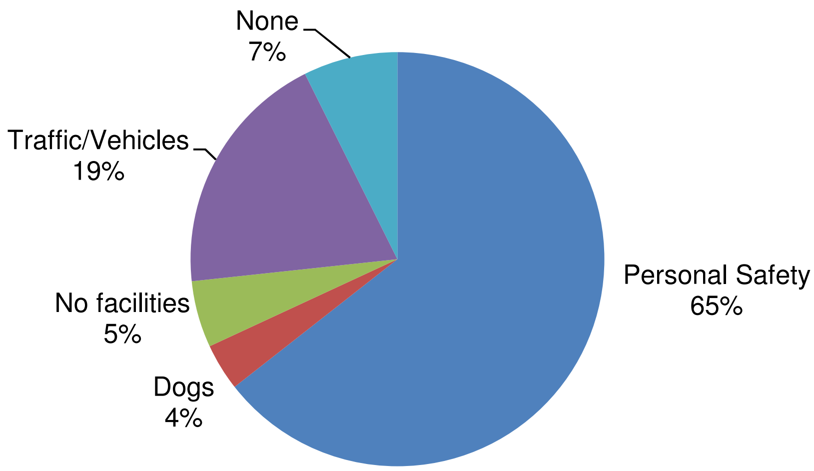

Figure 4.21 Major concerns that respondents have while walking in the neighbourhood.

In the final part of the survey, respondents were asked if they preferred to walk on the sidewalk or the roadway. 76.3% of respondents indicated that they prefer to walk on the sidewalk, where possible; the main reason being the fear of being struck by a vehicle. On the other hand, 23.8% of respondents indicated that they prefer to walk on the roadway. Some of the reasons given were that it was easier and faster to walk on and that the sidewalks are mostly inaccessible.

Summary of Findings

Having analysed the data regarding gender, age, education, income, and walking experience, the following observations were made:

- The majority of pedestrians are students that attend the nearby university.

- Although the majority of pedestrians reside in Universitas, there are a large number of pedestrians from adjacent areas that also walk in Universitas.
- Most of the pedestrians walk in the neighbourhood on a daily basis, mainly to visit a point of interest.
- Pedestrians are obstructing the roadway for motorised transport in the neighbourhood.
- Major concerns for pedestrians are personal safety and colliding with vehicles.
- Pedestrians avoid sidewalks due to lack of infrastructure and facilities.
- Pedestrians would walk more often if it were safer and more comfortable.

4.5 CONJOINT ANALYSIS

4.5.1 Attributes and Mutual Independent Attributes

To select the appropriate attributes to evaluate, a comprehensive literature study was done to examine attributes researched internationally, as well as locally. Furthermore, the sidewalk attributes identified from physical surveys in Universitas were also taken into consideration.

From reviewing various tools and methods (see section 2.5) to measure sidewalk elements, common attributes are the presence of a sidewalk, sidewalk width, obstructions, surface, material, and slope (including vertical separation). However, while developing the first pedestrian environment assessment tool in South Africa, Albers *et al.* (2010) identified additional essential factors such as pavement material, obstructions, condition, slope, and driveway cuts. To more accurately evaluate actual conditions, the sidewalk attributes within the study area were also identified.

Figure 4.22 shows typical sidewalk and verge features found within the study area. Some of the more prominent features are:

- Changes in elevation due to driveway cuts.
- Built up gardens over a portion or full width of the sidewalk.
- Various surface material, such as paving blocks, short vegetation (grass), and fine to coarse gravel.
- A range of obstructions, namely: trees, signboards, street lighting posts, refusal bins, garden décor, and electrical junction boxes.

The average sidewalk and verge width from 35 measurements was found to be 3.7m wide. Even though this space is sufficient in width, the sidewalks and verges are mostly littered with inappropriate urban furniture. Consequently, this results in various widths available for walking, from no space up to full width.

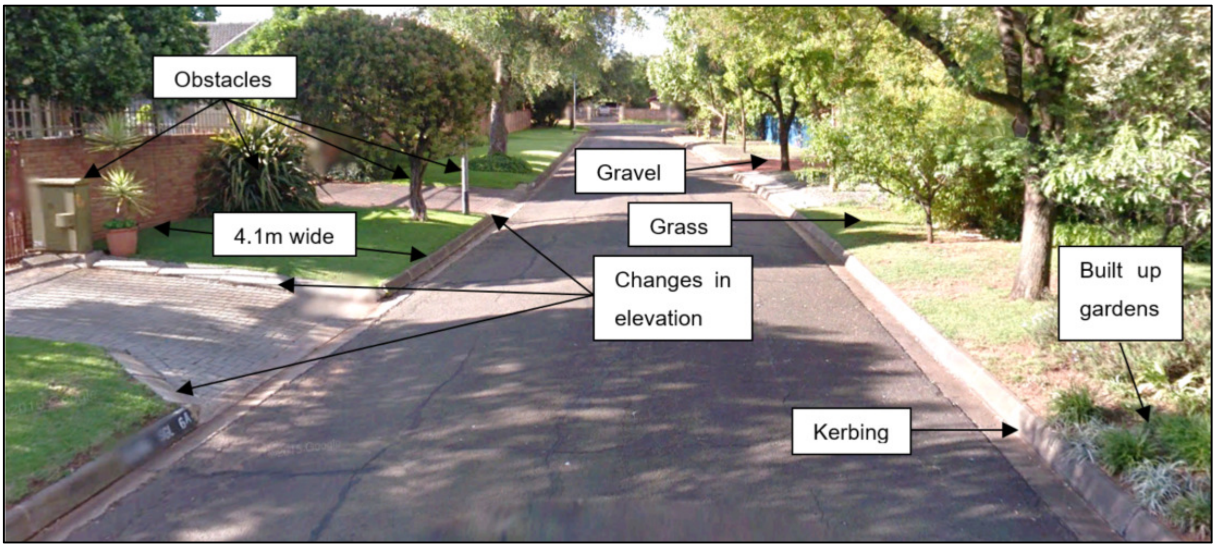

Figure 4.22 Clegg Crescent: Typical sidewalk and verge elements in the study area (Source: Author).

The attributes that were found to be most appropriate for evaluation were (a) walkable width, (b) number of obstacles, (c) walking surface, and (d) changes in elevation. Table 4.1 shows the selected attributes and their mutually independent levels that were used for evaluation.

Table 4.1 Selected sidewalk attributes and mutual independent levels.

Sidewalk Attributes	**Attribute Levels**		
	Level 1	**Level 2**	**Level 3**
Walkable Width (m)	>2m	1m - 2m	<1m
Number of Obstacles per 50m	No Obstacles	1 to 5 Obstacles	> 5 Obstacles
Walking Surface	Paved	Gravel	Vegetation
Changes in Elevation	No Change	1 to 3 Changes	>3 Changes

For clarity regarding the study, each attribute is further discussed and defined below:

a) Walkable Width

Design criteria indicate that the accepted minimum width is 1.2m (Vanderschuren *et al.*, 2014). This width was found to be inadequate for two persons to walk side-by-side, or to pass one another (CSIR Transportek, 2003). Thus, 1.8m is the recommended minimum width, and 3m is recommended as the optimal width (Vanderschuren *et al.*, 2014).

The full verge widths in the study area cannot be used to measure pedestrian use, due to encroaching gardens and various barriers. Thus, the physical space requirements shown in Figure 4.23 were used as a template to evaluate the available space for walking. For the purpose of this study, this was used to identify the walkable width, considering that a pedestrian has a physical space need of 600mm x 500mm (Vanderschuren *et al.*, 2014).

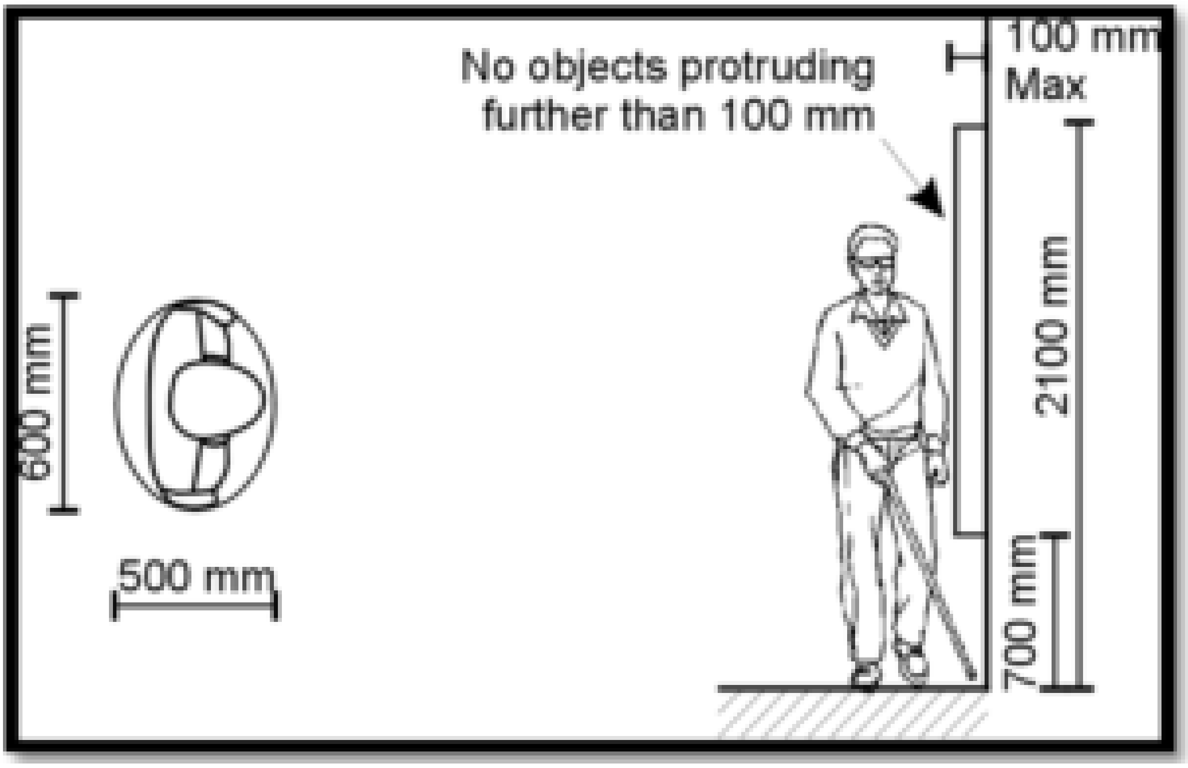

Figure 4.23 Physical space requirements for pedestrians. (Vanderschuren *et al.*, 2014)

To evaluate the walkable width of the sidewalks, the widths were grouped into three levels, which are as follows: Level 1 (best case), more than 2 meters, Level 2 (median case), between 1 and 2 meters, and Level 3 (worst case), less than 1 meter.

b) Obstacles and Obstructions

Obstacles refer to objects that impede travel on the sidewalk or walkway. The principle of less conflict is crucial to non-motorised transport design (Vanderschuren *et al.*, 2014). The

Non-Motorised Transport Facility Guidelines (Vanderschuren *et al.*, 2014) indicate that, ideally, there should be no obstacles within non-motorised transport paths, such as benches, lamp posts, property encroachments, and signboards. Furthermore, protruding objects are a potential hazard, and can cause bodily harm to persons, particularly those that have visual impairments. A vertical clearance of 2.1m should be provided for items such as banners, tree branches, and road signs (CSIR Transportek, 2003).

For this study, the number of obstacles per sidewalk section were evaluated. These obstacles include, but are not limited to, lamp posts, refuse bins, trees, large bushes, electrical junction boxes, building rubble, and garden decorations, such as large rocks and pots. The number of obstacles was grouped into three levels: Level 1 (best case), no obstacles, Level 2 (median case), 1 to 5 obstacles, and Level 3 (worst case), more than 5 obstacles.

c) Walking Surface

Walking surfaces are considered to be the most essential universal design feature (Fransolet, Thompson, Baufeldt, Gibberd, Loser, Vanderschuren & Frieslaar, 2016). Good quality walking surfaces do not necessarily have to be expensive. They have to address key factors appropriately, namely: sufficient friction, smooth and even surfaces; gradient, drainage, horizontal changes, vertical changes in elevation, and specification of surface type (Fransolet *et al.*, 2016; Vanderschuren *et al.*, 2014). Paved surfaces are ideal for sidewalks and walkways, due to the smooth hard surface they provide, and their various maintenance benefits (Vanderschuren *et al.*, 2014). Table 4.2 shows a summary of evaluated walking surface materials.

Table 4.2 Summary of surface material characteristics for sidewalks and walkways (Vanderschuren *et al.*, 2014)

Type	Levelling	Stability	Friction/ Traction	Comfort	Noise	Recyclable Material	Recommend
Clay Pavers	++	++	++	++	--	++	Yes
Cobbles	-	+	+	--	---	++	With Caution
Natural Stone[a]	+	++	+	+	--	++	Yes
Concrete pavers	++	++	++	++	--	++	Yes
Concrete slabs	+++(new) --(old)	++	++	++(new) --(old)	-	---	No
Cast Concrete[b]	+++	+++	++	+++	++	--	Yes
Pattern concrete	+	+++	++	--/+[c]	--	--	With Caution
Asphalt	+++	+++	++	+++	++	--	Yes
Unsealed gravel	---	---	---	---	---	+++	No
Sealed gravel	++	++	++	+++	++	+	Yes

a = Friction of granite can be problematic
b = Friction of poured concrete needs to be attended to during installation
c = Depending on the pattern

In the study area, it was identified that pedestrians walk on short vegetation that eventually carves out into gravel paths. Thus, the three surface materials selected for evaluation are paved material, gravel material, and short vegetation (mostly grass). The surface material was grouped into three levels. Level 1 (best case), paved surface. Level 2 (median case), gravel surface. Level 3 (worst case), short vegetation (grass).

d) Elevation Changes

Changes in elevation are points where the surface of the sidewalk is uneven. This is usually due to driveways, heaving, settling, and built up areas. One of the critical factors of a good quality walking surface is the avoidance of vertical gaps or changes in level (Fransolet *et al.*, 2016). Sudden changes in the level of the sidewalk can make passage difficult for pedestrians and particularly for those with disabilities. It is thus recommended that pavement levels should not change by more than 10 mm over a distance of 1 meter (CSIR Transportek, 2003).

For the study, the number of changes in elevation per sidewalk section was evaluated. The number of changes in elevation was grouped into three levels: Level 1 (best case), no change in elevation, Level 2 (median case), 1 to 3 changes in elevation, and Level 3 (worst case), more than 5 changes in elevation.

4.5.2 Conjoint Profiles

To evaluate selected attributes, hypothetical profiles were compiled with various combinations of these attributes. However, the generation of all possible combinations of these attributes would result in 81 (3x3x3x3=81) profiles. Since Conjoint Analysis uses a ranking response technique, this would be tedious for respondents to the extent that it could compromise the data. To resolve this issue, the use of the statistical method of the orthogonal fractural design was employed. The orthogonal fractional design is a method used to reduce product configurations, while all attributes are arranged to be presented equally and on an uncorrelated basis. The orthogonal fractional design was performed by using IBM SPSS Statistics (IBM Corp., 2015) software. The 81 hypothetical profiles were then reduced to 9 profiles, as shown in Table 4.3.

Table 4.3 Nine hypothetical profiles generated using orthogonal fractional design.

Card	Walkable Width	Number of Obstacles	Walking Surface	Changes in Elevation
1	<1m	1 - 5 Obstacles	Vegetation	No Change
2	<1m	> 5 Obstacles	Paved	1 to 3 Changes
3	1m-2m	No Obstacles	Vegetation	1 to 3 Changes
4	1m-2m	> 5 Obstacles	Gravel	No Change
5	1m-2m	1 - 5 Obstacles	Paved	>3 Changes
6	>2m	> 5 Obstacles	Vegetation	>3 Changes
7	>2m	No Obstacles	Paved	No Change
8	<1m	No Obstacles	Gravel	>3 Changes
9	>2m	1 - 5 Obstacles	Gravel	1 to 3 Changes

Each hypothetical profile was then constructed into a three-dimensional model by using Sketchup Make (Trimble Inc., 2017). Reasonable care was taken to ensure the uniformity of each profile to minimise any influence other than the attributes being evaluated. The attributes were visually constructed as follows:

a) Walkable Width

The walkable width is represented by the width of the sidewalk from the kerb up to the boundary wall. The boundary wall was used to ensure consistency throughout the different profiles regarding being a barrier for the full height of an average person.

b) Number of Obstacles

The obstacles used were limited to a few selected obstacles, in order to ensure consistency. The selected obstacles were identified from the physical surveys of the existing sidewalks in the neighbourhood. These obstacles were tall trees, electrical junction boxes, street light posts, and dustbins.

c) Walking Surface

The walking surface was easy to implement. The full width of the sidewalk was covered with the selected surface material as required by the profile.

d) Changes in Elevation

Changes in elevation could have been presented in various ways, but to realistically and adequately isolate sudden elevation changes, it was decided to make use of driveways. Driveways were identified in the physical surveys to be a significant cause of changes in elevation.

Visual Representation of Conjoint Profiles

The constructed profiles were then employed in Section 2 of the pedestrian questionnaire for respondents to rank from 1 (most preferred) to 9 (least preferred). These profiles are shown in Figures 4.24 to 4.32 below.

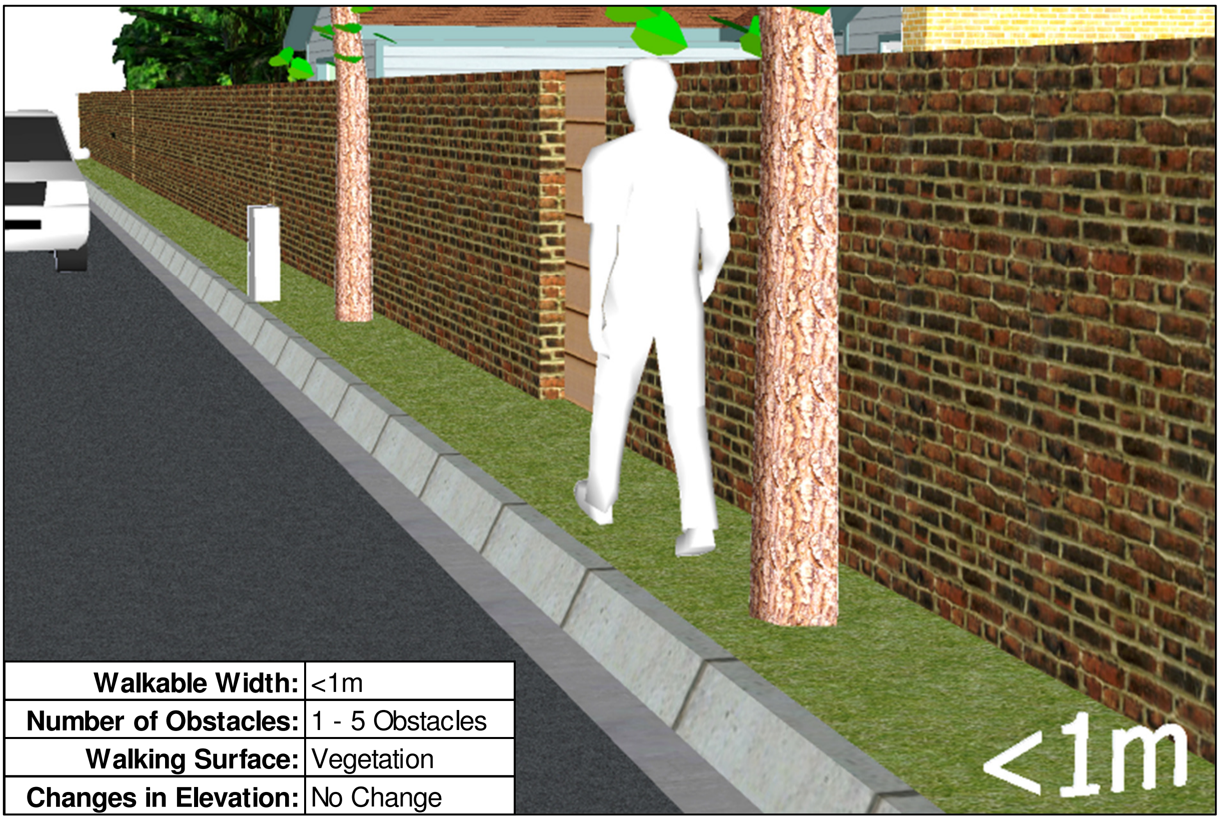

Figure 4.24 Conjoint Generated Profile: Card 1

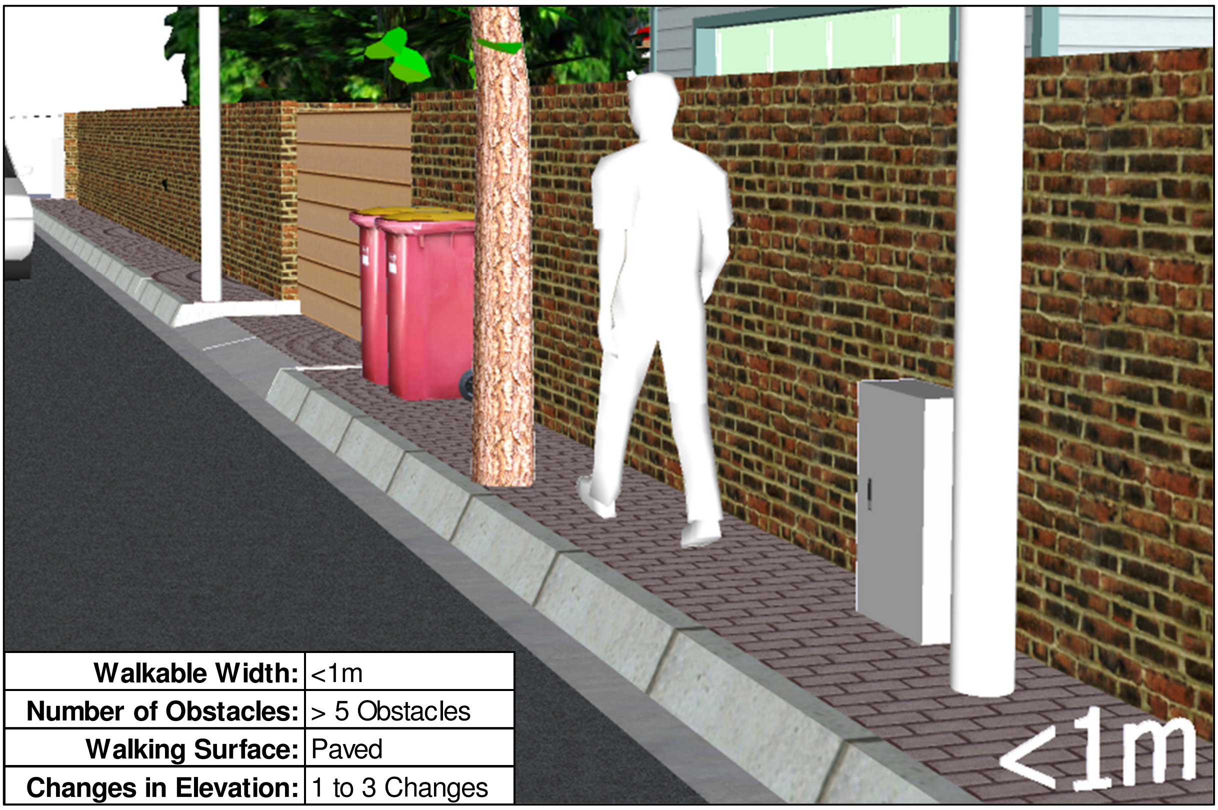

Figure 4.25 Conjoint Generated Profile: Card 2

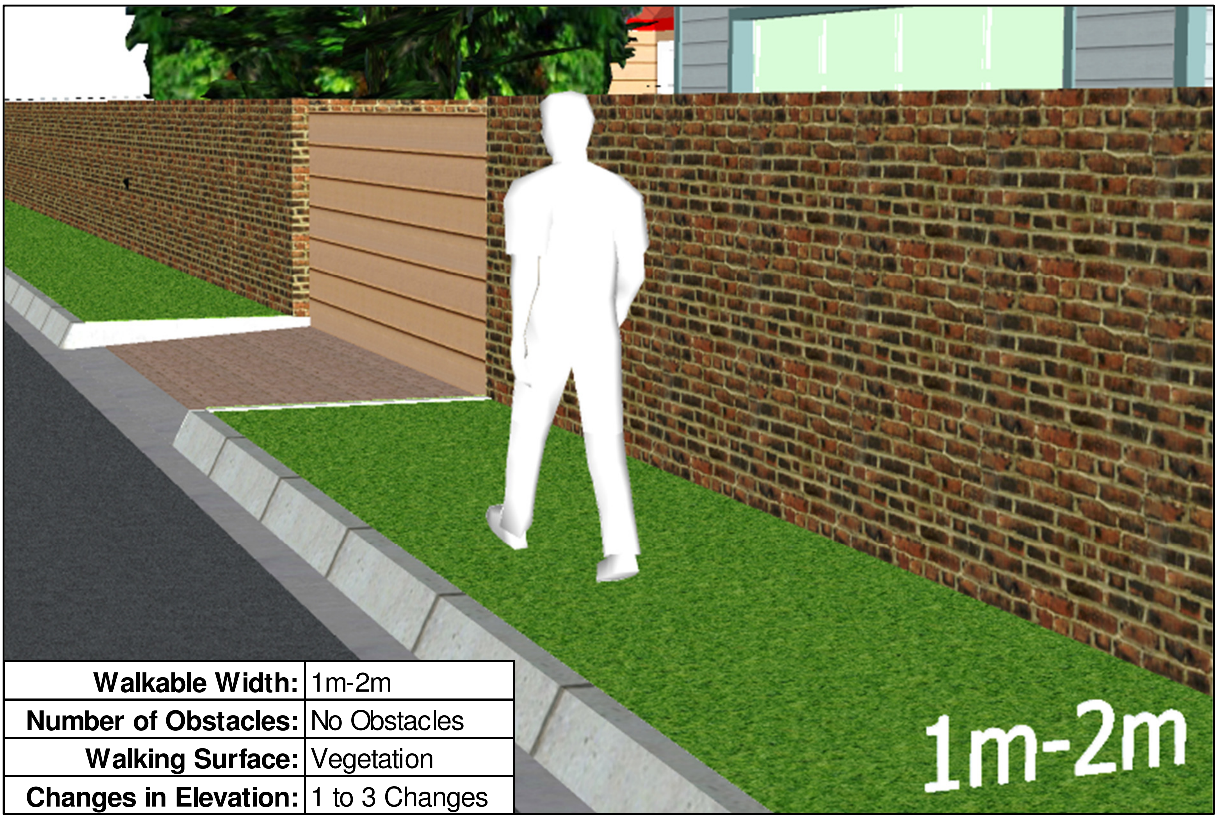

Figure 4.26 Conjoint Generated Profile: Card 3

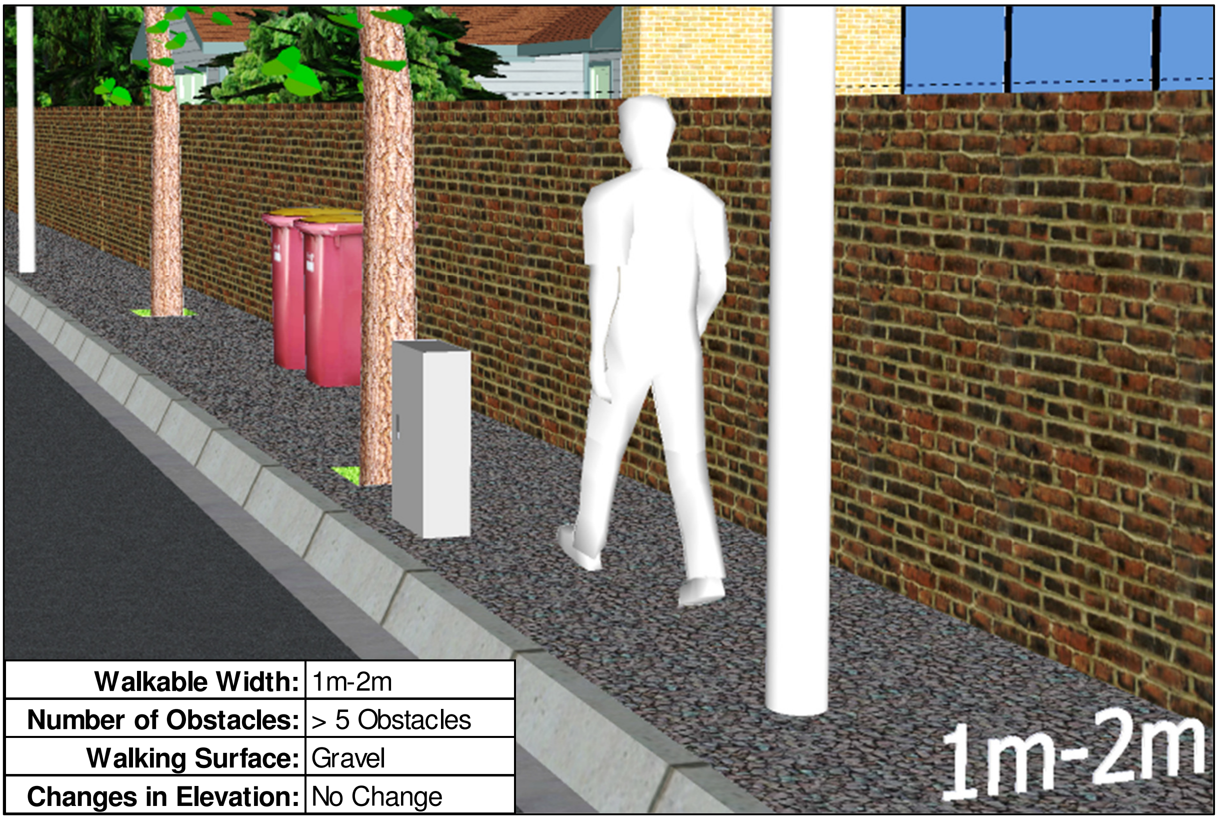

Figure 4.27 Conjoint Generated Profile: Card 4

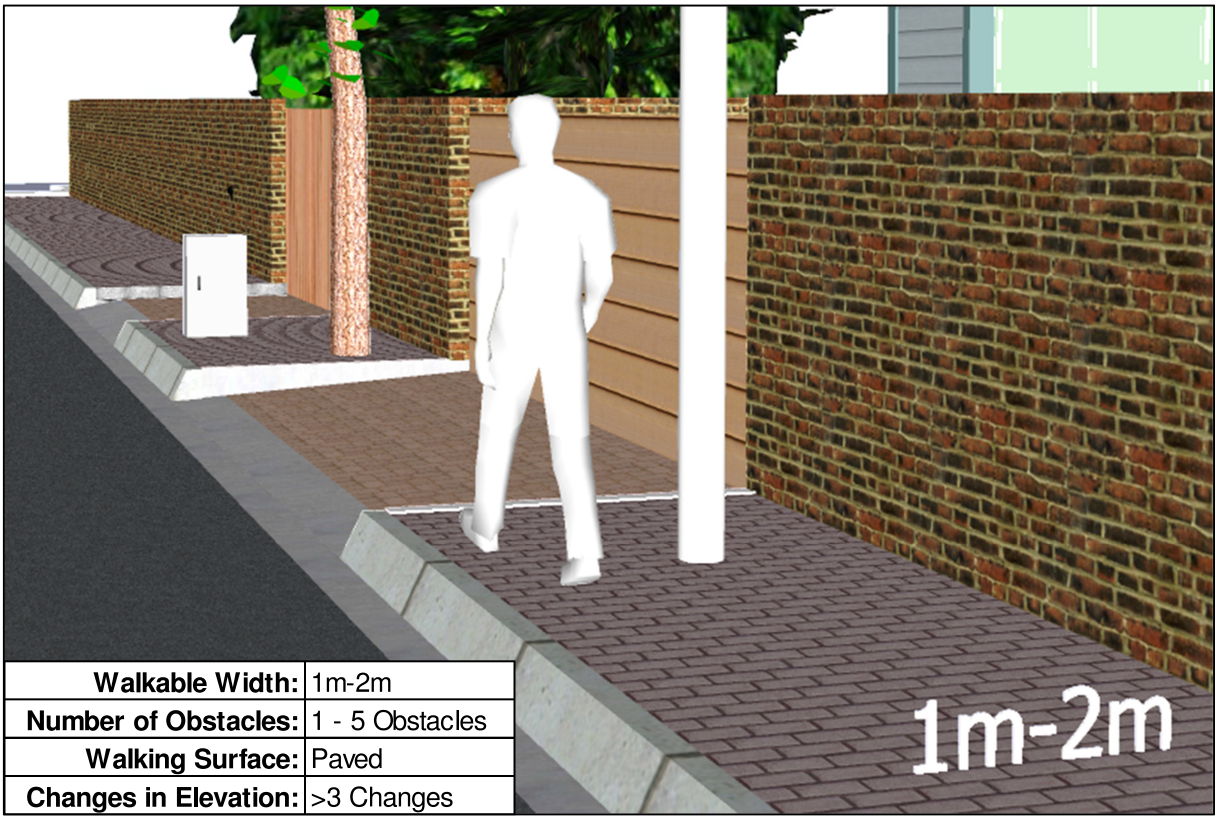

Figure 4.28 Conjoint Generated Profile: Card 5

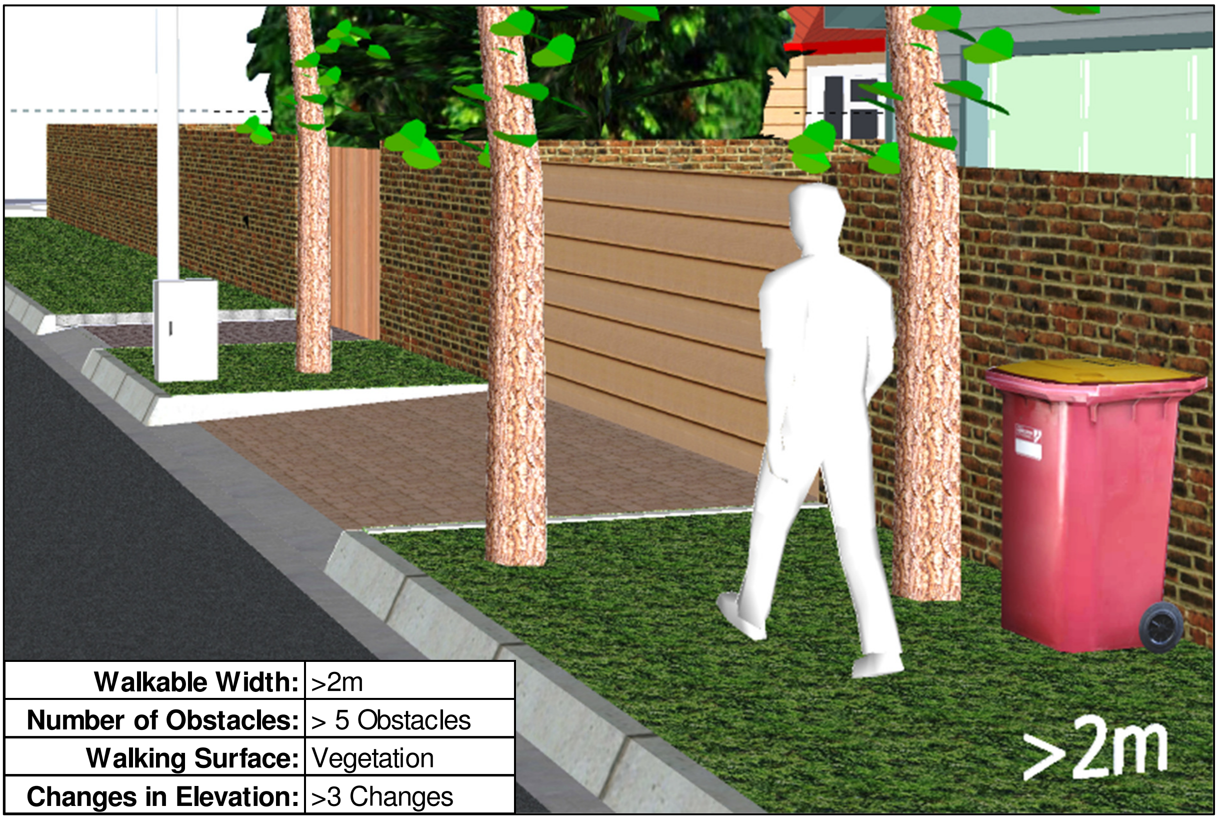

Figure 4.29 Conjoint Generated Profile: Card 6

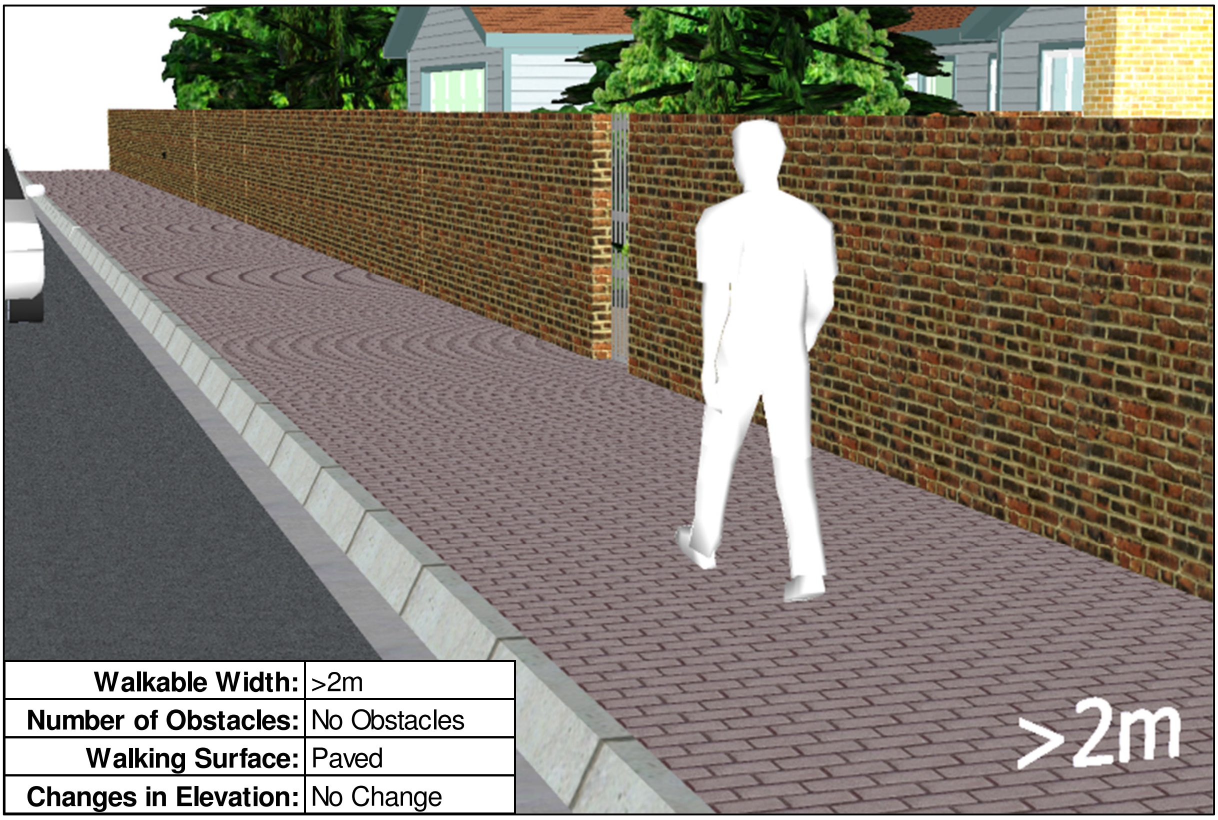

Figure 4.30 Conjoint Generated Profile: Card 7

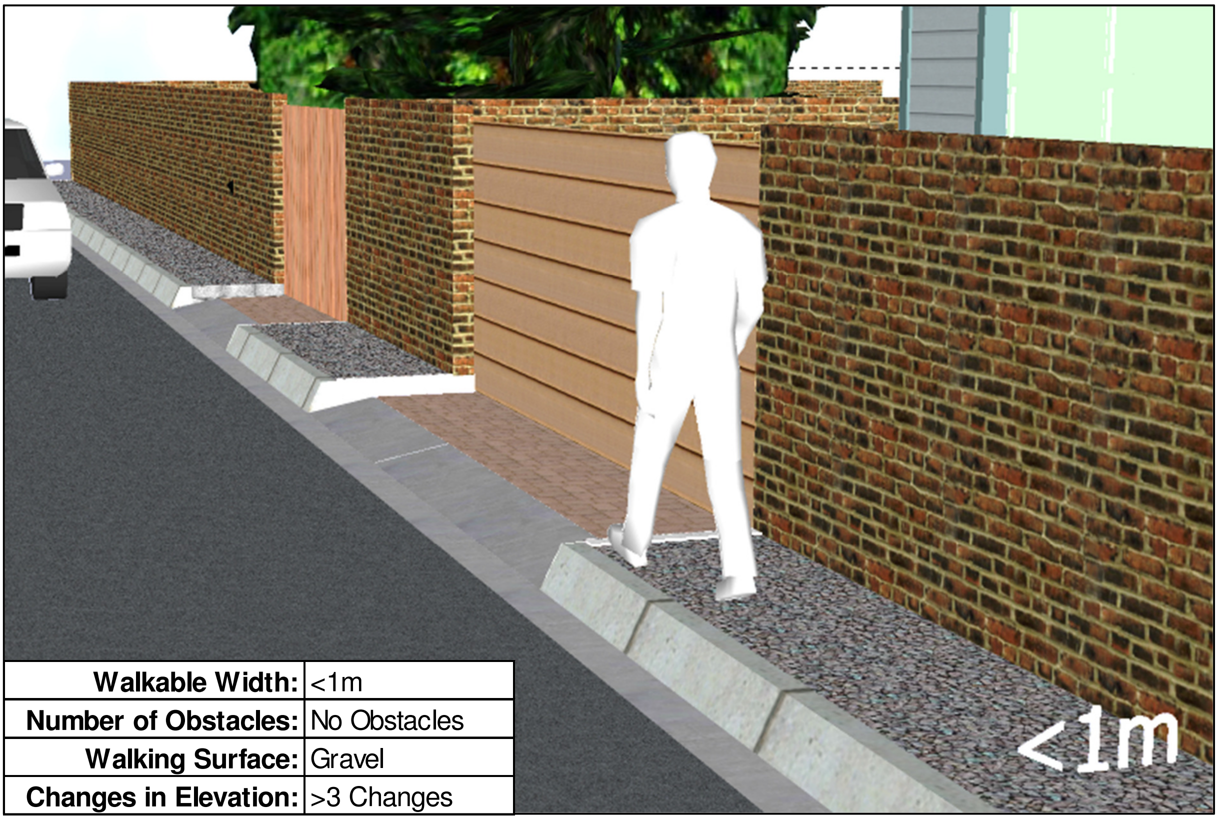

Figure 4.31 Conjoint Generated Profile: Card 8

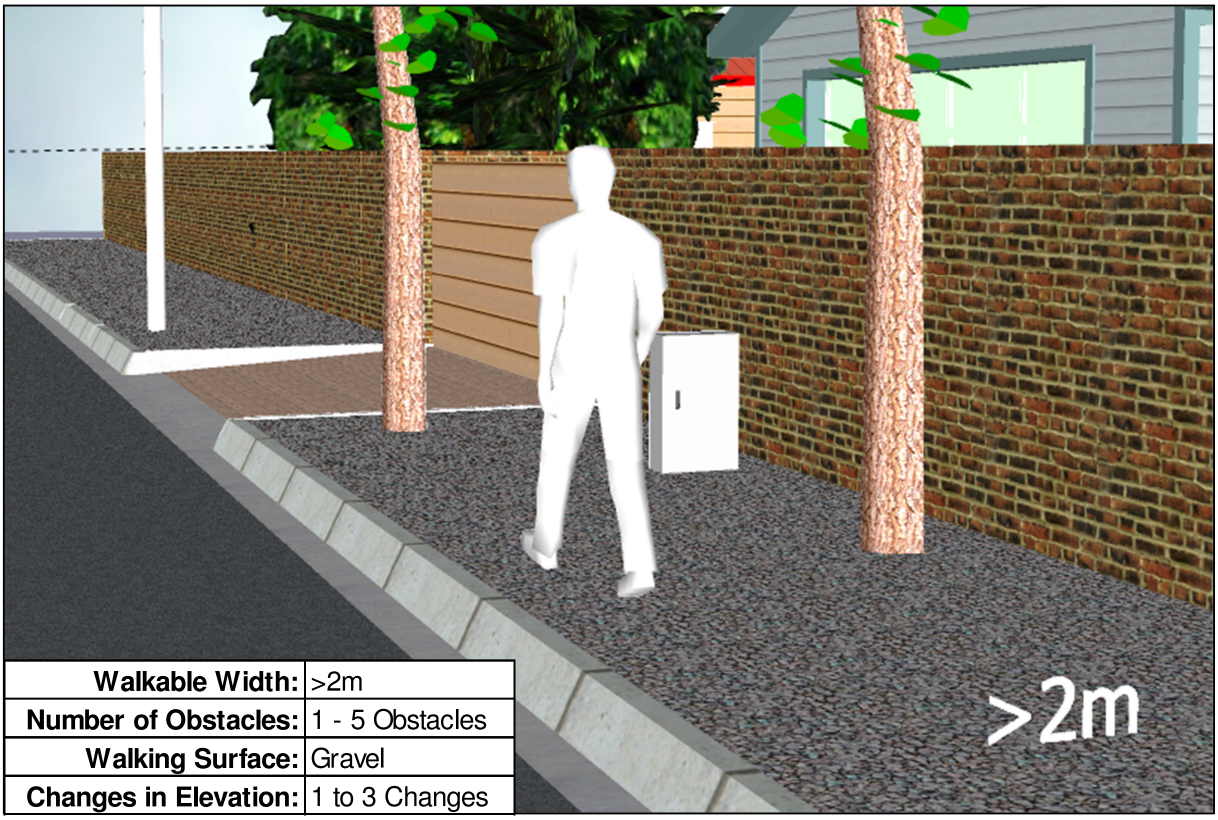

Figure 4.32 Conjoint Generated Profile: Card 9

4.5.3 Compilation, Analysis, and Synthesis of Results

The total number of usable responses to this section of the questionnaire was 284. These responses were compiled and analysed using the Conjoint Analysis feature of IBM SPSS Statistics (IBM Corp., 2015). The results obtained are presented below.

Model Description

When executing Conjoint Analysis, a model to describe the expected relationship between attributes and ranking scores is required. For this analysis, a discrete relationship between factors and ranking scores is assumed. A discrete model indicates that the attribute levels are categorical and that no assumption is made about the relationship between the attributes and the ranks (see Table 4.4).

Table 4.4 Conjoint Analysis Model Description

Model Description		
Attributes	**No of Levels**	**Relation to Ranks or Scores**
Walkable Width	3	Discrete
Number of Obstacles	3	Discrete
Surface	3	Discrete
Elevation Changes	3	Discrete
All factors are orthogonal.		

Importance

Conjoint Analysis produces the relative importance of each attribute. The importance values indicate the importance of an attribute in comparison to other attributes. To derive the importance of an attribute, the amount of difference that each attribute makes in the total utility of a product is considered. That difference is the range in the attributes' utility values. Figure 4.33 illustrates the procedure to calculate the percentage of importance from the relative ranges. Importance depends on the particular attribute levels chosen for the evaluation. For example, the larger the range, the more important the attribute would be. The importance measures are ratio-scaled, relative, and study-specific measures. Thus, an attribute with an importance of 60% is twice as important as an attribute with an importance of 30%.

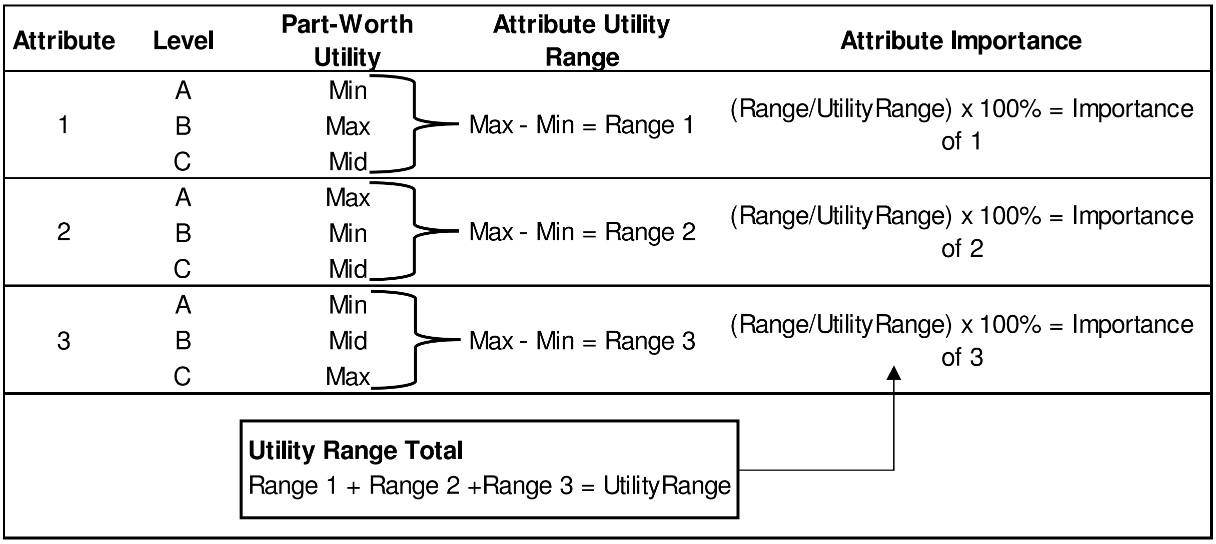

Figure 4.33 Determination of Attribute Importance

The results of the evaluated attributes are shown in Table 4.5. As anticipated, the walkable width of a sidewalk (49.4%) and its number of obstacles (36.6%) were found to have high relative importance. Interestingly, the results of the surface type (9.6%) and amount of changes in elevation (4.4%) are meagre in comparison.

Table 4.5 Conjoint Analysis Results: Importance Values

Importance Values	
Walkable Width	49.4%
Number of Obstacles	36.6%
Surface	9.6%
Elevation Changes	4.4%

A summary of the relative importance of each attribute in relation to each other is shown in Figure 4.34. Regarding the use of sidewalks, walkable width was found to be the most important attribute. The second most important attribute was found to be the number of obstacles. The number of obstacles, in this case, is closely related to walkable width due to large obstacles that often reduce the walkable width on a sidewalk. The more surprising result is that the number of obstacles is four times as important as the surface material. Finally, the surface material was found to be twice as important as the changes in elevation.

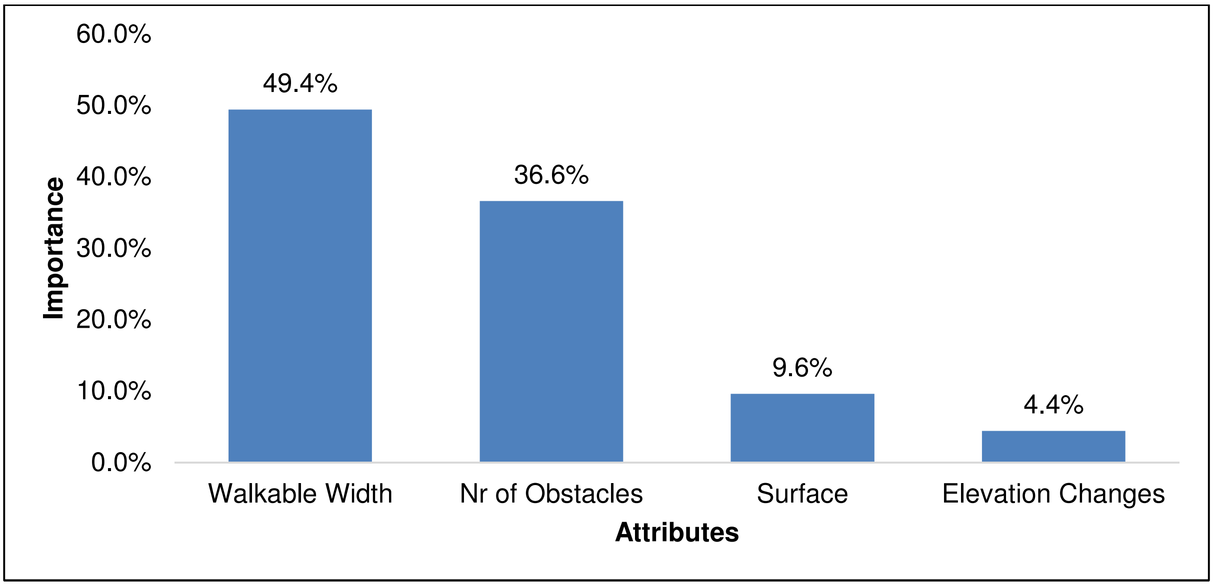

Figure 4.34 Conjoint Analysis Results: Attribute Importance Summary.

The next section describes the part-worth utility results for each attribute level. It is critical, however, to understand the importance of each attribute when evaluating the results of the part-worth utilities.

Part-Worth Utilities

Part-worth utilities allow for a deeper understanding of what specific features within an attribute drives respondents' choices. Part-worth utilities are numerical values assigned to each attribute level, regarding how much each attribute and level influenced the respondents to make that choice. Attribute levels that are more preferred by customers are assigned higher scores and levels that are less preferred are assigned lower (in comparison) scores.

It is important to note that the part-worth is relative. If an attribute level received a negative utility value, it is does not mean that the attribute level was unattractive. In fact, an attribute level with a negative value may have been accepted by all respondents. However, all else being equal, a more positive value is better.

Part-worth, in the Conjoint Analysis technique, is scaled to an arbitrary additive constant within each attribute and is interval data. Utilities are thus scaled to sum to zero within each attribute.

The results for the relative and individual part-worth utilities are summarised in Table 4.6.

Table 4.6 Conjoint Analysis Results: Part-Worth Utilities

Part-Worth Utilities		
Attributes	**Attribute Levels**	**Utility Estimate**
Walkable width	>2m	1.329
	1-2m	-.007
	<1m	-1.322
Number of Obstacles	No Obstacles	1.194
	1 - 5 Obstacles	-.424
	> 5 Obstacles	-.770
Surface	Paved	-.180
	Gravel	.335
	Vegetation	-.155
Elevation Changes	No Change	.122
	1 to 3 Changes	-.113
	>3 Changes	-.009
(Constant)		5.000

What stands out in the table is the range of the walkable width. More than 2m was found to be the most desirable attribute and less than 2m was found to be the least desirable attribute in relation to the other attributes. This also indicates the importance of the attribute (see Table 4.5). Another observation is that the walkable width attribute levels seem to have a logical and relative linear relationship.

The number of obstacles is the attribute with the second highest importance (see Table 4.5). The attribute levels indicate a logical increase in importance with more than five obstacles being the least important, followed by one to five obstacles, and then of the highest importance, no obstacles. In relation to the other attributes and their attribute levels, no obstacles was found to be the second most important attribute level.

At first, the results of the surface material seem to be counter-intuitive, with gravel material receiving a higher preference score than paved material. Similarly, vegetation material also has a slightly higher value than paved material. The main reason for this is the nature of the conjoint generated profiles. The conjoint profiles are generated to represent all attribute levels equally in an uncorrelated manner; thus resulting in attribute level combinations that forces the respondent to choose the most preferred attributes while sacrificing other attributes of less importance. For example, conjoint profile card nine with gravel surfacing and a width of more than 2m could be chosen over profile card two with a paved surface and a walkable width of less than 1m. In relation to the walkable width and number of obstacles, the importance of surface material was found to be very low and therefore seemingly disregarded.

Similar to the surface material, changes in elevation were, even more so, identified as the least important attribute. Looking carefully, more than three changes in elevation received a higher importance score than one to three changes in elevation. This is also due to the combination of attributes in the generated conjoint profiles as mentioned under the surface material. The part-worth utilities for the changes in elevation are very low and would, therefore, make little difference in calculating Total Utility Values.

Summary of Results

The results of the Conjoint Analysis provide valuable insight into the use of sidewalks and the avoidance thereof. In summary, the results show that a walkable area with no obstacles is the most preferred scenario. Moreover, a walkable width of more than 2m was found to be the most desirable attribute. The most striking result to emerge from the data is the lack of importance of surface material and changes in elevation. In relation to walkable width and number of obstacles, the surface material and changes in elevation were found to be of little importance.

In the next section, the calculated part-worth values of each attribute are applied to actual sidewalks within the study area for further evaluation and validation in section 4.7.

4.5.4 Calculate Total Utility Value at Selected Locations

The part-worth utility index derived in the previous section was used to calculate the Total Utility Value of the selected sidewalk locations by making use of equation (1). The Conjoint Analysis theory states that the product (in this case, sidewalk) that receives a higher Total Utility Value than the other products will be considered more valuable (Green & Srinivasan, 1978).

Total Utility Value $U(Xij) = Constant + \sum_{i=1}^{m} \sum_{j=1}^{k_i} u_{ij} X_{ij}$ (1)

U(Xij) = Total utility of an alternative

m = Number of attributes

k_i = Number of levels in i^{th} attribute

u_{ij} = Utility associated with j^{th} level of the i^{th} attribute

X_{ij} = Dummy variable that takes on 1 if the j^{th} level of the i^{th} attribute is present or 0 other

After matching appropriate attribute levels at each location, the Total Utility Values of all eleven locations were calculated (see Table 4.7). Table 4.8 shows an example of this by illustrating how the Total Utility Value is calculated at location 8.

Table 4.7 Attribute levels and Total Utility Value of each selected location

Location	Walkable Width (m)		Number of Obstacles		Surface Material		Elevation Changes		Constant	Total Utility Value
1	1-2	-0.01	> 5	-0.77	Veg.	-0.15	1 to 3	-0.11	5	3.96
2	1-2	-0.01	1 – 5	-0.42	Veg.	-0.15	None	-0.01	5	4.40
3	>2	1.33	> 5	-0.77	Gravel	0.33	1 to 3	-0.11	5	5.78
4	>2	1.33	1 – 5	-0.42	Paved	-0.18	1 to 3	-0.11	5	5.61
5	>2	1.33	> 5	-0.77	Veg.	-0.15	1 to 3	-0.11	5	5.29
6	1-2	-0.01	> 5	-0.77	Gravel	0.33	1 to 3	-0.11	5	4.44
7	<1	-1.32	1 - 5	-0.42	30% Gravel 70% Veg.	-0.01	None	-0.01	5	3.24
8	>2	1.33	None	1.19	Paved	-0.18	None	-0.01	5	7.33
9	<1	-1.32	1 – 5	-0.42	Gravel	0.33	None	-0.01	5	3.58
10	>2	1.33	1 – 5	-0.42	40% Paved 60% Gravel	0.13	None	-0.01	5	6.02
11	<1	-1.32	1 – 5	-0.42	Veg.	-0.15	1 to 3	-0.11	5	2.99

Table 4.8 Example of calculating Total Utility Value at a location

Attribute	Applicable Attribute Level	Part-Worth Utility	Sum	Conjoint Constant	Total Utility Value
Walkable Width	> 2m	1.33	2.33	+ 5	= 7.33
Nr. of Obstacles	None	1.19			
Surface Material	Paved	-0.18			
Elevation Changes	None	-0.01			

A summary of the Total Utility Values of each location is shown in Table 4.9. The TUV Rank column ranks the sidewalks according to Total Utility Value. The calculated Total Utility Value of each location is compared and evaluated against the Pedestrians' Preference Score in section 4.7.

Table 4.9 Summary of Total Utility Values at each selected location

Location	Street Name	TUV	TUV Rank
1	Stofberg Street 1	3.96	8
2	Stofberg Street 2	4.40	7
3	Graniet Street	5.78	3
4	Paul Kruger Avenue	5.61	4
5	Tommy Border Street	5.29	5
6	De Bruyn Street	4.44	6
7	Walter Sisulu	3.24	10
8	Christoffel Du Plessis Street	7.33	1
9	Scholtz Street	3.58	9
10	Weitz Street	6.02	2
11	Magneet Street	2.99	11

4.6 PEDESTRIANS' PREFERENCE SCORE

4.6.1 Calculate Pedestrians' Preference Score at Selected Locations

Pedestrian preference was collected using the third section of the questionnaire. Each respondent had to indicate how likely it is that they would make use of the selected location by selecting a value from 1 (least likely) to 5 (most likely).

While summarizing the answers from 287 respondents, using equation (2), the Pedestrian Preference Score was calculated for each location.

$$\text{Pedestrian Preference Score } (PPS_j) = \frac{1}{n}\sum_{i=1}^{n}(WTC)_{ij} \qquad (2)$$

$(WTC)_{ij}$ = Willingness to use at the jth sidewalk by ith respondent

N = Number of respondents

Table 4.10 shows the calculated Pedestrians' Preference Score for each location. The column PPS Rank ranks the Pedestrians' Preference Score in ascending order from the most preferred (1) sidewalk to the least preferred (11). The Pedestrians' Preference Score is compared with and evaluated against the calculated Total Utility Values of each location in the next section.

Table 4.10 Pedestrians' Preference Score for each location

Location	Street Name	PPS	PPS Rank
1	Stofberg Street 1	2.53	9
2	Stofberg Street 2	2.87	5
3	Graniet Street	3.80	4
4	Paul Kruger Avenue	4.01	2
5	Tommy Border Street	2.70	8
6	De Bruyn Street	2.73	7
7	Walter Sisulu	1.92	11
8	Christoffel Du Plessis Street	4.22	1
9	Scholtz Street	2.81	6
10	Weitz Street	3.93	3
11	Magneet Street	2.15	10

4.7 EVALUATE AND VALIDATE

To evaluate and validate the index developed by Conjoint Analysis, the Total Utility Value is compared to the Pedestrians' Preference Score for each location. The results from both data sets for each location is summarised in Table 4.11 below.

Table 4.11 Summary of Total Utility Values and Pedestrians' Preference Scores for each location

Location	Street Name	TUV	PPS
1	Stofberg Street 1	3.96	2.53
2	Stofberg Street 2	4.40	2.87
3	Graniet Street	5.78	3.80
4	Paul Kruger Avenue	5.61	4.01
5	Tommy Border Street	5.29	2.70
6	De Bruyn Street	4.44	2.73
7	Walter Sisulu	3.24	1.92
8	Street	7.33	4.22
9	Scholtz Street	3.58	2.81
10	Weitz Street	6.02	3.93
11	Magneet Street	2.99	2.15

Firstly, the two data sets were comparatively plotted on a line graph in Figure 4.35. From the graph below, we can see that the two data sets follow a similar trend. The Total Utility Value, in descending order, peaks at locations 8, 10, and 3. Similarly, the Pedestrians' Preference Score, in descending order, peaks at locations 8, 4, and 10. An interesting observation from the three peaks of the Pedestrians' Preference Score, which are relatively similarly rated, is that all three has a width of more than 2m and a paved surface or a portion thereof.

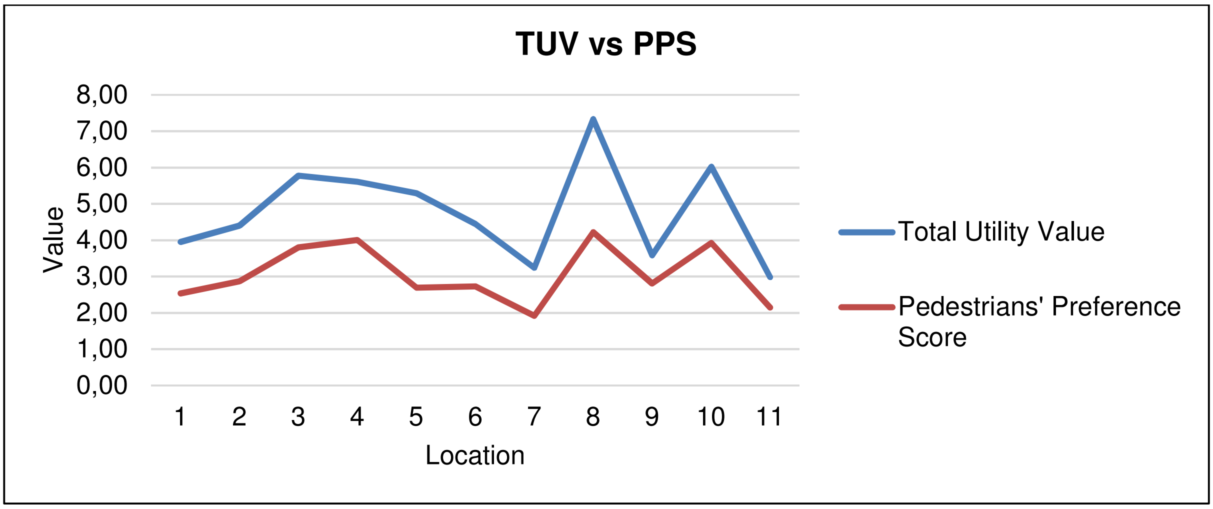

Figure 4.35 Line Graph of Total Utility Value and Pedestrians' Preference Score

Finally, a correlation and regression analysis was done to evaluate the relationship, if any exists, between the Total Utility Value and Pedestrians' Preference Score for each sidewalk location. The calculated Total Utility Value and Pedestrians' Preference Score was plotted on a scatterplot graph for each location in Figure 4.36.

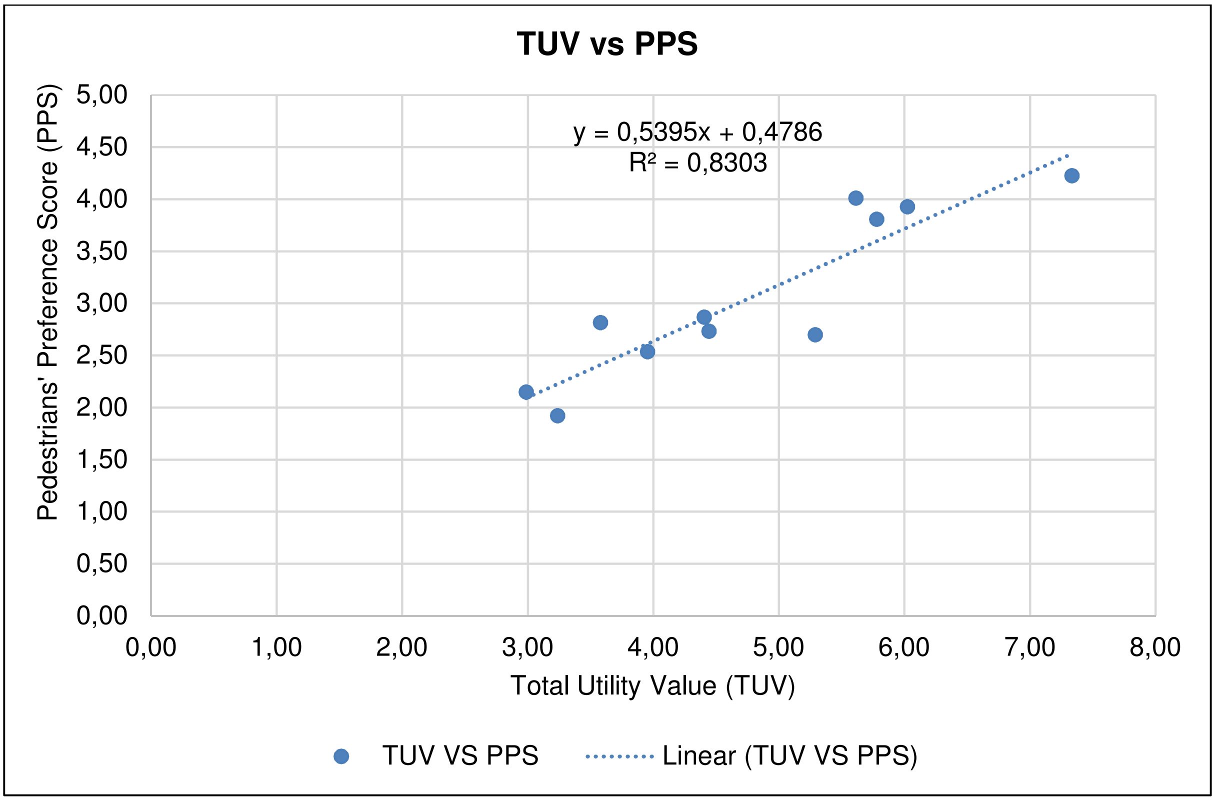

Figure 4.36 Correlation between Total Utility Value and Pedestrians' Preference Score for each of the 11 locations.

There was a significant positive correlation found between the Total Utility Value and Pedestrians' Preference Score. The Pearson Correlation (r) of the two data sets shows a strong positive linear pattern with a strength of 0.91. The positive linear pattern indicates that, when the Total Utility Value increases or decreases, that the Pedestrians' Preference Score will do the same.

After that, a regression analysis revealed that the data fit the linear model well, with the Total Utility Value explaining 83% (R-squared) of the variability of the Pedestrians' Preference Score. Therefore, the linear model indicates that the Total Utility Value can be used to predict how likely it is that a pedestrian would choose to use a specific sidewalk.

4.8 SUMMARY AND DISCUSSION

As mentioned in the literature review, several sidewalk assessment tools and methods have been developed to evaluate various aspects and attributes related to sidewalks. However, some shortcomings were acknowledged throughout. The most prominent of these were the bias of auditors when doing audits (Clifton *et al.*, 2007) and the lack of reliable methods to collect data for the level of service methods (Asadi-Shekari *et al.*, 2014). To address these shortcomings, some researchers evaluated the use of the Conjoint Analysis technique (Van Cauwenberg *et al.*, 2016; Muraleetharan *et al.*, 2003). The Conjoint Analysis technique was found to be a very suitable method to realise the aim of the study.

The study aimed to analyse sidewalk attributes that contribute to the walkability of residential areas and to evolve planning and design solutions for pedestrian infrastructure. For this purpose, the findings addressed the four primary objectives in the following manner:

(1) The first objective of this study sought to explore sidewalk attributes and to categorise the importance thereof. From international and local literature, in conjunction with actual surveyed conditions, four main sidewalk attributes were identified (see section 4.5.1). These attributes were walkable width, number of obstacles, walking surface, and changes in elevation. Conjoint Analysis produced the relative importance values of these attributes and their respective independent attribute levels. This makes it possible to compare and evaluate individual attributes or various combinations thereof. Figure 4.37 shows a summary of attribute importance.

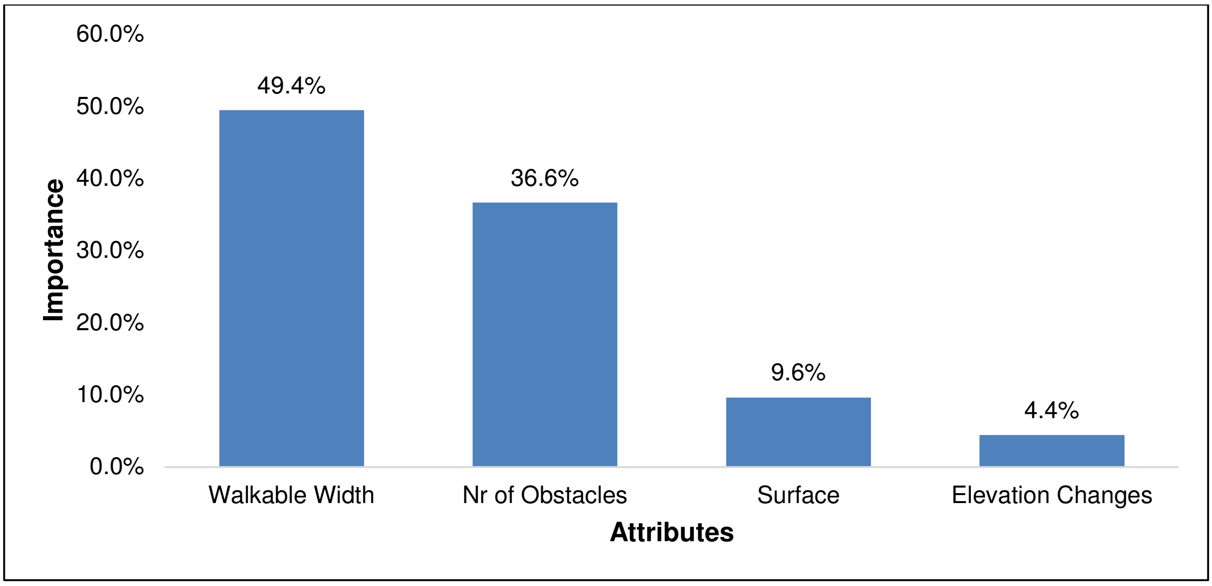

Figure 4.37 Sidewalk Attribute Importance Summary

Walkable width was found to be the most critical attribute. The second most important attribute was found to be the number of obstacles. The more surprising result was the number of obstacles being four times as important as the surface material. Finally, the surface material was found to be twice as valuable as changes in elevation.

One unanticipated finding was that the walking surface and changes in elevation are of much less importance compared to walkable width and number of obstacles. The demographics of respondents may somewhat limit these findings. None of the respondents were physically disabled, which may explain the low importance of changes in elevation.

(2) The second objective of this research was to identify additional walkability factors that are unique to residential areas in South Africa. The overwhelming factor raised by respondents was personal safety. This finding was also reported by Albers *et al.* (2010). The perceived safety of an area may influence pedestrian behaviour, which, in turn, leads to a pedestrian using the roadway. For example, if a pedestrian feels unsafe, they may choose to walk on the road, due to better visibility.

As mentioned earlier, obstructions on sidewalks are one of the biggest deterrents for pedestrians, which is understandable, given that some obstructions are physically impossible to manoeuvre through. Once pedestrians circumnavigate obstacles on the sidewalks by stepping into the roadways, they tend to remain in the roadway instead of returning to the sidewalk, which is why they prefer no obstacles on sidewalks. Due to the historic planning of neighbourhoods in South Africa, homeowners are the most significant contributors to creating sidewalk obstacles with built up gardens and driveways. Collaborative efforts will need to take place between city planners and homeowners to create sidewalks in residential areas that are obstacle free.

In this study, a significant portion of respondents was found to be students. Field surveys and observations confirm the findings of Ackermann & Visser (2016); that the neighbourhood is undergoing a studentification process. The continuous inflow of students into the area adds to the growing problem of pedestrians using the roadway, while little to no walking infrastructure exists. Although not included in the study, another factor identified during implementation, which is also relevant to South Africa, is the presence of gated communities within residential areas. Further walkability research, with a focus on the studentification of an area as well as gated communities, is recommended.

(3) The third objective was to analyse and define infrastructural, social, and environmental attributes that contribute to the successful creation of a walkable environment in residential areas. In the literature review (see Chapter 2), the attributes that contribute to the successful creation of a walkable environment is analysed and defined in detail. To summarise, the inferences drawn from the literature is set out in section 5.2.

(4) The fourth objective of this study set out to formulate planning and design guidelines to improve walkability in residential areas in Bloemfontein City. Concerning the first three objectives, the proposed planning and design guidelines were formulated and set out in detail in Chapter 5.

In addition to reaching the objectives of this study, the application of Conjoint Analysis proved successful in evaluating the importance of individual sidewalk attributes, as well as producing valuable information to simulate and predict the usability of sidewalks. Thus, the results of this study provide further support for the hypothesis that the Conjoint Analysis technique can be successfully applied to evaluate attributes that contribute to walkability.

This combination of findings provides some support for the conceptual premise that South Africa is unique in its challenges and it is hoped that awareness will be raised around the importance of local walkability research. A summary of the main findings, together with the developed policy guidelines, as well as the conclusion, are provided in the next chapter.

CHAPTER 5: FINDINGS, GUIDELINES & RECOMMENDATIONS, AND CONCLUSION

5.1 INTRODUCTION

The development of a set of planning and design guidelines to improve walkability in the residential areas of Bloemfontein City required an investigation that evaluated the existing pedestrian facilities, as well as the factors contributing to the use or avoidance of these facilities. Therefore, for this investigation, existing literature was reviewed, and statistical analyses were done at various stages, which included analyses of data from questionnaire surveys, physical surveys, and secondary sources. The factors of and causes for avoiding sidewalks and walkways in residential areas were then examined and evaluated.

In this chapter, inferences are drawn from the results of the analyses conducted, followed by the development of a planning concept for the improvement of walkability in residential areas. The inferences drawn and the planning concept was then used to evolve plausible recommendations to improve walkability in the study area. These inferences are presented in the sections that follow.

5.2 INFERENCES FROM LITERATURE REVIEW

The following inferences can be made:

- Non-motorised transport, walking, and cycling are increasingly being recognised as a vital part of a successful transportation network.
- Most trips begin and end in residential areas. Thus, residential areas should be included in the overall integrated transportation plan of a city.
- Walking is well known for its numerous health benefits, as well as the benefits related to reduced emissions.
- Walkable neighbourhoods have critical economic value, boosting real estate values and encouraging social and economic exchanges.
- Safe and effective pathways and sidewalks require careful planning; especially where budgetary constraints play a role in infrastructure upgrades and maintenance.

- On a macro level, a walkable residential area should have origin and destination points that are well connected, as well as functional integration with other modes of transport.
- On a micro level, a walkable residential area should consist of sidewalks and walkways with sufficient space to travel and that are free of obstructions. Moreover, it should be safe and sufficient for walking.
- The lack of pedestrian infrastructure is observed as constraints in the accessibility of amenities, and economic and recreational activities.
- Individual preferences and socioeconomic characteristics are influences on walkability, but the built environment has a significant influence on the choice to walk.
- Personal safety, travel time, and infrastructure are among the most important preconditions for walking.
- The lack of adequate walkways is the result of insufficient and neglected municipal planning and budgets.
- Walkability is still addressed with far less intensity as compared to other modes of transport.
- There is a need to objectively quantify how roadways accommodate pedestrians and satisfying this need would greatly aid in prioritising sidewalk and roadway design and upgrades.
- Sidewalks developed for pedestrians were found to be highly correlated with walking and forms an integral part of the walkability of an area.
- Many factors related to the measuring of walkability are qualitative and difficult to measure. Essential qualities identified are imageability, enclosure, human scale, transparency, and complexity.
- By reviewing methods to measure walkability, consistent correlations were found between walking for transportation and density, distance to non-residential destinations, and land mix use.
- Pedestrian level of service methods, audits, and questionnaires are the main approaches followed for the assessment of sidewalks.
- Although various methods exist to measure sidewalk walkability, several drawbacks are mentioned throughout, which includes the lack of reliable methods to collect data and the bias of auditors when conducting audits.
- Recently, a method called Conjoint Analysis used in market research has been applied to unbiasedly evaluate the importance of sidewalk attributes according to the perceptions of users.
- 60% of the South African population relies on walking as a mode of transport.

- 66% of all road fatalities in South Africa are pedestrian fatalities.
- In South Africa, the rezoning of land use and socio-economic transformation both contribute to the migration of residents from rural areas to larger cities. This increase results in an increase in pedestrians and the need for usable walkways and sidewalks.
- Standard procedures for planning and sidewalk development in residential areas have been followed by city and urban planners for many years.
- Established residential areas in South Africa have been changing due to new developments, rezoning of land use, and transformation. These changes are not supported by the upgrading of infrastructure, specifically non-motorised transportation.
- Research regarding walkability in the residential areas of cities in South Africa is scarce.

5.3 INFERENCES FROM SURVEYS, SPATIAL ANALYSES, AND CONJOINT ANALYSIS MODEL IN THE STUDY AREA

The inferences drawn from the physical surveys, questionnaire surveys, spatial analysis, and statistical analysis are presented below:

- The study area is the most diverse residential area in Bloemfontein City, with regard to trip generating destinations.
- Little to no provision is made to accommodate pedestrians within the study area.
- Similar to residential areas throughout the city, verges and sidewalks are present throughout the study area with an average width of 3.7m. However, the sidewalks are undeveloped and mostly inaccessible.
- Sidewalks are inaccessible mainly due to inappropriate urban furniture, lack of maintenance, built up gardens, unmaintained stormwater inlets, uneven driveways, and vegetation.
- Homeowners are the most significant contributors to the inaccessibility of sidewalks.
- Pedestrians have no other option but to use the roadway for walking.
- The number of pedestrians in the study area has grown to the extent that the normal flow of traffic is obstructed regularly.
- Approximately 93% of pedestrians in the study area are below the age of 30.
- 45% of pedestrians are educated up to high school level or less, whereas 44% of pedestrians are in possession of an undergraduate degree.

- The majority of pedestrians in the study area are students attending the nearby university.
- 64% of pedestrians are residents of the study area, while the remaining portion are visiting destination points or using the study area as a thoroughfare.
- 46% of pedestrians indicated that they do not own a vehicle and thus have to travel by foot. Moreover, 68% of pedestrians walk in the area every day.
- 23% of respondents indicated that, when they drive in the study area, the roadway is obstructed by pedestrians more than once per day.
- Approximately 50% of pedestrians stated that they would walk more often if it were safe and comfortable to do so.
- A primary concern raised by the majority (65%) of pedestrians is personal safety, followed by the fear of being struck by a vehicle.
- 76.3% of pedestrians prefer to walk on the sidewalk where possible, mainly out of fear of being struck by a vehicle.
- 23.8% of pedestrians prefer to walk on the roadway, due to sidewalks being mostly undeveloped and inaccessible.
- From the sidewalk attributes evaluated, the walkable width is the most desirable attribute with an importance value of 49.4%, followed by the number of obstacles or obstructions with an importance value of 36.6%. The surface material and changes in elevation were identified as much less critical with values of 9.6% and 4.4% respectively.
- In more detail, the most desired attributes for a sidewalk is a walkable width of more than 2m and 0 obstacles.
- If the most crucial sidewalk attributes are present, the less essential attributes will not influence a pedestrian to avoid a sidewalk.
- Conjoint Analysis is a suitable methodology to group sidewalks based on Pedestrians' Preference Scores and sidewalk attributes. For example, part-worth utilities generated by Conjoint Analysis can be used to predict the likelihood of pedestrians using a particular sidewalk. Subsequently, Conjoint Analysis represents a reliable information source using the qualitative judgments of pedestrians.

From this investigation, it is observed that the four sidewalk attributes (walkable width, number of obstacles, surface material, and changes in elevation) evaluated are not equally significant. All these attributes influence pedestrians to a different extent. It is found that prioritising the most important attributes when developing or upgrading sidewalks will result in pedestrians choosing to walk on the sidewalks instead of the roadway. Furthermore, if budgetary constraints burden the development of sidewalks and walkways, investment in the most important factors could be much more beneficial as compared to a blanket approach.

5.4 PLANNING CONCEPT

Based on the findings of this study, a concept to create walkable residential areas has been devised. This investigation reveals that improvements to and the development of sidewalks and walkways in residential areas are essential and produce a multitude of benefits. Hence, to develop plausible planning and design guidelines, the following broad concepts have been adopted:

1. The prioritisation of non-motorised transport in residential areas in South Africa has been overlooked (Vanderschuren et al., 2014). It is clear from research that a neighbourhood where walkability is successfully developed has countless benefits (Adkins *et al*., 2012; Ewing & Cervero, 2010; Gilderbloom *et al*., 2015). Benefits not only to the neighbourhood and its residents, but also to the rest of the city. Consequently, as found from this study (see section 4.4), there is a great need for the development of walkable neighbourhoods in South Africa

2. Pedestrians sharing the roadway with motorised transport are undesirable in residential areas, mostly due to the risk of pedestrians being struck by a vehicle. The majority of road fatalities in South Africa are pedestrian fatalities (South African National Department of Transport, 2011). A reasonable number of pedestrians in the area raised this as a significant concern (see section 4.4). Consequently, pedestrians indicated that they avoid walking in the area as far as reasonably possible. Therefore, to encourage walking in residential areas, it is essential to separate pedestrians from motorised traffic.

3. Personal safety is the foremost requirement to create a walkable environment, especially in South Africa. From local literature (Albers et al., 2010), and as this study has found (see section 4.4), personal safety is of significant concern to pedestrians. Undeveloped sidewalks and walkways provide pedestrians with the sense of an unsafe environment, as well as discouraging commuters from walking, which reduces the number of pedestrians. Accordingly, the development of walkability in an area encourages more users to make use of non-motorised transport, thus reducing crime and related activities (Flositz, 2010).

4. The lack of developed and accessible sidewalks and walkways results in pedestrians using the roadway for walking (see section 3.3.3). Many pedestrians are users that have no other choice but to walk and, as a result, are forced to use the roadway for walking. Furthermore, a small but significant portion of residents are composed of families, the elderly as well as disabled persons who do not wish to commute on the road, due to the absence of good sidewalks (see section 4.4). With the historical lack of sidewalk development, many homeowners have taken it upon themselves to create developed gardens and driveways on their front pavement, which results in sidewalks being completely inaccessible (see section 3.3.3). The pavement network does not belong to the adjacent homeowners and should be developed to support pedestrian activity. Consequently, one of the primary requirements is appropriate interventions that provide adequate, accessible and unobstructed pavements.

5. The walkable width of a sidewalk was found to be the most influential determinant that encourages pedestrians to use or avoid sidewalks in the study area (see section 4.5.3). The second most important determinant, which is closely related to walkable width, is the number of obstructions present. As found out from this investigation, different attributes affect the behaviour of pedestrians differently. For instance, the importance, and thus the influence of walking surface and changes in elevation, is minute and almost negligible when compared to the attributes above. Therefore, in order to deliver the most efficient and cost-effective solutions, the planning and development of sidewalks should be done in a manner that gives preference to the most important attributes.

5.5 PLAUSIBLE PLANNING AND DESIGN GUIDELINES AND RECOMMENDATIONS

The focus of this study has been to investigate the factors contributing to the use or avoidance of sidewalks in residential areas in order to improve and develop neighbourhood walkability. Based on the evaluation of various elements as discussed throughout this study, the following feasible recommendations are proposed.

Prioritisation of walkability in residential areas:

- Residential areas should be included as a priority in the non-motorised transport master planning of cities.

- Funding to develop walkability in residential areas should be prioritised and coordinated by local authorities.
- Businesses and residents in residential areas should be informed and encouraged to support the development of non-motorised transport in the area.
- Standards and minimum requirements for non-motorised transport in residential areas should be developed.
- When a Cost-Benefit Analysis is done to determine the viability of a new sidewalk or upgrade, the importance of sidewalk attributes should be taken into consideration. For example, the attributes of Table 5.1 can be incorporated with their respective importance weights for this study area.

Table 5.1 Walkway attributes importance weights for Cost-Benefit Analysis

Walkway Attribute	Importance Weight Value
Walkable width	12
Number of obstacles	9
Walking surface	2
Changes in elevation	1

Design Elements:

- The most cost-effective short-term solution in areas where pedestrians share the road with motorised traffic is to reduce speed limits to 40km/h (Vanderschuren *et al.*, 2014). Accidents are immensely reduced at this speed.
- Pedestrian facilities in residential areas should be either fully separated or partially separated from motorised traffic by means of a level difference, such as kerbed sidewalks.
- Paths and walkways should be developed to provide a complete connection between destination points. Paths and walkways should not start and end suddenly. Pedestrians choose to avoid walkways if they constantly have to navigate on and off a path.
- Neighbourhood access roads of seemingly less importance should not be ignored. Accessible sidewalks and walkways do not only allow for access but also encourages recreational activities, such as jogging or visiting the nearby public parks.
- A sidewalk or walkway should have a recommended minimum walkable width of 2m. A width of more than 2m would be ideal.

- A minimum number of zero obstructions are recommended for walkways. However, this will not always be the case with the upgrading of existing sidewalk infrastructure. In these circumstances, it is recommended that obstructions that cannot be completely removed should be relocated to allow a straight path with the recommended minimum width of 2m.
- If budgetary constraints exist, the following scenarios should be considered to provide the most effective walkability solutions in residential areas:
  - Longer and broader unpaved facilities with a gravel wearing course should be selected before a shorter and narrower paved facility. The walkability benefit to the pedestrian of the unpaved facility outweighs the paved facility. Additionally, paved facilities have an approximate cost of R450/m^2, while a gravel wearing course facility has an approximate cost of R50/m^2 (Vanderschuren *et al.*, 2014).
  - Removing or relocating obstructions on a walking facility should be preferred above the upgrade of the surface material. Pedestrians have shown to prefer fewer obstacles to a paved walking surface.

Operational Elements:

- The obstruction of sidewalks and walkways should not be allowed, and local authorities should apply appropriate enforcement measures.
- Regular maintenance should be conducted on sidewalks and walkways. Areas that are known for lack of maintenance should be planned and designed to require as little maintenance as possible.
- Local authorities should deploy measures to encourage homeowners not to obstruct or develop adjacent sidewalks for personal use.

Personal Security:

- Personal security should be included as a significant determinant for the development of walkability in residential areas.
- Parking on sidewalks and walkways should not be allowed. Stricter law enforcement should be applied in this regard.
- Obstacles should be removed from sidewalks as far as possible in order to prevent creating shelter for potential criminals.
- If maintenance of vegetation is a known problem, then vegetation should be removed completely.
- Signage can be erected to warn pedestrians about known criminal areas.

- Appropriate street lighting should be provided. Traditional street lighting is not sufficient.
- Alternative routes should be available to allow pedestrians to avoid insecure areas.
- Amenities that encourage people to loiter, such as seating and water fountains, should be avoided.
- Sight distances should be a significant consideration regarding placement of walkways.
- Efforts to encourage walkability should be pursued. More pedestrians using the facilities will deter criminal activities.

5.6 CONCLUSION, LIMITATIONS, AND FUTURE RESEARCH

The necessity of good sidewalks and walkways in residential areas is justified when looking at the benefits that a walkable neighbourhood provides to pedestrians and the overall transportation network. However, the sidewalks in the residential areas of the central region of South Africa are observed to be undeveloped and underutilised, thus resulting in pedestrians using the roadway for walking. Furthermore, the number of pedestrians using the roadway in recent years has grown to the extent that pedestrians regularly obstruct the normal flow of traffic. This, therefore, warranted an investigation to identify the walkability constraints of residential areas and to explore ways to effectively improve existing and planned walking infrastructure in the residential areas of the region.

For this purpose, a case study of sidewalks and walkways in the Universitas residential area of Bloemfontein City in South Africa was conducted. To realise the aim of the study, a survey research methodology was used for the collection of data and subsequently a Conjoint Analysis was conducted in an attempt to unbiasedly identify and categorise sidewalk attributes that contribute to the use or evasion of sidewalks. The Conjoint Analysis revealed that attributes such as walkable width and the number of obstacles are significant parameters which influence the use of sidewalks in residential areas (see section 4.5.3). Furthermore, the results produced the relative importance of each evaluated attribute, which provides valuable insight into the prioritisation (and possible budget allocation) of these attributes when it comes to the development of walkability. Finally, the Conjoint Analysis results were evaluated against pedestrians' genuine willingness to make use of selected sidewalks within the study area. This evaluation revealed that the utility values produced by Conjoint Analysis could be used to predict how likely it is that a pedestrian would use a specific sidewalk. Additionally, other significant concerns influencing neighbourhood walkability, such as personal safety and motorised traffic, were also identified by respondents.

Based on the results, several alternative planning and design guidelines were developed to improve the walkability of residential areas. Findings suggest that an enhancement of the most critical sidewalk attributes (increase in walkable width to more than two meters and the reduction in number of obstacles to zero) would substantially decrease the number of pedestrians using the roadway for walking. These changes are not unachievable, as some sidewalk sections (approximately 5%) of the study area, fulfil these attribute requirements. An example of this is Location 8 (see Figure 5.1) used in the evaluation. Location 8 received the highest preference rating and utility value, similar to the results of Conjoint Generated Profile 7 (see Figure 5.2).

Figure 5.1 Sidewalk location 8, Christoffel Du Plessis Street, Universitas (Source: Author).

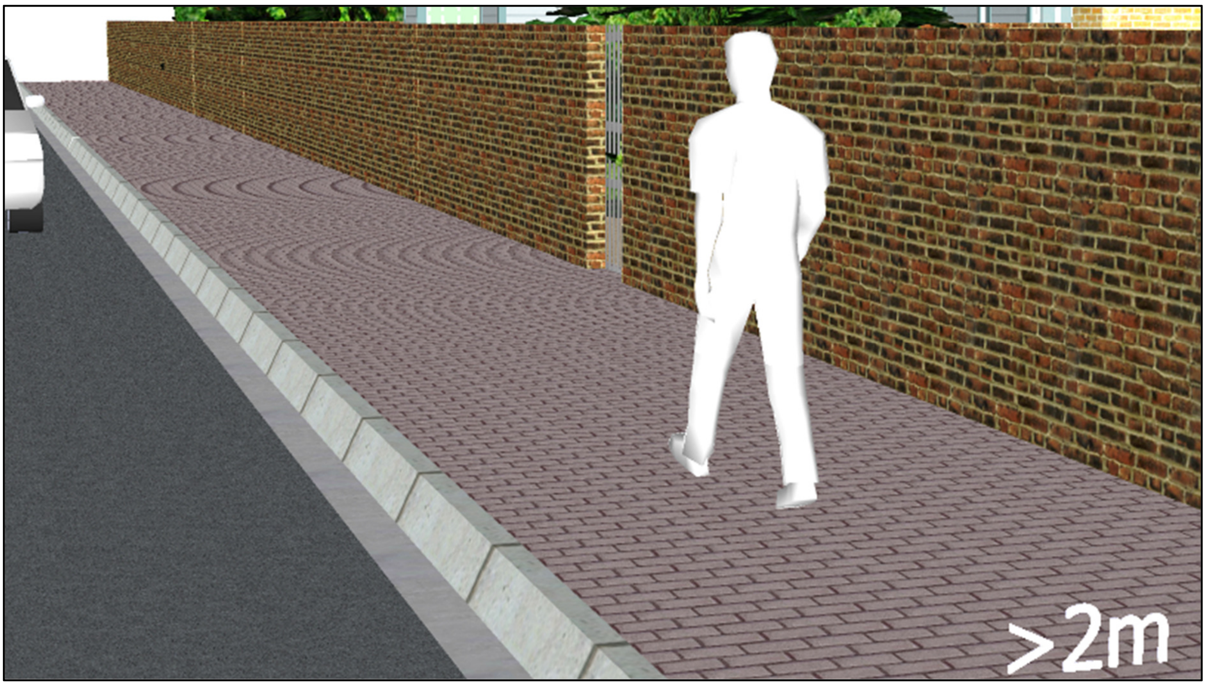

Figure 5.2 Conjoint Generated Profile: Card 7

The investigation also has certain limitations. Firstly, significant limitations of the study was the limited time, shortage of manpower, and budgetary constraints. This resulted in the limited nature of the surveys being conducted in the study area. The surveys were conducted in one seemingly representative residential area, where the problem was observed to be the most severe. The study also suffered from the lack of availability of structured statistical data. Additionally, the scope of the study was confined to Bloemfontein City. Consequently, in order to generalise the inferences of this study, similar investigations in other cities are needed. Secondly, due to the nature of the Conjoint Analysis technique (see section 4.5.2), only four sidewalk attributes could be evaluated. The model and the accuracy of the results could be improved by duplicating the study and comparatively evaluating other sidewalk attributes. Thirdly, other physical elements, such as crossing facilities and other non-motorised facilities, were not included in this investigation. Lastly, the scope of this investigation was confined to the assessment of physical attributes only. However, crime, socio-economic, and safety issues were identified by respondents that were kept out of the analysis, which offers prospects for further research.

This study also offers several opportunities for further research. Some of the possibilities for further research include the following:

- Improving the accuracy of the Conjoint Analysis model by evaluating more sidewalk attributes.

- The application of the Conjoint Analysis technique to evaluate the accessibility of trip generating destinations.
- The evaluation of the Conjoint Analysis technique for other non-motorised transportation modes.
- The impact of the studentification of an area on the transportation network.

This dissertation has provided a deeper insight into the development of walkability in a developing country such as South Africa. This new understanding should help to improve the predictions of the impact of individual walkability attributes as well as various combinations thereof. It is envisaged that, if the plausible planning and design guidelines developed by the current investigation are implemented, the accessibility of the residential area and its destination points, as well as the level of service for all modes of transport, will improve substantially.

CHAPTER 6: LIST OF REFERENCES

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ANNEXURE A

Sample of questionnaire survey

SIDEWALK USE SURVEY

IN RESIDENTIAL AREAS OF BLOEMFONTEIN CITY, SOUTH AFRICA.

This survey is voluntary and anonymous. Information will only be used for research purposes.

1.	**Name:** Optional – We respect your privacy		
2.	**Date:**		
3.	**Time:**		
4.	**Age:**		
5.	**Gender:**	☐ Male ☐ Female	
6.	**Neighbourhood where you stay?**	☐ Universitas	☐ Other; Please Specify: ___________
7.	**Highest Level of Education?**	☐ High School or less ☐ Trade or vocational school ☐ Undergraduate degree	☐ Graduate degree ☐ Prefer not to answer
8.	**Employment Status?**	☐ Student / Scholar ☐ Full-Time Employed ☐ Part-Time Employed	☐ Retired ☐ Unemployed ☐ Prefer not to answer
9.	**Do you/your household own a vehicle?**	☐ Yes, I own a car ☐ No, I don't own a car	☐ Yes, there is a car in the household ☐ No, there is not a car in the household

10. If/when you drive a vehicle in the neighbourhood, do pedestrians obstruct the roadway?

- ☐ Never
- ☐ Less than once per week
- ☐ 2 to 3 times per week
- ☐ Once per day or more
- ☐ Not applicable

11. How often do you walk in the neighbourhood?

- ☐ Never
- ☐ Less than once per month
- ☐ 2 to 3 times per month
- ☐ Once per week or more
- ☐ Every day

12. How would you rate your current walking experience in the neighbourhood?

1	2	3	4	5
Very Unsatisfied	Reasonably Unsatisfied	Acceptable	Reasonably Satisfied	Very Satisfied

13. If/when you walk in the neighbourhood, what is the main purpose?

- ☐ Fun/Relaxation
- ☐ Exercise
- ☐ Shopping
- ☐ To go to work
- ☐ Attend School/University
- ☐ Attend church
- ☐ Visit a public park
- ☐ Other; Please Specify: ___________________

14. What is the furthest distance you would walk to a point of interest?

- ☐ Less than 1km
- ☐ 1 to 2 km
- ☐ 2 to 3 km
- ☐ 3 to 5 km
- ☐ 5 to 10 km

15. If it was more comfortable and safe to walk, would you do it more often?

- ☐ Yes, definitely
- ☐ Maybe
- ☐ No, I would walk the same amount
- ☐ I have no choice but to walk anyway

16. If/When walking in the neighbourhood, what is your biggest concern?

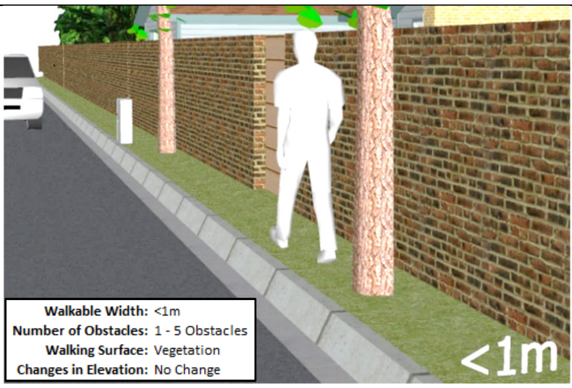
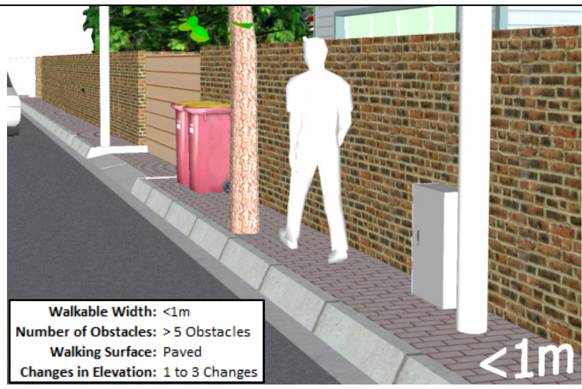
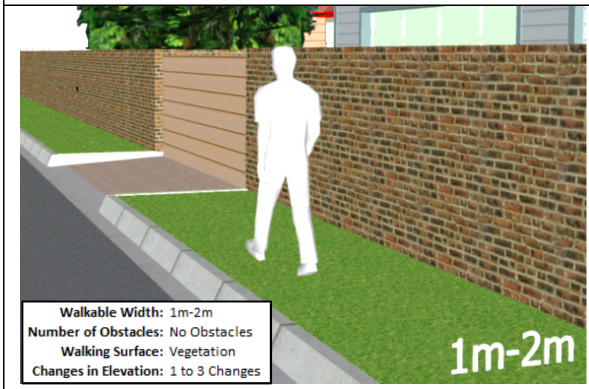
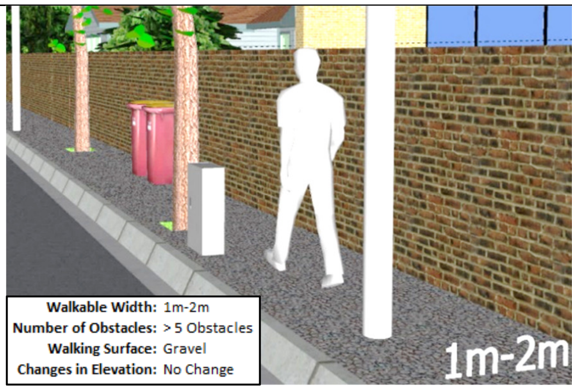
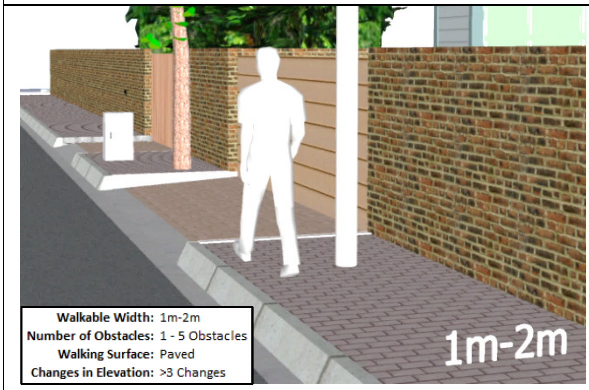
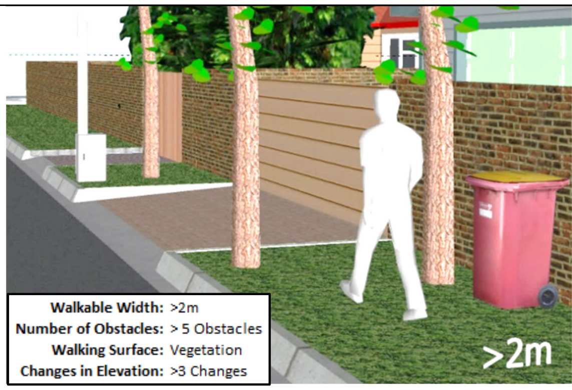
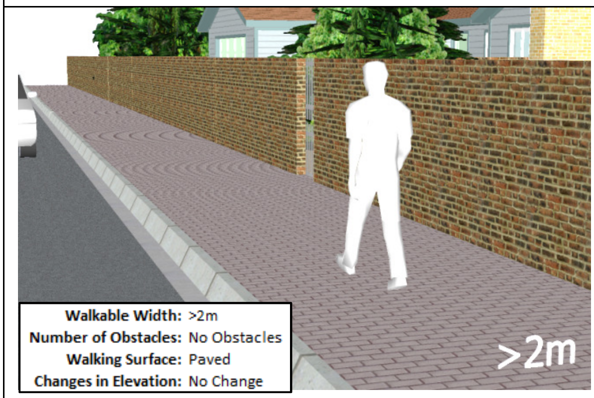
Please specify: ____

17. Where do you prefer to physically walk in the neighbourhood?

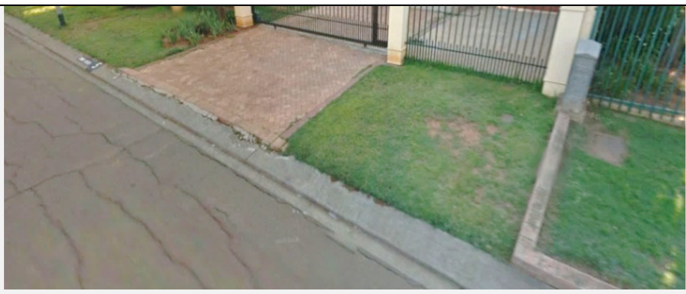
- ☐ Sidewalk; If chosen, why? ____
- ☐ Roadway; If chosen, why? ____

Rank the following sidewalk illustr ing to preference from **1 to 9**.

(1 = Most preferred) (9 = Least preferred) *NB: Use a number only once*

Sidewalk Illustrations	Rank	Sidewalk Illustrations	Rank
			
			
			
			
			

Indicate how likely you would use the following sidewalks in Universitas, Bloemfontein.

#	Sidewalk	Definitely Not	Probably Not	Not Sure	ProbablyYes	Definitely Yes
1		①	②	③	④	⑤
2		①	②	③	④	⑤
3		①	②	③	④	⑤
4		①	②	③	④	⑤
5		①	②	③	④	⑤
6		①	②	③	④	⑤

#	Sidewalk	Definitely Not	Probably Not	Not Sure	Probably Yes	Definitely Yes
7		①	②	③	④	⑤
8		①	②	③	④	⑤
9		①	②	③	④	⑤
10		①	②	③	④	⑤
11		①	②	③	④	⑤

Thank you for your participation.