DEVELOPMENT OF A MULTIMODAL INTEGRATION INDEX FOR MEASURING PASSENGER NEEDS AND PERFORMANCE OF INTERMODAL INTERCHANGES

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DISSERTATION SUMMARY

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Transportation is a basic need of modern society. In South Africa, more than half of the population are currently dependent on public transport and regularly commute long distances to and from places of employment, education and recreation. There is a shortage of research on passenger needs and experiences that could help to improve public transport interchange facilities in South Africa.

The objective of this research study is to develop a multimodal integration index to measure the level of integration at existing public transport interchange facilities from a passenger's perspective. Criteria of importance to users, as identified from other studies, formed the starting point for further investigation via qualitative assessment through focus groups. A quantitative survey was administered to 374 participants selected by random stratified sampling which ensured a comprehensive needs assessment for men, women, elderly users and scholars across mini-bus taxi, bus and rail modes. Respondents, who are regular users of the Isipingo, Pinetown

and Bridge City facilities located along the planned eThekwini Integrated Rapid Public Transport Network, rated their overall satisfaction with these facilities on a 5-point Likert scale. They also identified and rated the importance of the following criteria: comfort and convenience, universal access, personal security, road traffic safety, provision of information, integrated ticketing, provision of amenities and waiting time.

A statistical comparison of importance ratings across users from different age and gender groups using *t*-tests and ANOVA revealed that personal security, short walking distances and the provision of ATMs or banks are more important to women than to men. Short walking distances, the provision of ramps or lifts, handrails, tactile surfaces and lowered kerbs are more important to elderly users than to scholars. Lighting, CCTV cameras, directional signage, paying with one travel card, and fast food availability at facilities are more important to elderly users than to those in the 18-55-year-old age group. Thus, it can be concluded that users of different genders and different age groups have different requirements in terms of the interchange facilities, which further emphasises the need to gain a better understanding of the requirements of all user types.

The index is a single value that captures information from these criteria into one composite measure to provide an indication of the level at which facilities are integrated and it also serves as a detailed assessment tool to identify and prioritise interchanges in need of upgrades. The index values for the surveyed sites are Isipingo 9.3, Pinetown 8.6, and Bridge City 8.3 out of a maximum of 33.0. These values fall within a range that indicates poor integration. The index values rank the three facilities in the same order as the satisfaction ratings by existing users.

Taken together, these findings add valuable information about the perspective of South African transport users. The developed integration index can also serve as an assessment tool to ensure effective development and upgrading of transport facilities in South Africa.

DECLARATION

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Date: 1 August 2020

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With God, all things are possible.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
AMPTI	Assessment Method of Public Transport Interchanges
BCI	Bicycle Compatibility Index
BRT	Bus Rapid Transport
C-alpha	Cronbach Coefficient Alpha
CPTR	Current Public Transport Register
CSI	Customer Satisfaction Index
FA	Factor Analysis
IRPTN	Integrated Rapid Public Transport Network
ISA	Importance-Satisfaction Analysis
ITP	Integrated Transport Plan
LITA	Local Index of Transit Availability
LOS	Level of Service
LUPTAI	Land Use and Public Transport Accessibility Index
MCA	Multiple Correspondence Analysis
MNL	Multinomial logit
NSW	New South Wales
PCA	Principal Component Analysis
PLOS	Pedestrian Level of Service
RP	revealed preference
SEM	Structural Equation Modelling
SERVQUAL	Service Quality model
SP	stated preference
SQI	Service Quality Index
TCQSM	Transit Capacity Quality of Service Manual

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

Mobility is the ability to move passengers from one location to another to access employment, education, services and recreation. If properly planned, it is expected to have a positive effect on the economy and user's quality of life. As a consequence of the apartheid era where towns and cities were designed to spatially separate different race groups, approximately 77% of the 14,2 million South African households surveyed as part of the National Household Travel Survey (Department of Transport [DOT], 2013) are currently captives to public transport as their main transport mode to commute long distances to and from places of employment, education and recreation.

Surveys conducted as part of the National Household Travel Survey (DOT, 2013) indicate that the most important general problem mentioned by nearly half the households in South Africa was the lack of readily accessible public transport and the dissatisfaction with the existing public transport services. Public transport users indicated dissatisfaction with the high levels of crowding in all available transport modes, inadequate security at train stations, lack of shelters at bus stops, inadequate frequency of bus services, high fares for minibus taxi trips, poor roadworthiness of vehicles, and the lack of infrastructure at public transport ranks. Clearly, many of the factors that contribute to dissatisfaction among current public transport users, relate to inadequate infrastructure at interchanges.

In fact, the local user experience of multimodal integration at transport facilities is likely to grow in the coming years, as many public transport strategies in South African cities start to rely on transfers between two or more vehicles, such as in feeder-trunk operations. For example, the eThekwini Municipality in the KwaZulu-Natal province of South Africa has developed a public transport operational strategy which incorporates the Go Durban! integrated rapid public transport network (IRPTN). This network was developed to provide services and schedules that will allow passengers to move from their origins to destinations in the shortest possible times and with the minimum number of fare-paying transactions. In the eThekwini Municipality, the proposed IRPTN plan envisages eight road-based public transport corridors and one railed-based corridor with bus and taxi feeder services. To this end, transfer facilities will become an essential component of the successful functioning of the transport system. The success of such major public transport initiatives will ultimately depend on the extent to which facilities are integrated with their surrounding environments, as well as the efficiency of the transport modes.

Modal integration involves the linking of some or all of the different public transport modes (mainly the minibus taxi, bus and train modes) into the public transport system in such a way that these modes support and complement each other and operate as a coordinated public transport system, while providing an effective, efficient and affordable service to the user. Modal integration can play an important role in alleviating common problems such as fragmented public transport systems, utilisation of unsuitable transport modes and duplication of public transport services; thereby increasing the effectiveness and efficiency of public transport systems more. An effective and efficient transport system facilitates the optimal movement of passengers and goods while reducing travel distance, vehicle emissions, traffic congestion, transport costs, and travel time (through effective timetabling and route management).

A better understanding of the perceptions, needs and priorities of the daily or frequent public transport users as they travel through transport interchanges, can provide insight into designing future integrated interchanges which will ultimately benefit users. Since these users are the ones who use the services at the transfer facilities regularly and will most likely have specific requirements, their opinions should be given special attention and priority over other requirements considered when designing transfer facilities.

1.2 PROBLEM DEFINITION

Extensive international research has been undertaken on passengers' perceptions of the importance and satisfaction of physical infrastructure at facilities, as well customer service, safety, and comfort, as discussed in Chapter 2. In a South African context, relatively little research has been conducted specifically on passenger needs and experiences at interchange facilities. Available local papers focus on design aspects of interchange facilities relating to infrastructure and contractual issues that have an impact on public transport. In some research studies, the physical design of transport nodes and how accessible they are for pedestrians transferring between modes have been investigated, as all public transport users are pedestrians at some point in their journey.

Whilst there are data available on how to improve transfer facilities from an operator's perspective, it is evident that there are shortcomings in terms of the design of intermodal transfer facilities from a South African public transport user's perspective. Considering and prioritising the requirements of existing public transport users in the design of intermodal facilities is crucial, given that the passengers is the key focus element in the public transport

system. In addition, practitioners (planners and engineers) are lacking a practical method to translate this knowledge into a useful tool.

1.3 OBJECTIVES OF THE STUDY

The objective of this study is to develop a multimodal integration index to measure the level of integration at existing public transport interchange facilities from a passenger's perspective, taking into account a set of predefined criteria that can be easily and cost-effectively measured on site at the public transport facilities. The purpose of the index is to provide a detailed assessment of existing interchange facilities and to identify requirements and priorities at facilities in need of upgrades during the planning and design phases of projects.

1.4 SCOPE OF THE STUDY

A mixed methods approach was used in this study. This involved the incorporation of both qualitative insights from focus groups with interchange users, and quantitative data from surveys, to develop a multimodal integration index. The index itself is of a quantitative nature which will allow easier measurement to be performed on site at the facilities.

The geographical context for this research study is the City of Durban (local authority: eThekwini Municipality) situated in the province of Kwa-Zulu Natal within South Africa. Three existing transfer facilities have been selected for carrying out the study, namely:

- Isipingo CBD;
- Pinetown CBD; and
- Bridge City.

These facilities are also located along the route of the planned eThekwini Municipality IRPTN which will include the implementation of a Bus Rapid Transport (BRT) system operating on a dedicated right-of-way. The three interchanges are examples of typical facilities developed by local authorities in South Africa. They serve a combination of three urban public transport modes, namely bus, minibus taxi, and rail. Intercity modes including bus, minibus taxi, and rail, were excluded from the analysis.

The focus groups and surveys included various types of public transport users (men, women, elderly individuals, and scholars) to ensure a comprehensive assessment of the needs of users across the public transport modes.

1.5 METHODOLOGY

The research methodology is as follows:

- Literature review: The literature review serves as a starting point in providing a good understanding of the relevant criteria identified by public transport users in previous local and international studies. The literature review also identifies techniques and indices previously developed for measuring service quality and customer satisfaction of public transport facilities.

- Focus group workshops: A qualitative assessment in the form of focus group workshops are held with frequent passengers at the existing transfer facilities (Isipingo, Pinetown and Bridge City) who transfer between different modes or the same mode to reach their destinations. The intention of the workshops is to identify criteria which are of importance to existing users of the public transport system during their respective journeys. During the workshops, open-ended questions are asked and discussions among the users is encouraged in order to acquire a sense of the user experience of the specific interchange, likes and dislikes, quotes from users, and priority or order of importance of the raised issues.

- Identification of criteria for developing the index: Results from the focus groups are then considered together with the literature review, to select a set of criteria while taking the following into consideration; the importance of each criteria item as identified by users during the focus groups, the ease of unambiguous definition, and the ease of measurement. For the purpose of this study, the focus is on criteria that can be measured easily and cost-effectively. This may include criteria such as walking distances, number of unprotected vehicle-pedestrian crossings, vertical distances (e.g. stairs), information provision and lighting.

- Survey development: A quantitative survey is developed to collect data on the user experience based on the selected criteria of users frequently transferring through the selected interchange facilities. The surveys are conducted by staff that were hired and trained in undertaking the surveys. Consequently, the data collected from the survey is used to weight and measure the importance of the criteria in relation to their relative contribution to the passengers' perceived satisfaction with the overall transfer experience.

- Derivation of the index: Selected criteria are combined to derive a multimodal integration index.

- Testing of data collection methodology: The data collection methodology is tested by transportation planners and engineers at the selected transfer facilities. The intention is to develop a spreadsheet model which can be easily populated through a series of YES/NO questions completed on site, at a transfer facility. The spreadsheet is linked to a graphical interface to ensure ease of information input and output viewing.

- Reliability of the index: This is undertaken by using the overall passenger satisfaction ratings collected from the quantitative surveys. This step determines whether the data correspond to passengers' subjective perceptions of conditions at each interchange and whether the derived indices correspond to passengers' overall satisfaction.

1.6 ORGANISATION OF THE REPORT

The dissertation consists of the following chapters:

Chapter 1: Introduction

Chapter 2: Literature Review

Chapter 3: Methodology

Chapter 4: Data Collection and Processing

Chapter 5: Data Analysis and Findings

Chapter 6: Conclusion and Recommendations

Chapter 7: References

CHAPTER 2 LITERATURE REVIEW

This chapter provides an overview of the existing literature that is related to the research problem. Firstly, an introduction to the concepts relating to the definition and understanding of passenger interchanges is given. Secondly, literature review covers the techniques used by researchers in previous studies to weight or measure the importance of each criterion, statistical techniques to model the relationship between individual service criteria and passenger satisfaction, and techniques for using single indices to serve as summary indicators for multidimensional phenomena being measured. Lastly, data collection methods were reviewed along with local and international guideline documents.

2.1 DEFINING AND UNDERSTANDING PUBLIC TRANSPORT INTERCHANGES

The Auckland Transport Public Transport Interchange Design Guidelines (2013) defines a public transport interchange as a location where customers transfer from one mode of transport to another or between two services of the same mode. Interchanges represent one of the major interaction points that individuals have with the public transport system. It is also the largest and most noticeable forward-facing physical aspect of the transport system and as such have a significant impact on the perception of the public transport system.

A typical transit trip that takes a user from door-to-door involves walking from the trip origin to a public transport stop or station, waiting for the vehicle to arrive, boarding the vehicle, travelling, alighting from the vehicle and walking to the trip destination. Many trips also include transfers where travellers alight from one vehicle and move to a new public transport stop or platform, wait for the next vehicle and travel with that vehicle before walking to the final destination (Taylor *et al.*, 2009).

Desiderio (2000) stated that although intermodal interchanges are places where the waiting time has to be reduced as much as possible to permit faster transit of users between different modes of transport, such places should be considered as a more complex organism used by travellers and operators with precise requirements. The main users' needs were identified to be as follows:

- Accessibility and external circulation – comfortable seating, clean and safe environment, short walking distances within the interchange, safe pedestrian crossing points and infrastructure for vulnerable users;
- Physical design – waiting areas should be clean, comfortable, safe and warm, with ablutions, shops, newspapers, telephones and sufficient lighting;

- Shops and amenities – with facilities such as retail outlets, restaurants and cultural attractions such as cinemas and art centres;
- Security and psychological factors – presence of security guards, police, CCTV cameras and well-lit areas;
- Information – regarding services, travel times, tariffs, transmission of information to visually impaired users, real-time information on arrivals, departures and delays; and
- Ticketing – on-site selling and automatic distributors, joint ticketing.

2.2 MEASURING SERVICE QUALITY OF PUBLIC TRANSPORT SERVICES

The literature that was reviewed reveals several techniques for measuring service quality and customer satisfaction of public transport services. Many authors also introduced customer service indices for measuring the overall satisfaction of service quality.

2.2.1 Techniques to identify which criteria are more important to users

A review of the literature reveals that while some authors use the criteria identified in previous studies as a starting point, many actually conduct investigations at public transport interchanges to identify their own set of criteria derived from a passenger's perspective. Descriptive surveys and personal interviews by Verster (2004) determined end-user perceptions of public transport interchanges in Cape Town. The questionnaires were based on elements that were repeatedly mentioned in the literature available at the time, namely safety and security, interchange facilities and pedestrian movement.

Bernal (2016) considered successful international experiences in eight cities to identify common factors such as administration, connectivity, fare integration, intermodalism, and physical integration, to develop a scoring system for the level of integration. In addition, Taylor *et al.*, (2009) identified common evaluation criteria by reviewing transit transfer literature in order to understand the importance of service attributes. Behrens and Schalekamp (2011) undertook focus group discussions with public transport users in order to identify and verify a list of service attributes for inclusion in a short intercept survey. Regardless of what eventual quantitative analytical approaches are used, the process must begin with acquiring a list of service attributes from the customers, through an exhaustive "listening to the voice of the customer" process. This qualitative research is usually conducted through a series of focus groups (Transportation Research Board [TRB], 1999).

2.2.2 Techniques to weigh or measure the importance of criteria

Stated importance measures require respondents to explicitly state their perception of the importance of a certain attribute using a rating scale. On the other hand, derived importance methods use statistical methods such as correlation or multiple regression analysis to model the individual ratings (predictors) and an overall satisfaction rating (TRB, 1999).

Current literature reveals that the process of passengers ranking or rating the importance of criteria is critical in identifying the factors of the highest importance. Ranking requires the respondent to sort items by assigning a numerical ranking (i.e. 1st, 2nd, 3rd, etc.) to each item, thereby assigning a relative value to an item in relation to items before or after it. Rating scales assign an absolute value to an item without regard to other items. For the purposes of this research study, rating scales have been selected to measure the importance of criteria.

Ordinal data is a qualitative variable that incorporates an ordered position or ranking. Data is gathered through the use of measurement scales to weight satisfaction of users or importance of criteria by placing an item in a relative order using rating scales (for example, very satisfied, satisfied, neutral, dissatisfied, very dissatisfied). The more an individual prefers an option, the larger the weight associated with this selection (and vice versa). Numbers are sometimes used to code nominal ordered values (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree), but these are not true numbers. The distances between the numbers in the response set are equal, but meaningless (Sullivan and Artino (2013); de Winter and Dodou (2010)).

The Likert scale is a variant of ordinal scales that is commonly used to calculate customer or employee satisfaction. As a universal method of collecting data, it is an orderly scale from which respondents choose the option that best supports their opinion. It can be used to measure someone's attitude by measuring the extent to which they agree or disagree with a particular question or statement. For each item, the response set consists of a set of equally spaced numbers accompanied by equally spaced anchors, for example very satisfied, or dissatisfied (Sullivan and Artino (2013); de Winter and Dodou (2010); Boone and Boone (2012); Bertram (2017)).

Service attributes can either be tangible or non-tangible. Tangible attributes include the physical infrastructure used to serve the customer, while non-tangible attributes would include attributes such as the manner in which personnel treat the customer, and cost. Eboli and Mazzulla (2007)

investigated service quality attributes that are important for customer satisfaction with a bus transit service in Cosenza, Italy. Respondents were asked to rate the importance of and their satisfaction with 16 service quality attributes (bus stop availability, route characteristics, frequency, reliability, bus stop furniture, bus overcrowding, cleanliness, cost, information, promotion, safety on board, personal security, personnel, complaints, environmental protection and bus stop maintenance).

Eboli and Mazzulla (2012) measured passenger perceptions regarding the importance and satisfaction of railway service attributes on a scale of 1 to 10. The weight that passengers gave to each of the attributes and the measure of satisfaction with it, help in improving service quality and preparing better investment plans.

Bryniarska (2019) undertook a passenger satisfaction and preference survey in the city of Krakow, Poland. Passengers expressed their opinions on Likert rating scales to show levels of agreement or disagreement and responded about their preferences and the importance of certain aspects of service provision. Respondents were asked to assess eleven selected quality attributes of public transport which included the frequency of running, punctuality, direct connections, convenience of transfer, information at stops and in vehicles, conditions of travel in vehicles, conditions of waiting at stops, safety at bus stops, running rhythmicity, reliability of the planned journey, and the speed of travel (duration of the journey). The overall satisfaction with service quality was also surveyed.

The National Household Travel Survey (DOT, 2013) requested users to rate satisfaction levels (very satisfied, satisfied, neutral/don’t know, dissatisfied, very dissatisfied) for a list of train, bus and mini-bus taxi mode-specific attributes. The exclusion of an importance rating for the various attributes is one of the shortcomings of the method used in this survey, as satisfaction levels alone do not give an indication of the relative attribute importance for ascertaining which attributes should be prioritised.

Importance-Satisfaction Analysis (ISA) is a technique that allows one to make recommendations that will maximize the impact that new investments have on customer satisfaction by emphasising improvements in areas where the level of satisfaction is relatively low and the perceived importance of the issues are relatively high.

Taylor *et al.*, (2009) used the ISA method to examine stop and station attributes of security and safety, amenities, availability of information, access, connection and reliability in order to

identify the attributes which passengers deemed the most important (importance level) and attributes most in need of improvement (satisfaction level). Survey participants were asked to rate the importance of service features and their level of satisfaction with each feature on a four-point scale from "very important" to "not important", and "strongly agree" to strongly disagree", respectively. An Importance-Satisfaction rating matrix was produced as illustrated in Figure 2.1 below.

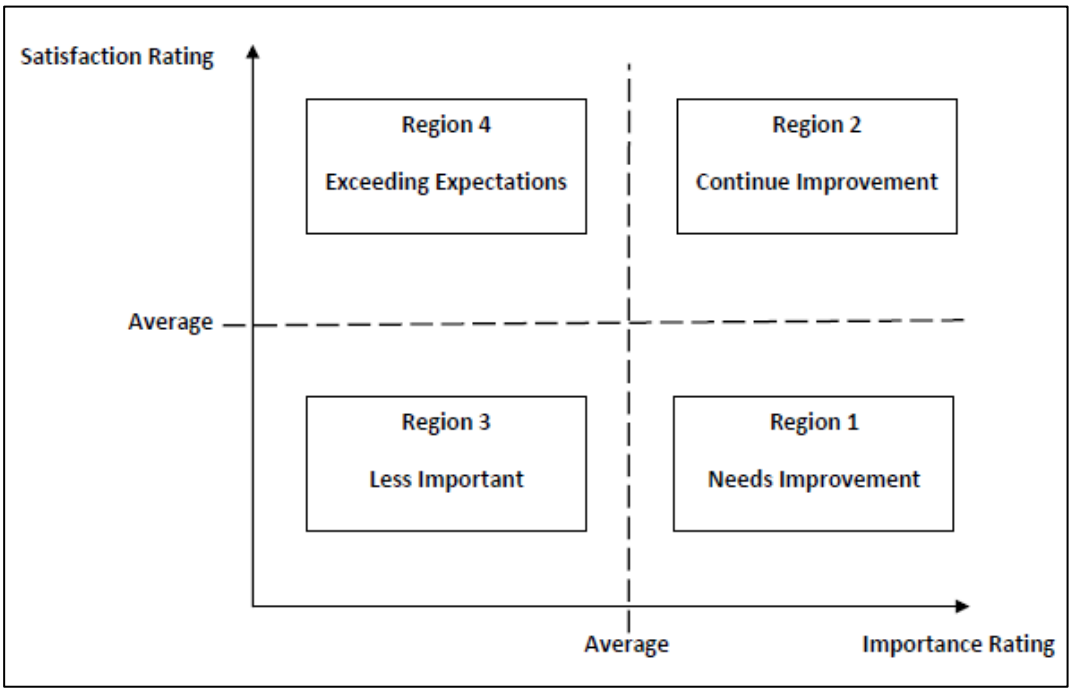

Figure 2.1: Importance-Satisfaction Rating Graph Template (Source: Taylor *et al.*, 2009*)*

The graph (Figure 2.1) is divided into four regions which highlight areas where improvement could be required:

- Region 1: Attributes have above-average importance and a less than average level of satisfaction. These attributes should be high on the list of priorities for improvement;
- Region 2: Attributes have above-average importance and an above-average level of satisfaction. Priority should be given to maintaining the quality of these attributes;
- Region 3: Attributes have less than average satisfaction levels but also less than average importance ratings. These attributes are warranted only at low cost or if all the attributes in regions 1 and 2 have been fully addressed; and
- Region 4: Attributes have above average satisfaction and importance ratings that are less than average. These attributes exceed expectations and do not require further attention (Taylor *et al.*, 2009).

In order to gain insight into the relative importance of service attributes and satisfaction based on public transport passengers' attitudes and perceptions, a study was undertaken by Behrens and Schalekamp (2010). A Likert satisfaction rating (strongly agree, agree, neutral/do not know, disagree and strongly disagree) was performed in relation to a list of service attributes specific to train, bus and mini-bus taxi modes. Respondents were then asked to indicate the importance given to a service attribute, rated by using a scale ranging from very unimportant, unimportant, neutral/do not know, important to very important. The mean importance and mean satisfaction ratings were then plotted on a graph to enable comparison, as illustrated in Figure 2.2.

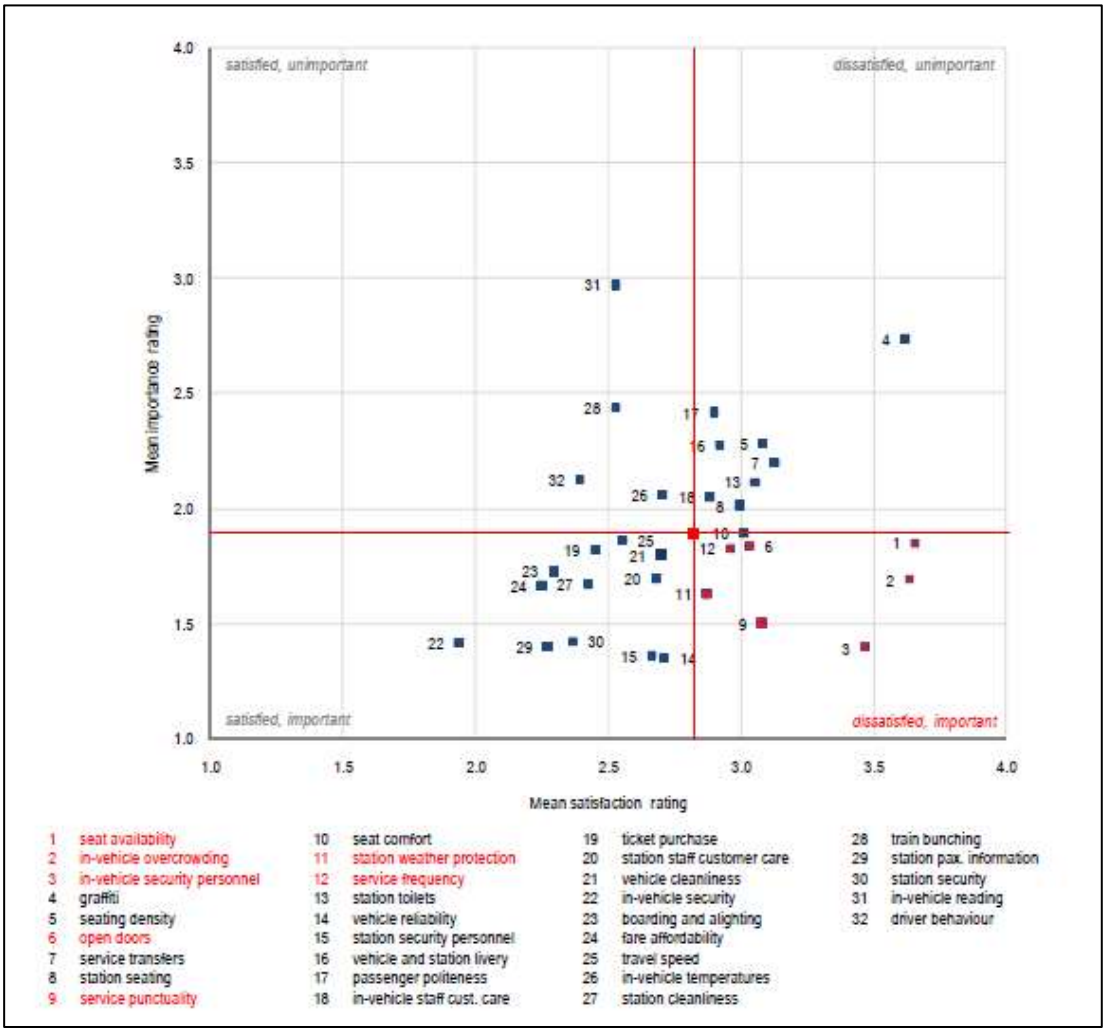

Figure 2.2: Plot of mean satisfaction against mean importance (Source: Behrens and Schalekamp, 2010)

The simplest method of measuring the importance customers place on specific BRT service characteristics would be to calculate mean scores for each characteristic using a numerical scale (Baltes 2003).

Aghaabbassi *et al.*, (2016) developed questionnaires to evaluate the importance of sidewalk attributes on a five-point Likert scale (1 being least important to 5 being extremely important). Because the identified factors do not have the same impact on the overall condition of the sidewalks and the perceived importance of factors may vary based on the user's physical condition and characteristics (ethnicity, age and gender), the data collected from the questionnaire were used as follows to generate the relative weight of each of the sidewalk attributes:

$$NSATScore = \sum_{j=1}^{18} SI_j w_j$$

Equation 2.1

Where:

$NSATScore$ = neighbourhood sidewalk assessment score.

w = sidewalk indicator weight.

SI = indicator score.

j = indicator number.

$$Wi = \left(\frac{1}{R_t}\sum_{i=1}^{n} R_{ij}\right) * 100$$

Equation 2.2

Where:

W = normalised weight of each sidewalk factor.

R = indicator rate.

R_t= sum of all indicators rated.

i= indicator number.

j = respondent number.

The assessment score for each factor is then calculated by determining the mean score from the five-point Likert rating scale to indicate the level of agreement with the proposed statements for each factor. The mean score of the questions within each sidewalk indicator is calculated

by adding up the rates given by the respondents to the questions and then dividing it by the total number of respondents.

Bivina *et al.*, (2018) proposed a method to assess the Pedestrian Level of Service (PLOS) of sidewalks in India using pedestrians' perceptions towards streets and sidewalk infrastructures that they frequently use. The relative weight of sidewalk characteristics was generated based on a five-point Likert scale questionnaire which was used to rate the sidewalk characteristics according to their importance ranging from 1 (immaterial) to 5 (most important). The results of the questionnaire generated the relative weight for each sidewalk characteristic. The PLOS was mathematically computed as the product of the relative importance weights for physical and user characteristics, and the quality satisfaction score for physical and user characteristics for a set of parameters. The relative importance weight formula is as follows:

$$A_i = \frac{\sum_{j=1}^{j=5} I_j \times n_j}{N}$$

Equation 2.3

Where:

A = the relative weight of each sidewalk factor.

i = the number of parameters.

I = the importance rating.

j = the rating from 1 to 5.

n = the number of pedestrians choosing 'j' rating.

N = the total number of pedestrians.

2.2.2.1 Summary of techniques to weight or measure criteria

The ISA is a very useful visual comparison of the mean satisfaction and mean importance and has the benefit of easily highlighting service attributes that have high importance and dissatisfaction to users. Despite this method being valid for measuring attributes which are currently being experienced by public transport users, it is not suitable for the purposes of this research for the following reasons:

- Satisfaction ratings seem to be used more in customer service quality index development and for criteria that are already being provided;
- Some of the concepts or criteria which are meant to represent the future interchange integration are new concepts which are not currently implemented at any of the existing

transfer facilities, such as integrated ticketing and universal access concepts which passengers have not been exposed to at the existing facilities. Therefore, respondents would not be able to rate the level of satisfaction of these criteria.

The Likert 5-point rating scale has been selected as the method to determine the importance of criteria directly from users of the existing transfer facilities for the following reasons:

- The service attribute importance ratings obtained directly from respondents would be reliable;
- It is a universal method which is easy to understand, especially at the selected transport facilities where language barriers may warrant some translation into one of the official languages of South Africa;
- Since the scale does not require the participant to provide a simple and concrete "yes" or "no" answer, it does not force the participant to take a stand on a particular topic but allows them to respond in a degree of agreement or disagreement. This facilitates easier answering of questions for the respondent;
- It is very quick, efficient and inexpensive to run this type of survey. This method is versatile and can be performed through the mail, the internet, or in person.

For the purpose of this study, the relative importance weight formula was adapted to calculate the relative weight of each of the criteria.

2.2.3 Statistical techniques to model the relationship between individual service criteria and passenger satisfaction

Based on this literature review, various statistical approaches are available to analyse and comprehend the data collected through passenger satisfaction surveys and to assess travellers' perceptions of public transport services. More widely used multivariate statistical methods that allow the simultaneous investigation of more than two variables include:

i. Principal Component Analysis (PCA);
ii. Factor Analysis (FA);
iii. Cronbach's alpha (C-alpha);
iv. Multiple Correspondence Analysis (MCA);
v. Structural Equation Modelling (SEM);
vi. Service Quality model (SERVQUAL);
vii. Various regression models;
viii. Analysis of Variance (ANOVA); and

ix. Statistical significance (*t*-tests).

i. Principal Component Analysis

Principal Component Analysis (PCA) is a variable reduction technique used to estimate the factor loading in multivariate data and assigns factor loadings based on whether a subsequent indicator shares a common factor with another variable in the data set. A new set of variables is created as linear combinations of the original variables. If X_1, X_2, X_3 … X_P are variables, then variable Y forms a linear combination of these: $Y = a_1X_1 + a_2X_2 \ldots + a_pX_p$ where the different possibilities of a_i (i = 1, 2, … p) form numbers i.e. principal components. The linear combination that explains the maximum amount of variation is called the first principal component. A second principal component is then created, independent of the first component, which explains as much as possible of the remaining variability. In cases where there are more than two principal components extracted, then subsequent components explain the rest of the variability. This means that less important factors are added one by one (Abeyasekera, 2005). In a study by Singh (2016), PCA was used to determine underlying factors that influenced passenger satisfaction with bus public transport services in India.

ii. Factor Analysis

Factor Analysis (FA) is a method used to extract the common variance in multivariate data and convert them into factors. It is a technique that is used to reduce a large number of variables into a fewer number of factors. Exploratory FA is used to investigate a potential structure for how the variables group together and at the same time identify any variable which does not belong in the framework of an index. Each factor is estimated as being a linear weighted combination of the observed variables (Nardo *et al.*, 2005). The model is based on the formula:

$$X_1 = \alpha_{11} F_1 + \alpha_{12} F_{12} + \ldots \alpha_{1m} F_m + e_1$$
$$X_2 = \alpha_{21} F_1 + \alpha_{22} F_{12} + \ldots \alpha_{2m} F_m + e_2$$
$$X_Q = \alpha_{Q1} F_1 + \alpha_{Q2} F_2 + \ldots \alpha_{Qm} F_m + e_i$$

Equation 2.4

Where:

X_i = variable with zero mean and unit variance.

α_{i1} = factor loadings related to the variable X_i

$F_1, F_2 \ldots F_m$ = m uncorrelated common factors, each with zero mean and unit variance.

e_i = error terms which serve to indicate that the hypothesised relationships are not exact.

Rotation is done so that the first axis contains as much variation as possible, and the subsequent axes contain as much of the remaining variation. This change of coordinates is known as varimax rotation. Varimax simplifies the interpretation of the results of FA because the varimax method minimizes the number of variables that have high loadings on each factor and operates to make small loadings even smaller.

The weaknesses of both the PCA and FA methods are as follows:

- Correlations do not represent the real influence of individual indicators on the phenomenon being measured;
- Sensitivity to modifications in the base data rendering these methods unsuitable for revisions or updates;
- Sensitivity to the presence of outliers; and
- Sensitivity to small-sample problems (Organization for Economic Co-Operation and Development [OECD], 2008).

iii. Cronbach's alpha

The Cronbach's alpha (C-alpha) is an alternative method to investigate the degree of correlation among a set of variables. C-alpha is the most common estimate of internal consistency of items in a model or survey. It is most commonly used to determine the reliability of scales for surveys with multiple Likert questions (Gadermann *et al.*, 2012; Sijtsma, 2009).

Cronbach's alpha is a coefficient of reliability based on the correlation between individual indicators. A C-alpha value of zero means that there is no correlation and the individual indicators are independent. A C-alpha value of one means that the individual indicators are perfectly correlated (OECD, 2008).

Cronbach's alpha is computed by correlating the score for each scale item with the total score for each observation and then comparing that to the variance for all the individual item scores. C-alpha can be written as a function of the number of indicators p and the average inter-correlation $\bar{r}$ among the indicators. An increase in the number of indicators is associated with an increase in α (Saisana and Tarantola, 2002).

$$\alpha = \frac{p \cdot \bar{r}}{1 + (p-1) \cdot \bar{r}}$$

Equation 2.5

iv. Multiple Correspondence Analysis

Multiple Correspondence Analysis (MCA) is an exploratory multivariate statistical technique that attempts to reduce the variability in a model by calculating the minimum number of factors that can explain the most variability in the model. MCA is similar to PCA which extracts a reduced set of factors that accounts for the most variance in a set of variables. Dell'Asin *et al.* (2014) applied an exploratory approach of MCA on a set of 21 identified criteria to gain an understanding of the level of satisfaction of customers with quality attributes at interchanges. One of the key conclusions of the study is that whilst MCA is an exploratory technique which can provide insight into service quality, the results are not useful by themselves for decision-making or making predictions.

v. Structural Equation Modelling

A structural equation model (SEM) is a multivariate technique combining regression, FA and analysis of variance (ANOVA) to estimate interrelated dependence relationships simultaneously. Eboli and Mazzulla (2007) used a SEM to illustrate the relationship between passenger satisfaction of bus services and the attributes of the services provided. One of the conclusions of the study was that although this model is well known and widely applied in several fields of research, there are not many practical applications in public transport or for measuring customer satisfaction. A follow-up study was thereafter undertaken by Eboli and Mazzulla (2012) using a model based on SEM to investigate the influence of a series of service quality attributes on the overall service quality of a railway service. SEM is a useful tool as it allows some latent variables to be revealed. In the proposed model latent variables such as safety, cleanliness, comfort, service, additional services and personnel were introduced together with a variable called service quality. A latent variable can be measured indirectly by determining its influence on responses on measured variables.

A SEM was also used by Pavlina (2015) in order to evaluate the model proposed by Eboli and Mazzulla and find the optimal model. The factor analysis and varimax rotation method were used to quantify factors and identify the most important factors influencing customer satisfaction with public transport.

vi. Service Quality model

The Service Quality (SERVQUAL) model is a scale representing quality, defined as a gap between customers' expectations, and their perceptions of a given service. Parasuraman *et al.*

(1985) argue that, regardless of the type of service, with SERVQUAL the following ten criteria are used by customers to formulate expectations and evaluate service quality:

- Reliability: involves consistency of performance and dependability.
- Responsiveness: concerns the willingness or readiness of employees to provide the service and includes the timeliness of the service.
- Competence: possession of the required skills and knowledge to perform the service.
- Access: involves approachability and ease of contact.
- Courtesy: involves politeness, respect, consideration and friendliness of contact personnel.
- Communication: keeping customers informed in a language that they can understand, and listening to them.
- Credibility: involves trustworthiness, believability and honesty. It involves having the customers' best interests at heart.
- Security: is the freedom from danger, risk or doubt.
- Understanding/knowing the customer: involves making the effort to understand the customer's needs.
- Tangibles: the physical environment and representations of the service.

Hadzalic and Pestek (2014) used the SERVQUAL model to measure the service quality of the Sarajevo Public Transportation system. The scale can be modified for different services, but a base model is the RATER model which consists of five dimensions, namely: Reliability, Assurance, Tangibles, Empathy and Responsiveness.

A review of the literature reveals that SERVQUAL appears to be the most widely used model for measuring customer satisfaction. Some of the largest criticisms towards the SERVQUAL model, as identified by Al-Allak and Bekhet (2011), are that expectations cannot stay fixed over time (therefore the model cannot provide management with sufficient information for implementation of strategies to increase customer satisfaction), and that the model cannot be applied to every service activity. Research by Al-Allak and Bekhet (2011) concludes that some of the restrictions of the SERVQUAL model are that it is unclear whether the model is measuring service quality or customer satisfaction and that the surveys are very long and time-consuming.

vii. Various regression models

Another method of deriving weights for use in index aggregation is through the regression processes. A reliable measure can be used as the dependent variable in a regression framework, with the index components used as independent variables and the resulting coefficient as weights (OECD, 2008). According to Yatskiv and Kolmakova (2011), regression methods such as linear, logistic and ordinal regression are useful tools to analyse the relationship between multiple explanatory variables (quality attributes) and a dependent variable (overall service quality).

a) Multiple linear regression

Regression analysis is a best-fitting model in the form of an equation that expresses the dependent variable as a combination of several independent variables. A multiple linear regression model can be constructed to calculate relative weights of the sub-indicators using a linear relationship and is expressed as:

$$Y = a + b_1X_1 + ...+ b_nX_n$$

Equation 2.6

Where:

Y = indicator.

a = Y intercept whan all x-values are zero

b_n = regression coefficients (weights) of the sub-indicators X_n (Saisana and Tarantola, 2002).

A technique used by Baltes (2003) was to measure the importance of service attributes by deriving the importance using STEP wise regression analysis. This statistical method estimates the relative importance of each attribute when determining what attributes or combination of attributes comprises overall customer satisfaction.

b) Logistic regression

Sharaby and Shiftan (2012) researched the impact of fare integration on travel behaviour and transit ridership. The methodology included using Fare-box data and surveys for passenger counts by fare/ticket type and questionnaires. The multinomial logit model developed was based on a stated preference question, asking travellers what they would have done for their current trip if the new integrated fare system had not been introduced and there were no free transfers.

Taylor *et al.* (2009) used a logistic regression model to measure the influence of sixteen selected attributes on overall satisfaction, while simultaneously controlling for the effects of all other measured attributes on satisfaction.

Ceder *et al.* (2014) developed two separate binary logistic regression models based on user preference surveys at two main transport centres in New Zealand. A statistical software package was used to fit the two data sets into binary logistic regression models.

c) Ordinal regression

For data collected using ratings or ranking data, the most common form of estimation technique is to model this type of data using regression analysis where the rating or ranking is the dependent variable in the model (Hensher *et al.*, 2005).

Ordinal multiple regression estimates the cumulative probability of an outcome where the outcome is an ordinal variable (ordered variable with arbitrary scale) and assumes that the effects of explanatory variables are proportional across the outcomes (proportional odds assumption). The coefficients are then estimated by solving a proportional odds model. Where *j* indexes the cut-off points for all categories (*k*) of the outcome variable, the ordinal regression takes on the form:

$$f\left(\gamma_j(X)\right) = \log\left(\frac{\gamma_j(X)}{1-\gamma_j(X)}\right) =$$

$$\text{Log}\left(\frac{P\{Y \leq y_j/X\}}{P\{Y > yj/X\}}\right) = \alpha_j + \beta_X \text{ , } j = 1, 2\ldots., k\text{-}1$$

$$\gamma_j(x) = \frac{e^{\alpha_j+\beta X}}{1+e^{\alpha j}+\beta X}$$

Equation 2.7

Qualitative surveys by Mokonyama and Venter (2012) confirmed aspects of the Kano model in terms of varying degrees of attribute effects on customer satisfaction. The Kano model was originally developed for product marketing and can be used to identify service attributes and classify them in terms of their impact on customer satisfaction. Mokonyama and Venter (2012) then selected service attributes for further investigation using a modelling framework that resembles the Kano model. A rating-based conjoint analysis approach was used to design a survey for the estimation of the model. The researchers also developed questionnaires whereby respondents provided feedback on a rating scale of 0 to 10. The conjoint model parameters were estimated using ordinal multiple regression.

Yatskiv and Kolmakova (2011) used the ordinal regression method to describe the relationship between the overall quality of service and a set of attributes relating to quality. The method was used to model the dependency between the overall quality of service and attributes of quality at the Riga Coach Terminal in Latvia based on seven groups, namely accessibility, information, time characteristics of service, customer service, comfort, safety, infrastructure and environment. The overall quality of service and the attribute quality was measured on a rating scale of 1 to 5.

viii. Analysis of Variance

Analysis of variance (ANOVA) is a test used to determine whether there are any statistically significant differences between the means of three or more independent groups. The one-way ANOVA is commonly used to compare the means of at least three groups using the F-distribution (McDonald, 2014). The ANOVA is suggested by Boone and Boone (2012) and Bertram (2017) as the preferred method for statistical analysis of Likert scale data. The one-way ANOVA is very similar to the independent samples *t*-test. The only difference is that the one-way ANOVA allows one to have more than two categories in the independent variable (Almquist *et al*., 2014).

Shen *et al.* (2016) examined the effects of passenger load factor and in-vehicle time on passenger comfort perception on a bus line in China by conducting a two-way ANOVA of Likert scale data collected under two circumstances (seated and standing). The ANOVA results showed that both in-vehicle time and passenger load significantly affect passenger comfort.

Imam (2014) conducted a survey to explore the satisfaction with the public transport services of bus, minibus and jitney modes in Amman, the capital of Jordan. The respondents were asked to rate their satisfaction on a Likert scale from 1 to 10; where 1 is least satisfied, and 10 most satisfied. The respondents were also asked to rate the importance of each feature using a Likert scale on five levels ranging from 1 (not important) to 5 (very important). The one-way ANOVA revealed significant differences in perceptions among the users of the three modes regarding air-conditioning availability, availability of transit ease, ease of entering/exiting the vehicle, ease of payment and staff behaviour.

ix. Statistical significance (*t*-test)

The independent samples *t*-test is a method for comparing the mean of one variable between two unrelated groups (Almquist *et al*.,2014). The *t*-test can be used as an alternative to ANOVA

when there are only two groups of data to compare. The benefit of the *t*-test is that it indicates how significant the differences in means are, by using the *t*-distribution (McDonald, 2014).

2.2.3.1 Summary of statistical techniques

This literature review reveals that there are various methods available to weight the criteria in relation to their relative contribution to the passengers' perceived satisfaction with the overall transfer experience. The strengths and weaknesses of the various techniques are summarised in Table 2.1

Table 2.1: Summary of strengths and weaknesses of the various statistical techniques

Technique	Strengths	Weaknesses
PCA/FA	Can summarise a set of individual indicators while preserving the maximum possible proportion of the total variation of the original data set.	The results are not useful by themselves for decision-making or making predictions.
	Largest factor loadings are assigned to the indicators that have the largest variation (OECD, 2008).	Correlations do not represent the real influence of the individual indicators on the phenomenon being measured.
		Sensitive to modifications in the basic data such as data revision and updates. (OECD, 2008).
C-alpha	Measures the internal consistency of a set of individual indicators (OECD, 2008).	Correlations do not necessarily represent the real influence of the individual indicators on the phenomenon expressed by the composite indicator.
		Is meaningful only when the composite indicator is computed as a scale (OECD, 2008).
MCA	Attempts to reduce the variability in a model by calculating the minimum number of factors that can explain the most variability.	The results by themselves are not useful for decision-making or making predictions.
SEM	Is a useful tool because it allows some latent variables to be revealed.	There are not many practical applications in public transport and for measuring customer satisfaction.

Technique	Strengths	Weaknesses
SERV-QUAL	Can assess service quality performance on the basis of each dimension individually as well as the overall dimensions.	The model cannot provide sufficient information for implementation of strategies to increase customer satisfaction and it is unclear whether the model is measuring service quality or customer satisfaction.
		User expectations cannot be expected to stay fixed over time.
		Surveys are very long.
Regression analysis	Has the ability to determine the relative influence of one or more predictor variables on the criterion value.	The functional relationship that is established between any two or more variables on the basis of some limited data may not hold good as more and more data are taken into consideration.
	Suitable for analysis of categorical and ordinal data.	
	Has the ability to identify outliers or anomalies in the data.	
ANOVA	Can test three or more groups	Although it indicates whether or not there is a significant difference, it does not provide direction as to which group is higher or lower.
	Suitable for analysis of Likert scale data	
***T*-Test**	Indicates how significant the difference in means are.	Can only test differences between two groups.
	Suitable for analysis of Likert scale data	

The PCA, FA and MCA are not being considered for the purposes of this research as it is preferred to retain all the criteria identified as part of the qualitative research (focus groups) in the proposed index in order to incorporate the opinions of the passengers. The use of these variable reduction techniques will result in the removal of criteria which could be of great importance to users of the public transport system.

For the purposes of this research, the ANOVA and *t*-tests are deemed most suitable for examining the relationship and the significance of these relationships, based on the Likert scale data collected for this study. The intention is to use the one-way ANOVA for age group comparisons and the *t*-test for gender comparisons. The C-alpha is to be used to assess how well a set of criteria measures a single unidimensional object for the proposed index.

2.2.4 Techniques using single indices to serve as summary indicators of the multidimensional phenomena being measured

Different dimensions are sometimes combined into some form of index that summarises service quality. The common interpretation of an index is a single value that captures information from several variables into one composite measure (Abeyasekera, 2005). Examples of some of the indices developed in previous studies are discussed below.

The impact-score approach determines the relative impact of attributes on overall satisfaction by measuring customers' relative decrease in overall satisfaction when a recent problem with an attribute is reported. This technique uses a three-step process to measure customer satisfaction as follows, by developing a composite index which indicates which attributes require urgent attention (TRB, 1999):

i. Step one: is to determine which attributes have the largest impact on overall customer satisfaction. For each attribute, the sample is divided into two groups. The first group would comprise of those respondents who have had a recent problem with the attribute, and the second group would comprise of those respondents who have not recently experienced a problem with the attribute. The mean overall satisfaction ratings of the two groups would then be compared. The difference between the two mean overall satisfaction ratings is called the "gap score".

ii. Step two: lists the attribute problem incidence rate for each attribute in a column next to its gap scores. The incident rate is the percentage of customers who experienced a problem with the service attribute within the previous 30 days.

iii. Step three: a composite index is created by multiplying the attribute's overall satisfaction gap score by the attribute's problem incidence rate. The result is an attribute "impact score". The attributes are then placed in descending order of their impact scores.

A decision-aiding tool to optimise and measure how well land use, transport and walking are integrated, was piloted on the Gold Coast of Australia. The Land Use and Public Transport Accessibility Index (LUPTAI) was developed to measure how easy it is to access health, education, retail, banking and employment destinations by walking and/or using public transport. The LUPTAI is a composite measure which seeks to measure and quantify the accessibility of a location. The methodology consists of:

- Measuring accessibility based on walking distances;
- Measuring accessibility based on public transit travel time; and
- Combining both accessibility measures based on walking distances and public transit travel time/service frequencies and assigning accessibility index values (Pitot *et al.*, 2006).

A composite index of public transport accessibility which combined the positive features of existing public transit accessibility indices was developed by Al Mamun and Lownes (2011). This index considers three primary accessibility measures, namely trip coverage, spatial coverage and temporal coverage by integrating the three methods of Local Index of Transit Availability (LITA), Transit Capacity Quality of Service Manual (TCQSM) and the Time-of-Day Tool. LITA was developed by Rood (1998) to measure the transit accessibility in an area by integrating three aspects of transit service: route coverage (spatial availability), frequency (temporal availability) and capacity (comfort and convenience). The Time-of-Day Tool considers both spatial and temporal coverage at the trip destinations and takes into consideration the demand side of temporal coverage by incorporating the travel demand time-of-day distribution on an hourly basis (Polzin *et al.*, 2002).

Poliakova (2015) applied the Customer Satisfaction Index (CSI) to public transport services in the Slovak Republic to quantify customers' needs and expectations regarding the level of performance of the service provided. The CSI model is a structural model which consists of a number of latent factors, each of which is operationalised by multiple indicators.

$$CSI = \sum_{i=1}^{n} CS\,I_{i^*} w_i$$

Equation 2.8

Where:

CSI = Customer Satisfaction Index.

CSI_i = Individual Customer Satisfaction Index for a defined concrete service.

w_i = weight (importance) of a particular service.

Putra *et al.* (2014) used a qualitative research method where a CSI was applied to determine the level of overall satisfaction with the approach that considers the expectations of public transport users. Eboli and Mazzulla (2009) proposed a Heterogeneous Customer Satisfaction Index which was inspired by the traditional CSI but takes into account the heterogeneity among user judgments about different service aspects. This index allows service quality to be monitored, the causes generating customer satisfaction or dissatisfaction to be identified, and the strategies for improving the service quality to be defined.

Hensher *et al.* (2001) provide a framework for implementing performance-based contracts through a Service Quality Index (SQI) which is based on discrete choice models. Multinomial logit (MNL) models were estimated to establish the relative weights attached to the statistically significant attributes, representing the contribution of each service attribute to the calculation of an overall SQI. Mazzulla and Eboli (2006) used an SQI to measure the effectiveness of supplied services according to the main service quality attributes and their weights, using the following equation:

$$SQI = \sum_i [IV(X_i) \cdot X_i]$$

Equation 2.9

Where:

$IV(X_i)$ = i-th factor Importance Value.

X_i = value assumed by the i-th factor.

Olszewski and Krukowski (2012) proposed an original method called the Assessment Method of Public Transport Interchanges (AMPTI) for evaluating public transport interchanges by using eight indicators, as well as application of the method for assessing ten interchanges in Warsaw, Poland. The original AMPTI methodology was proposed by Olszewski and his research team as part of the NICHES plus project funded by the EU. The set of quantitative

indicators can be used to assess existing and planned interchanges, including the quality of basic infrastructure, spatial integration, accessibility for elderly and disabled individuals, ease of orientation, personal security, traffic safety, passenger information, and the availability of additional facilities. In 2017, Bryniarska and Zakowska (2017) performed an indicator assessment at three selected interchanges in Poland by applying the indicators proposed in the NICHES plus project. The usefulness of the method was presented on the basis of the assessments undertaken, which revealed that the advantage of this method is that it is based on multiple criteria and allows for a comprehensive analysis of the interchange. The limitations of this method were connected to traditional survey costs and that it is time consuming. Bryniarska (2018) then undertook a quantitative assessment of the largest interchange in the public transport network in Krakow, Poland, by using the eight indicators proposed in the NICHES plus project.

A Bicycle Compatibility Index (BCI) was developed to determine how compatible a roadway is for allowing operation of both bicycle and motor vehicle traffic. The BCI uses several independent variables for the model such as the presence of bicycle lane, bicycle lane width, curb-lane width, curb-lane volume, other lane(s) volume, 85th percentile speed of traffic, presence of parking lane, type of roadside development and adjustment factors. The analysis approach was to use regression modelling to determine all main effects, search for significant square and interaction terms, and ultimately eliminate all variables that were not significant (Federal Highway Administration, 1998a).

$$BCI = 3.67 - 0.966\,BL - 0.498\,CLW + 0.002\,CLV + 0.0004\,OLV + 0.022\,SPD + 0.506\,PKG - 0.264\,AREA + AF$$

Equation 2.10

Where:

BCI = Bicycle Compatibility Index.

BL = presence of a bicycle lane or paved shoulder.

CLW = curb lane width.

CLV = curb lane volume.

OLV = other lane(s) volume.

SPD = 85th percentile speed of traffic in km/hr.

PKG = presence of parking lane.

$AREA$ = type of roadside development.

AF = adjustment factors.

The most widely used linear aggregation is the summation of weighted and normalised individual indicators:

$$CI_c = \sum_{q=1}^{Q} w_q I_{qc}$$

Equation 2.11

Where:

CI = Index value for a country.

w_q = the corresponding weight.

I_{qc}= level of individual indicator q= 1 … Q for country c= 1 … M (OECD, 2008).

Where surveys involve determining the attitudes or views on quality requiring answers on a 1 to 5 scoring scale, the resulting scores could be summed across all relevant questions to provide an index reflecting the respondents' view on the subject. The data determines the form of the index by use of a multivariate analysis technique. The index will take the following form:

$$Index = a_1X_1 + a_2X_2 + a_3X_3 + \ldots a_pX_p$$

Equation 2.12

Where:

a_i = weights which are determined from the data

X_i = an appropriate subset of p variables measured in a survey (Abeyasekera, 2005)

The investigation of linear relationships between individual attributes and an overall index is a very common approach and is flexible enough for weights to be estimated in a variety of ways. Therefore, this approach is suitable for the present study.

2.3 CRITERIA IDENTIFIED FOR PASSENGER NEEDS

A review of previous studies and guidelines reveals the various criteria identified by public transport facility users. A study by Dell'Asin *et al.* (2014), identified ticketing, physical environmental issues, services, temporal issues and interconnectivity as the main issues raised via customer satisfaction surveys undertaken at urban interchanges. Interestingly, the authors concluded that classical issues such as safety, security and information are not perceived as important by intermodal travellers when compared with quality aspects (Dell'Asin *et al.*, 2014).

Hensher and Prioni (2002) proposed the following attributes to best represent the needs of public transport users:

i. Reliability;
ii. One-way fare;
iii. Walking distance to bus stop;
iv. Personal safety at bus stop;
v. Travel time;
vi. Bus stop facilities;
vii. Air conditioning;
viii. Information at bus stop;
ix. Service frequency;
x. Safety on board;
xi. Seat cleanliness;
xii. Ease of access into bus; and
xiii. Driver behaviour.

A corridor study undertaken by the Council for Scientific and Industrial Research (CSIR,1999) in South Africa, determined that the following attributes were important to rail and mini-bus taxi public transport users:

a) Ticket type;
b) Service reliability;
c) Heating on trains;
d) Feedback to customers;
e) Space for luggage; and
f) Mini-bus taxi safety.

In addition, ten service quality determinants were determined in a handbook for measuring customer satisfaction and service quality (TRB, 1999):

i. Reliability;
ii. Responsiveness;
iii. Competence;
iv. Access;
v. Courtesy;
vi. Communication;
vii. Credibility;
viii. Security;

ix. Understanding/knowing the customer; and

x. Tangibles.

The research by Ceder *et al.* (2013) indicated that users revealed a greater preference for answering questions on the transfer route with less uncertainty in answering the questions on the out-of-vehicle times. For the attribute of comfort, transit users displayed risk-taking characteristics when the waiting time for a seat was less than 5 minutes. This suggests that increasing the consistency in out-of-vehicle times will increase the attractiveness of transfer routes which will enable a more efficient and integrated network of public transport, thereby increasing ridership (Ceder *et al.*, 2013). Taylor *et al.* (2009) found that service quality improvements (i.e. good connection and reliability) and personal safety and security are more important to transit users than the physical condition of transit stops and stations. Bernal (2016) concluded that it was important to note that reliable and legible information, travel and waiting times and a sense of safety and security were raised by passengers using international facilities. Price, timeliness, safety and comfort were identified as criteria based on a passenger survey in the Slovak Republic, designed by Poliakova (2015).

The New South Wales (NSW) Ministry of Transport Guidelines for the Development of Public Transport Interchange Facilities (2008) identified the following critical issues for users of a public transport interchange:

- Actual and perceived security and safety;
- Punctual services;
- Well maintained and clean interchange facilities;
- A pleasant and comfortable environment;
- Clear service and timetable information; and
- Way-finding and directional signage.

The Auckland Transport Public Transport Interchange Design Guidelines (2013) identified the following five attributes as being consistently reported to be most important based on the outcomes of six studies:

- Security (including safety);
- Service information (including ticketing and way-finding);
- Shelter (the general waiting environment including seating and cleanliness);
- Accessibility (including access between modes – ease and distance); and
- Facilities (toilets, food, retail, among others).

Based on the literature reviewed here, the following evaluation criteria were most commonly raised by public transport users at an international level:

- Transfer waiting time;
- Walking distance;
- Reliable services
- Comfort and convenience;
- Safety and security;
- Information; and
- Fare integration.

At a local level, there is limited information available on passengers' perceptions of public transport facilities. Verster (2004) undertook a study to determine the perceptions of public transport interchange users regarding the public transport interchange environment in Cape Town, South Africa. The study identified shelter, seating and cleanliness as major determining factors regarding the quality of the space. Safety and security were also identified as factors contributing to a positive interchange environment. Behrens and Schalekamp (2008) undertook case studies of the user experience during transfers between public transport modes at public transport interchanges in Cape Town and Sao Paulo, Brazil. The research aim was to analyse the links between existing policy, institutional fragmentation, and the quality of the actual public transport user experience during transfers. The measured characteristics were the physical extent of interchanges, effective accessibility provision and effective way-finding provision. In a South African context, a key conclusion of Behrens and Schalekamp's research was that commonly used guidelines are oriented towards the needs of public transport vehicles and offer little input regarding the quality of the user experience during transfers. In conclusion, comfort and convenience, safety and security and information are criteria which are commonly raised in both the international and local research.

2.4 DATA COLLECTION METHODS

Data collected through surveys can be obtained in the form of a stated preference (SP), or revealed preference (RP) survey, or both. An SP survey obtains information about travellers' choices when faced with certain hypothetical situations, whereas an RP survey gathers information on travellers' current choices (Hensher *et al.*, 2005).

The data is made up of numerous observations on multiple variables. The variables may be qualitative or quantitative in nature. A qualitative variable is one in which the "true" or naturally occurring levels or categories are not described as numbers, but rather as verbal groupings. Qualitative data consists of open-ended information that is usually gathered through interviews, focus groups and observations. Quantitative variables, on the other hand, are measurable in some numerical unit and include close-ended information such as measures of attitudes, behaviours and performance (Hensher *et al.*, 2005).

The qualitative research method has proven to be useful as a starting point for exploratory studies, prior to commencing quantitative data collection. One of the advantages of primarily implementing qualitative research, is that a detailed perspective of the participants, together with the context, can be obtained, as qualitative research is built on the views of the participants and not the researcher (Creswell, 2004). The benefits listed in favour of qualitative survey techniques are that the interviews help to validate the underlying basis of a newly developed modelling framework, and that semi-structured exploratory interviews help to refine the research postulates and to sharpen the hypotheses for further testing (Mehndiratta *et al.*, 2003). The authors further argue that open-ended surveys are an invaluable tool for the study of complex behaviour such as human activity patterns. Focus groups are favoured in the social sciences for exploratory investigations of consumer attitudes.

The mixed-methods approach is a combination of qualitative and quantitative research approaches within the same study, in order to gather a complete understanding of the subject being studied. One of the major advantages of the mixed-methods approach is that it can be used to cancel out any biases that could be associated with one method (quantitative or qualitative), while providing a comprehensive understanding of the research problem which allows for more context-specific survey instruments to be developed for quantitative data collection. The disadvantage of this method is that more time and resources areas are required to plan and implement this type of research (Creswell, 2004).

After careful review and consideration of the methods discussed above, the mixed-methods approach was determined as the most appropriate method for this study. The qualitative research in the form of focus group workshops with open-ended discussions is to be used to inform the development of the survey instrument for quantitative data collection.

2.5 INTERNATIONAL AND LOCAL GUIDELINE DOCUMENTS

A number of local and international guideline documents for the design of public transport facilities are available in the current literature. The CSIR Guideline for Human Settlement Planning and Design (2000) covers various design aspects of public transport infrastructure in terms of public transport bays, radii and location of public transport facilities. The modes of transport covered include bus, mini-bus taxis and rail, and excludes BRT and intermodal facilities. The Guideline document briefly mentions that provision must be made for pedestrians, disabled users and potential cycle networks, however, it lacks guidance from a passenger or user point of view. There are guidelines on walkability which can be used to quantify walking distance criteria for the index to be developed as part of this research study.

The eThekwini Municipality Guidelines for Public Transport Facilities and Standard Operating Procedures for the Design of Bus and Mini-bus Taxi Facilities (2011) makes mention of a passenger needs assessment that was undertaken in the 2005 Integrated Transport Plan (ITP) which highlighted lighting, shelters, facilities to transport bicycles on public transport, display of public transport timetables and catering for special needs passengers as key issues. Whilst the Guidelines mentions design elements to address passenger needs at public transport facilities, there is a clear shortcoming regarding passengers needs in terms of public transport integration at these facilities. This guideline document contains design criteria for bus and mini-bus taxi facilities but makes no mention of any integrated or multimodal transport facilities.
The Department of Transport Guidelines for the Design of Mini/midi-bus Taxi Facilities (2006) includes the following suggestions for multimodal operations: minimum conflict with vehicles of other modes; each mode should use clearly defined loading areas separated from other modes; vehicle ingress and egress as well as circulation within the transfer station should be kept separate for each mode; and special considerations should be given to the movement of pedestrians, as they usually have to cross loading areas of different modes in order to gain access to pedestrian islands. The procedure to determine ancillary infrastructure requirements includes discussions with operators and passengers and identify their specific needs as far as ancillary infrastructure is concerned.

The New South Wales (NSW) Ministry of Transport Guidelines for the Development of Public Transport Interchange Facilities (2008) provides a scope of minimum facility provision by interchange category (i.e. Global or Regional, Major or Specialised, Multi-access, Local, and Strategic Bus Corridor) for the following:

- Comfort and convenience facilities (shelter, seating, ticketing, pay telephone, etc.);

- Information (interchange/station map, fare information, route information, service disruption information, etc.);
- Parking and set-down facilities (passenger drop-off and pick-up zones, commuter car parking, bicycle parking, etc.); and
- Safety and security (lighting, video surveillance, emergency help point, etc.).

The Auckland Transport Public Transport Interchange Design Guidelines (2013) provides guidelines for different interchange types (i.e. major, intermediate, minor and neighbourhood) on the following key design priorities:

- Visibility;
- Wayfinding;
- Shelter;
- Security;
- Accessibility;
- Service information;
- Facilities; and
- Bus operations.

At an international level, available guidelines consider the needs and priorities of passengers at intermodal facilities. However, it can be concluded that in a South African context, the available guidelines are oriented towards the needs of public transport vehicles and do not consider the passengers' experience and needs. Whilst the guidelines are clear on design aspects and mention provisions for pedestrians, non-motorised planning and universal access design considerations, there exists a shortcoming in terms of the consideration of passenger needs.

CHAPTER 3 METHODOLOGY

This chapter provides the overall description of the research approach and methodology. The steps undertaken for this research are illustrated below (Figure 3.1) and discussed in the following sections.

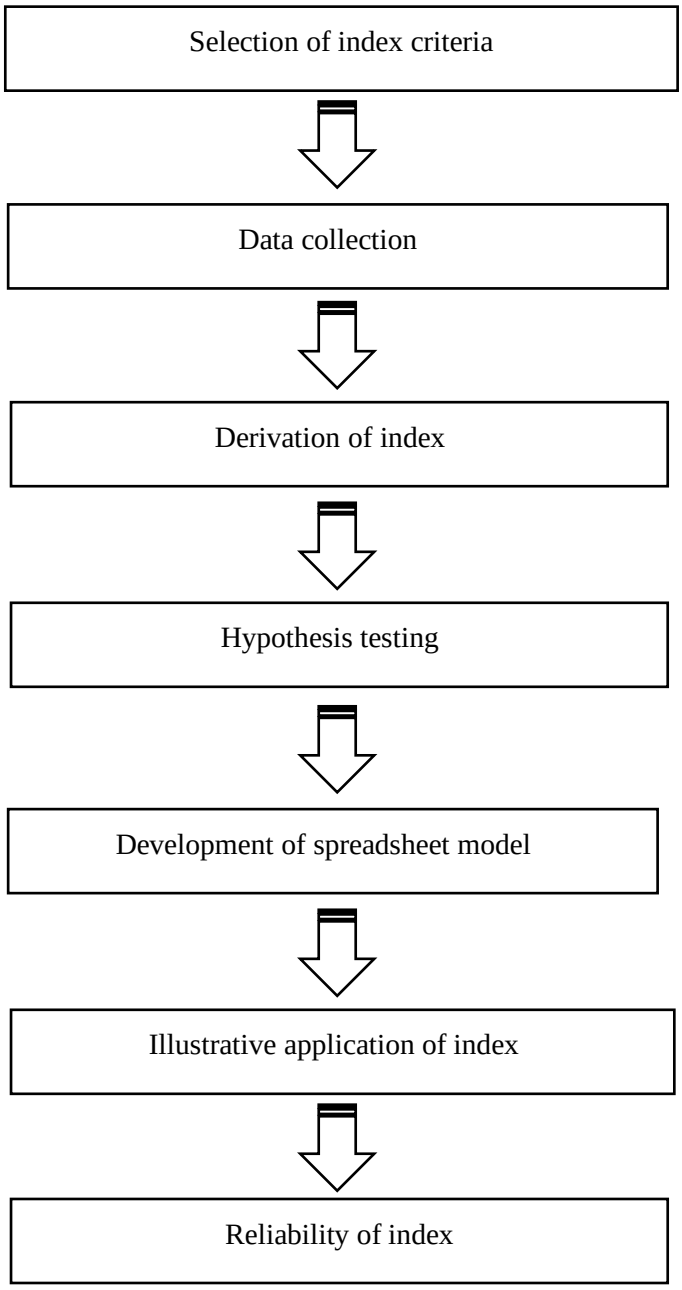

Figure 3.1: Flow chart of the research approach

3.1 SELECTION OF INDEX CRITERIA

3.1.1 Review of previous studies

The literature available on local and international studies that were reviewed in Chapter 2 revealed that the following criteria are frequently raised as important to public transport users:

- Transfer waiting time;
- Walking distances;
- Reliable services;
- Comfort and convenience (shelter, seating and facilities);
- Safety and security;
- Information; and
- Fare integration.

Comfort and convenience, safety, and security and information are criteria which are commonly raised in both the international and local research. Fare integration is not currently implemented in South African public transport services and is, therefore, a new concept in a South African context. Nevertheless, fare integration has been selected for inclusion in this research as it is a key component of future intermodal transport systems and will form part of the proposed eThekwini IRPTN. The intention is to use the criteria identified in previous studies which are of importance to users of public transport as a starting point for further exploration during focus group discussions.

3.1.2 Focus groups (qualitative research)

A qualitative assessment in the form of focus groups was held with existing transferring passengers at the existing transfer facilities (Isipingo, Pinetown and Bridge City) who transfer between different modes or the same mode to reach their destination. The objective of the focus groups is to confirm the relevance of the criteria selected from the literature review as well as to identify any additional criteria which are of importance to existing users of the public transport system while on their respective journeys. The focus groups are aimed at targeting various types of existing public transport users (including men, women, elderly individuals and scholars) across the various public transport modes (mini-bus taxi, bus and rail). A pre-screening was conducted as part of the selection process to ensure that frequent users are chosen and that the respondents adequately represent their specific gender and age groups. For the purposes of this research study, criteria identified in the literature review forms the starting point for the focus group discussions. A facilitator was hired to orchestrate the focus group

workshops. During the workshops, open-ended questions were asked and discussions among the users were encouraged in order to get a sense of the user experience and needs specific to the interchange, likes and dislikes, quotes from users and priority or order of importance of the items raised.

Due to gender dynamics, focus group workshops were performed in three separate ways: with either men or women only, or in mixed groups including both men and women. The workshops were undertaken in the isiZulu language to ensure that respondents feel comfortable during the process and fully understand the content of the discussion. The information collected was thereafter translated and captured in English.

3.1.3 Criteria selection process

The data collected from the focus groups were then used to select a set of criteria taking into consideration the importance placed on criteria by the frequent users of the public transport facility. Criteria which can be easily and cost-effectively measured such as walking distance, extent of overcrowding, provision of seating, shelter, ablutions, universal access infrastructure, information, lighting, security related infrastructure, and amenities, among others, were selected for this research.

The criteria were then organised, so that elements which describe a particular criterion are then grouped under the relevant criterion. For example, the criteria of comfort and convenience include elements such as seating, shelter and short walking distances, among others.

3.2. DATA COLLECTION (QUANTITATIVE RESEARCH)

3.2.1 Questionnaire and survey instrument development

Once the criteria and elements were selected, a survey instrument was developed to obtain and quantify public transport users' perceptions of the importance of the selected criteria and elements on a Likert 5-point rating scale (very important, fairly important, important, slightly important and unimportant). The survey questionnaire included a question to gauge the overall satisfaction with the particular facility currently in use, on a 5-point rating scale (very satisfied, satisfied, neutral, dissatisfied and very dissatisfied). For items such as waiting times, the rating scale will gauge how acceptable waiting times are to the public transport users (very acceptable, fairly acceptable, acceptable, slightly acceptable, or not acceptable). The data collected from the surveys were used to weight and measure the importance of the criteria in relation to their

relative contribution to the passenger's perceived satisfaction with the overall transfer experience.

3.2.2 Survey respondents

To ensure a comprehensive assessment of public transport users, the selection of respondents at the transfer facilities included regular or frequent public transport users that transfer between two different modes or the same modes (mini-bus taxi, bus and rail) and various types of public transport users (men, women, elderly people and scholars). The purpose of collecting age- and gender-related information is to develop a research hypothesis regarding the relationship between user perceptions or preferences and demographic factors.

3.2.3 Administration of survey

The survey is conducted by staff hired and trained by Majesa Research and Project Management (Pty) Ltd to facilitate respondents in completing the questionnaire at the three existing transfer facilities (Isipingo CBD, Pinetown CBD and Bridge City). A pilot survey was conducted to ensure that the rating scales and concepts were unambiguous and easy to understand for the respondents.

The respondents were selected using the stratified random sampling method to ensure adequate representation of age and gender (Richardson *et al.*, 1995). Prior to commencing with the questionnaire, a quick pre-screening of respondents was undertaken to ensure that frequent public transport users that transfer between two or more modes are selected on a voluntary basis.

3.3. DERIVATION OF INDEX

3.3.1 Descriptive statistics

Statistical descriptive analysis was performed on the survey data collected using IBM Statistical Package for the Social Sciences (SPSS) software version 25. Prior to data analysis, the data set was screened in SPSS to identify any missing data.

3.3.2 Reliability tests

Cronbach's alpha gives an estimate of internal consistency or reliability of items in surveys with multiple Likert questions**.** The data set was analysed in SPSS using C-alpha to determine

whether the items (criteria and elements) to be included in the proposed index reflect the same underlying dimension by measuring how closely related a number of items are as a group.

3.3.3 Weighting of criteria

The key task in constructing the index is the estimation of weights for the criteria and elements. The weighting is based on the number of responses that rate particular criteria or element as important in relation to the other criteria or elements. The criteria or elements with greater frequency will have a greater impact on the weighting. The aim of assigning weights is to reflect the relative importance of the criteria and elements to the overall index and is calculated in Microsoft Excel. The following equation adapted from the relative importance weight formula used by Bivina *et al.* (2018) was used in this research study:

$$w_i = \frac{\sum_{j=1}^{j=5} I_j \times n_j}{N}$$

Equation 3.1

Where:

w_i = relative weight of criterion or element.

I = importance rating.

n_j = number of respondents choosing rating *'j'*.

N = total number of respondents.

3.3.4 Scoring of index criteria

The index criteria comprised of elements which contribute to each individual criterion. The score was multiplied by the weights to give either a full score (total score is a maximum of 1), a partial score (if some of the sub-criteria are present), or a zero score (if none of the sub-criteria are present). The scoring was done at an interchange level. i.e. for the entire facility to give an integration index of a specific facility. The index criteria scores were assigned as follows:

- A numeric value was assigned to indicate the presence of an element, and
- A value of 0 was assigned to indicate the absence of an element.

For example, the criteria of comfort and convenience comprise of elements such as seating, shelter, ablutions, spaciousness (i.e. no overcrowding) and short walking distances. For elements such as seating, shelter and ablutions, a score of either 1 (YES, present at the facility) or 0 (NO, absent at the facility) was assigned. Elements such as overcrowding and walking

distances require more nuanced graduation of scoring. For example, scoring for overcrowding was done in the following manner: excessive overcrowding (score of 0), moderate overcrowding (score of 0.5) and little or no overcrowding (score of 1). Walking distances were scored as follows: short comfortable walking distance (score of 1), medium walking distance i.e. an acceptable level of comfort (score of 0.5) and long walking distance i.e. an unacceptable level of comfort (score of 0).

3.3.5 Index aggregation by additive methods

The proposed index is adapted from Abeyasekera (2005), and the equation will take the form of:

$$Index = w_1X_1 + w_2X_2 + w_3X_3 + ... w_pX_p$$

Equation 3.2

Where:

w_i= relative importance weights which are determined from the quantitative survey data.

X_i= Criteria which are scored during site audits.

3.3.6 Index value range

The aim of the index value is to indicate the level at which facilities are integrated. A high index value will indicate fully or well-integrated facilities, whilst low index values will indicate very low levels of integration. A proposed index scoring range and definitions (Table 3.1) was developed as part of this research:

Table 3.1: Index ranges and definitions

Integration range	Level of integration
High score	High level of integration, or well-integrated
Medium score	Partial level of integration
Low score	Very low level of integration

A proposed index range was developed as part of this research. A full score of one (1) on every criteria and element yields a full score on the index, thereby indicating a fully integrated facility. A partial score on every criteria and element yields a partial index value, thereby indicating a partially integrated facility. A score of zero on every criteria and element yields an index score of zero, thereby indicating no integration at the facility. The mapping of the index values onto

descriptive levels of integration is preliminary at this stage. Future research is required to confirm the validity of this proposed index range.

3.4 HYPOTHESIS TESTING

3.4.1 Research hypothesis statements

The aim of this research is to estimate the relationship between users' perception of the importance of criteria relating to specific interchanges and demographic backgrounds. The aim of the research is two-fold:

1. To determine whether there is a significant relationship between perceptions of public transport users (difference in answering tendencies) based on gender.
2. To determine whether there is a significant relationship between perceptions of public transport users (differences in answering tendencies) based on age.

For this analysis, the research hypotheses are as follows:

- $H_0 1$ – There is no relationship between passengers' perceptions of the importance of the individual index criteria or elements and gender.
- $H_a 1$ – There is a relationship between passengers' perceptions of the importance of the individual index criteria or elements and gender.
- $H_0 2$ – There is no relationship between passengers' perceptions of the importance of the individual index criteria or elements and age.
- $H_a 2$ – There is a relationship between passengers' perceptions of the importance of the individual index criteria or elements and age.

3.4.2 Statistical analysis

Statistical analysis was conducted in SPSS using independent *t*-tests and ANOVA to determine whether the mean responses between groups are different. The independent *t*-test was used to compare the two gender groups and ANOVA was used to perform an age group comparison.

3.5 DEVELOPMENT OF A SPREADSHEET MODEL

A spreadsheet model was developed with the intention that it will assist with easily populating data through a series of YES/NO questions to be answered on site at the three transfer facilities. The spreadsheet input is linked to a graphical interface. This was done so that the information captured, and outputs generated, can be viewed easily using graphic features.

3.6 ILLUSTRATIVE APPLICATION OF THE INDEX

The data collection methodology was tested at the selected transfer facilities. Transport planners and engineers were requested to assist on a voluntary basis to populate audit forms at the selected facilities. This was done to get feedback on the ease of use and to ascertain whether the spreadsheet model was unambiguous.

3.7 RELIABILITY OF THE INDEX

The reliability of the index was assessed using the passenger overall satisfaction ratings obtained from the quantitative data collected. This was done to determine whether the data corresponds to passengers' subjective perceptions of conditions in each interchange, and whether the derived indices correspond to passengers' overall satisfaction.

CHAPTER 4 DATA COLLECTION AND PROCESSING

The data collection for the development of the index follows the mixed-methods approach which is a combination of qualitative and quantitative methodologies. For this research study, the qualitative surveys were undertaken first to provide a more in-depth understanding of what criteria are important for customer satisfaction from the public transport user's perspective, within a local context. Outputs from the qualitative survey were then used to provide a contextual basis for the quantitative data collection process.

4.1 SURVEY LOCATIONS

The existing public transport system within the eThekwini municipal area comprises three primary transport modes, namely commuter rail, buses and mini-bus taxis. By 2030, the implementation of the IRPTN will see the establishment of nine trunk routes (corridors), of which eight are road- and one rail-based.

As shown in Figure 4.1, the proposed eThekwini IRPTN comprises approximately 250 km of trunk public transport corridors with the following corridors:

- Corridor 1 (C1) Bridge City to Durban CBD
- Corridor 2 (C2) North-South Rail Corridor, from Bridge City to Isipingo Station
- Corridor 3 (C3) Bridge City to Pinetown CBD
- Corridor 4 (C4) Bridge City to Clairwood
- Corridor 5 (C5) Chatsworth Town Centre to CBD
- Corridor 6 (C6) Mpumalanga to Durban CBD
- Corridor 7 (C7) Hillcrest to Chatsworth Town Centre
- Corridor 8 (C8) Durban CBD to Tongaat CBD
- Corridor 9 (C9) Bridge City to Umhlanga Rocks New Town

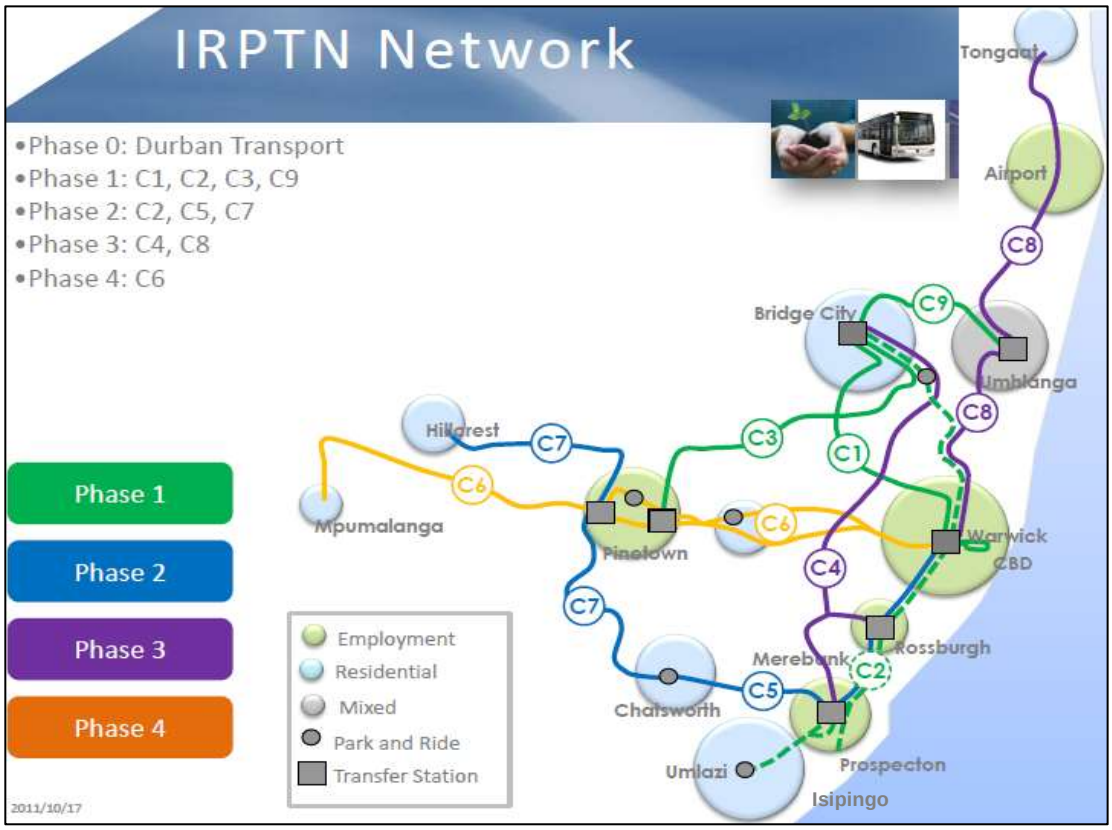

Figure 4.1: Proposed IRPTN Network (Source: Public Transport Improvement Program for eThekwini)

The following three proposed transfer facilities which are located along the future eThekwini IRPTN corridors have been selected for the purpose of undertaking this research:

a) Isipingo (in the South);
b) Pinetown (in the West); and
c) Bridge City (in the North).

a) Isipingo

The Isipingo public transport hub currently caters for different trip types and activities, such as:

- Inbound trips for employment activities in the Isipingo area and nearby Prospecton area;
- Interchanging onto other modes such as mini-bus taxi, bus or rail; and
- Outbound trips for residents in the area to access areas of employment, shopping, health care and education outside their residential area.

The existing formal public transport interchange located between Alexander Avenue and Thomas lane is small and caters for a very small portion of mini-bus taxis. There are several

facilities that are informally operating on various properties in the vicinity of the Isipingo Rail Station. Mini-bus taxis occupy open spaces and parking lots in the informal locations illustrated in Figure 4.2. The eThekwini Integrated Transport Plan (ITP) of 2010 refers to the Isipingo area to be in the greatest need for formal activities. It should be noted that the surveys were only undertaken at the formal Isipingo bus and mini-bus taxi rank.

Figure 4.2: Facility Location – Isipingo (Source: eThekwini Municipality GIS Database)

b) Pinetown

Pinetown is the primary public transport interchange point serving a large part of the western portion of the Municipality. The Pinetown CBD is very well-serviced by bus and mini-bus taxi routes. A rail service is also maintained between Pinetown and Durban Station.

There are a few ranks located in the Pinetown CBD along Anderson Street and Hill Street. Hill Street Rank is the main rank in the area. Most facilities are currently in need of significant upgrades. It should be noted that the surveys were only undertaken at the Pinetown Hill Street Rank (Figure 4.3).

Figure 4.3: Facility Location – Pinetown CBD (Source: eThekwini Municipality GIS Database)

c) Bridge City

Bridge City is an enclosed two-storey shopping centre built on top of the PRASA train station and integrates a number of public transport services into one transport hub (Figure 4.4). A passenger railway line connects to a newly developed station located underneath the Bridge City Shopping Centre and currently has 22 trains that provide services to and from Bridge City to the Durban CBD.

The hub also includes a bus and mini-bus taxi interchange. The bus terminal adjacent to the Bridge City Shopping Centre will be upgraded in future to accommodate the BRT's mega and midibuses. The mini-bus taxi rank is currently situated on the rooftop of the Bridge City Shopping Centre. However, feasibility studies are in the process of being undertaken to relocate the rank to a more suitable and accessible location.

Figure 4.4: Facility Location – Bridge City Shopping Centre (Source: eThekwini Municipality GIS Database)

Appendix J contains photographs of the conditions at the three transfer facilities.

4.2 QUALITATIVE SURVEYS (FOCUS GROUP WORKSHOPS)

Qualitative surveys in the form of focus group workshops were held with existing passengers at the existing transfer facilities (Isipingo, Pinetown and Bridge City) that transfer between different modes or the same mode to reach their destinations. The intention of conducting the focus groups was to identify criteria which are of importance to frequent or regular users of the public transport system while on their respective journeys.

The basic concept of group discussions is that a small number of respondents (five respondents per focus group for the purposes of this study), specifically selected according to a pre-determined set of criteria (men, women, scholars and elderly people), exchange experiences, attitudes and beliefs about a particular topic.

4.2.1 Role of the facilitator

A facilitator was hired to coordinate the focus group workshops. The role of the focus group facilitator is to:

- Ask open-ended questions and encourage discussion amongst the users in order to get a sense of the user experience specific to the interchange, likes and dislikes, quotes from users and priority or order of importance of the items raised;
- Get a sense of which criteria are important specific to the interchange facility;
- Guide the flow of the discussion related to areas that are important to the purposes of the survey;
- Recognise important points of discussion and encourage the group to explore these and elaborate on them;
- Observe non-verbal communication within the group;
- Create an atmosphere that allows respondents to relax and lower some of their defences; and
- Summarise and record the understanding gained with the problems and objectives of the survey.

4.2.2 Respondent criteria

The criteria used to recruit respondents are as follows:

- Frequent public transport users, preferably daily users of the public transport facility or mode of transport;
- Users transferring between two different modes or the same modes;
- Users travelling in morning peak period (05:30 – 08:30); and
- A mixture of respondents of different age groups (elderly travellers included), genders (male and female) and commuter types (including scholars and general commuters).

4.2.3 Focus group mixture

Gender and age are two key factors affecting public transport users' experiences and preferences. Separate groups for men and women were also formed, to avoid gender dynamic issues where women may not speak their mind when men are present.

Two focus group workshops (with five respondents per group) were undertaken at each of the three selected facilities (Isipingo, Pinetown and Bridge City) during the weekday morning commuter peak period (05:30 – 08:30), as per Table 4.1 below.

Table.4.1: Focus group mixture

Group no.	Location	Group mixture
1	Pinetown	Men only. Includes scholars and different age groups.
2	Pinetown	Women only. Includes scholars and different age groups.
3	Isipingo	Both men and women. Includes scholars and different age groups.
4	Isipingo	Both men and women. Includes scholars and different age groups.
5	Bridge City	Men only. Includes scholars and different age groups.
6	Bridge City	Women only. Includes scholars and different age groups.

The facilitator and assistant facilitator (hired from Bala Surveys Pty (Ltd)) approached passengers on a random basis, introduced themselves and explained the purpose of the research. A copy of a letter from the University of Pretoria (refer to Appendix A) was also shown to the potential respondents. Passengers were requested to assist on a voluntary basis, however upon conclusion of the focus group discussions a take-away meal purchased from the local vendor was given to each respondent as a token of appreciation for their participation and contribution to the research.

4.2.4 Information captured

The following general information of the focus group members were captured:

- Gender;
- Age group;
- Modes of transport used; and
- Purpose of travel: school, place of employment, or other.

The start and end times of the focus groups were also captured. The focus group duration was kept between 20 and 25 minutes as the morning peak period is a very busy time for respondents travelling to school or their place of employment. The data collected during the focus groups can be accessed in Appendix B.

4.2.5 Findings of qualitative surveys

The focus group workshops at the three existing public transport facilities revealed the following common issues raised by users of existing transferring public transport:

a) **Crime:** The lack of lighting is a serious problem for users, especially in winter. Furthermore, users fell victims to theft as a result of the lack of lighting or lights not

working at the facilities. Users did not feel safe from crime, especially when it got darker earlier and many had been victims of theft on more than one occasion. Users felt that personal safety was very important to them as they worked hard for their money and were inconvenienced and had to make lifestyle changes after being robbed. Users agreed that police presence, security and cameras at the facility would assist in preventing them from being targeted by criminals.

b) **Road traffic safety:** Users did not feel safe whilst crossing the road in the vicinity of the facilities where pedestrian crossings were provided, due to the high volumes of pedestrians crossing and the impatience of drivers, making it difficult to cross the road safely. Some users felt that there should be a traffic light or crossing guard to temporarily stop the traffic to allow them to cross safely. Reckless drivers coupled with the absence of pedestrian crossings, traffic control measures or crossing guards resulted in users feeling unsafe and at risk of being injured.

c) **Shelters:** One of the most common issues was the lack of shelters and how passengers were affected during rain, hot weather and windy weather conditions. This, combined with long waiting times, made the experience uncomfortable for users.

d) **Seating:** The lack of seating, combined with long waiting times, made the travel experience uncomfortable, especially for elderly users of the facility. Elderly users also indicated that the long times spent standing was very tiring to them.

e) **Ablutions:** The lack of sufficient ablution facilities was another issue. Users had to wait in long queues to use the ablutions as the passenger volumes were large and the number of ablutions provided did not cater for it.

f) **Information:** Users agreed that information is important to their trips. Information about the following was deemed to be important: when transport was delayed, travel routes, and times on which vehicles would arrive at the facility. Sufficient information would prevent them from waiting too long for their transport and becoming victims of crime or missing their transport and being late for work. Users further agreed that this information would prevent them from entering the wrong vehicle or missing their transport. In addition, they could find alternative transport options if they were aware of delays.

Information provided on the cost of trip was important as sometimes the price increased, and the drivers were very impatient towards passengers when they didn't know about the new fares. Some drivers shouted at them if they didn't know the price and in most cases, different drivers had different prices for the same trip. This was disappointing to users as they tried to have exact taxi fare ready, to prevent them from receiving incorrect change.

Directional signage which showed where ablutions, shops, ATMs, etc. are located, is very important for security reasons. Criminals would rob users on the pretext of asking for directions. Some respondents mentioned that people asked them for directions often and it wasted their time, especially during morning peak times, if they had to stop and provide directions.

g) **Walking distances:** The importance of short walking distances whilst carrying heavy shopping bags and the convenience of facilities in close proximity such as retail outlets, banking and fast food shops, were highlighted. Users agreed that short walking distances are very important as they do their shopping and have to carry heavy bags for long distances. In a South African context, people carrying bags, luggage or goods while travelling via public transport can prove to be a great challenge experienced by low-income communities. Most users stated that they do not like to walk for more than 5 minutes.

h) **Provision of banks and shops:** Users agreed that it was important to have amenities such as banks and shops at the facility so that they didn't have to walk a long distance to do their shopping or to buy something to eat whilst waiting at the facility. Users believed that this would also reduce the risk of getting robbed of their groceries and cash. Some respondents stated that it would be very convenient as it will allow them to shop quickly without the fear of missing their transport. Users explained that the trolley boys at the facility charges too much to transport groceries, so it would be better if shops were located at the facility to eliminate this cost. Most users stated that the convenience of shopping facilities at some ranks was really pleasant.

i) **Stairs versus ramps:** Most users preferred ramps as they felt that the elderly seemed to struggle with the stairs and that the ramps shortened the walking distances. Stairs were difficult to climb up especially while carrying heavy bags. The elderly and shoppers who carried heavy bags preferred ramps to stairs. Scholars did not seem to mind having stairs at the facility.

j) **Integrated ticketing and the payment by travel card system:** Users were open to the concept of integrated ticketing, as well as the payment by travel card system. Some users currently have a travel card to pay for bus or train services, however, these are separate cards for each mode. Some of the reasons users prefer a fare system are as follows:

- Due to the crime, respondents did not feel safe when carrying cash with them on a daily basis;
- The fear of losing their transport money;
- One scholar mentioned that when he lost his cash or was robbed on the way to the facility, he ended up missing school and was stranded until a family member came to him with money for transport;
- Most respondents stated that they used cards for bus transport and that they preferred this method of payment;
- One of the elderly travellers stated that due to failing eyesight he sometimes mistakenly paid with a R100 banknote for a trip that costs R10, because he couldn't see the difference between the notes properly;
- One of the scholars stated that the card method was used on trains and she would like to have one card to pay for both her train and mini-bus taxi trips as this would be convenient and safer for her trips to school.

k) **Waiting times:** Long waiting times were also raised as an issue; respondents were arriving late at school or work as a result thereof. Users also felt that the prolonged waiting made rendered them as easier targets to crime. Users stated that when the train was delayed, they missed their transferring vehicle. However, if they were informed of the delay, they could have sought other transport.

l) **Overcrowding:** Overcrowding at facilities was raised by very few of the users. This is likely due to the fact that they are used to this problem as captives of public transport and because other issues are deemed more important. It is also possible that the users have become accustomed to the overcrowding and view this as an accepted norm.

Towards the end of the discussions, the respondents were asked to identify what the single most important and least important criteria was to them as an individual, chosen from the criteria discussed during the workshop. The responses stated are summarised below in Tables 4.2 and 4.3, both at an overall level across all facilities and at a facility-specific level.

Table 4.2: Criteria of highest importance identified across all facilities

Criteria of highest importance	No. of respondents	Percentage of respondents (%)
Protection from crime	11	37
Road safety, provision of pedestrian crossings	6	20
Provision of shelters	5	17
Shelter and seating	4	13
Provision of security guards	1	3
Directional signage	1	3
Lighting	1	3
Payment by travel card method	1	3
Total	**30**	**100**

Table 4.3: Most important criteria identified specific to each facility

Criteria of highest importance	Percentage of users choosing the criteria (%)		
	Isipingo	Pinetown	Bridge City
Protection from crime	20	10	80
Provision of security guards	0	10	0
Road safety, provision of pedestrian crossings	20	40	0
Directional signage	0	10	0
Provision of shelters	10	30	10
Shelter and seating	40	0	0
Lighting	0	0	10
Payment by travel card method	10	0	0
Total	**100**	**100**	**100**

The criteria selected from the focus group respondents as being the most important were items relating to comfort and convenience such as provision of seating and shelter, personal security (protection from crime and provision of security guards), traffic safety (when crossing roads and the provision of pedestrian crossings), directional signage, lighting and the payment by travel card method.

When asked what the least important criterion was to them as individuals, all respondents across all groups were unable to identify it. The consensus was that all the criteria which came forward during the focus group workshops were equally important to them as users.

4.2.6 Criteria selected for developing the index

The elements raised during the workshops were then organised into criteria that were named accordingly, so that elements which describe particular criteria are then grouped under the appropriate criteria. The criteria raised during the workshops as being of the highest importance were used as a starting point to select the criteria and their respective elements that were used for developing the index. The remaining criteria raised by users during the workshops were also incorporated into the selection process. The following eight criteria were selected for developing the index:

a) **Comfort and convenience:** Seating, shelter, ablutions, overcrowding (spaciousness) and short walking distances are grouped together as elements describing this criterion.

b) **Universal Access:** The focus group respondents also emphasised the challenges of the elderly using stairs, and users carrying heavy shopping bags. Universal accessibility features are included in the proposed eThekwini IRPTN design in order to make the facility usable in a safe and comfortable manner for individuals with the widest range of physical and cognitive abilities. The National Land Transport Act of 2009 defines passengers with 'special categories of need' as follows:

- People with disabilities: defined as people with a physical, sensory or mental disability, which may be permanent or temporary;
- The aged: elderly people usually over the age of 55;
- Pregnant women: usually taken as women in their last three months of pregnancy;
- Young children: usually defined as children between the ages of 0 and 14; and
- Those who are limited in their movements by children: men and women accompanying young children.

To this end, a special needs user criterion will be included as part of the index development to incorporate universal accessibility. The AusAID Accessibility Design Guide: Universal design principles for Australia's aid program (2013) was reviewed and the following elements were selected for the criterion for Universal Access for special needs users:

- Provision of ramps or lifts as an alternative to stairs;

- Provision of railings along ramps;
- Tactile surfaces;
- Lowered kerbs or ramps at crossing points; and
- Audible traffic signals crossings.

c) **Personal security:** Adequate provision of lighting, CCTV camera monitoring, the presence of police or security guards and the provision of an emergency help point are included as elements for this criterion.

d) **Road traffic safety:** The provision of signalised pedestrian crossings, traffic calming measures (such as speed humps) near pedestrian crossings and guards to assist pedestrians to cross roads were selected as elements that comprise this criterion.

Information, integrated ticketing and waiting times were also identified during the focus group discussions and have been included here since these criteria play an important role in intermodal integration.

e) **Provision of information:** This criterion includes the following elements which were raised during the focus group discussions:
   - Provision of timetables and routes;
   - Provision of fares or cost of travel for trip
   - Directional signage, wayfinding, or a layout map; and
   - Information on service delays or disruptions.

f) **Integrated ticketing:** Regarding this criterion, the focus groups raised the following as being important to users: paying for all transport modes with one travel card and reducing the need to carry or pay with cash for travelling.

g) **Provision of amenities:** The focus group respondents preferred the convenience of having shops, take away outlets, etc. at the facility. Therefore, from a future intermodal interchange point of view, this criterion is included for the development of the proposed Index. The provision of amenities criterion includes the following elements:
   - Retail/shopping
   - Food/takeaways
   - ATMs/banks

h) Waiting time: For this criterion, it is of importance to gauge which waiting times are acceptable to users. Therefore, the following waiting time ranges were proposed by the researcher to be included as elements for the waiting time criterion:

- Waiting less than 10 minutes;
- Waiting between 11 minutes and 20 minutes;
- Waiting between 21 minutes and 30 minutes; and
- Waiting for more than 30 minutes.

A list of the eight criteria proposed for developing the integration index and the respective elements describing them are shown in Table 4.4.

Table 4.4: List of criteria and elements

Criteria	Elements
Comfort and convenience	Seating
	Shelter
	Ablutions
	Spaciousness/Overcrowding
	Short walking distances
Universal Access	Provision of ramps or lifts as an alternative to stairs
	Provision of railings along ramps
	Tactile surfaces
	Lowered kerbs or ramps at crossing points
	Audible traffic signals crossings
Personal security	Adequate lighting
	CCTV camera monitoring
	Police or security guards
	Emergency help point
Road traffic safety	Signalised pedestrian crossings
	Traffic calming (speed humps) near pedestrian crossings
	Provision of guards at pedestrian crossings
Provision of information	Provision of timetables or routes
	Provision of fares or cost of travel for trip
	Directional signage, wayfinding, or layout map
	Information on service delays or disruptions
Integrated ticketing	Paying for all transport modes with one travel card
	Reducing the need to carry or pay cash for travel
Provision of amenities	Retail/shopping
	Food/takeaways
	ATMs/banks

Waiting times	How acceptable are the following waiting times for transport?
	Waiting less than 10 minutes
	Waiting between 11 minutes and 20 minutes
	Waiting between 21 minutes and 30 minutes
	Waiting more than 30 minutes

4.2.7 Structure of index

The index criteria and its abbreviations are listed in Table 4.5 and the proposed integration index will take the form of:

$$\textit{Multimodal Integration Index} = (w_1 \text{ x } X_1) + (w_2 \text{ x } X_2) + (w_3 \text{ x } X_3) + (w_4 \text{ x } X_4) + (w_5 \text{ x } X_5) + (w_6 \text{ x } X_6) + (w_7 \text{ x } X_7) + (w_8 \text{ x } X_8)$$

Equation 4.1

Where:

w_i= relative importance weights of each criterion *i* which are determined from the quantitative survey data.

X_i= Criteria *i* which is scored during site audits.

Table 4.5: List of index criteria and abbreviations

Index criteria		**Abbreviation**
X_1	Comfort and convenience	CC
X_2	Universal access	UA
X_3	Personal security	PS
X_4	Road traffic safety	RTS
X_5	Provision of information	PI
X_6	Integrated ticketing	IT
X_7	Provision of amenities	PA
X_8	Waiting times	WT

4.3 DATA COLLECTION

4.3.1 Sampling method

The surveys were undertaken as intercept surveys at the three selected facilities, using the stratified random sampling method. This method involves breaking the sample down into different strata before randomly selecting samples in each stratum, with the aim of having an

equal sample of men and women and scholars. This will ensure that every stratum is adequately represented (Richardson *et al.*, 1995 and Taherdoost, 2016). For the purposes of this research the strata were classified according to gender and age group, as illustrated in Table 4.6 below:

Table 4.6: Classification of strata for stratified random sampling

Female scholar (Age group <18)	Female (Age group 18-55)	Elderly female (Age group >55)
Male scholar (Age group <18)	Male (Age group 18-55)	Elderly male (Age group >55)

Instructions to the data collectors were as follows:

Step 1: Randomly select a female scholar;

Step 2: Randomly select a male scholar;

Step 3: Randomly select a female in the age group 18-55;

Step 4: Randomly select male in age group 18-55;

Step 5: Randomly select an elderly female;

Step 6: Randomly select an elderly male; and

Repeat steps 1 to 6.

4.3.2 Sample Size

The target population was made up of the number of passengers using the selected transfer facilities. The eThekwini Transport Authority's Public Transport Planning branch was consulted regarding the Current Public Transport Register (CPTR) data. The branch advised that the latest available passenger numbers at the public transport facilities were captured in 2012, however, the information was not validated and should, therefore, be used with discretion. The passenger numbers provided according to the CPTR data at the three facilities are shown in Table 4.7 below:

Table 4.7: Number of passengers per facility in 2012 morning peak period (2012 CPTR)

Facility	No. of passengers in AM peak period
Isipingo	5003
Pinetown	7506
Bridge City	2279
Total	**14788**

The sample size is calculated below (Richardson *et al.*, 1995; Taherdoost, 2017):

$$n = \frac{p\,(100 - p)\,Z^2}{E^2}$$

$$= \frac{0.5\,(0.5)\,(1.96)^2}{0.05^2}$$

$$= 384$$

Equation 4.2

Where:

n = sample size of infinite population.

E = margin of error = 5%.

Level of confidence = 95%.

Z = 1.96.

p = variance/heterogeneity of population = 50%.

$$Na = \frac{n}{1 + \frac{(n - 1)}{N}}$$

$$= \frac{384}{1 + \frac{(384 - 1)}{14788}}$$

$$= 374$$

Equation 4.3

Where:

Na = adjusted sample size for a finite population.

n = sample size of infinite population.

N = population size.

The sample size of 374 was distributed proportionally amongst the three locations, based on the number of passengers per facility, as shown in Table 4.8.: This means that an adequate

sample size has been obtained across the whole sample, but not at individual sites. Therefore, the weight values will be derived across the whole sample and not at site level.

Table 4.8: Sample distribution among facilities

Facility	No. of passengers in AM peak period	Distribution per location (%)	No. of respondents per location
Isipingo	5003	33.83	127
Pinetown	7506	50.76	190
Bridge City	2279	15.41	58
Total	**14788**	**100**	**374**

4.3.3 Respondent criteria

For the purpose of this research, respondents who travel during the weekday morning peak period (between 05:30 and 08:30) at the three different locations, were targeted. This time period is when the commuter mixture should have a sufficient pool of scholars, general commuters and elderly daily users of the facility for the stratified random sample. One of the pre-screening criteria specified for respondents was the use of at least two or more modes or the use of the same mode at least two or more times between origin and destination for a single trip.

4.3.4 Measurement scales

The criteria and their respective elements were rated on a 5-point scale to measure:

- Overall satisfaction with the current facility (5= very satisfied, 4 = satisfied, 3 = neutral, 2 = dissatisfied, 1 = very dissatisfied);
- Importance of criteria (5= very important, 4 = fairly important, 3 = important, 2 = slightly important, 1 = unimportant); and
- Acceptability of time spent waiting for transport (5 = very acceptable, 4 = fairly acceptable, 3 = acceptable, 2 = slightly acceptable, 1 = not acceptable).

4.3.5 Survey instrument

The surveys also captured demographic information of respondents, such as:

- Age group;
- Gender;
- Transport mode used; and
- Purpose of travel.

The survey questionnaires were printed in English, as can be seen in Appendix C. Because English is not always the first language for some respondents, key concepts were translated into isiZulu during the data collection training workshops to ensure that the language or phrases used are understandable to all the respondents. The importance of all data collectors using the same translated phrases to describe the survey content was critical to data collection. The key concepts translated from English to isiZulu can be seen in Appendix D.

Due to the possibility that some of the concepts relating to universal access would be unfamiliar to some of the respondents, photos and images along with the explanation of these concepts were given to the data collectors during the training workshop. This proved to be particularly useful in explaining concepts such as tactile paving which are not present at the facilities and are unfamiliar to the users.

4.3.6 Survey procedure

During the training workshop the data collectors were briefed on how to approach respondents. A copy of a letter from the University of Pretoria (refer to Appendix E) was given to each of the data collectors. They were instructed to approach a potential respondent, greet the respondent, introduce themselves and explain the purpose of the study. After this, a quick pre-screening of each respondent was undertaken to ensure that only regular or frequent public transport users that transfer between two or more modes, were considered. The data collector then requested whether the respondent would like to voluntarily provide information for academic purposes. On consent from the respondent, the survey would then proceed.

4.3.7 Pilot survey

A reasonable rule of thumb for pilot surveys is to include 5-10% of the sample size of the main survey (Richardson *et al.*, 1995). For the purpose of this research 10% of the main survey was piloted at the three facilities prior to the commencement of surveying the full sample group, as per Table 4.9 below.

Table 4.9: Sample size per facility for pilot survey

Facility	No. of respondents
Isipingo	18
Pinetown	15
Bridge City	5
TOTAL	**38**

The pilot survey was undertaken to ensure that the respondents understood the 5-point rating scales as well as the key criteria being measured. The pilot survey revealed that the survey instrumentation worked well. The provision of the images and photos to describe the universal access concepts were very useful to the respondents in order to provide an understanding of unfamiliar concepts.

4.3.8 Data capturing

The survey forms were captured in Microsoft Excel with the ratings in a numeric format for data analysis procedures.

CHAPTER 5 DATA ANALYSIS AND FINDINGS

This chapter describes the data analysis methodology and tools used for assessing the data that were collected for this research. Moreover, a comprehensive discussion is provided regarding the findings from the data analysis. Statistical tools (IBM SPSS version 25) was used for data input and analysis. Descriptive statistics, correlation, reliability and hypothesis testing forms the key methodology for data assessment.

The quantitative data were collected for the sample size of 374 participants using 5-point Likert rating scales to measure overall satisfaction with the facility, the importance of criteria and elements as well as acceptability of waiting times. The data set captured in Microsoft Excel was verified to ensure that there were no missing data, prior to commencing with analysis in SPSS.

5.1 DEMOGRAPHICS

Since respondent profiling is very important in order to comprehend the background and characteristics of the respondents, the data were analysed in SPSS using statistical descriptive analysis. From this analysis an understanding of the data for the percentages of respondents such as gender, age, mode of travel and purpose of travel is obtained.

5.1.1 Gender

Three hundred and seventy-four participants provided responses during the data collection phase, with 188 respondents (50.3%) being female and the remainder 186 respondents (49.7%) being male (Table 5.1 and Figure 5.1). This is expected as it simply reflects the stratified random sampling approach followed.

Table 5.1: Gender

Gender	Frequency (No. of respondents)	Percentage (%)
Female	188	50.3
Male	186	49.7
Total	**374**	**100.0**

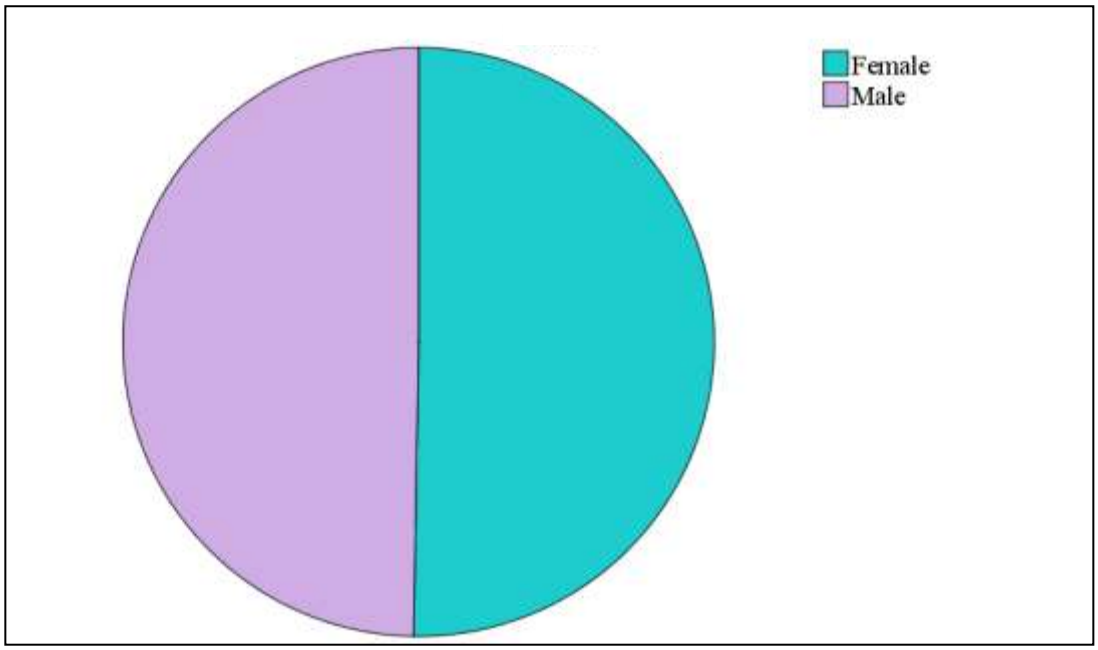

Figure 5.1: Gender distribution among participants

5.1.2 Age groups

In this research study, the respondents were classified into three age groups, namely <18, 18 – 55 and >55 years old. A purposive sample has been selected using the stratified random sampling method, to ensure adequate representation of certain sub-groups, in this case age groups. The proportion of respondents based on age can be seen in Table 5.2 and Figure 5.2.

Table 5.2: Age group distribution among participants

Age group	Frequency (No. of respondents)	Percentage (%)
<18 (scholar)	124	33.1
18 – 55	127	34.0
>55 (elderly)	123	32.9
Total	**374**	**100.0**

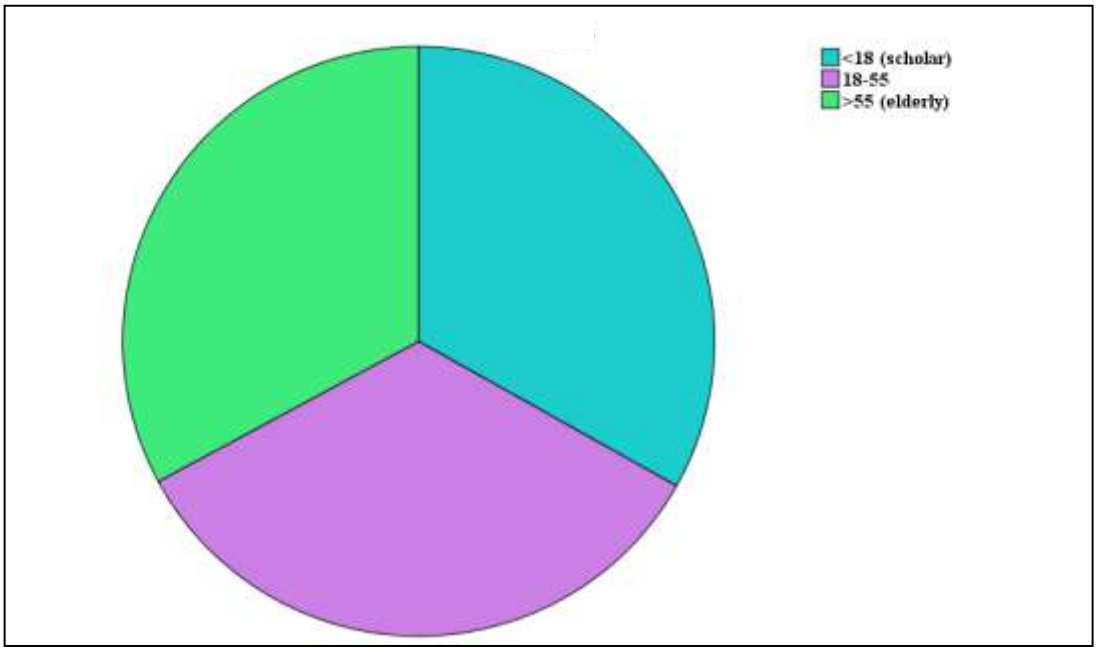

Figure 5.2: Age group distribution among participants

5.2 TRIP CHARACTERISTICS

5.2.1 Mode of travel

The frequent or daily users' transfers between modes for their respective trips can be seen in the Table 5.3 and Figure 5.3. The use of two taxis between the origin-destination trip has the highest frequency (36.9%). Approximately 79.2% of the respondents commence their trip using a mini-bus taxi, with 24.1% switching to bus and 18.2% transferring to train. Approximately 20.8% of the respondents commenced their journey by bus, with 15.2% of these transferring to mini-bus taxis.

Table 5.3: Modes of transport used

Mode	Frequency (No. of respondents)	Percentage (%)
Bus-Taxi	57	15.2
Bus-Train	21	5.6
Taxi-Bus	90	24.1
Taxi-Taxi	138	36.9
Taxi-Train	68	18.2
Total	**374**	**100.0**

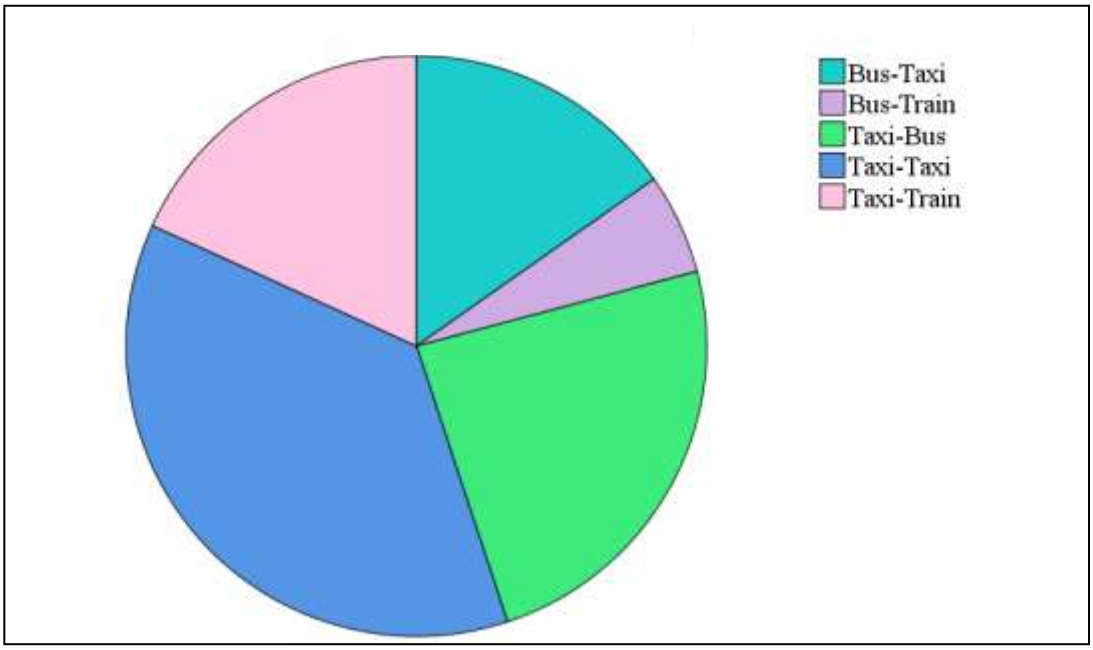

Figure 5.3: Modes of transport used

5.2.2 Purpose of travel

Approximately 42% of the respondents travelled to work, 36.4 % for educational purposes (32.9% to school and 3.5% to college) and 9.6% for shopping. As shown in Table 5.4 and Figure 5.4, the remaining trips were undertaken for the collection of government pension, clinic or doctor (medical), gym or church (religious) visits.

Table 5.4: Purpose of travel

Journey Purpose	Frequency (No. of respondents (%)	Percentage (%)
Church	10	2.7
College	13	3.5
Gym	3	0.8
Medical	21	5.6
Pension	11	2.9
School	123	32.9
Shopping	36	9.6
Work	157	42.0
Total	**374**	**100.0**

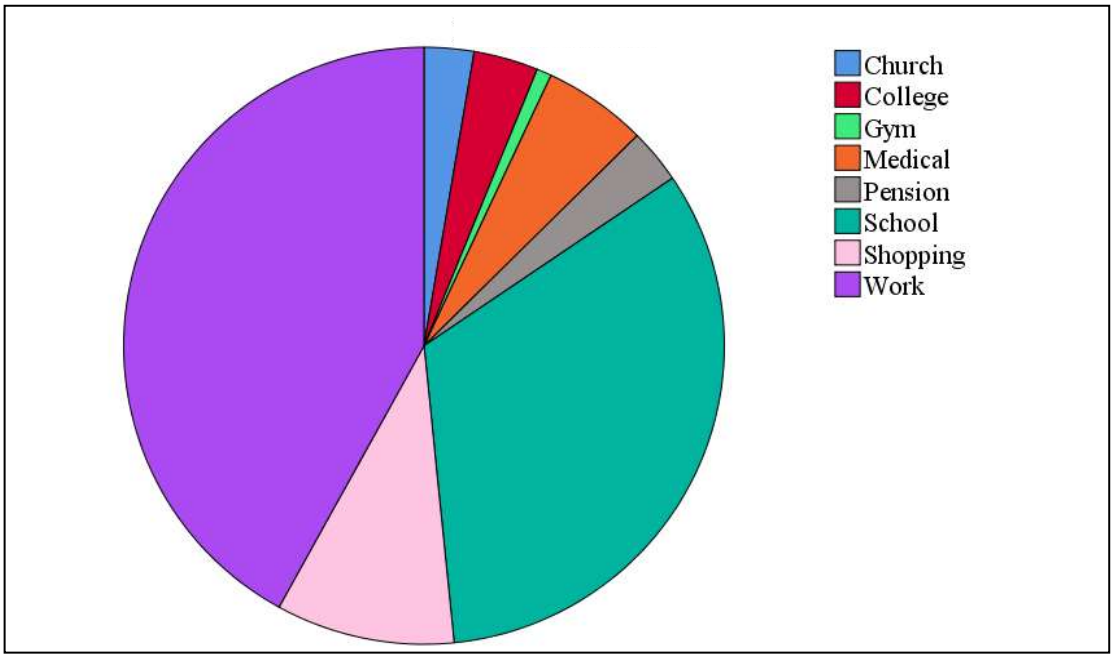

Figure 5.4: Purpose of travel

5.3 DESCRIPTIVE STATISTICS

Descriptive statistics on the Likert data was analysed with SPSS software. These descriptive statistics included frequency tables, means and standard deviations for the data set.

As shown in Figure 5.5, approximately 57% of existing users were dissatisfied or very dissatisfied with the facilities and 35% responded neutral. Approximately 6% responded that they were satisfied and 2% were very satisfied. Table 5.5 shows a mean value of 2.39 for the overall satisfaction score, thereby indicating that passengers in general are not satisfied with the facilities investigated.

Table 5.5: Mean and standard deviation of overall satisfaction

No.	How satisfied are you with the rank/facility which you are currently using on a scale of 1 to 5?	Mean	Standard deviation
Q0	Overall satisfaction with facility	2.39	0.904

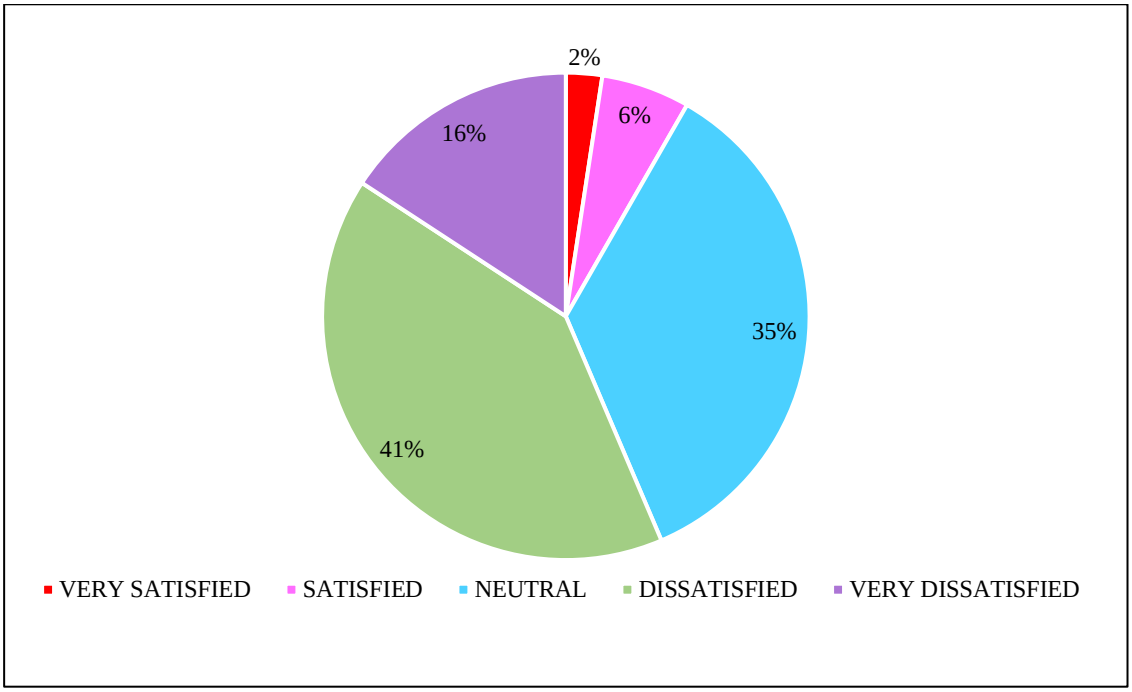

Figure 5.5: Overall satisfaction of participants

Table 5.6 and Figure 5.6 shows the general distribution of the responses in terms of the importance of the selected criteria. More than 80% of respondents indicated that seating, shelter and lighting is very important. In addition, between 61% and 66% of the same respondents rated CCTV camera monitoring, police or security guards, emergency help points, signalised pedestrian crossings and lowered kerbs as very important. Paying for all modes of transport with one travel card was rated as most important by 18% of respondents and reducing the need to carry cash was very important to 16% of respondents. Elements relating to criteria of comfort and convenience, personal security, road traffic safety and universal access were rated as more important than provision of information, integrated ticketing, provision of amenities and waiting time.

Table 5.6: Distribution of responses to importance ratings

How important are the following?	Very important (%)	Fairly important (%)	Important (%)	Slightly important (%)	Unimportant (%)
Seating	86	8	4	2	0
Shelter	80	14	5	1	0
Ablutions	53	23	16	6	3
No overcrowding	45	21	24	8	2
Short walking distances	46	22	20	10	2
Ramps/lifts	36	15	20	13	17
Railings or handrails	34	24	23	11	8
Tactile surfaces	52	28	18	1	1
Lowered kerbs	64	22	12	2	0
Audible traffic signals	59	20	16	4	1
Lighting	84	8	6	1	1
CCTV camera monitoring	66	19	10	3	1
Police or security guards	62	21	13	2	2
Emergency help point	64	17	18	1	0
Signalised pedestrian crossings	61	19	16	3	1
Speed humps	54	24	16	4	2
Crossing guards at pedestrian crossings	39	16	24	14	8
Information on timetables and routes	57	14	19	6	5
Information on costs	50	24	16	8	3
Directional signage	33	36	21	8	2
Information on service delays or disruptions	56	17	17	9	2
Paying for all transport modes with one travel card	18	13	28	23	18
Reducing the need to carry cash	16	16	26	25	17
Retail/shopping	36	17	24	20	5
Fast food/take-aways	23	18	32	20	7
ATMs/banks	30	11	20	20	19

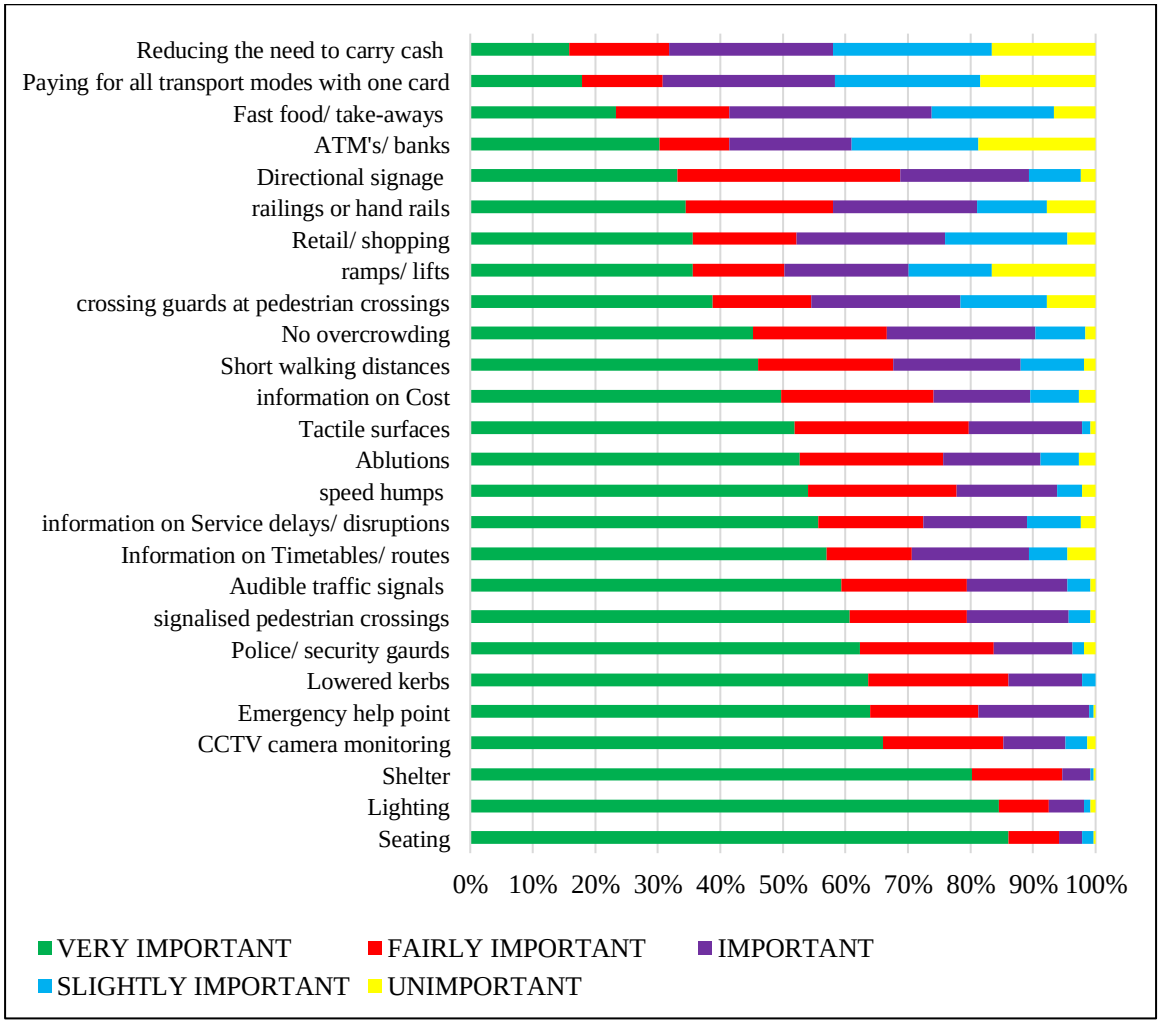

Figure 5.6: Distribution of responses in terms of importance of elements

The mean and standard deviation of the overall importance of the criteria are summarised in Table 5.7 and Figure 5.7. Comfort and convenience, universal access, personal security, road traffic safety and waiting time showed a higher importance level with mean values of greater than 4.0. The least important criterion was integrated ticketing, with a mean value of 2.95. The standard deviation also decreased as the mean rating increased, indicating that there was more agreement amongst respondents on the more important criteria.

Table 5.7: Mean and standard deviation of overall importance of criteria

No.	How important is the following to you on a rating scale of any number between 1 and 5?	Mean	Standard deviation
Q1	Comfort and convenience	4.77	0.616
Q2	Universal access	4.48	0.821
Q3	Personal security	4.69	0.687
Q4	Road traffic safety	4.29	0.834
Q5	Provision of information	3.90	1.226
Q6	Integrated ticketing	2.95	1.333
Q7	Provision of amenities	3.45	1.265
Q8	Waiting time	4.49	0.828

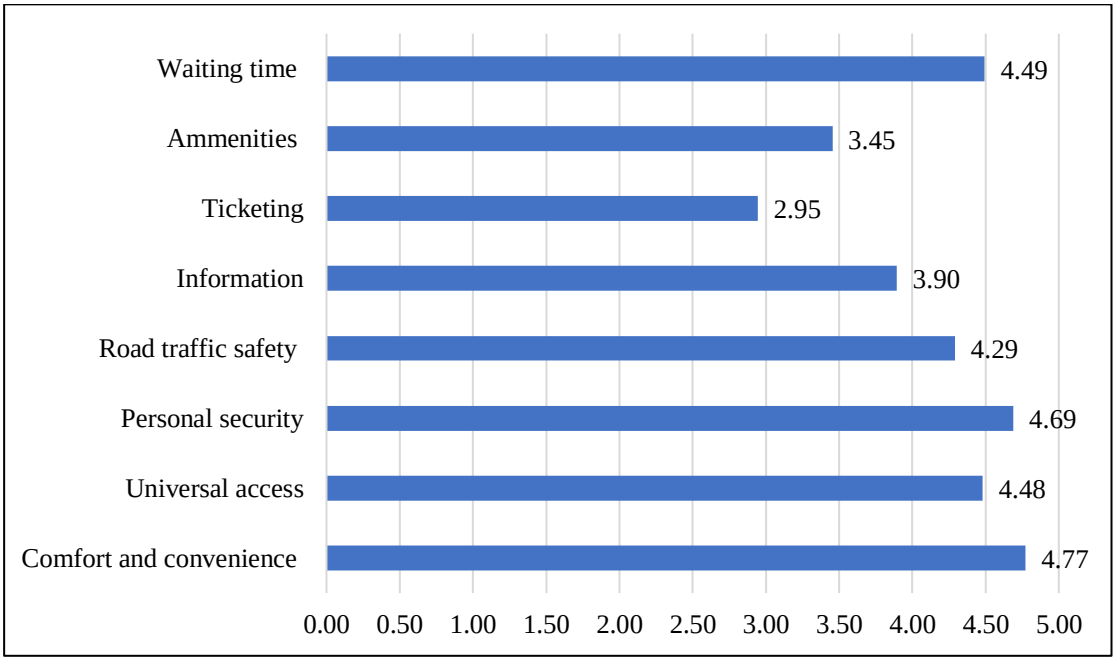

Figure 5.7: Mean for importance of criteria

The mean value for each item that represents the importance of the elements of the criteria are indicated in Table 5.8 and Figure 5.8. The elements relating to the criteria of comfort and convenience, universal access, personal security, and road traffic safety shows higher mean values, revealing that higher importance is placed on these elements. The elements relating to integrated ticketing have the lowest mean values. This is consistent with the means displayed for the overall importance of criteria in Table 5.7 and Figure 5.7.

Table 5.8: Mean and standard deviation of importance of the elements of the criteria

No.	How important is the following to you on a rating scale of any number between 1 and 5?	Mean	Standard deviation
Q1.1	Seating	4.78	0.627
Q1.2	Shelter	4.74	0.591
Q1.3	Ablutions	4.17	1.069
Q1.4	No overcrowding	4.01	1.076
Q1.5	Short walking distances	4.00	1.114
Q2.1	Ramps or lifts	3.39	1.489
Q2.2	Railings or handrails	3.66	1.269
Q2.3	Tactile surfaces	4.29	0.864
Q2.4	Lowered kerbs	4.48	0.784
Q2.5	Audible traffic signals	4.33	0.931
Q3.1	Lighting	4.74	0.682
Q3.2	CCTV camera monitoring	4.45	0.904
Q3.3	Police or security guards	4.40	0.912
Q3.4	Emergency help point	4.44	0.825
Q4.1	Signalised pedestrian crossings	4.35	0.928
Q4.2	Speed humps	4.24	1.000
Q4.3	Crossing guards at pedestrian crossings	3.64	1.324
Q5.1	Information on timetables and routes	4.12	1.183
Q5.2	Information on costs	4.11	1.093
Q5.3	Directional signage	3.89	1.037
Q5.4	Information on service delays or disruptions	4.15	1.124
Q6.1	Paying for all transport modes with one travel card	2.89	1.344
Q6.2	Reducing the need to carry cash	2.89	1.304
Q7.1	Retail/ shopping	3.59	1.273
Q7.2	Fast food/take-aways	3.32	1.216
Q7.3	ATMs/banks	3.14	1.503

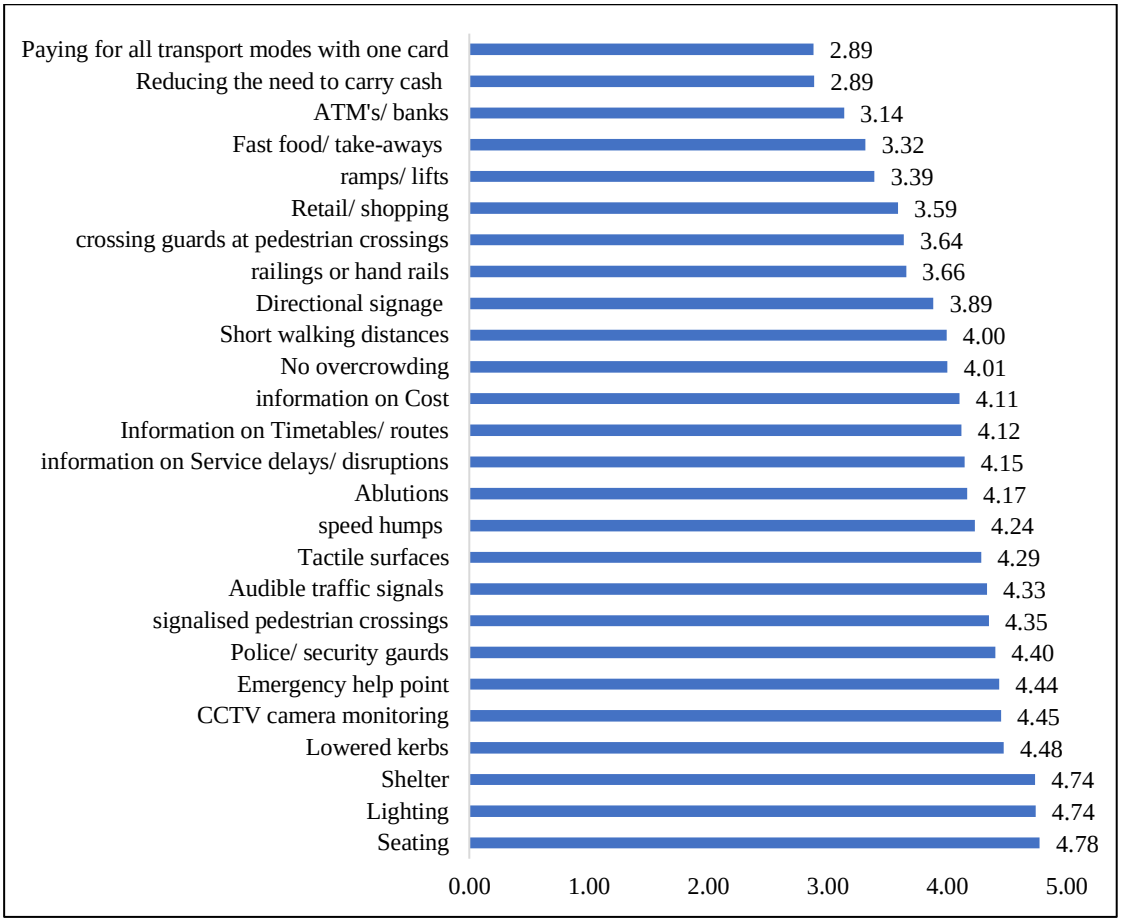

Figure 5.8: Mean for importance of elements of the criteria

The mean descriptive statistics presented in Table 5.9 indicates the mean value for each item that represents the acceptable waiting time. The waiting time of less than 10 minutes has a mean of 4.75 whilst waiting times of more than 30 minutes has a mean of 1.15. This suggests that on average, passengers find that a waiting time of less than 10 minutes is more acceptable. Thus, these values emphasise the importance of shorter waiting times, as one of the issues raised during the focus group discussions was the long waiting times which resulted in passengers arriving late for work or school.

Table 5.9: Mean and standard deviation of acceptable waiting times

No.	How acceptable is the following to you on a rating scale of any number between 1 and 5?	Mean	Standard deviation
Q8.1	Waiting less than 10 minutes	4.75	0.677
Q8.2	Waiting between 11 – 20 minutes	2.90	1.318
Q8.3	Waiting between 21 – 30 minutes	1.69	0.966
Q8.4	Waiting more than 30 minutes	1.15	0.501

In figure 5.9, the intercept of the plot of the percentage of passengers for whom waiting times is acceptable and of the percentage of passengers for whom waiting time is unacceptable, indicates that half (50%) of passengers surveyed, regarded the waiting time as unacceptable.

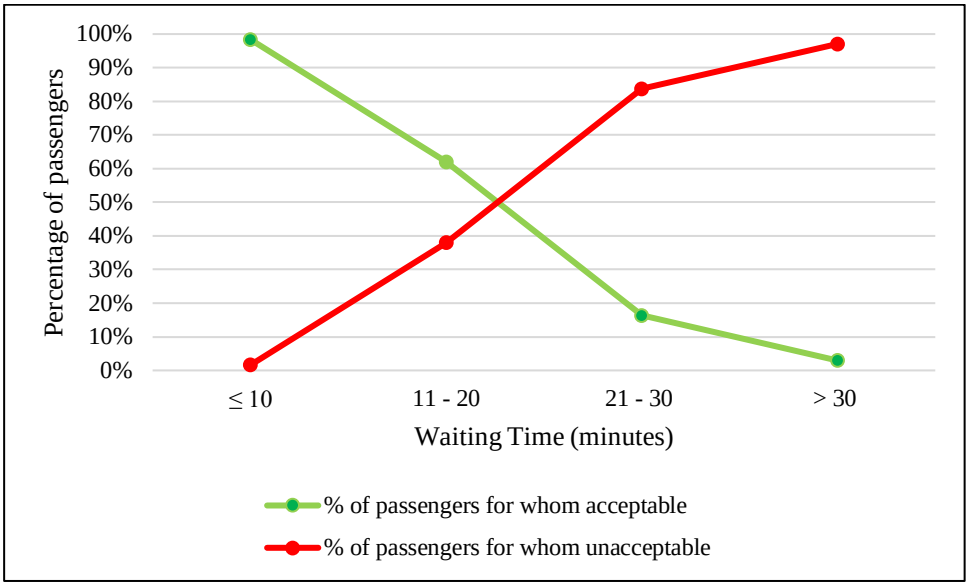

Figure 5.9: Acceptable waiting time

5.4 HYPOTHESIS TESTING

The aim of this research is to understand the relationship between South African public transport users' perception of the importance of criteria in relation to elements of the interchange and users' demographic backgrounds. The research hypothesis is two-fold:

1. To see whether there is a significant relationship between perceptions of public transport users (difference in answering tendencies) and gender.
2. To see whether there is a significant relationship between the perceptions of public transport users (differences in answering tendencies) and age.

Statistical inferential testing was undertaken to determine whether there are any statistically significant differences in the means of independent or unrelated groups. An independent-samples *t*-test is used to compare the mean scores of two different groups of people or conditions and will be used for comparison of gender groups for the purposes of this research. The one-way ANOVA test is used to determine whether there are significant differences in the mean scores across three groups (namely <18, 18-55 and >55 years old).

5.4.1 Research hypothesis

The research hypotheses are as follows:

- $H_0$1 – There is no relationship between passengers' perception of the importance of criteria and elements relating to the intermodal interchange and gender.
- H_a1 – There is a relationship between passengers' perception of the importance of criteria and elements relating to the intermodal interchange and gender.
- $H_0$2 – There is no relationship between passengers' perception of importance of the importance of criteria and elements relating to the intermodal interchange and age.
- H_a2 – There is a relationship between passengers' perception of the importance of criteria and elements relating to the intermodal interchange and age.

5.4.2 Results of hypotheses testing

5.4.2.1 *T*-tests for hypothesis 1 (gender)

The output table of the independent samples test provide the results of Levene's test for equality of variances which determines whether there is a variation in scores between the two groups (males and females). If the significance (sig.) values are greater than 0.05, it can be concluded that the assumption of equal variances holds and that the variability of the two groups is not significantly different. If the sig. value is less than 0.05, it means that the variances for the two groups (males and females) are not the same. The data violates the assumption of equal variance. A 2-tailed sig. of less than 0.05 indicates that there is a significant difference in the mean scores on the dependent variable for each of the two groups (Pallant, 2002).

As shown in Appendix F (Table F1), a comparison of the mean importance of the criteria between female and male passengers indicates that women have a slightly higher perception of importance of comfort and convenience, universal access, personal security, provision of information, integrated ticketing, provision of amenities and waiting times. For road traffic safety, on the other hand, the mean values for both women and men are equal.

As it can be seen in Appendix F (Table F2), for the criteria of personal security, the 2-tailed sig. value of "equal variances not assumed" is 0.031 ($p<0.05$). This indicates that the null hypothesis is not true and it is therefore rejected. It can therefore also be concluded that the means for the two groups (men and women) are statistically significantly different for the criterion of personal security.

For all other criteria the p-values are greater than 0.05, indicating that there is not sufficient evidence to support statistically significant differences in the gender groups. Therefore, the null hypothesis is accepted for these criteria and it can be concluded that there is no difference between the gender groups.

A comparison of the group means for the elements (as shown in Appendix F, Table F3) revealed that men had slightly higher means for seating, audible traffic lights, lighting, police/security, emergency help points, timetable information and fast food/take-aways. For the element of information on costs of travel, the mean for men and women were equal.

As per Appendix F (Table F4), the 2-tailed sig. of "equal variances not assumed" for short walking distances has a significance of 0.018 ($p<0.05$), indicating that the null hypothesis is not true and it is therefore rejected. The element of ATMs/banks has a significance of 0.034 ($p<0.05$), which indicates that the null hypothesis is rejected.

Subsequently, the alternative hypothesis is accepted for the elements of short walking distances and the provision of ATMs/banks. It is therefore concluded that there is a statistically significant difference between the means for men and women regarding short walking distances and the provision of ATMs/banks.

For all other elements, the 2-tailed sig. indicates that there is very little evidence to refute the null hypothesis ($p>0.05$). It can be concluded that there is no difference between men and women in terms of these elements.

5.4.2.2 One-way ANOVA for hypothesis 2 (age groups)

The one-way ANOVA test for the criteria indicates that there is a statistically significant difference (at the 5% level) regarding the provision of information, as shown in Appendix G (Table G1). Considering the multiple comparisons in Appendix G (Table G2), the groups with the differences are scholars (<18) and the elderly (>55). All other criteria have a p-values of >0.05, which indicates a failure to reject the null hypothesis. Thus, it is concluded that there is no significant difference in these criteria between the different age groups.

The following elements have a p-value of <0.05, indicating that there is a statistically significant difference between the age groups:

- Short walking distance (elderly and scholars);
- Ramps or lifts (elderly and scholars);

- Railings or handrails (elderly and scholars);
- Tactile surfaces (elderly, scholars and 18-55);
- Lowered kerbs (elderly and scholars);
- Lighting (elderly and 18-55);
- CCTV cameras (elderly and 18-55);
- Speed humps (elderly and scholars);
- Directional signage (elderly and 18-55);
- Paying with one travel card (elderly and 18-55);
- Reduce the need to carry cash (scholars and 18-55);
- Fast food/take-aways (elderly and 18-55).

5.4.2.3 Conclusion of hypotheses testing

A summary of the hypotheses testing is given in Table 5.10, listing the criteria and elements for the groups where the null hypothesis has been rejected and there is a statistically significant difference in the means.

Table 5.10: Summary of hypotheses testing

Group	Criteria	Elements
Gender	Personal security	Short walking distances Provision of ATMs/banks
Age groups	Provision of information (scholars and elderly)	Short walking distance (elderly and scholars) Ramps or lifts (elderly and scholars) Railings or handrails (elderly and scholars) Tactile surfaces (elderly, scholars and 18-55) Lowered kerbs (elderly and scholars) Lighting (elderly and 18-55) CCTV cameras (elderly and 18-55) Speed humps (elderly and scholars) Directional signage (elderly and 18-55) Paying with one travel card (elderly and 18-55) Reduce the need to carry cash (scholars and 18-55) Fast food/take-aways (elderly and 18-55)

The following can be concluded:

- The criterion of personal security is more important to women than to men.
- With regards to elements, short walking distances and the provision of ATMs or banks are more important to women than men.
- Short walking distances, universal access elements (ramps or lifts, railings or handrails, tactile surfaces, and lowered kerbs) are more important to elderly users than to scholars. This can be attributed to the ability to be mobile that decreases with increased age.
- Lighting, CCTV cameras, directional signage, paying with one travel card and fast food or take-aways are more important to elderly than to the users in the 18-55 age group.

Statistical analysis revealed that, except for three criteria, there were only minor differences between the answering tendencies of men and women. From the hypotheses testing it is concluded that different age groups have different requirements in terms of the interchange facilities, keeping in consideration the decreased mobility and difficulties experienced by elderly users is an important part of providing integrated facilities that meets the needs of these users.

In order to implement efficient and integrated public transport interchanges and improve existing public transport facilities, knowledge and understanding of the requirements based on gender and age are critical. The differences in the answering tendencies between the gender and age groups relating to the criteria and elements specific to facilities emphasise the need to design future intermodal facilities which will cater for the needs and priorities of the various types of users.

5.5 Derivation of the index

The ultimate goal of this study is to develop a composite index to indicate the level of multimodal integration at any given public transport facility. The structure of the index is illustrated in Figure 5.10.

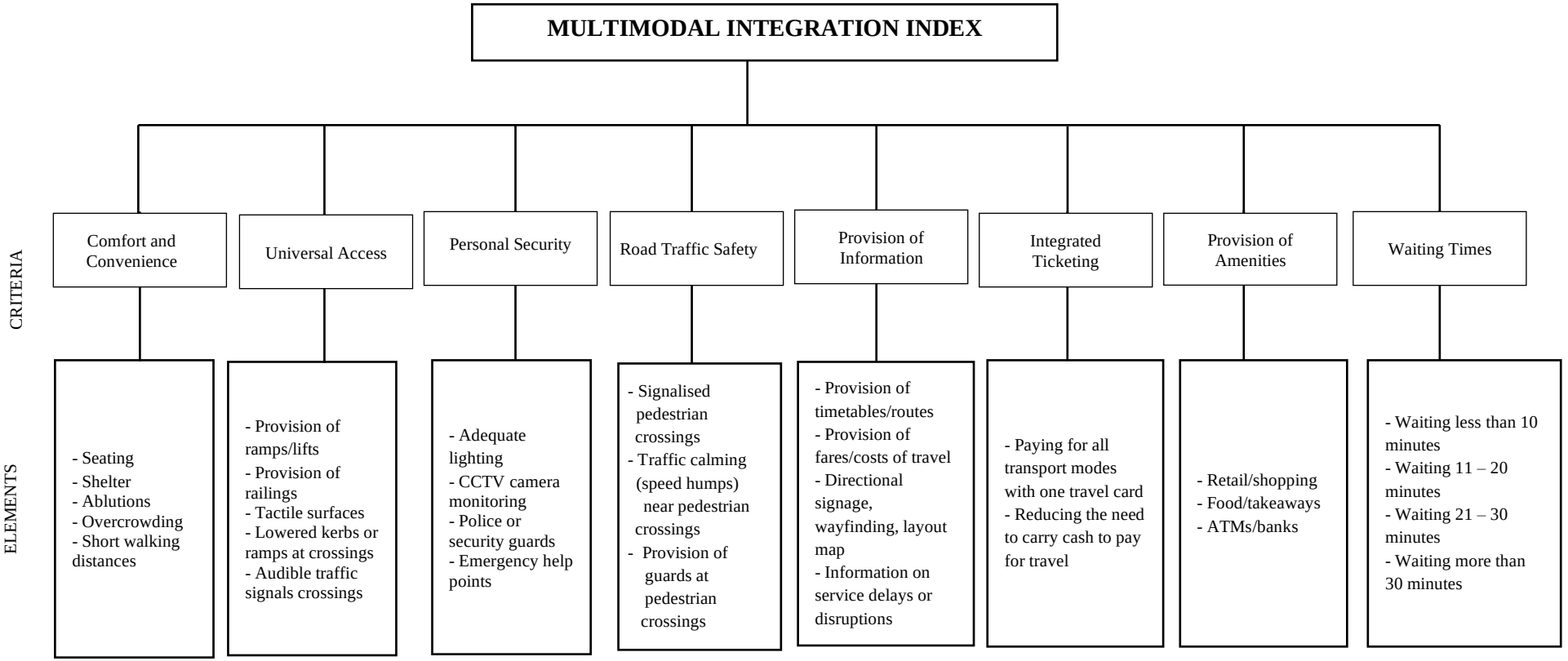

Figure 5.10: Structure of multimodal integration index

5.5.1 Internal consistency: Cronbach's alpha

High reliability indicates that the data is correctly applied to consistently measure what it is intended to measure. Cronbach's alpha is applied when a composite measure such as an index is being developed and can be used to determine whether the variables to be included in the index reflect the same underlying dimension. This is done by measuring the internal consistency to investigate how closely related a number of items are as a group. An alpha value of 0.7 and greater indicates reliability of the scale (Almquist. *et al.*, 2014).

As per Table 5.11, the C-alpha for the Likert responses regarding the elements of the criteria is 0.789, which indicates that the data set to be used for the index has acceptable internal consistency.

The corrected item-total correlation indicates the degree to which each item correlates with the total score. If the scale's overall C-alpha value is too low (i.e. less than 0.7), the items with low item-total correlations should be considered for removal. Squared multiple correlation is the predicted multiple correlation coefficient squared, obtained by regressing the identified individual item on all the remaining items. The alpha value that is reported in the "Cronbach's Alpha If Item Deleted" column is the first C-alpha value which is not based on standardised items. This column provides the impact of removing each item from the scale. Any values in this column that are higher than the final alpha value should be considered for removal (Pallant, 2002; Gliem and Gliem, 2003).

The removal of any questions, except questions 3.3 (presence of police or security guards) and 3.4 (provision of emergency help points), would result in a lower C-alpha (Table 5.12). In addition, the removal of questions 3.3 and 3.4 will also not result in a significant increase in C-alpha. To this end, a decision was made by the researcher to retain all questions for the development of the proposed index.

Table 5.11: Cronbach's alpha

Reliability statistics				
Cronbach's alpha		Cronbach's alpha based on standardised items		No. of items
0.789		0.783		30
Item statistics				
		Mean	Standard deviation	No.
Q1.1	Seating	4.78	0.627	374
Q1.2	Shelter	4.74	0.591	374
Q1.3	Ablutions	4.17	1.069	374
Q1.4	No overcrowding	4.01	1.076	374
Q1.5	Short walking distances	4.00	1.114	374
Q2.1	Ramps/lifts	3.39	1.489	374
Q2.2	Railings or handrails	3.66	1.269	374
Q2.3	Tactile surfaces	4.29	0.864	374
Q2.4	Lowered kerbs	4.48	0.784	374
Q2.5	Audible traffic signals	4.33	0.931	374
Q3.1	Lighting	4.74	0.682	374
Q3.2	CCTV camera monitoring	4.45	0.904	374
Q3.3	Police or security guards	4.40	0.912	374
Q3.4	Emergency help point	4.44	0.825	374
Q4.1	Signalised pedestrian crossings	4.35	0.928	374
Q4.2	Speed humps	4.24	1.000	374
Q4.3	Crossing guards at pedestrian crossings	3.64	1.324	374
Q5.1	Information on timetables or routes	4.12	1.183	374
Q5.2	Information on costs	4.11	1.093	374
Q5.3	Directional signage	3.89	1.037	374
Q5.4	Information on service delays or disruptions	4.15	1.124	374
Q6.1	Paying for all transport modes with one travel card	2.89	1.344	374
Q6.2	Reducing the need to carry cash	2.89	1.304	374
Q7.1	Retail/ shopping	3.59	1.273	374
Q7.2	Fast food/take-aways	3.32	1.216	374
Q7.3	ATMs/banks	3.14	1.503	374
Q8.1	Waiting less than 10 minutes	4.75	0.677	374
Q8.2	Waiting 11 – 20 minutes	2.90	1.318	374
Q8.3	Waiting 21 – 30 minutes	1.69	0.966	374
Q8.4	Waiting more than 30 minutes	1.15	0.501	374

Table 5.12: Item-total statistics

Item-Total Statistics						
		Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Squared Multiple Correlation**	**Cronbach's Alpha if Item Deleted**
Q1.1	Seating	109.89	140.194	0.157	0.275	0.788
Q1.2	Shelter	109.93	140.038	0.181	0.274	0.787
Q1.3	Ablutions	110.50	132.664	0.370	0.328	0.780
Q1.4	No overcrowding	110.66	134.959	0.272	0.271	0.784
Q1.5	Short walking distances	110.67	133.814	0.305	0.419	0.783
Q2.1	Ramps/lifts	111.28	127.053	0.406	0.511	0.777
Q2.2	Railings or handrails	111.01	128.783	0.435	0.547	0.776
Q2.3	Tactile surfaces	110.38	137.872	0.212	0.313	0.786
Q2.4	Lowered kerbs	110.19	137.834	0.243	0.363	0.785
Q2.5	Audible traffic signals	110.33	136.100	0.274	0.311	0.784
Q3.1	Lighting	109.93	137.973	0.279	0.281	0.785
Q3.2	CCTV camera monitoring	110.22	136.342	0.273	0.286	0.784
Q3.3	Police or security guards	110.26	139.466	0.122	0.194	0.790
Q3.4	Emergency help point	110.23	141.668	0.029	0.267	0.793
Q4.1	Signalised pedestrian crossings	110.32	134.663	0.343	0.304	0.781
Q4.2	Speed humps	110.43	134.396	0.324	0.336	0.782
Q4.3	Crossing guards at pedestrian crossings	111.03	133.235	0.259	0.327	0.786
Q5.1	Information on timetables or routes	110.55	129.846	0.433	0.407	0.776
Q5.2	Information on costs	110.56	134.349	0.291	0.501	0.783
Q5.3	Directional signage	110.78	131.126	0.451	0.466	0.776
Q5.4	Information on service delays or disruptions	110.52	130.937	0.417	0.416	0.777
Q6.1	Paying for all transport modes with one travel card	111.78	131.017	0.328	0.498	0.782
Q6.2	Reducing the need to carry cash	111.78	132.044	0.306	0.521	0.783
Q7.1	Retail/shopping	111.08	128.989	0.426	0.566	0.776
Q7.2	Fast food/take-aways	111.35	129.531	0.430	0.535	0.776
Q7.3	ATMs/banks	111.53	129.826	0.316	0.386	0.783
Q8.1	Waiting less than 10 minutes	109.92	138.962	0.219	0.203	0.786
Q8.2	Waiting 11 – 20 minutes	111.77	134.757	0.210	0.473	0.788
Q8.3	Waiting 21 – 30 minutes	112.98	136.166	0.258	0.594	0.785
Q8.4	Waiting more than 30 minutes	113.52	140.915	0.147	0.379	0.788

5.5.2 Weighting of criteria and elements

The relative importance weight of the criteria and elements which will be included in the index were calculated using the following equation:

$$w_i = \frac{\sum_{j=1}^{j=5} I_j \times n_j}{N}$$

Equation 5.1

Where:

w_i = relative weight of criterion or element.

I = importance rating.

n_j = number of respondents choosing rating *'j'*.

N = total number of respondents.

The relative importance weight has been estimated using the respondent's perception of the importance of the criteria and is shown in Table 5.13. The criterion for comfort and convenience has the highest weighting and integrated ticketing has the lowest weighting.

Table 5.13: Relative importance weight of criteria

Criteria for index	Relative importance weight
Comfort and convenience	4.773
Universal access	4.481
Personal security	4.690
Road traffic safety	4.291
Provision of information	3.896
Integrated ticketing	2.947
Provision of amenities	3.455
Waiting times	4.495

A set of elements (which make up each criterion) will be weighted using the relative importance weight formula. The weights of each group of elements (specific to a criterion) will then be normalised – to a sum of 1 for each criterion. The purpose of normalising the weighting of elements so that the sum weight of all elements in a criterion is 1 is to keep the criteria weights in the index formula from being skewed by scale differences. Weights are adjusted by dividing each element

weight by the sum of the means of all element weights in that particular criterion. In this manner, the relative values of the weights are not changed, but they are adjusted so that the sum of the mean is 1, as shown in Table 5.14.

Table 5.14: Relative importance weight of elements

Criteria	Elements	Relative importance weight
Comfort and convenience	Seating	0.221
	Shelter	0.218
	Ablutions	0.192
	No overcrowding	0.185
	Short walking distances	0.184
Universal access	Ramps/lifts	0.168
	Railings or handrails	0.182
	Tactile surfaces	0.213
	Lowered kerbs	0.222
	Audible traffic signals	0.215
Personal security	Lighting	0.263
	CCTV camera monitoring	0.247
	Police or security guards	0.244
	Emergency help point	0.246
Road traffic safety	Signalised pedestrian crossings	0.356
	Speed humps	0.346
	Crossing guards at pedestrian crossings	0.298
Provision of information	Information on timetables and routes	0.253
	Information on costs	0.253
	Directional signage	0.239
	Information on service delays or disruptions	0.255
Integrated ticketing	Paying for all transport modes with one travel card	0.500
	Reducing the need to carry cash	0.500
Provision of amenities	Retail/shopping	0.358
	Fast food/take-aways	0.330

	ATMs/banks	0.312
Waiting times	Waiting less than 10 minutes	0.453
	Waiting between 11 – 20 minutes	0.276
	Waiting between 2 – 30 minutes	0.161
	Waiting more than 30 minutes	0.110

5.5.3 Scoring of elements of index criteria

The index criteria comprise various elements which contribute to each individual criterion. The intention is to use a simple scoring system for the elements that could be easily populated by transport planning professionals during site visits. The scoring was developed with the main objective that the data collection should be simple and straightforward and could be undertaken in a short amount of time. The intention is to assign the scoring at an interchange level. i.e. for the entire facility to give an integration index value for the facility as a whole.

Previous research revealed that some authors have used a scoring system relating to absence or presence of items observed on site at facilities. The Bicycle compatibility index used a scoring criteria based on the presence of a bicycle lane (no = 0, yes=1), the presence of a parking lane (no = 0, yes = 1), the presence of a gutter (no = 0, yes = 1), the presence of sidewalks (no = 0, yes = 1), etc. (Federal Highway Administration, 1998a). Scoring based on visual assessment to indicate the presence or absence of items relating to the sidewalk performance such as lighting, obstacles, pedestrian safety, sidewalk features, etc., was undertaken in a study by Sousa *et al.* (2017).

The scores will be assigned as follows:

- A numeric value will be assigned to indicate the presence of an element. A full score of 1 will be assigned if the element is present on site, and a partial score (i.e. 0.25, 0.5, or 0.75, etc.) if the element is partially provided on site, based on the extent of provision. The use of equal intervals as gradations (e.g. 0, 0.5,1.0) for partial scores were selected so that, as far as possible, a partial score of 0.5 corresponds to a situation that achieves about 50% of the ideal case. This was also the case for the other partial scores of 0.25, 0.75, etc.
- A value of 0 will be assigned to indicate the absence of an element.

The spreadsheet model will contain an audit to be populated on site using a series of YES/NO questions or a description of the site condition which will be selected from a list by selecting an option that best describes it. Tables 5.15 to 5.22 contain details of the scoring for the various elements comprised in the index.

5.5.3.1 Comfort and convenience

For the elements of seating, shelter and ablutions a score of 1 will be assigned where these elements are present and a score of 0 will be assigned in the absence of elements. For overcrowding and walking distance a more nuanced gradation is proposed. An observation of the percentage of passengers experiencing short, medium and long walking distances will be undertaken to estimate a weighted average of scores, i.e. the sum of the product of percentage of passengers and proposed scoring for each description.

The scoring for the levels of crowding are based on observations during the site audit. The Highway Capacity Manual (TRB, 2010) contains a graphical representation of level of service (LOS), as illustrated in in Figure 5.11.

For the proposed index, excessive crowding was selected based on visual observations of LOS E or LOS F, moderate crowding based on LOS D or LOS C, and little or no overcrowding was based on LOS B or LOS A.

The walking distances within the facility were based on the approximate distances to key destinations such as loading areas, seating areas, ablutions, retail outlets, etc. The CSIR Guidelines for Human Settlement Planning and Design (2000) recommends catchment distances for planning walkable neighbourhoods near major centres and close to public transport. It is recommended that walking distances should be limited to 400 metres (5 minutes) to towns or neighbourhood centres and 800 metres (10 minutes) to railway stations (CSIR, 2000). For the purposes of the proposed index, these walking distances are adopted to describe levels of walking distances within the facility for scoring during the site audits, as shown in Table 5.15.

LOS A
Pedestrian Space > 60 ft²/p, Flow Rate = 5 p/min/ft
At a walkway LOS A, pedestrians move in desired paths without altering their movements in response to other pedestrians. Walking speeds are freely selected, and conflicts between pedestrians are unlikely.

LOS B
Pedestrian Space > 40-60 ft²/p, Flow Rate > 5-7 p/min/ft
At LOS B, there is sufficient area for pedestrians to select walking speeds freely to bypass other pedestrians, and to avoid crossing conflicts. At this level, pedestrians begin to be aware of other pedestrians, and to response to their presence when electing a walking path.

LOS C
Pedestrian Space > 24-40 ft²/p, Flow Rate > 7-10 p/min/ft
At LOS C, space is sufficient for normal walking speeds, and for bypassing other pedestrians in primarily unidirectional streams. Reverse-direction or crossing movements can cause minor conflicts, and speeds and flow rate are somewhat lower.

LOS D
Pedestrian Space > 15-24 ft²/p, Flow Rate > 10-15 p/min/ft
At LOS D, freedom to select individual walking speed and to bypass other pedestrians is restricted. Crossing or reverse-flow movements face a high probability of conflict, requiring frequent changes in speed and position. The LOS provides reasonably fluid flow, but friction and interaction between pedestrians is likely.

LOS E
Pedestrian Space > 8-15 ft²/p, Flow Rate > 15-23 p/min/ft
At LOS E, virtually all pedestrians restrict their normal walking speed, frequently adjusting their gait. At the lower range, forward movement is possible only by shuffling. Space is not sufficient for passing slower pedestrians. Cross- or reverse-flow movements are possible only with extreme difficulties. Design volumes approach the limit of walkway capacity, with stoppages and interruptions to flow.

LOS F
Pedestrian Space = 8 ft²/p, Flow Rate varies p/min/ft
At LOS F, all walking speeds are severely restricted, and forward progress is made only by shuffling. There is frequent unavoidable contact with other pedestrians. Cross-and reverse-flow movements are virtually impossible. Flow is sporadic and unstable. Space is more characteristic of queued pedestrians than of moving pedestrian streams.

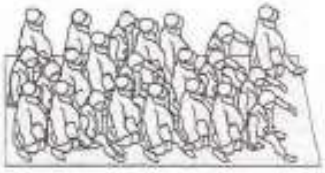

Figure 5.11: Pedestrian level of service according to the Highway Capacity Manual (Source: TRB, 2010)

Table 5.15: Scoring for the provision of elements relating to comfort and convenience

Scoring for criteria: Comfort and convenience	
Elements	**Site audit form scoring description**
Seating Shelter Ablutions	Provided on site (YES), score =1 or Not provided on site (NO), score = 0
Overcrowding	Choose one of the following: • Excessive crowding, score = 0 • Moderate crowding, score = 0.5 • Little or no crowding, score = 1
Walking distance (and comfort level)	Observations of percentage of passengers experiencing the following walking distance ranges: • Short walking distance <400 m (comfortable), score = 1 • Medium walking distance 400 to 800 m (acceptable level of comfort, score = 0.5 • Long walking distance >800 m (unacceptable level of comfort), score = 0

5.5.3.2 Universal access

The elements for the universal access criterion will be assigned a score of 1 where these elements are present, 0.5 for partial provision and a score of 0 in the absence of elements, as shown in Table 5.16.

Table 5.16: Scoring for provision of elements relating to universal access

Scoring for criterion: Universal access	
Elements	**Site audit form scoring description**
Ramps/lifts as an alternative at facilities with stairs Railings along ramps or stairs Tactile surfaces	Choose one of the following: • Good/adequate provision, score = 1

Lowered kerbs/ramps at crossing points	• Poor provision or existing infrastructure in disrepair, score = 0.5 • No provision, score = 0
Audible traffic signals crossings	

5.5.3.3 Personal security

Provision of lighting was scored based on the levels of lighting provided on site, where a full score of 1 will be assigned for adequate or good lighting, a partial score of 0.5 for poor provision of lighting or sites where the existing lighting is frequently out of order and a score of 0 where no lighting is provided. The elements for CCTV camera monitoring. police or security guards and emergency help points will be assigned a score of 1 where these elements are present and a score of 0 in the absence of elements, as shown in Table 5.17.

Table 5.17: Scoring for elements relating to personal security

Scoring for criterion: personal security	
Elements	**Site audit form scoring description**
Provision of lighting	Choose one of the following: • Good/adequate lighting, score = 1 • Poor lighting or existing lighting frequently out of order, score = 0.5 • No lighting, score = 0
CCTV camera monitoring	Provided on site (YES), score = 1 or Not provided on site (NO), score = 0
Police or security guards	
Emergency help point	

5.5.3.4 Road traffic safety

Olszewski and Krukowski (2012) used a scoring system for traffic safety based on the degree of safety provided at the interchange for different road crossing types as follows:

- underground or overhead crossing = 100%;
- signalised crossing, no conflicts with turning vehicles = 70%;
- signalised crossing, conflicts with turning vehicles = 50%;
- unsignalised crossing = 30%; and

- unmarked pedestrian crossing = 0%.

For the proposed index, the road traffic safety elements will be scored in a similar manner, as shown in Table 5.18. Based on the proposed scoring system, the relative importance weights for the individual elements from the passenger survey will not be used for the scoring. Only the overall criterion weighting for road traffic safety will be used.

Table 5.18: Scoring for elements relating to road traffic safety

Scoring for criteria: Road traffic safety	
Elements	**Site audit form scoring description**
Underground or overhead pedestrian crossings (no pedestrian-vehicle conflict)	Choose one of the following: • Score = 1
Signalised pedestrian crossing	• Score = 0.75
Unsignalised marked pedestrian crossing with traffic calming	• Score = 0.5
Unmarked or unprotected crossing (based on observed pedestrian desire line)	• Score = 0

5.5.3.5 Provision of information

The elements for provision of information will be assigned a score of 1 where these elements are provided and a score of 0 where the elements are not provided, as shown in Table 5.19.

Table 5.19: Scoring for elements relating to the provision of information

Scoring for criteria: Provision of information	
Elements	**Site audit form scoring description**
Provision of timetables or routes	Provided on site (YES), score = 1 or Not provided on site (NO), score = 0
Provision of fares/cost of travel	
Provision of directional signage, wayfinding, or facility layout map	
Provision of information on service delays or disruptions	

5.5.3.6 Integrated ticketing

The elements for integrated ticketing will be assigned a score of 1 where these elements are provided and a score of 0 where elements are not provided, as shown in Table 5.20.

Table 5.20: Scoring for elements relating to integrated ticketing

Scoring for criteria: Integrated ticketing	
Elements	**Site audit form scoring description**
Fare integration across modes Travel card system for at least one mode	Provided on site (YES), score = 1 or Not provided on site (NO), score = 0

5.5.3.7 Provision of amenities

The elements relating to provision of amenities will be assigned a score of 1 where these elements are provided and a score of 0 where elements are not provided, as shown in Table 5.21.

Table 5.21: Scoring for criteria relating to provision of amenities

Scoring for criteria: Provision of amenities	
Elements	**Site audit form scoring description**
Retail/shopping	Provided on site (YES), score = 1 or Not provided on site (NO), score = 0
Food/take-aways	
ATMs/banks	

5.5.3.8 Waiting time

The element weighting for the acceptability of the various waiting time ranges serves to confirm that shorter waiting times are more acceptable to passengers and that passengers indeed prefer a shorter waiting time. The waiting time scores were derived from the intercept plot (Figure 5.9) of the percentage of passengers for whom waiting time is acceptable. Waiting times are scored as shown in Table 5.22, where observations are undertaken regarding the percentage of passengers with an approximate waiting time in each of the proposed time ranges. This is done to estimate a weighted average of scores, i.e. the sum of the product of percentage of passengers and proposed scoring for each description.

Table 5.22: Scoring for waiting times

Waiting Time	Scoring
Observations of percentage of passengers experiencing:	
0 – 10 minutes	1
11 – 20 minutes	0.62
21 – 30 minutes	0.16
More than 30 minutes	0

5.5.4 Index aggregation

The proposed index equation will take the following form:

$$INDEX = w_1X_1 + w_2X_2 + w_3X_3 + ... w_pX_p$$

Equation 5.2

Where:

w_i = relative importance weights which are determined from the data.

X_i = scores of the elements of the criteria assigned based on-site observations.

The integration index is written as follows based on the abbreviations provided in Table 5.23:

$$MULTIMODAL\ INTEGRATION\ INDEX = (4.773 \times CC) + (4.481 \times UA) + (4.690 \times PS) + (4.291 \times RTS) + (3.869 \times PI) + (2.947 \times IT) + (3.455 \times PA) + (4.495 \times WT)$$

Equation 5.3

Table 5.23: Index criteria abbreviations

Index criteria	Abbreviation
Comfort and convenience	CC
Universal access	UA
Personal security	PS
Road traffic safety	RTS
Provision of information	PI
Integrated ticketing	IT
Provision of amenities	PA

Waiting times	WT

The purpose of normalising the weighting of elements (i.e. the sum weight of all elements in a criterion is 1) is to prevent the criteria weights in the index formula from being skewed by scale differences. When the scoring is undertaken during audits, one of the following will occur when the element scoring (X_i) is inserted into the index equation:

- The weighting of the main criteria will remain unaffected if all the elements are present or provided on site. The index calculation will give the maximum value (i.e. full score), thereby indicating full or complete integration of the facility; or
- The weighting of the main criteria will be partially reduced if some elements are present or provided on site. The index calculation will give a partial value (i.e. partial score), thereby indicating partial integration; or
- The weighting of the main criteria will be 0 if all the elements are not present or provided on site. The index calculation will give a zero value (i.e. zero score), thereby indicating no integration.

5.5.5 Index value range

The aim of the index value is to indicate the level at which facilities are integrated. A high index value will indicate a fully or well-integrated facility, whilst low index values will indicate a very low level of integration, as described in Table 5.24.

Table 5.24: Proposed index ranges and definitions

Integration range	**Level of integration**
High score	High level of integration / well- integrated
Medium score	Partial level of integration
Low score	Very low level of integration

To calculate the index range values, the following degrees of scoring intervals were assumed:

- 1 = 100% integrated (i.e. fully integrated);
- 0.8 = 80% integrated;
- 0.6 = 60% integrated;
- 0.4 = 40% integrated;
- 0.2 = 20% integrated; and

- 0 = 0% integrated.

The interval values above were substituted into the index formula for X_i to obtain the proposed index scores for each interval range, as shown in Table 5.25.

Table 5.25: Calculation of proposed index ranges

Criteria for index	Weight	Integration (%)					
		100	**80**	**60**	**40**	**20**	**0**
Comfort and convenience	4.773	4.773	3.818	2.863	1.909	0.954	0
Universal access	4.481	4.481	3.585	2.688	1.792	0.896	0
Personal security	4.690	4.690	3.752	2.814	1.876	0.938	0
Road traffic safety	4.291	4.291	3.432	2.574	1.716	0.858	0
Provision of information	3.896	3.896	3.116	2.337	1.558	0.779	0
Integrated Ticketing	2.947	2.947	2.357	1.768	1.178	0.589	0
Provision of amenities	3.455	3.455	2.764	2.073	1.382	0.691	0
Waiting times	4.495	4.495	3.596	2.697	1.798	0.899	0
Index scores		**33.0**	**26.4**	**19.8**	**13.2**	**6.6**	**0.0**

The proposed index ranges in Table 5.26 are indicative descriptions and are subject to further research and validation.

Table 5.26: Proposed index range

Multimodal integration index range	**Level of integration**	**Score range (percentage of criteria that were met)**
26.4 – 33.0	Very High	> 80
19.8 – 26.3	High	60 – 80
13.2 – 19.7	Average	40 – 60
6.6 – 13.1	Poor	20 – 40
0 – 6.5	Very poor	< 20%

5.6 DEVELOPMENT OF A SPREADSHEET MODEL AND ILLUSTRATIVE APPLICATION OF INDEX

A spreadsheet model has been developed using Microsoft Excel software. This spreadsheet can be easily populated on-site at a transfer facility by selecting an appropriate option from a drop-down menu for each of the elements relating to each of the criteria. The spreadsheet input has been linked to a graphical interface to ensure the ease of viewing the outputs using graphic features. The spreadsheet model is provided in Appendix H.

There are two levels of data input into the spreadsheet:

- Level 1: respondents' perceptions of the importance of elements and criteria in the facility environment (i.e. weighting); and
- Level 2: audit observations at facilities.

5.6.1 Spreadsheet testing

In order to test the spreadsheet model for ease of use and unambiguity, transport planners and engineers who are involved with public transport projects within eThekwini Municipality (including graduates and senior professionals) were requested to assist on a voluntary basis to populate the audit forms at the three investigated facilities and to provide feedback on the audit form. The audit form template can be seen in Appendix I.

A total of ten graduates from Pink Africa Consulting Engineers and professional engineers and planners from SMEC South Africa (Durban office) provided feedback on the audit form. The graduates found that the simple structure with YES/NO questions made the form easy to use on site and they were able to quickly populate the audit forms as they moved through the facility. Prior to the site visits, the graduates were briefed on the elements which are not commonly found at some of the existing facilities, namely universal access and integrated ticketing.

The professional engineers and planners who are involved with public transportation studies at one of the selected facilities (Pinetown) indicated that while the simplicity and ease of use of the forms was convenient, additional detail on some of the elements could have been collected. For example, the element of seating could have included detailed categories of descriptions for scoring such as: seating provided but in disrepair, insufficient seating in busy areas, etc. The element of shelter

could have included varying degrees of provision of shelter (namely, full cover, partial cover, etc.), shelter provided but in disrepair, etc. The professionals also advised that for less experienced transport planners and engineers a briefing session as well as instructions on how to observe and score the elements would be useful. This will ensure that there is consistency in scoring of elements by all users of the audit form.

The suggestion from the professionals relating to the universal access criterion was that the provision of universal access vehicles is key to creating an environment that is fully accessible to users with special needs. Provision of universal access infrastructure at facilities is futile if these passengers cannot enter a vehicle which cannot lower to allow wheelchair access.

The professionals suggested that the criterion for waiting time could be scored based on waiting time per line, for example at each loading aisle. This would require a more complex collection method such as using a software application to capture this level of detail on site. Other existing issues at public transport facilities which have an impact on the comfort and convenience of users raised by the professionals include the following:

- Informal traders: the absence of adequate designated areas within facilities to cater for informal trade results in traders taking up space along stairways, loading aisles and sidewalks. This affects the flow of pedestrians in designated pedestrian areas, thereby negatively impacting the level of comfort and convenience experienced by the users.
- Washing of public transport vehicles creates conflict with users of the facilities. Some users must step onto the road to avoid walking in the water puddles created by vehicles being washed in undesignated areas.
- Waiting areas for staff or facility managers: The absence of provision of designated areas for the staff negatively affects the users, as staff are found seated in user areas, thereby impacting user comfort and convenience.

5.6.2 Audit observations

Audit observations were undertaken by the researcher at each of the three investigated facilities during the weekday morning peak period. General site observations relating to the three facilities are discussed below and photographs of the selected facilities can be viewed in Appendix J.

a) Isipingo

Comfort and convenience: Seating is not provided., but shelter is. Walking distances between ablutions, loading areas, etc. within the facility are short, however, passengers shopping at the nearby areas have to walk long distances with heavy shopping bags. The facility size is not adequate for passenger volumes, resulting in overcrowding.

Universal access: Loading islands are damaged and have street furniture (namely rubbish bins) positioned on them, thereby reducing the effective width and creating obstructions to passenger flow, in particular special-needs users. There are no ramps or lifts provided at the facility and the stairs have no railings.

Personal security: Lighting is provided at the facility. There are no CCTV cameras and police or security guards present at the facility. There is also no emergency help point provided on site.

Road traffic safety: No marked or designated pedestrian crossings are provided. Pedestrians were observed crossing between traffic streams at different points.

Provision of information: Information is provided on public transport schedules (timetables/ routes), but no information regarding fares, wayfinding and delays or disruptions is provided.

Integrated ticketing: No such system exists at this facility. Public transport users do have the option of using the Muvo cards for bus travel (limited to only three bus operators namely Durban Transport, People Mover and Mynah). However, there is no Muvo fixed pay point (to load money onto the cards) located at the facility. This is inconvenient to users who have to travel to where these fixed pay point locations. The Muvo smart van is a mobile service traveling to selected locations at specific timeslots. Metro rail services offer passengers a prepaid ticket (daily, weekly or monthly options available) for a specific route. All mini-bus taxis and the buses that are not part of the Muvo system operate on a cash only basis with a specific fee for a specific trip.

Provision of amenities: Shops and fast food retailers are located in the vicinity of the facility.

Waiting times: Long waiting times are experienced by users in the majority of the loading queues.

b) Pinetown

Comfort and convenience: Seating is provided, but may be insufficient to cater for peak times. Shelter is provided over a few of loading areas, but large areas connected to the loading areas are uncovered, offering no protection to users. Walking distances are within the acceptable range of between 400-800 metres. The size of the facility does not cater for the high passenger volumes, resulting in excessive overcrowding.

Universal access: No ramps are provided as an alternative to stairs. Railings along stairs are also not provided. Informal traders occupy the space along the walls on the side of the stairs, thus elderly passengers cannot hold onto these walls for support. There is no tactile paving provided to assist visually impaired users to find their way. Lowered kerbs are provided at some points within the facility to allow wheelchairs and elderly people with walking sticks to cross easily.

Personal security: Very minimal lighting is provided in very few locations and is insufficient to adequately illuminate a facility of this size. There are no CCTV cameras and police or security guards present at the facility. There is no on-site emergency help point provided.

Road traffic safety: No pedestrian crossings are provided. Users cross the road through the traffic stream at any point.

Provision of information: No directional signage is available at this facility. Passengers rely on personal communication for information.

Integrated ticketing: No such system exists at this facility. Public transport users do have the option of using the Muvo cards for bus travel (as for Isipingo users, limited to only three bus operators namely Durban Transport, People Mover and Mynah). There is also no Muvo fixed pay point located at the facility, which is inconvenient to users. The Muvo smart van is available at specific timeslots. Here, Metro rail services also offer passengers a prepaid ticket (daily, weekly or monthly options available) for a specific route. Similar to Isipingo and Bridge City, all mini-bus taxis and the buses that not part of the Muvo system operate on a cash only basis for a specific trip.

Provision of amenities: Shops and fast food shops are located in close vicinity to the facility.

Waiting times: There are long waiting times in some of the queues.

c) Bridge City

Comfort and convenience: No shelter is provided on this rooftop facility; therefore, passengers have no protection from the elements. Seating is also not provided. However, the walking distances within the facility are short and there are very low levels of crowding observed during the peak times.

Universal access: There are lifts available which carry passengers to the roof top where the facility is located. However, there are no railings along the staircases. Also, no tactile paving is provided for visually impaired users. The loading islands have very high kerbs, which pose a challenge to elderly passengers or passengers with limited mobility to step up onto it.

Personal security: No lighting is provided. There are also no CCTV cameras, police or security guards present at the facility. As for the other two facilities, there is no on-site emergency help point.

Road traffic safety: No pedestrian crossings are available. The facility shares the rooftop deck with parking space for the shopping centre customers – this creates a vehicle-pedestrian conflict with public transport users crossing roads at random points.

Provision of information: No information is provided at this facility.

Integrated ticketing: No such system exists at this facility. Here, public transport users also have the option of using the Muvo cards for bus travel (limited to the same three bus operators namely Durban Transport, People Mover and Mynah). However, there is also no Muvo fixed pay point located at the facility, but the Muvo smart van is available to travel to selected locations at specific timeslots. Metro rail services offer passengers a prepaid ticket (daily, weekly or monthly options available) for a specific route. As for Isipingo and Pinetown, all mini-bus taxis and buses that are not part of the Muvo system operate on a cash only basis for a specific trip.

Provision of amenities: Good provision of retail, fast food and banking facilities are available at the Bridge City Shopping Centre.

Waiting times: Very long waiting times were observed during peak operation times.

The audit observations were captured into the spreadsheet model as shown in Tables 5.27 to 5.29.

Table 5.27 Audit form – Isipingo

Name of Facility:	ISIPINGO	
Date of Audit:	2019/10/22 (6:30 -7:30)	
COMFORT AND CONVENIENCE	Seating	No
	Shelter	Yes
	ablutions	Yes
	Description of level of overcrowding	Excessive overcrowding
	Observations of percentage of passengers experiencing the following walking distances and comfort levels:	
	Short walking distance – comfortable < 400m	80%
	Medium walking distance – acceptable level of comfort 400-800m	15%
	Long walking distance – unacceptable level of comfort >800m	5%
UNIVERSAL ACCESS	Provision of ramps/ lifts as an alternative at facilities with stairs	No provision
	Provision of railings along ramps	No provision
	Tactile surfaces	No provision
	Lowered kerbs/ ramps at crossing points	No provision
	Audible traffic signals crossings	No provision
PERSONAL SECURITY	Provision of lighting:	Good/ adequate lighting provided
	CCTV camera monitoring	No
	Police/ security guards	No
	Emergency help point	No
ROAD TRAFFIC SAFETY	Provision of safe crossing	Unmarked or unprotected crossing (based on observed pedestrian desire line)
PROVISION OF INFORMATION	Provision of timetables/ routes	Yes
	Provision of fares/ cost of travel for trips	No
	Provision of Directional signage/ way-finding/ facility layout map	No
	Provision of Information on service delays/ disruptions	No
INTEGRATED TICKETING	Fare integration across modes	No
	Card system for at least one mode of travel	Yes
PROVISION OF AMENITIES	Retail/shopping	Yes
	Food	Yes
	ATM's/ banks	No
WAITING TIMES	Observation of percentage of passengers with the following average waiting times	
	0 minutes – 10 minutes	0%
	11 minutes – 20 minutes	0%
	21 minutes – 30 minutes	70%
	more than 30 minutes	30%

Table 5.28: Audit Form – Pinetown

Name of Facility:	PINETOWN	
Date of Audit:	2019/10/23 (6:30 -7:30)	
COMFORT AND CONVENIENCE	Seating	Yes
	Shelter	No
	ablutions	Yes
	Description of level of overcrowding	Excessive overcrowding
	Observations of percentage of passengers experiencing the following walking distances and comfort levels:	
	Short walking distance – comfortable < 400m	10%
	Medium walking distance – acceptable level of comfort 400-800m	70%
	Long walking distance – unacceptable level of comfort >800m	20%
UNIVERSAL ACCESS	Provision of ramps/ lifts as an alternative at facilities with stairs	No provision
	Provision of railings along ramps	No provision
	Tactile surfaces	No provision
	Lowered kerbs/ ramps at crossing points	Good/ adequate provision
	Audible traffic signals crossings	No provision
PERSONAL SECURITY	Provision of lighting:	No lighting provided
	CCTV camera monitoring	No
	Police/ security guards	No
	Emergency help point	No
ROAD TRAFFIC SAFETY	Provision of safe crossing	Unmarked or unprotected crossing (based on observed pedestrian desire line)
PROVISION OF INFORMATION	Provision of timetables/ routes	No
	Provision of fares/ cost of travel for trips	No
	Provision of Directional signage/ way-finding/ facility layout map	No
	Provision of Information on service delays/ disruptions	No
INTEGRATED TICKETING	Fare integration across modes	No
	Card system for at least one mode of travel	Yes
PROVISION OF AMENITIES	Retail/shopping	Yes
	Food	Yes
	ATM's/ banks	No
WAITING TIMES	Observation of percentage of passengers with the following average waiting times	
	0 minutes – 10 minutes	0%
	11 minutes – 20 minutes	40%
	21 minutes – 30 minutes	40%
	more than 30 minutes	20%

Table 5.29: Audit Form – Bridge City

Name of Facility:	BRIDGE CITY	
Date of Audit:	2019/10/24 (6:30 -7:30)	
COMFORT AND CONVENIENCE	Seating	No
	Shelter	No
	ablutions	Yes
	Description of level of overcrowding	Little/ no overcrowding
	Observations of percentage of passengers experiencing the following walking distances and comfort levels:	
	Short walking distance – comfortable < 400m	80%
	Medium walking distance – acceptable level of comfort 400-800m	20%
	Long walking distance – unacceptable level of comfort >800m	0%
UNIVERSAL ACCESS	Provision of ramps/ lifts as an alternative at facilities with stairs	Good/ adequate provision
	Provision of railings along ramps	No provision
	Tactile surfaces	No provision
	Lowered kerbs/ ramps at crossing points	No provision
	Audible traffic signals crossings	No provision
PERSONAL SECURITY	Provision of lighting:	No lighting provided
	CCTV camera monitoring	No
	Police/ security guards	No
	Emergency help point	No
ROAD TRAFFIC SAFETY	Provision of safe crossing	Unmarked or unprotected crossing (based on observed pedestrian desire line)
PROVISION OF INFORMATION	Provision of timetables/ routes	No
	Provision of fares/ cost of travel for trips	No
	Provision of Directional signage/ way-finding/ facility layout map	No
	Provision of Information on service delays/ disruptions	No
INTEGRATED TICKETING	Fare integration across modes	No
	Card system for at least one mode of travel	Yes
PROVISION OF AMENITIES	Retail/shopping	Yes
	Food	Yes
	ATM's/ banks	Yes
WAITING TIMES	Observation of percentage of passengers with the following average waiting times	
	0 minutes – 10 minutes	0%
	11 minutes – 20 minutes	0%
	21 minutes – 30 minutes	5%
	more than 30 minutes	95%

5.7 RELIABILITY OF INDEX

The reliability of the index was assessed by verifying the correspondence between the overall satisfaction ratings from the quantitative surveys and the derived indices of each of the sites. This was done to determine whether the data corresponds to passengers' subjective perceptions of conditions in each interchange, and whether the derived indices correspond to the passengers' overall satisfaction. The index calculated for each of the facilities is shown in Table 5.30. The graphical representation of the indices for these facilities is shown in Figures 5.12 – 5.14. The derived indices place these three facilities in a poor integration range.

Table 5.30: Derived indices per facility

Facility	Multimodal integration index value
Isipingo	9.3
Pinetown	8.6
Bridge City	8.3

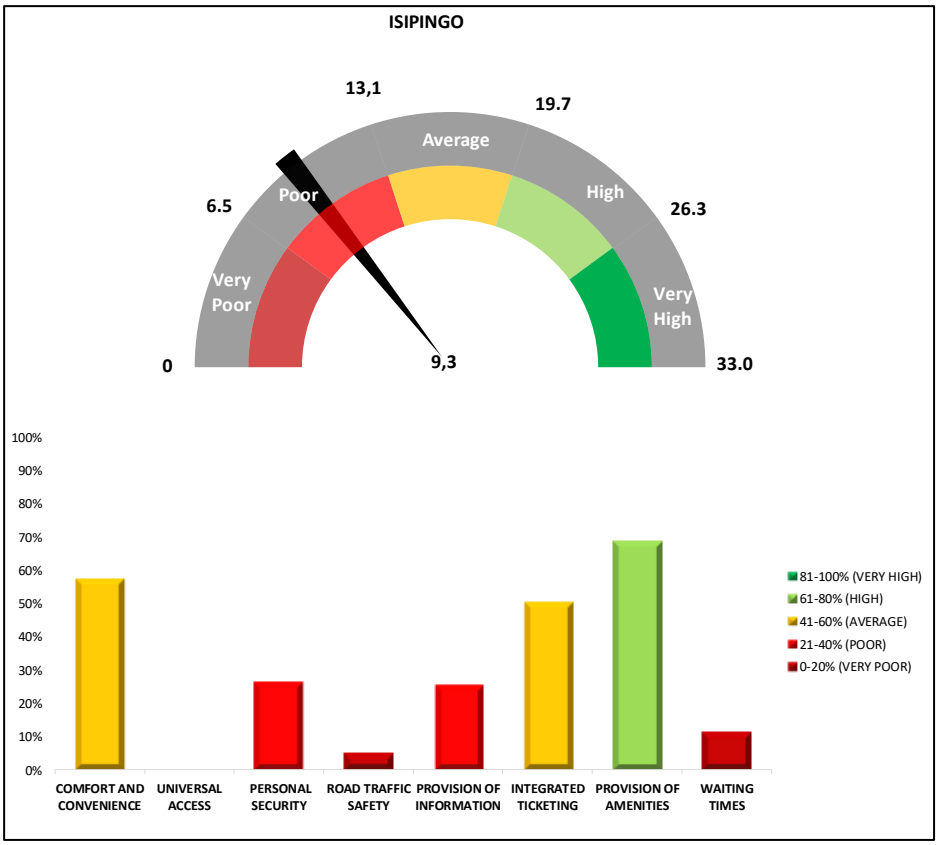

Figure 5.12: Graphical representation of index – Isipingo

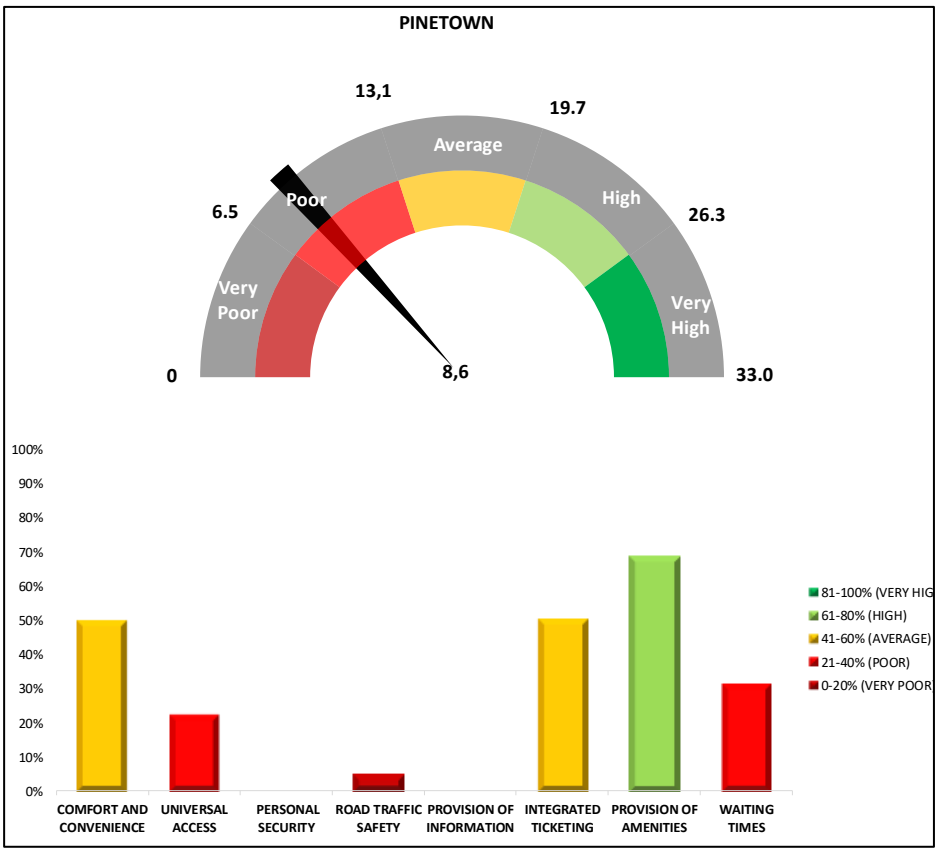

Figure 5.13: Graphical representation of index – Pinetown

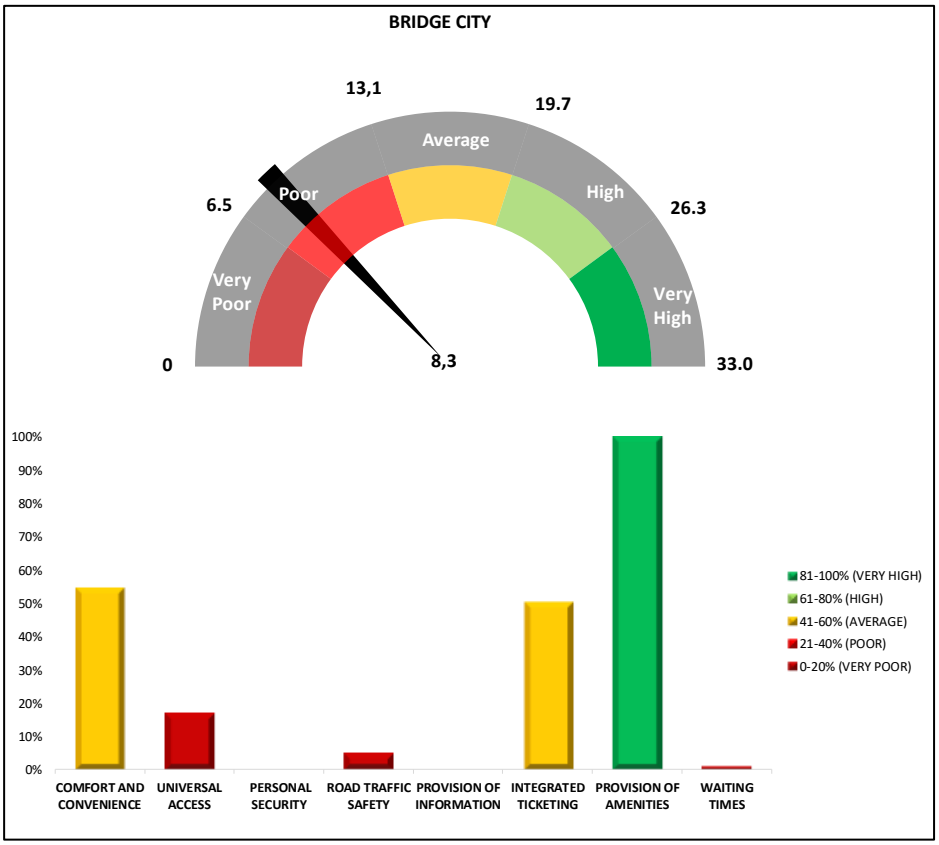

Figure 5.14: Graphical representation of index – Bridge City

From the data collected through the surveys, respondents rated the level of satisfaction of their respective facility on a Likert 5-point rating scale (5 = very important, 4 = fairly important, 3 = important, 2 = slightly important and 1 = unimportant). The average satisfaction of the facilities are provided in Table 5.31.

Table 5.31: Overall satisfaction per facility

Facility	Average overall satisfaction
Isipingo	2.69
Pinetown	2.24
Bridge City	2.17

A comparison of Tables 5.30 and 5.31 shows that the ranking of the site (in order of highest to the lowest) of index values correspond to the satisfaction ranking (in order of highest to lowest) of each rank. It is therefore concluded that the index values rank the three sites in the same order as the satisfaction ratings by regular or frequent users of these facilities.

5.8 DISCUSSION OF RESULTS

The objective of this research is to develop a multimodal integration index to measure the quality of integration at existing public transport interchange facilities from a passenger's experience, by incorporating the needs and priorities of public transport users at intermodal interchanges. The multimodal integration index is to serve as a detailed assessment tool to identify and prioritise interchanges in need of upgrades and to assist in identifying requirements during the planning and designing phases of projects. The index is of a quantitative nature which allows for ease of measurement on site at the facilities.

Relatively little research has been conducted specifically on passenger needs and experiences at interchange facilities in South Africa and no work appears to have been carried out regarding what the public transport users want for future intermodal interchanges. This research study aims to investigate the criteria of importance relating to the interchange environment from the South African public transport users' point of view. The literature review formed the starting point of identifying criteria of importance. The criteria were then explored, confirmed and expanded on during focus group discussions with users at three existing facilities located along the planned future eThekwini Municipality IRPTN.

The focus group outcomes were categorised into eight main criteria with elements describing each criterion. The main criteria selected for developing the index are comfort and convenience, universal access, personal security, road traffic safety, provision of information, integrated ticketing, provision of amenities and waiting time. The concepts of universal access and integrated ticketing are not implemented at most existing public transport facilities. Although these are new concepts in a South African context, this research highlights that in terms of future intermodal interchanges, these criteria are important to users.

Quantitative surveys undertaken included various types of public transport users as respondents (men, women, elderly users and scholars) to ensure a comprehensive needs assessment for users across the various public transport modes (mini-bus taxi, bus and rail). A random stratified sample of 374 respondents was used to ensure adequate representation of the relevant gender and age groups. Users of the Isipingo, Pinetown and Bridge City facilities in eThekwini (KwaZulu-Natal) were asked to rate their overall satisfaction of the facility as well as the importance of the criteria and elements within the respective criteria on a 5-point Likert scale. The importance ratings by passengers were used to assign weights to the different criteria and their respective elements to reflect their relative importance to integration. The purpose of collecting age- and gender-related information is to develop a research hypothesis regarding the relationship between user perceptions or preferences relating to demographic factors.

The overall facility satisfaction ratings revealed that approximately 57% of existing users are either very dissatisfied or dissatisfied with the facilities and 35% responded neutral. Approximately 6% responded that they were satisfied and only 2% were very satisfied. In general, passengers are not satisfied with the investigated facilities, as revealed by a mean satisfaction rating value of 2.39. The distribution of the importance ratings of the elements indicated that more than 80% of the respondents perceived seating, shelter and lighting as very important. Between 61% and 66% of the respondents rated CCTV camera monitoring, police or security guards, emergency help points, signalised pedestrian crossings and lowered kerbs as very important. Paying for all modes of transport with one travel card was rated as most important by 18% of the respondents and reducing the need to carry cash was very important to 16% of the respondents.

Comfort and convenience, universal access, personal security, road traffic safety and waiting time shows a higher importance level with mean values of greater than 4. The least important criterion is integrated ticketing, with a mean value of 2.95. Waiting times of less than 10 minutes has a mean of 4.75 whilst waiting times of more than 30 minutes has a mean of 1.15,

suggesting that on average, passengers find that a waiting time of less than 10 minutes is more acceptable.

The C-alpha for the Likert responses regarding the elements of the criteria is 0.789, indicating that the data set that was used for the index has acceptable internal consistency. The removal of any items will not result in an increase in C-alpha; therefore, all criteria and elements were retained for the development of the index.

The relative importance weights estimated using the respondents' perception of the importance of the criteria are as follows: Comfort and convenience (4.773), universal access (4.481), personal security (4.690), road traffic safety (4.291), provision of information (3.896), integrated ticketing (2.947), provision of amenities (3.455) and waiting times (4.495). The integration index is written as follows: Multimodal integration index = (4.773 x CC) + (4.481 x UA) + (4.690 x PS) + (4.291 x RTS) + (3.869 x PI) + (2.947 x IT) + (3.455 x PA) + (4.495 x WT).

Scoring of the index is assigned at an interchange level by assigning a numeric value to indicate the presence of an element: a full score of 1 if the element is present on site; a partial score (i.e. 0.25, 0.5, 0.75, etc.) to represent elements that are partially provided on site; and a value of 0 to indicate the absence of an element. The index is a single value that captures information from the criteria of importance into one composite measure of intermodal integration and indicates whether a facility is fully integrated or poorly integrated. The proposed index ranges are indicative descriptions and are subject to further research and validation.

A statistical comparison of the importance ratings across the age and gender groups using *t*-tests and ANOVA revealed differences in the answering tendencies of men, women and the various age groups, thereby indicating that participants did not tend towards the same preferences for all the criteria and the respective elements.

A spreadsheet model linked to a graphical interface was developed with the intention of assisting users of the spreadsheet with easily populating data through a series of YES/NO questions on site at a transfer facility. The respondents' perception of the importance of elements and criteria in the facility environment (i.e. weighting) and audit observations at facilities formed the basis of the spreadsheet input. The ranking of the site index values corresponds to the satisfaction ranking of the three facilities, concluding that the index values

rank the three sites in the same order as the satisfaction ratings by regular users of these facilities. All criteria used for development of the index are of a quantitative nature and can be used for assessing existing interchanges. Further research is required for the index to be adapted for use in assessing plans for new facilities or for proposed upgrades to existing facilities.

The site audit observations at the three selected facilities indicated that these public transport interchanges are generally in poor conditions. Infrastructure relating to seating, shelter, lighting, universal access, road traffic safety, and information are not provided, or inadequately provided. Overcrowding and long waiting times are experienced at all three facilities and need attention.

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The following can be concluded:

- This research study reveals what is most important for South African public transport users from an intermodal interchange point of view, based on the perceptions of importance and the point of view of frequent or regular users of the transport system.
- It also concludes that different age groups have different requirements regarding interchange facilities.
- The differences in the answering tendencies between these groups relating to the criteria and elements specific to interchange facilities places emphasis on the need to gain a better understanding of the preferences and attitudes of all public transport user types, in order to design future intermodal facilities which cater for the needs and priorities of all users.
- Considering and prioritising the needs of the users of public transport in the design of intermodal facilities is crucial, given that passengers are the key focus element in the public transport system.

6.2 RECOMMENDATIONS FOR FURTHER RESEARCH

The following recommendations are made for future research:

- For the purposes of this research study, only three existing facilities were investigated with a sample size of 374 respondents. It is recommended that more research into passenger needs in a South African context should be undertaken. Further research is essential to gain a better understanding of the preferences and attitudes of users, especially relating to demographic factors.

- The development of a software application compatible with GPS enabled smart phones is recommended to assist with easy capturing of inputs on site. Walking distances and waiting times can be easily measured using a software application. The spreadsheet model is currently set up to perform an audit of a single facility. The development of a software application is recommended to provide a feature for the simultaneous comparison of several sites. This will aid in providing a quick graphical representation of comparison indicating which sites are in more urgent need of intervention.

- The use of GPS features to measure walking distances between key points within facilities are also recommended. For the purposes of this research, measurement of walking distances within the facility were based on the approximate distances to key destinations such as loading areas, seating areas, ablutions, retail, etc. The use of GPS features will assist in capturing distances easily, quickly and more accurately.

- Further refinement is needed for enhancing the scoring of the elements from a site audit perspective as well as a measurement approach. Future research is needed to develop a more accurate measuring method for some of the elements such as walking distance and waiting times. Therefore, the proposed index provides an opportunity for researchers to investigate these further.

- A limitation of the study is that at the time of undertaking the research, no drawings of the existing premises or any proposed upgrades for the Isipingo, Pinetown and Bridge City facilities were available from the eThekwini Transport Authority. The index and spreadsheet model could therefore not be developed to assess both existing interchange facilities and plans or drawings, as initially intended. Further research is recommended to adapt the index to assess plans for proposed upgrades or the development of new facilities. The spreadsheet model was therefore only tested at the existing facilities for the purposes of the proposed research and not on layouts or architectural plans of the facilities. Additional research is required to adapt the spreadsheet model regarding the measurement and scoring of elements such as overcrowding. Guidelines containing pedestrian LOS for platoon flow in transport terminals, as well as stairs and queuing areas measured as pedestrians/m^2 can be referenced to as a starting point (Federal Highway Administration, 1998b).

- Conducting follow-up research to confirm and validate the proposed ranges for the index is also recommended.

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APPENDIX A – LETTER FROM UNIVERSITY FOR FOCUS GROUP WORKSHOPS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

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FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

Dept of Civil Engineering-UP

TO WHOM IT MAY CONCERN

1 February 2018

Sumashni Moodley is currently enrolled in the MSc. (Applied Sciences) Transportation Planning course in the Department of Civil Engineering at the University of Pretoria, under the supervision of Prof. Christo Venter. Sumashni is in the process of writing a master's thesis on a public transport topic. For the purposes of educational research only, some surveys with public transport passengers will need to be undertaken. The focus of the surveys will be on the needs of passengers and identifying criteria to improve the experience of passengers at public transport facilities.

In order to undertake the surveys, Bala Surveys (Pty) Ltd have been requested to assist with obtaining the necessary clearance to engage with passengers, facilitating the surveys and collecting data for the purposes of the master's research. The facilitators for this study will be staff reporting to Mr. Sekake Moshesh.

All data collected will be treated strictly as confidential and in accordance with the University's ethics guidelines. The data is used purely for academic purposes.

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APPENDIX B – FOCUS GROUPS DATA COLLECTION

FOCUS GROUP 1 (5 Men, includes scholar and different age groups)

Date:	19/06/2018	**Start Time:**	05:45
Location:	Pinetown	**End Time:**	06:10

Group General Information				
Respondent No.	**Gender**	**Age Group**	**Mode of transport used**	**Purpose of travel (school/ place of employment/ other)**
1	Male	< 18 (SCHOLAR)	Taxi, Bus	School
2	Male	18 - 35	Taxi, Taxi	Work
3	Male	> 60 (ELDERLY)	Taxi, Taxi	Other (Medical**)**
4	Male	< 18 (SCHOLAR)	Taxi, Bus	School
5	Male	35 - 60	Taxi, Taxi	Work

Summary:

What do you think about the public transport facilities that you are using?
All respondents felt that the facility needed to be upgraded. Respondents 4 stated that the upgrade in terms of provision of lighting was important, whilst respondent 5 felt that the facility had insufficient space and was very crowded during the peak times.

Likes: Respondent 1 didn't like anything about the facility. Respondents 2 and 3 liked that the people using the facility were respectful and kind to each other. Respondents 4 and 5 liked that there was a good level of safety at this facility compared to other facilities.

Dislikes: Respondent 4 raised the issue of absence of directional signage. The remaining respondents all raised the issue of the lack of shelters and how they were affected during rain, hot weather and windy weather conditions. Respondent 1 further raised the lack of seating available which meant that standing for long periods of time whilst waiting for vehicles.

What would you like to be provided at the facility: Respondent 1 – shelter and seating. Respondent 2 – seating, shelter, ablutions. Respondent 3 – shelter, lighting, pedestrian crossings. Ablutions. Respondent 4 – lighting and shelter.

Challenges that arise when transferring from one vehicle to another: all respondents agree that the long waiting times which cause delays and result in them getting late to school, work, etc.

What is important to you:
All respondents agreed that information was important to their trips. Information to advise when their transport was delayed, information showing the routes and information on what time vehicles would arrive at the facility. Respondents also agreed that information provide on the cost of the trip was important as sometime the price increased, and the drivers were very impatient towards passengers when they didn't know about the new fares. Respondents agreed that directional signage which showed where ablutions, shops, ATM's etc. are located are very important – for security reasons they did not feel comfortable asking around for directions.

All respondents agreed that short walking distances were very important as they did their shopping and had to carry heavy bags for long distances. Most respondents stated that they didn't like to walk more than 5 minutes.
Respondent 1 who was a scholar preferred stair at the facility. Whilst the other respondents preferred ramps as they felt that the elderly seemed to struggle with the stairs and that the ramps shortened the walking distance. Stairs were difficult to climb up especially while carrying heavy bags.

All respondents agreed that it was important to have banks and shops at the facility – so they didn't have to walk a long distance to do their shopping or buy something to eat whilst waiting at the facility.

All respondents stated that the lack of lighting was a serious problem to them, especially in winter and also due to being victims of theft as a result of the lack of lighting at the facility.

All respondents agree that they did not feel safe whilst crossing the road in the vicinity of the facility – there was a pedestrian crossing there, however due to the high volume of pedestrians crossing and impatience of the car drivers – it was difficult to cross the road safely.

Most of the respondents felt that they did not feel safe from crime, especially when it got darker earlier and a few had been victims of theft. This was very important to them as they worked hard for their money and were inconvenienced when robbed.

All respondents felt that using a travel card system to pay for their trips would be very important – for safety reasons they didn't like carrying cash. The scholar mentioned that when he lost his cash or was robbed on the way to the facility, he ended up missing school and was stranded until his family came there with money.

Most important from the above to you as an individual:
Respondent 1 – protection from crime
Respondent 2 – safety when crossing road
Respondent 3 – safety when crossing road
Respondent 4 – directional signage
Respondent 5 – provision of shelters

Least important from the above to you as an individual:
All respondents stated that everything was equally important and that there was nothing they felt was the least important.

FOCUS GROUP 2 (5 women, includes scholar and different age groups)

Date:	18/06/2018	**Start Time:**	06:30
Location:	Pinetown	**End Time:**	06:55

Group General Information				
Respondent No.	**Gender**	**Age Group**	**Mode of transport used**	**Purpose of travel (school/ place of employment/ other)**
1	Female	< 18 (SCHOLAR)	Taxi, Bus	School
2	Female	18 - 35	Taxi, Taxi	Work
3	Female	35 - 60	Taxi, Taxi	Work
4	Female	> 60 (ELDERLY)	Taxi, Bus	Home affairs
5	Female	> 60 (ELDERLY)	Taxi, Taxi	Clinic

Summary:

What do you think about the public transport facilities that you are using?
All respondents felt that the facility needed to be upgraded. Respondent 5 stated that the toilets were inadequate and there was no shelter from the rain and wind.

Likes: Most of the respondents didn't like anything about the facility. Respondent 4 felt that it was safe in the morning.

Dislikes: Respondent 1 raised the issue of absence of directional signage. The remaining respondents all raised the issues of the lack of shelters, seating, toilets and lighting especially in winter.

What would you like to be provided at the facility: all respondents agreed on seating, provision of more toilets, shelters and more lighting.

Challenges that arise when transferring from one vehicle to another: all respondents agree that the long waiting times which cause delays and result in them getting late to their destinations.

What is important to you:
All respondents agreed that information was important to their trips. Information to advise when their transport was delayed, information showing the routes and information on what time vehicles would arrive at the facility. This would prevent them from waiting too long for their transport and becoming victims of crime or missing their transport and getting late to work etc.
Respondents also agreed that information provide on the cost of the trip was important as sometimes the price increased, and they needed to have exact fare for the taxis.
Respondents agreed that directional signage which showed where ablutions, shops, ATM's etc. are located are very important – for security reasons they did not feel comfortable asking around for directions.

All respondents agreed that short walking distances were very important as they did their shopping and had to carry heavy bags for long distances. Most respondents stated that they didn't like to walk more than 5 minutes.

All respondents stated that ramps were better as they sometimes carried heavy bags with them. Respondents 4 and 5 were elderly and agreed that they had great difficulty walking up the stairs. Stairs were difficult to climb up especially while carrying heavy bags.

All respondents agreed that it was important to have banks and shops at the facility – so they didn't have to walk a long distance to do their shopping or buy something to eat whilst waiting at the facility. Respondent 1 stated that it was very convenient as she could go quickly and shop without the fear of missing her transport.

All respondents stated that the lack of lighting was a serious problem to them, especially in winter and also due to being victims of theft as a result of the lack of lighting at the facility. Respondents 2 and 3 stated that the few lights that were at the facility were not working properly.

All respondents agree that they did not feel safe whilst crossing the road in the vicinity of the facility – there was a pedestrian crossing there, but respondents felt that there should be a robot or someone to stop traffic to allow them to cross safely.

Most of the respondents felt that they did not feel safe from crime, especially when it got darker earlier and a few had been victims of theft. All respondents agreed that security guards or police were required.

All respondents felt that using a travel card system to pay for their trips would be very important – for safety reasons and the fear of losing money they didn't like carrying cash. Respondent 1 sated that they used cards for the bus transport and they really liked this method of payment, so they didn't have to fear losing their transport money. Respondent 4 stated that as they were getting older, with failing eyesight they sometimes mistakenly paid with a R100 for a trip that cost R10 because they couldn't see properly.

Most important from the above to you as an individual:
Respondent 1 – provision of security guards
Respondent 2 – safe pedestrian crossing
Respondent 3 – shelter
Respondent 4 – shelter
Respondent 5 – pedestrian crossing

Least important from the above to you as an individual:
All respondents stated that everything was equally important and that there was nothing they felt was the least important.

FOCUS GROUP 3 (5 Mixed, includes scholar and different age groups)

Date:	19/06/2018	**Start Time:**	05:45
Location:	Isipingo	**End Time:**	06:10

Group General Information				
Respondent No.	**Gender**	**Age Group**	**Mode of transport used**	**Purpose of travel (school/ place of employment/ other)**
1	Female	< 18 (SCHOLAR)	Taxi, Bus	School
2	Female	18 - 35	Taxi, Taxi	Work
3	Female	> 60 (ELDERLY)	Bus, Train	Other (Medical/ SASSA)
4	Male	< 18 (SCHOLAR)	Taxi, Taxi	School
5	Male	35 - 60	Taxi, Train	Work

Summary:

What do you think about the public transport facilities that you are using?
All respondents felt that the facility was not good, respondent 1 stated that the rank was too small and overcrowded.

Likes: All respondents agreed that they didn't like anything about the facility.

Dislikes: Respondent 1 raised the issue of lack of space and that most taxis park outside the facility and that there were not enough toilets. The remaining respondents all raised the issue of the lack of shelters, toilets, not enough seating.

What would you like to be provided at the facility: shelter, seating, ablutions, lighting, pedestrian crossings.

Challenges that arise when transferring from one vehicle to another: all respondents agree that the long waiting times which cause delays and result in them getting late to school, work, etc.

What is important to you:
All respondents agreed that information was important to their trips. Information to advise when their transport was delayed, information showing the routes and information on what time vehicles would arrive at the facility. Respondents agreed that this information would prevent them from entering the wrong vehicle. Respondents also agreed that information provide on the cost of the trip was important as some drivers shouted at them if they didn't know the price and different drivers had different prices for the same trip. Respondents agreed that directional signage which showed where ablutions, shops, ATM's etc. are located are very important – for security reasons they did not feel comfortable asking around for directions.

All respondents agreed that short walking distances were very important as they did their shopping and had to carry heavy bags for long distances. Most respondents stated that they didn't like to walk more than 5 minutes.

Respondents 1, 2 and 4 preferred stairs at the facility. Whilst the other respondents preferred ramps as they felt that the elderly seemed to struggle with the stairs and that the ramps shortened the walking distance.

All respondents agreed that it was important to have banks and shops at the facility – so they didn't have to walk a long distance to do their shopping and carry heavy bags. Respondent 5 stated that the trolley boys at the facility charged too much to transport groceries, so it would be better if the shops were at the facility.

All respondents stated that the lack of lighting was a serious problem to them. There were lights in some places, but they rarely worked.

All respondents agree that they did not feel safe whilst crossing the road in the vicinity of the facility – there was no pedestrian crossing and no one to assist them with crossing.

All of the respondents felt that they did not feel safe from crime. They would like police, security and cameras at the facility to prevent them from being targeted by criminals.

All respondents felt that using a travel card system to pay for their trips (similar to the bus) would be very important – for safety reasons they didn't like carrying cash.

Most important from the above to you as an individual:
Respondent 1 – protection from crime
Respondent 2 – protection from crime
Respondent 3 – payment by travel card method
Respondent 4 – pedestrian crossing
Respondent 5 – provision of shelters

Least important from the above to you as an individual:
All respondents stated that everything was equally important and that there was nothing they felt was the least important.

FOCUS GROUP 4 (5 Mixed, includes scholar and different age groups)

Date:	19/06/2018	**Start Time:**	06:45
Location:	Isipingo	**End Time:**	07:10

Group General Information				
Respondent No.	**Gender**	**Age Group**	**Mode of transport used**	**Purpose of travel (school/ place of employment/ other)**
1	Female	< 18 (SCHOLAR)	Taxi, Bus	School
2	Female	18 - 35	Bus, Train	Work
3	Female	18 - 35	Taxi, Taxi	Work
4	Male	18 - 35	Taxi, Taxi	Work
5	Male	35 - 60	Taxi, Train	Work

Summary:

What do you think about the public transport facilities that you are using?
All respondents felt that the facility was not good, respondents 2,3 and 4 stated that the rank needed to be upgraded, insufficient toilets, not enough seating.

Likes: All respondents agreed that they didn't like anything about the facility. Respondent 3 stated that it was a very busy rank so you couldn't get easily robbed by criminals.

Dislikes: Respondent 1 raised the issue of frequent delays with the trains and not knowing when trains will arrive. The remaining respondents all raised the issue of the lack of shelters, toilets, not enough seating.

What would you like to be provided at the facility: Respondent 1 stated that the hours of train services to accommodate all users needed to be better. All other respondents would like seating, shelters and a safe rank.

Challenges that arise when transferring from one vehicle to another: Respondent 1 stated that when the train was delayed, they missed their transferring vehicle - if they were informed that there was a delay they would seek other transport. All respondents agree that the long waiting times and vehicles arriving late which results in them getting late to school, work, etc.

What is important to you:
All respondents agreed that information was important to their trips. Information to advise when their transport was delayed, information showing the routes and information on what time vehicles would arrive at the facility. Respondents agreed that this information would prevent them from missing their transport and they could find alternate transport if the they knew there was a delay. Respondents 1, 2 and 5 agreed that information provide on the cost of the trip was important as some drivers shouted at them if they didn't know the price and different drivers had different prices for the same trip. Respondents 3 and 4 didn't believe that information on the cost of trip was important to them. Respondents agreed that directional signage which showed where ablutions, shops, ATM's etc. are located are very important – for security reasons. Some respondents agreed that people asked them for directions a lot and it wasted their time especially in the morning if they had to stop and give directions.

All respondents agreed that short walking distances were very important as they did their shopping and had to carry heavy bags for long distances. Most respondents stated that they didn't like to walk more than 5 minutes.

Respondents 1, 2, 3 and 4 preferred ramps at the facility as they felt that the elderly seemed to struggle with the stairs and that the ramps shortened the walking distance and effort whilst carrying shopping. Whilst respondent 5 preferred stairs walking distance.

All respondents agreed that it was important to have banks and shops at the facility – so they didn't have to walk a long distance to do their shopping and carry heavy bags and didn't have to pay for assistance from the trolley boys.

All respondents stated that the lack of lighting was a serious problem to them. There were lights in some places which didn't work.

All respondents agree that they did not feel safe whilst crossing the road in the vicinity of the facility – there was no marked pedestrian crossing and no one to assist them with crossing.

All of the respondents felt that they did not feel safe from crime. They would like police and security at the facility to prevent them from being targeted by criminals.

All respondents felt that using a travel card system to pay for their trips (similar to the bus) would be very important – for safety reasons they didn't like carrying cash. Respondent 1 stated that the card method was used on trains and she would like one card to pay for her train and taxi trips as this would be convenient and safer for her trips to school.

Most important from the above to you as an individual:
Respondent 1 – shelter and seating
Respondent 2 – pedestrian crossing
Respondent 3 – shelter and seating
Respondent 4 – shelter and seating
Respondent 5 – shelter and seating

Least important from the above to you as an individual:
All respondents stated that everything was equally important and that there was nothing they felt was the least important.

FOCUS GROUP 5 (5 Men, includes scholar and different age groups)

Date:	15/06/2018	**Start Time:**	05:45
Location:	Bridge City	**End Time:**	06:10

Group General Information				
Respondent No.	**Gender**	**Age Group**	**Mode of transport used**	**Purpose of travel (school/ place of employment/ other)**
1	Male	18 - 35	Taxi, Bus	Work
2	Male	18 - 35	Bus, Taxi	Work
3	Male	> 60 (ELDERLY)	Taxi, Taxi	Other (Medical & SASSA)
4	Male	35 - 60	Taxi, Taxi	Work
5	Male	35 - 60	Bus, Train	Work

Summary:

What do you think about the public transport facilities that you are using?
All respondents agreed that there was security issue and did not feel safe from crime and that there was no shelter. Respondent 2 stated that he felt that the rank should have been located in the lower level and not on the roof level.

Likes: Respondents 1, 2 and 5 agreed that the convenience of the shopping was really nice. Respondents 3 and 4 liked that the rank was closer to their homes which was very convenient.

Dislikes: all respondents agreed that the security from criminals was lacking, they had been victims to crime far too many times at this facility. Respondent 1 and 2 agreed that the rank being on the roof level made it isolated at times which made them easy targets to criminals. Respondents also felt that the time they waited for their transport was very long and they became targets to criminals.

What would you like to be provided at the facility: Respondent 1 – police security. Respondent 2 – security, shelter. Respondent 3 – shelter and security. Respondent 4 and 5 – shelter and security

Challenges that arise when transferring from one vehicle to another: all respondents agree that the long waiting times which cause delays and result in them getting late to school, work, etc. and getting robbed.

What is important to you:
All respondents agreed that information was important to their trips. Information to advise when their transport was delayed, information showing the routes and information on what time vehicles would arrive at the facility. Respondents also agreed that information provide on the cost of the trip was important as sometime the price increased, and the drivers were very impatient towards passengers when they didn't know about the new fares. Respondents agreed that directional signage which showed where ablutions, shops, ATM's etc. are located are very important – for security reasons.

All respondents agreed that short walking distances were very important as they did their shopping and had to carry heavy bags for long distances. Most respondents stated that they didn't like to walk more than 5 minutes.

Respondent 2 preferred stairs at the facility. Whilst the other respondents preferred ramps as they felt that the elderly seemed to struggle with the stairs and that the ramps shortened the walking distance as they carried their shopping.

All respondents agreed that it was important to have banks and shops at the facility – so they didn't have to walk a long distance to do their shopping and risk getting robbed of their groceries and cash.

All respondents stated that the lack of lighting was a serious problem to them, especially in winter and also due to being victims of theft as a result of the lack of lighting at the facility.

All respondents agree that they did not feel safe whilst crossing the road in the vicinity of the facility – there was no pedestrian crossing.

Most of the respondents felt that they did not feel safe from crime and wanted security guards to be provided.

All respondents felt that using a travel card system to pay for their trips would be very important – for safety reasons they didn't like carrying cash.

Most important from the above to you as an individual:
Respondent 1 – protection from crime
Respondent 2 – protection from crime
Respondent 3 – lighting
Respondent 4 – protection from crime
Respondent 5 – protection from crime

Least important from the above to you as an individual:
All respondents stated that everything was equally important and that there was nothing they felt was the least important.

FOCUS GROUP 6 (5 Women, includes scholar and different age groups)

Date:	15/06/2018	**Start Time:**	06:45
Location:	Bridge City	**End Time:**	07:10

Group General Information				
Respondent No.	**Gender**	**Age Group**	**Mode of transport used**	**Purpose of travel (school/ place of employment/ other)**
1	Female	>18	Taxi, Taxi	School
2	Female	>18	Bus, Taxi	School
3	Female	18 - 35	Taxi, Taxi	Work
4	Female	18 - 35	Taxi, Train	Work
5	Female	35 - 60	Bus, Train	Work

Summary:

What do you think about the public transport facilities that you are using?
All respondents agreed that there was security issue and did not feel safe from crime and that there was no shelter.

Likes: All respondents agreed that the convenience of the shopping was really nice, they didn't have to walk far to go the shops

Dislikes: all respondents agreed that the security from criminals was lacking.
Respondents also felt that the time they waited for their transport was very long and they became targets to criminals. The lack of shelter from rain and cold weather conditions.

What would you like to be provided at the facility: Respondent 1 – police security. Respondent 2 – security, shelter and short waiting times. Respondent 3 – shelter and security. Respondent 4 and 5 – shelter and security

Challenges that arise when transferring from one vehicle to another: all respondents agree that the long waiting times which cause delays and result in them getting late and long waiting times make them easy targets to crime.

What is important to you:
All respondents agreed that information was important to their trips. Information to advise when their transport was delayed, information showing the routes and information on what time vehicles would arrive at the facility. Respondents also agreed that information provide on the cost of the trip was important as they were sometimes robbed by drivers. Respondents agreed that directional signage which showed where ablutions, shops, ATM's etc. are located are very important – for security reasons.

All respondents agreed that short walking distances were very important as they did their shopping and had to carry heavy bags for long distances. Most respondents stated that they didn't like to walk more than 5 minutes.

Respondents 1 -4 preferred stairs at the facility. Whilst respondent 5 felt that ramps were better as she is getting older and the stirs were difficult to climb up.

All respondents agreed that it was important to have banks and shops at the facility – so they didn't have to walk a long distance to do their shopping and risk getting robbed of their groceries and cash.

All respondents stated that the lack of lighting was a serious problem to them, especially in winter and also due to being victims of theft as a result of the lack of lighting at the facility.

All respondents agree that they did not feel safe whilst crossing the road in the vicinity of the facility – there was no pedestrian crossing and they felt that the drivers drove recklessly. Respondents 4 and 5 wanted a robot so they could cross safely.

Most of the respondents felt that they did not feel safe from crime and wanted security guards to be provided. Respondents 4 and 5 agreed that the security guards were not helpful, and they thought that having the police would be safer for them.

All respondents felt that using a travel card system to pay for their trips would be very important – for safety reasons they didn't like carrying cash.

Most important from the above to you as an individual:
Respondent 1 – protection from crime
Respondent 2 – protection from crime
Respondent 3 – shelters
Respondent 4 – protection from crime
Respondent 5 – protection from crime

Least important from the above to you as an individual:
All respondents stated that everything was equally important and that there was nothing they felt was the least important.

APPENDIX C – SURVEY QUESTIONNAIRE FOR QUANTITATIVE DATA COLLECTION

Date		**Time**		**Location:**					
Age Group		<18(SCHOLAR)		18-35		35-55		>55 (ELDERLY)	
Gender									
Transport mode				**Purpose of travel**					

		VERY SATISFIED	SATISFIED	NEUTRAL	DISSATISFIED	VERY DISSATISFIED
0	**How satisfied are you with the rank/ facility which you are currently using on a scale of 1 to 5:**	**5**	**4**	**3**	**2**	**1**

	How important is the following to you on a rating scale of any number between 1 and 5:	VERY IMPORTANT	FAIRLY IMPORTANT	IMPORTANT	SLIGHTLY IMPORTANT	UNIMPORTANT
		5	**4**	**3**	**2**	**1**
1	Comfort and convenience (seating, shelter, ablutions, no overcrowding, short walking distances)					
2	Ramps for elderly and people carrying heavy shopping bags					
3	Personal security from crime (cameras, security guards, police, good lighting)					
4	Road traffic safety (Pedestrian crossings etc.)					
5	Provision of information(timetables, cost, directional signange, delays in transport)					
6	Ticketing (paying with one card for all modes)					
7	Ammenities (shopping, fast food, ATM's)					
8	Waiting time for transport (short waiting times)					

	How important is the following to you on a rating scale of any number between 1 and 5:	VERY IMPORTANT	FAIRLY IMPORTANT	IMPORTANT	SLIGHTLY IMPORTANT	UNIMPORTANT
		5	**4**	**3**	**2**	**1**
1.1	provision of Seating					
1.2	provision of Shelter					
1.3	provision of Ablutions					
1.4	No overcrowding at facilities					
1.5	Short walking distances within the rank					

	How important is the following to you on a rating scale of any number between 1 and 5:	VERY IMPORTANT	FAIRLY IMPORTANT	IMPORTANT	SLIGHTLY IMPORTANT	UNIMPORTANT
		5	**4**	**3**	**2**	**1**
2.1	Provision of ramps/ lifts, as an alternative to stairs					
2.2	Provision of railings or hand rails along ramps to hold onto while walking up the ramps					
2.3	Tactile surfaces - special paving for blind/ partially blind users with guidance stick					
2.4	Lowered kerbs/ ramps at road crossing points for wheelchairs, people with walking sticks etc					
2.5	Audible traffic signals - pedestrian crossing signals with beeping sound for hearing impaired users					

	How important is the following to you on a rating scale of any number between 1 and 5:	VERY IMPORTANT	FAIRLY IMPORTANT	IMPORTANT	SLIGHTLY IMPORTANT	UNIMPORTANT
		5	**4**	**3**	**2**	**1**
3.1	provision of Lighting					
3.2	provision of CCTV camera monitoring					
3.3	Presence of Police/ security gaurds					
3.4	provision of an Emergency help point					

How important is the following to you on a rating scale of any number between 1 and 5:		VERY IMPORTANT	FAIRLY IMPORTANT	IMPORTANT	SLIGHTLY IMPORTANT	UNIMPORTANT
		5	4	3	2	1
4.1	Provision of signalised pedestrian crossings					
4.2	Provision of speed humps to slow vehicles near pedestrian crossings					
4.3	provision of crossing guards at pedestrian crossings					

How important is the following to you on a rating scale of any number between 1 and 5:		VERY IMPORTANT	FAIRLY IMPORTANT	IMPORTANT	SLIGHTLY IMPORTANT	UNIMPORTANT
		5	4	3	2	1
5.1	Information on Timetables/ routes displayed at the rank					
5.2	information on Cost of travel for trips to be displayed at the rank					
5.3	Directional signage to be provided at the rank					
5.4	information on Service delays/ disruptions to be provided					

How important is the following to you on a rating scale of any number between 1 and 5:		VERY IMPORTANT	FAIRLY IMPORTANT	IMPORTANT	SLIGHTLY IMPORTANT	UNIMPORTANT
		5	4	3	2	1
6.1	Paying for all transport modes with one card					
6.2	Reducing the need to carry cash to pay for transport					

How important is the following to you on a rating scale of any number between 1 and 5:		VERY IMPORTANT	FAIRLY IMPORTANT	IMPORTANT	SLIGHTLY IMPORTANT	UNIMPORTANT
		5	4	3	2	1
7.1	provision of Retail/ shopping at the rank					
7.2	provision of Fast food/ take-aways at the rank					
7.3	provision of ATM's/ banks at the rank					

How **ACCEPTABLE** is the following to you on a rating scale of any number between 1 and 5:		VERY ACCEPTABLE	FAIRLY ACCEPTABLE	ACCEPTABLE	SLIGHTLY ACCEPTABLE	NOT ACCEPTABLE
		5	4	3	2	1
8.1	Waiting less than 10 minutes for transport at the rank					
8.2	Waiting between 11 minutes and 20 minutes for transport at the rank					
8.3	Waiting between 21 minutes and 30 minutes for transport at the rank					
8.4	Waiting more than 30 minutes for transport at the rank					

Informed consent

I, ... hereby voluntarily grant my permission for participation in the project as explained to me by Majesa Research & Project Management (Pty) Ltd. I understand my right to choose whether to participate in the project and that the information furnished will be handled confidentially. I am aware that the results of the investigation may be used for the purposes of publication.

Signature (Respondent) ..... Date: .....

Signature (Surveyor): ..... Date: .....

APPENDIX D – TRANSLATION OF KEY CONCEPTS FROM ENGLISH TO ISIZULU

Section A

Road traffic safety	Ukuphepha emgwaqeni
Personal security from crime	Ukuphepha ebugebengwini
Provision of information	Ukutholakala kolwazi (e-rank)
Integrated Ticketing	Amathikithi okugibela
Comfort and convenience	Ukuphatheka kahle (kwezokuthutha)
Provision of amenities: Retail/shopping Fast food/take-aways ATMs/banks)	 Izitolo Izindawo zokuthenga ukudla Amabhange
Waiting time for transport	Izinkathi zokulinda into zokuthutha
Ramps for elderly	Ama-ramp abantu abadala/asebekhulile

Section B

Seating	Indawo yokuhlala
Shelter	Umpheme
Ablutions	Izindawo zokuzikhulula?
No overcrowding	Ukungagcwali kakhulu (e-rank)
Short walking distance	Ukuhamba ibanga elifushane

Section C

Timetables/routes	Izinkathi/imizila
Cost of travel for trips	Inani lohambo
Directional signage	Imininingwane ngalapho ufuna ukuya khona
Service delays	Ukubambezeleka

Section D

Lighting	Ukuba khona kukagesi/ukukhanya
CCTV camera monitoring	Ama-khamera agadile
Police/security guards	Ukuba khona kwamaphoyisa noma onogada
Emergency help point	Ukuba khona kwabosizo lokuqala

Section E

Retail/shopping	Izitolo
Fast food/take-aways	Izindawo zokuthenga ukudla
ATMs/banks	Amabhange

APPENDIX E – LETTER FROM UNIVERSITY FOR QUANTITATIVE DATA COLLECTION

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

www.up.ac.za

FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

Dept of Civil Engineering-UP

TO WHOM IT MAY CONCERN

23 November 2018

Sumashni Moodley is currently enrolled in the MSc. (Applied Sciences) Transportation Planning course in the Department of Civil Engineering at the University of Pretoria, under the supervision of Prof. Christo Venter. Sumashni is in the process of writing a master's thesis on a public transport topic. For the purposes of educational research only, some surveys with public transport passengers will need to be undertaken. The focus of the surveys will be on the needs of passengers and identifying criteria to improve the experience of passengers at public transport facilities.

In order to undertake the surveys, Majesa Research & Project Management (Pty) Ltd have been requested to assist with engaging with passengers, facilitating the surveys and collecting data for the purposes of the master's research. The facilitator for this data collection to whom surveyors will be reporting to is Mr. TK Mbatha.

All data collected will be treated strictly as confidential and in accordance with the University's ethics guidelines. The data is used purely for academic purposes.

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APPENDIX F – STATISTICAL OUTPUT FROM SPSS – *T*-TESTS

Table F1: Group Statistics for comparing criteria and gender group

Group Statistics					
Criteria	Gender	N	Mean	Std. Deviation	Std. Error Mean
Comfort and convenience	Female	188	4.82	0.533	0.039
	Male	186	4.72	0.688	0.050
Universal access	Female	188	4.54	0.797	0.058
	Male	186	4.42	0.842	0.062
Personal security	Female	188	4.77	0.611	0.045
	Male	186	4.61	0.750	0.055
Road traffic safety	Female	188	4.29	0.868	0.063
	Male	186	4.29	0.800	0.059
Provision of information	Female	188	3.95	1.153	0.084
	Male	186	3.84	1.297	0.095
Integrated ticketing	Female	188	3.06	1.378	0.101
	Male	186	2.83	1.279	0.094
Provision of amenities	Female	188	3.55	1.280	0.093
	Male	186	3.36	1.245	0.091
Waiting times	Female	188	4.52	0.850	0.062
	Male	186	4.47	0.807	.059

Table F2: Independent samples T-test for comparing criteria by gender group

Independent Samples Test										
Criteria		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Comfort and convenience	Equal variances assumed	9.604	0.002	1.636	372	0.103	0.104	0.064	-0.021	0.229
	Equal variances not assumed			1.634	348.622	0.103	0.104	0.064	-0.021	0.229
Universal access	Equal variances assumed	2.601	0.108	1.453	372	0.147	0.123	0.085	-0.043	0.290
	Equal variances not assumed			1.453	370.357	0.147	0.123	0.085	-0.044	0.290
Personal security	Equal variances assumed	13.986	0.000	2.165	372	0.031	0.153	0.071	0.014	0.292
	Equal variances not assumed			2.163	355.752	0.031	0.153	0.071	0.014	0.292
Road traffic safety	Equal variances assumed	1.295	0.256	0.026	372	0.979	0.002	0.086	-0.168	0.172
	Equal variances not assumed			0.026	370.129	0.979	0.002	0.086	-0.167	0.172
Provision of information	Equal variances assumed	3.709	0.055	0.894	372	0.372	0.113	0.127	-0.136	0.363
	Equal variances not assumed			0.893	366.024	0.372	0.113	0.127	-0.136	0.363
Integrated ticketing	Equal variances assumed	2.211	0.138	1.715	372	0.087	0.236	0.138	-0.035	0.506
	Equal variances not assumed			1.716	370.476	0.087	0.236	0.137	-0.034	0.506
Provision of amenities	Equal variances assumed	1.653	0.199	1.437	372	0.152	0.188	0.131	-0.069	0.445
	Equal variances not assumed			1.437	371.891	0.152	0.188	0.131	-0.069	0.444
Waiting times	Equal variances assumed	0.004	0.951	0.500	372	0.617	0.043	0.086	-0.126	0.211
	Equal variances not assumed			0.500	371.374	0.617	0.043	0.086	-0.126	0.211

Table F3: Group Statistics for comparing elements and gender group

Group Statistics					
Elements	Gender	N	Mean	Std. Deviation	Std. Error Mean
seating	Female	188	4.77	0.693	0.051
	Male	186	4.79	0.554	0.041
shelter	Female	188	4.77	0.619	0.045
	Male	186	4.71	0.561	0.041
ablutions	Female	188	4.20	1.049	0.076
	Male	186	4.14	1.091	0.080
no overcrowding	Female	188	4.04	1.044	0.076
	Male	186	3.97	1.110	0.081
short walking distances	Female	188	4.13	1.049	0.076
	Male	186	3.86	1.163	0.085
ramps or lifts	Female	188	3.42	1.516	0.111
	Male	186	3.37	1.465	0.107
railings or handrails	Female	188	3.71	1.314	0.096
	Male	186	3.61	1.222	0.090
tactile surfaces	Female	188	4.34	0.871	0.064
	Male	186	4.24	0.856	0.063
lowered kerbs	Female	188	4.49	0.777	0.057
	Male	186	4.46	0.793	0.058
audible traffic lights	Female	188	4.31	0.959	0.070
	Male	186	4.36	0.903	0.066
lighting	Female	188	4.72	0.700	0.051
	Male	186	4.76	0.664	0.049
cctv cameras	Female	188	4.51	0.910	0.066
	Male	186	4.40	0.896	0.066
police or security	Female	188	4.37	0.936	0.068
	Male	186	4.44	0.888	0.065
emergency help point	Female	188	4.42	0.840	0.061
	Male	186	4.46	0.813	0.060
signalised pedestrian crossing	Female	188	4.37	0.901	0.066
	Male	186	4.33	0.957	0.070
speed humps	Female	188	4.25	0.940	0.069
	Male	186	4.22	1.060	0.078
crossing guards	Female	188	3.64	1.347	0.098
	Male	186	3.63	1.305	0.096
timetable info	Female	188	4.06	1.263	0.092
	Male	186	4.19	1.096	0.080

cost info	Female	188	4.11	1.156	0.084
	Male	186	4.11	1.029	0.075
directional signage	Female	188	3.96	1.067	0.078
	Male	186	3.81	1.004	0.074
service delay info	Female	188	4.20	1.134	0.083
	Male	186	4.09	1.114	0.082
paying with one travel card	Female	188	2.91	1.432	0.104
	Male	186	2.86	1.253	0.092
reduce the need to carry cash	Female	188	2.99	1.338	0.098
	Male	186	2.78	1.264	0.093
retail or shopping	Female	188	3.69	1.333	0.097
	Male	186	3.49	1.205	0.088
fast food or takeaway	Female	188	3.28	1.244	0.091
	Male	186	3.36	1.187	0.087
ATM or bank	Female	188	3.30	1.502	0.110
	Male	186	2.97	1.490	0.109
waiting less than 10 mins	Female	188	4.73	0.681	0.050
	Male	186	4.76	0.674	0.049
waiting 10 - 20 mins	Female	188	2.89	1.406	0.103
	Male	186	2.90	1.226	0.090
waiting 20 - 30 mins	Female	188	1.72	1.070	0.078
	Male	186	1.66	0.850	0.062
waiting more than 30 mins	Female	188	1.13	0.432	0.032
	Male	186	1.17	0.562	0.041

Table F4: Independent samples T-test for comparing elements by gender group

Independent Samples Test										
Elements		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
seating	Equal variances assumed	1.031	0.311	-0.375	372	0.708	-0.024	0.065	-0.152	0.103
	Equal variances not assumed			-0.376	356.457	0.707	-0.024	0.065	-0.152	0.103
shelter	Equal variances assumed	1.057	0.305	0.920	372	0.358	0.056	0.061	-0.064	0.177
	Equal variances not assumed			0.921	369.212	0.358	0.056	0.061	-0.064	0.176
ablutions	Equal variances assumed	0.919	0.338	0.515	372	0.607	0.057	0.111	-0.161	0.275
	Equal variances not assumed			0.515	371.055	0.607	0.057	0.111	-0.161	0.275
no overcrowding	Equal variances assumed	0.953	0.330	0.672	372	0.502	0.075	0.111	-0.144	0.294
	Equal variances not assumed			0.671	370.080	0.502	0.075	0.111	-0.144	0.294
short walking distances	Equal variances assumed	4.428	0.036	2.382	372	0.018	0.273	0.115	0.048	0.498
	Equal variances not assumed			2.381	367.229	0.018	0.273	0.115	0.047	0.498
ramps or lifts	Equal variances assumed	0.411	0.522	0.354	372	0.723	0.055	0.154	-0.249	0.358
	Equal variances not assumed			0.354	371.796	0.723	0.055	0.154	-0.249	0.358
railings or handrails	Equal variances assumed	0.960	0.328	0.761	372	0.447	0.100	0.131	-0.158	0.358
	Equal variances not assumed			0.762	370.591	0.447	0.100	0.131	-0.158	0.358
tactile surfaces	Equal variances assumed	0.068	0.794	1.103	372	0.271	0.099	0.089	-0.077	0.274
	Equal variances not assumed			1.103	371.984	0.271	0.099	0.089	-0.077	0.274
lowered kerbs	Equal variances assumed	0.201	0.654	0.333	372	0.740	0.027	0.081	-0.133	0.187

	Equal variances not assumed			0.333	371.659	0.740	0.027	0.081	-0.133	0.187
audible traffic lights	Equal variances assumed	2.605	0.107	-0.537	372	0.592	-0.052	0.096	-0.241	0.138
	Equal variances not assumed			-0.537	371.083	0.592	-0.052	0.096	-0.241	0.138
lighting	Equal variances assumed	1.121	0.290	-0.567	372	0.571	-0.040	0.071	-0.179	0.099
	Equal variances not assumed			-0.568	371.351	0.571	-0.040	0.071	-0.179	0.099
cctv cameras	Equal variances assumed	0.791	0.375	1.150	372	0.251	0.107	0.093	-0.076	0.291
	Equal variances not assumed			1.150	371.990	0.251	0.107	0.093	-0.076	0.291
police or security	Equal variances assumed	0.228	0.633	-0.669	372	0.504	-0.063	0.094	-0.249	0.122
	Equal variances not assumed			-0.669	371.322	0.504	-0.063	0.094	-0.249	0.122
emergency help point	Equal variances assumed	1.169	0.280	-0.430	372	0.667	-0.037	0.085	-0.205	0.131
	Equal variances not assumed			-0.430	371.822	0.667	-0.037	0.085	-0.205	0.131
signalized pedestrian crossing	Equal variances assumed	0.319	0.572	0.351	372	0.726	0.034	0.096	-0.155	0.223
	Equal variances not assumed			0.351	370.131	0.726	0.034	0.096	-0.155	0.223
speed humps	Equal variances assumed	0.966	0.326	0.285	372	0.775	0.030	0.104	-0.174	0.233
	Equal variances not assumed			0.285	365.781	0.776	0.030	0.104	-0.174	0.233
crossing guards	Equal variances assumed	0.088	0.767	0.067	372	0.947	0.009	0.137	-0.260	0.279
	Equal variances not assumed			0.067	371.843	0.946	0.009	0.137	-0.260	0.279
timetable info	Equal variances assumed	1.905	0.168	-1.060	372	0.290	-0.130	0.122	-0.370	0.111
	Equal variances not assumed			-1.060	365.823	0.290	-0.130	0.122	-0.370	0.111
cost info	Equal variances assumed	1.762	0.185	-0.010	372	0.992	-0.001	0.113	-0.224	0.221
	Equal variances not assumed			-0.010	367.924	0.992	-0.001	0.113	-0.224	0.221
directional signage	Equal variances assumed	0.041	0.839	1.409	372	0.160	0.151	0.107	-0.060	0.362
	Equal variances not assumed			1.409	371.076	0.160	0.151	0.107	-0.060	0.362
service delay info	Equal variances assumed	0.041	0.839	0.953	372	0.341	0.111	0.116	-0.118	0.339
	Equal variances not assumed			0.953	371.982	0.341	0.111	0.116	-0.118	0.339
	Equal variances assumed	5.908	0.016	0.355	372	0.723	0.049	0.139	-0.224	0.323

paying with one travel card	Equal variances not assumed			0.355	366.522	0.723	0.049	0.139	-0.224	0.323
reduce the need to carry cash	Equal variances assumed	0.579	0.447	1.558	372	0.120	0.210	0.135	-0.055	0.474
	Equal variances not assumed			1.558	371.189	0.120	0.210	0.135	-0.055	0.474
retail or shopping	Equal variances assumed	4.605	0.033	1.539	372	0.125	0.202	0.131	-0.056	0.461
	Equal variances not assumed			1.540	369.014	0.124	0.202	0.131	-0.056	0.461
fast food or takeaway	Equal variances assumed	0.526	0.469	-0.665	372	0.507	-0.084	0.126	-0.331	0.164
	Equal variances not assumed			-0.665	371.514	0.507	-0.084	0.126	-0.331	0.164
ATM or bank	Equal variances assumed	0.627	0.429	2.133	372	0.034	0.330	0.155	0.026	0.634
	Equal variances not assumed			2.133	371.997	0.034	0.330	0.155	0.026	0.634
waiting less than 10 mins	Equal variances assumed	0.507	0.477	-0.343	372	0.732	-0.024	0.070	-0.162	0.114
	Equal variances not assumed			-0.343	372.000	0.732	-0.024	0.070	-0.162	0.114
waiting 10 - 20 mins	Equal variances assumed	9.205	0.003	-0.070	372	0.944	-0.010	0.137	-0.278	0.259
	Equal variances not assumed			-0.070	366.236	0.944	-0.010	0.136	-0.278	0.259
waiting 20 - 30 mins	Equal variances assumed	7.018	0.008	0.568	372	0.570	0.057	0.100	-0.140	0.253
	Equal variances not assumed			0.569	355.467	0.570	0.057	0.100	-0.140	0.253
waiting more than 30 mins	Equal variances assumed	2.759	0.098	-0.856	372	0.392	-0.044	0.052	-0.146	0.058
	Equal variances not assumed			-0.855	347.151	0.393	-0.044	0.052	-0.146	0.058

APPENDIX G – STATISTICAL OUTPUT FROM SPSS – ONE-WAY ANOVA

Table G1: One-way Anova for comparing criteria by age group

ANOVA						
Criteria		Sum of Squares	df	Mean Square	F	Sig.
Comfort and convenience	Between Groups	0.647	2	0.324	0.852	0.428
	Within Groups	141.034	371	0.380		
	Total	141.682	373			
Universal access	Between Groups	0.637	2	0.318	0.471	0.625
	Within Groups	250.732	371	0.676		
	Total	251.369	373			
Personal security	Between Groups	0.509	2	0.254	0.538	0.585
	Within Groups	175.513	371	0.473		
	Total	176.021	373			
Road traffic safety	Between Groups	3.603	2	1.801	2.614	0.075
	Within Groups	255.630	371	0.689		
	Total	259.233	373			
Provision of information	Between Groups	18.236	2	9.118	6.233	0.002
	Within Groups	542.697	371	1.463		
	Total	560.933	373			
Integrated ticketing	Between Groups	8.293	2	4.146	2.350	0.097
	Within Groups	654.638	371	1.765		
	Total	662.930	373			
Provision of amenities	Between Groups	3.051	2	1.525	0.953	0.386
	Within Groups	593.676	371	1.600		
	Total	596.727	373			
Waiting times	Between Groups	1.289	2	.645	0.941	0.391
	Within Groups	254.200	371	.685		
	Total	255.489	373			

Table G2: Multiple comparisons for comparing criteria by age group (the mean difference is significant at the 0.05 level)

Multiple Comparisons							
Tukey HSD							
Dependent Variable	(I) Age Group	(J) Age Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
comfort and convenience	<18 (scholar)	18-55	0.027	0.078	0.935	-0.16	0.21
		>55 (elderly)	0.099	0.078	0.417	-0.09	0.28
	18-55	<18 (scholar)	-0.027	0.078	0.935	-0.21	0.16
		>55 (elderly)	0.072	0.078	0.626	-0.11	0.26
	>55 (elderly)	<18 (scholar)	-0.099	0.078	0.417	-0.28	0.09
		18-55	-0.072	0.078	0.626	-0.26	0.11
universal access	<18 (scholar)	18-55	-0.100	0.104	0.600	-0.34	0.14
		>55 (elderly)	-0.060	0.105	0.832	-0.31	0.19
	18-55	<18 (scholar)	0.100	0.104	0.600	-0.14	0.34
		>55 (elderly)	0.040	0.104	0.923	-0.20	0.28
	>55 (elderly)	<18 (scholar)	0.060	0.105	0.832	-0.19	0.31
		18-55	-0.040	0.104	0.923	-0.28	0.20
personal security	<18 (scholar)	18-55	-0.039	0.087	0.896	-0.24	0.17
		>55 (elderly)	0.051	0.088	0.828	-0.15	0.26
	18-55	<18 (scholar)	0.039	0.087	0.896	-0.17	0.24
		>55 (elderly)	0.090	0.087	0.556	-0.11	0.29
	>55 (elderly)	<18 (scholar)	-0.051	0.088	0.828	-0.26	0.15
		18-55	-0.090	0.087	0.556	-0.29	0.11
Road traffic safety	<18 (scholar)	18-55	0.238	0.105	0.061	-0.01	0.48
		>55 (elderly)	0.143	0.106	0.367	-0.11	0.39

	18-55	<18 (scholar)	-0.238	0.105	0.061	-0.48	0.01
		>55 (elderly)	-0.095	0.105	0.636	-0.34	0.15
	>55 (elderly)	<18 (scholar)	-0.143	0.106	0.367	-0.39	0.11
		18-55	0.095	0.105	0.636	-0.15	0.34
provision of information	<18 (scholar)	18-55	0.280	0.153	0.161	-0.08	0.64
		>55 (elderly)	0.543*	0.154	0.001	0.18	0.91
	18-55	<18 (scholar)	-0.280	0.153	0.161	-0.64	0.08
		>55 (elderly)	0.264	0.153	0.198	-0.10	0.62
	>55 (elderly)	<18 (scholar)	-0.543*	0.154	0.001	-0.91	-0.18
		18-55	-0.264	0.153	0.198	-0.62	0.10
integrated ticketing	<18 (scholar)	18-55	0.292	0.168	0.191	-0.10	0.69
		>55 (elderly)	-0.041	0.169	0.968	-0.44	0.36
	18-55	<18 (scholar)	-0.292	0.168	0.191	-0.69	0.10
		>55 (elderly)	-0.333	0.168	0.118	-0.73	0.06
	>55 (elderly)	<18 (scholar)	0.041	0.169	0.968	-0.36	0.44
		18-55	0.333	0.168	0.118	-0.06	0.73
provision of amenities	<18 (scholar)	18-55	-0.220	0.160	0.353	-0.60	0.16
		>55 (elderly)	-0.100	0.161	0.807	-0.48	0.28
	18-55	<18 (scholar)	0.220	0.160	0.353	-0.16	0.60
		>55 (elderly)	0.120	0.160	0.735	-0.26	0.50
	>55 (elderly)	<18 (scholar)	0.100	0.161	0.807	-0.28	0.48
		18-55	-0.120	0.160	0.735	-0.50	0.26
waiting times	<18 (scholar)	18-55	-0.124	0.105	0.461	-0.37	0.12
		>55 (elderly)	-0.125	0.105	0.460	-0.37	0.12
	18-55	<18 (scholar)	0.124	0.105	0.461	-0.12	0.37
		>55 (elderly)	-0.001	0.105	1.000	-0.25	0.25

	>55 (elderly)	<18 (scholar)	0.125	0.105	.460	-0.12	0.37
		18-55	0.001	0.105	1.000	-0.25	0.25

Table G3: One-way Anova for comparing elements by age group

ANOVA						
elements		Sum of Squares	df	Mean Square	F	Sig.
seating	Between Groups	1.650	2	0.825	2.112	0.122
	Within Groups	144.930	371	0.391		
	Total	146.580	373			
shelter	Between Groups	1.167	2	0.583	1.676	0.189
	Within Groups	129.154	371	0.348		
	Total	130.321	373			
ablutions	Between Groups	3.206	2	1.603	1.405	0.247
	Within Groups	423.182	371	1.141		
	Total	426.388	373			
no overcrowding	Between Groups	4.683	2	2.342	2.033	0.132
	Within Groups	427.306	371	1.152		
	Total	431.989	373			
short walking distances	Between Groups	11.074	2	5.537	4.545	0.011
	Within Groups	451.924	371	1.218		
	Total	462.997	373			
ramps or lifts	Between Groups	23.206	2	11.603	5.354	0.005
	Within Groups	804.016	371	2.167		
	Total	827.222	373			
railings or handrails	Between Groups	13.687	2	6.844	4.329	0.014

	Within Groups	586.505	371	1.581		
	Total	600.193	373			
tactile surfaces	Between Groups	13.263	2	6.632	9.280	0.000
	Within Groups	265.125	371	0.715		
	Total	278.388	373			
lowered kerbs	Between Groups	4.128	2	2.064	3.401	0.034
	Within Groups	225.155	371	0.607		
	Total	229.283	373			
audible traffic lights	Between Groups	.180	2	0.090	0.103	0.902
	Within Groups	323.042	371	0.871		
	Total	323.222	373			
lighting	Between Groups	3.008	2	1.504	3.275	0.039
	Within Groups	170.351	371	0.459		
	Total	173.358	373			
cctv cameras	Between Groups	7.597	2	3.799	4.744	0.009
	Within Groups	297.037	371	0.801		
	Total	304.634	373			
police or security	Between Groups	1.742	2	0.871	1.048	0.352
	Within Groups	308.292	371	0.831		
	Total	310.035	373			
emergency help point	Between Groups	2.429	2	1.214	1.790	0.168
	Within Groups	251.657	371	0.678		
	Total	254.086	373			
signalised pedestrian crossing	Between Groups	2.827	2	1.414	1.648	0.194
	Within Groups	318.288	371	0.858		
	Total	321.115	373			

speed humps	Between Groups	9.131	2	4.565	4.651	0.010
	Within Groups	364.163	371	0.982		
	Total	373.294	373			
crossing guards	Between Groups	9.446	2	4.723	2.717	0.067
	Within Groups	644.824	371	1.738		
	Total	654.270	373			
timetable info	Between Groups	6.999	2	3.500	2.519	0.082
	Within Groups	515.343	371	1.389		
	Total	522.342	373			
cost info	Between Groups	6.395	2	3.197	2.700	0.069
	Within Groups	439.327	371	1.184		
	Total	445.722	373			
directional signage	Between Groups	8.646	2	4.323	4.085	0.018
	Within Groups	392.638	371	1.058		
	Total	401.283	373			
service delay info	Between Groups	7.217	2	3.608	2.887	0.057
	Within Groups	463.695	371	1.250		
	Total	470.912	373			
paying with one travel card	Between Groups	22.205	2	11.103	6.319	0.002
	Within Groups	651.851	371	1.757		
	Total	674.056	373			
reduce the need to carry cash	Between Groups	10.226	2	5.113	3.039	0.049
	Within Groups	624.279	371	1.683		
	Total	634.505	373			
retail or shopping	Between Groups	8.369	2	4.184	2.605	0.075
	Within Groups	596.040	371	1.607		

	Total	604.409	373			
fast food or takeaway	Between Groups	11.103	2	5.552	3.814	0.023
	Within Groups	540.033	371	1.456		
	Total	551.136	373			
ATM or bank	Between Groups	11.974	2	5.987	2.674	0.070
	Within Groups	830.796	371	2.239		
	Total	842.770	373			
waiting less than 10 mins	Between Groups	.342	2	0.171	0.372	0.690
	Within Groups	170.527	371	0.460		
	Total	170.869	373			
waiting 10 - 20 mins	Between Groups	2.111	2	1.056	0.606	0.546
	Within Groups	646.028	371	1.741		
	Total	648.139	373			
waiting 20 - 30 mins	Between Groups	3.278	2	1.639	1.764	0.173
	Within Groups	344.744	371	0.929		
	Total	348.021	373			
waiting more than 30 mins	Between Groups	0.691	2	0.345	1.379	0.253
	Within Groups	92.924	371	0.250		
	Total	93.615	373			

Table G4: Multiple comparisons for comparing elements by age group (the mean difference is significant at the 0.05 level)

Multiple Comparisons							
Tukey HSD							
Dependent Variable	(I) Age Group	(J) Age Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
seating	<18 (scholar)	18-55	-0.108	0.079	0.358	-0.29	0.08
		>55 (elderly)	0.051	0.080	0.799	-0.14	0.24
	18-55	<18 (scholar)	0.108	0.079	0.358	-0.08	0.29
		>55 (elderly)	0.159	0.079	0.112	-0.03	0.34
	>55 (elderly)	<18 (scholar)	-0.051	0.080	0.799	-0.24	0.14
		18-55	-0.159	0.079	0.112	-0.34	0.03
shelter	<18 (scholar)	18-55	-0.061	0.074	0.690	-0.24	0.11
		>55 (elderly)	0.075	0.075	0.576	-0.10	0.25
	18-55	<18 (scholar)	0.061	0.074	0.690	-0.11	0.24
		>55 (elderly)	0.136	0.075	0.162	-0.04	0.31
	>55 (elderly)	<18 (scholar)	-0.075	0.075	0.576	-0.25	0.10
		18-55	-0.136	0.075	0.162	-0.31	0.04
ablutions	<18 (scholar)	18-55	-0.058	0.135	0.902	-0.38	0.26
		>55 (elderly)	0.161	0.136	0.463	-0.16	0.48
	18-55	<18 (scholar)	0.058	0.135	0.902	-0.26	0.38
		>55 (elderly)	0.219	0.135	0.237	-0.10	0.54
	>55 (elderly)	<18 (scholar)	-0.161	0.136	0.463	-0.48	0.16
		18-55	-0.219	0.135	0.237	-0.54	0.10
no overcrowding	<18 (scholar)	18-55	-0.006	0.135	0.999	-0.32	0.31
		>55 (elderly)	0.235	0.137	0.198	-0.09	0.56

	18-55	<18 (scholar)	0.006	0.135	0.999	-0.31	0.32
		>55 (elderly)	0.241	0.136	0.179	-0.08	0.56
	>55 (elderly)	<18 (scholar)	-0.235	0.137	0.198	-0.56	0.09
		18-55	-0.241	0.136	0.179	-0.56	0.08
short walking distances	<18 (scholar)	18-55	-0.249	0.139	0.174	-0.58	0.08
		>55 (elderly)	-0.421*	0.140	0.008	-0.75	-0.09
	18-55	<18 (scholar)	0.249	0.139	0.174	-0.08	0.58
		>55 (elderly)	-0.171	0.140	0.437	-0.50	0.16
	>55 (elderly)	<18 (scholar)	0.421*	0.140	0.008	0.09	0.75
		18-55	0.171	0.140	0.437	-0.16	0.50
ramps or lifts	<18 (scholar)	18-55	-0.257	0.186	0.350	-0.69	0.18
		>55 (elderly)	-0.611*	0.187	0.003	-1.05	-0.17
	18-55	<18 (scholar)	0.257	0.186	0.350	-0.18	0.69
		>55 (elderly)	-0.353	0.186	0.141	-0.79	0.08
	>55 (elderly)	<18 (scholar)	0.611*	0.187	0.003	0.17	1.05
		18-55	0.353	0.186	0.141	-0.08	0.79
railings or handrails	<18 (scholar)	18-55	-0.139	0.159	0.657	-0.51	0.23
		>55 (elderly)	-0.459*	0.160	0.012	-0.84	-0.08
	18-55	<18 (scholar)	0.139	0.159	0.657	-0.23	0.51
		>55 (elderly)	-0.320	0.159	0.110	-0.69	0.05
	>55 (elderly)	<18 (scholar)	0.459*	0.160	0.012	0.08	0.84
		18-55	0.320	0.159	0.110	-0.05	0.69
tactile surfaces	<18 (scholar)	18-55	0.059	0.107	0.843	-0.19	0.31
		>55 (elderly)	-0.367*	0.108	0.002	-0.62	-0.11
	18-55	<18 (scholar)	-0.059	0.107	0.843	-0.31	0.19
		>55 (elderly)	-0.427*	0.107	0.000	-0.68	-0.18

	>55 (elderly)	<18 (scholar)	0.367*	0.108	0.002	0.11	0.62
		18-55	0.427*	0.107	0.000	0.18	0.68
lowered kerbs	<18 (scholar)	18-55	0.002	0.098	1.000	-0.23	0.23
		>55 (elderly)	-0.223	0.099	0.065	-0.46	0.01
	18-55	<18 (scholar)	-0.002	0.098	1.000	-0.23	0.23
		>55 (elderly)	-0.224	0.099	0.060	-0.46	0.01
	>55 (elderly)	<18 (scholar)	0.223	0.099	0.065	-0.01	0.46
		18-55	0.224	0.099	0.060	-0.01	0.46
audible traffic lights	<18 (scholar)	18-55	-0.032	0.118	0.961	-0.31	0.25
		>55 (elderly)	0.022	0.119	0.982	-0.26	0.30
	18-55	<18 (scholar)	0.032	0.118	0.961	-0.25	0.31
		>55 (elderly)	0.053	0.118	0.894	-0.22	0.33
	>55 (elderly)	<18 (scholar)	-0.022	0.119	0.982	-0.30	0.26
		18-55	-0.053	0.118	0.894	-0.33	0.22
lighting	<18 (scholar)	18-55	-0.045	0.086	0.861	-0.25	0.16
		>55 (elderly)	0.164	0.086	0.138	-0.04	0.37
	18-55	<18 (scholar)	0.045	0.086	0.861	-0.16	0.25
		>55 (elderly)	0.209*	0.086	0.040	0.01	0.41
	>55 (elderly)	<18 (scholar)	-0.164	0.086	0.138	-0.37	0.04
		18-55	-0.209*	0.086	0.040	-0.41	-0.01
cctv cameras	<18 (scholar)	18-55	-0.067	0.113	0.826	-0.33	0.20
		>55 (elderly)	0.264	0.114	0.054	0.00	0.53
	18-55	<18 (scholar)	0.067	0.113	0.826	-0.20	0.33
		>55 (elderly)	0.331*	0.113	0.010	0.06	0.60
	>55 (elderly)	<18 (scholar)	-0.264	0.114	0.054	-0.53	0.00
		18-55	-0.331*	0.113	0.010	-0.60	-0.06

police or security	<18 (scholar)	18-55	0.154	0.115	0.377	-0.12	0.42
		>55 (elderly)	0.134	0.116	0.480	-0.14	0.41
	18-55	<18 (scholar)	-0.154	0.115	0.377	-0.42	0.12
		>55 (elderly)	-0.019	0.115	0.985	-0.29	0.25
	>55 (elderly)	<18 (scholar)	-0.134	0.116	0.480	-0.41	0.14
		18-55	0.019	0.115	0.985	-0.25	0.29
emergency help point	<18 (scholar)	18-55	-0.023	0.104	0.974	-0.27	0.22
		>55 (elderly)	-0.182	0.105	0.193	-0.43	0.06
	18-55	<18 (scholar)	0.023	0.104	0.974	-0.22	0.27
		>55 (elderly)	-0.159	0.104	0.279	-0.40	0.09
	>55 (elderly)	<18 (scholar)	0.182	0.105	0.193	-0.06	0.43
		18-55	0.159	0.104	0.279	-0.09	0.40
signalised pedestrian crossing	<18 (scholar)	18-55	0.034	0.117	0.955	-0.24	0.31
		>55 (elderly)	0.200	0.118	0.208	-0.08	0.48
	18-55	<18 (scholar)	-0.034	0.117	0.955	-0.31	0.24
		>55 (elderly)	0.166	0.117	0.333	-0.11	0.44
	>55 (elderly)	<18 (scholar)	-0.200	0.118	0.208	-0.48	0.08
		18-55	-0.166	0.117	0.333	-0.44	0.11
speed humps	<18 (scholar)	18-55	0.247	0.125	0.121	-0.05	0.54
		>55 (elderly)	0.379*	0.126	0.008	0.08	0.68
	18-55	<18 (scholar)	-0.247	0.125	0.121	-0.54	0.05
		>55 (elderly)	0.132	0.125	0.545	-0.16	0.43
	>55 (elderly)	<18 (scholar)	-0.379*	0.126	0.008	-0.68	-0.08
		18-55	-0.132	0.125	0.545	-0.43	0.16
crossing guards	<18 (scholar)	18-55	0.359	0.166	0.080	-0.03	0.75
		>55 (elderly)	0.310	0.168	0.156	-0.08	0.70

	18-55	<18 (scholar)	-0.359	0.166	0.080	-0.75	0.03
		>55 (elderly)	-0.049	0.167	0.954	-0.44	0.34
	>55 (elderly)	<18 (scholar)	-0.310	0.168	0.156	-0.70	0.08
		18-55	0.049	0.167	0.954	-0.34	0.44
timetable info	<18 (scholar)	18-55	-0.130	0.149	0.655	-0.48	0.22
		>55 (elderly)	0.202	0.150	0.370	-0.15	0.56
	18-55	<18 (scholar)	0.130	0.149	0.655	-0.22	0.48
		>55 (elderly)	0.333	0.149	0.068	-0.02	0.68
	>55 (elderly)	<18 (scholar)	-0.202	0.150	0.370	-0.56	0.15
		18-55	-0.333	0.149	0.068	-0.68	0.02
cost info	<18 (scholar)	18-55	-0.227	0.137	0.225	-0.55	0.10
		>55 (elderly)	0.081	0.138	0.829	-0.25	0.41
	18-55	<18 (scholar)	0.227	0.137	0.225	-0.10	0.55
		>55 (elderly)	0.308	0.138	0.067	-0.02	0.63
	>55 (elderly)	<18 (scholar)	-0.081	0.138	0.829	-0.41	0.25
		18-55	-0.308	0.138	0.067	-0.63	0.02
directional signage	<18 (scholar)	18-55	-0.272	0.130	0.093	-0.58	0.03
		>55 (elderly)	0.083	0.131	0.803	-0.23	0.39
	18-55	<18 (scholar)	0.272	0.130	0.093	-0.03	0.58
		>55 (elderly)	0.355*	0.130	0.018	0.05	0.66
	>55 (elderly)	<18 (scholar)	-0.083	0.131	0.803	-0.39	0.23
		18-55	-0.355*	0.130	0.018	-0.66	-0.05
service delay info	<18 (scholar)	18-55	-0.339*	0.141	0.044	-0.67	-0.01
		>55 (elderly)	-0.171	0.142	0.455	-0.51	0.16
	18-55	<18 (scholar)	0.339*	0.141	0.044	0.01	0.67
		>55 (elderly)	0.169	0.141	0.459	-0.16	0.50

	>55 (elderly)	<18 (scholar)	0.171	0.142	0.455	-0.16	0.51
		18-55	-0.169	0.141	0.459	-0.50	0.16
paying with one travel card	<18 (scholar)	18-55	0.377	0.167	0.064	-0.02	0.77
		>55 (elderly)	-0.211	0.169	0.424	-0.61	0.19
	18-55	<18 (scholar)	-0.377	0.167	0.064	-0.77	0.02
		>55 (elderly)	-0.588*	0.168	0.001	-0.98	-0.19
	>55 (elderly)	<18 (scholar)	0.211	0.169	0.424	-0.19	0.61
		18-55	0.588*	0.168	0.001	0.19	0.98
reduce the need to acrry cash	<18 (scholar)	18-55	0.371	0.164	0.062	-0.01	0.76
		>55 (elderly)	0.049	0.165	0.954	-0.34	0.44
	18-55	<18 (scholar)	-0.371	0.164	0.062	-0.76	0.01
		>55 (elderly)	-0.322	0.164	0.123	-0.71	0.06
	>55 (elderly)	<18 (scholar)	-0.049	0.165	0.954	-0.44	0.34
		18-55	0.322	0.164	0.123	-0.06	0.71
retail or shopping	<18 (scholar)	18-55	-0.330	0.160	0.100	-0.71	0.05
		>55 (elderly)	-0.304	0.161	0.145	-0.68	0.08
	18-55	<18 (scholar)	0.330	0.160	0.100	-0.05	0.71
		>55 (elderly)	0.026	0.160	0.986	-0.35	0.40
	>55 (elderly)	<18 (scholar)	0.304	0.161	0.145	-0.08	0.68
		18-55	-0.026	0.160	0.986	-0.40	0.35
fast food or takeaway	<18 (scholar)	18-55	-0.301	0.152	0.119	-0.66	0.06
		>55 (elderly)	0.104	0.154	0.778	-0.26	0.46
	18-55	<18 (scholar)	0.301	0.152	0.119	-0.06	0.66
		>55 (elderly)	0.405*	0.153	0.023	0.05	0.76
	>55 (elderly)	<18 (scholar)	-0.104	0.154	0.778	-0.46	0.26
		18-55	-0.405*	0.153	0.023	-0.76	-0.05

ATM or bank	<18 (scholar)	18-55	-0.349	0.189	0.156	-0.79	0.10
		>55 (elderly)	-0.406	0.190	0.085	-0.85	0.04
	18-55	<18 (scholar)	0.349	0.189	0.156	-0.10	0.79
		>55 (elderly)	-0.056	0.189	0.952	-0.50	0.39
	>55 (elderly)	<18 (scholar)	0.406	0.190	0.085	-0.04	0.85
		18-55	0.056	0.189	0.952	-0.39	0.50
waiting less than 10 mins	<18 (scholar)	18-55	-0.070	0.086	0.695	-0.27	0.13
		>55 (elderly)	-0.014	0.086	0.986	-0.22	0.19
	18-55	<18 (scholar)	0.070	0.086	0.695	-0.13	0.27
		>55 (elderly)	0.056	0.086	0.793	-0.15	0.26
	>55 (elderly)	<18 (scholar)	0.014	0.086	0.986	-0.19	0.22
		18-55	-0.056	0.086	0.793	-0.26	0.15
waiting 10 - 20 mins	<18 (scholar)	18-55	0.172	0.167	0.555	-0.22	0.56
		>55 (elderly)	0.033	0.168	0.979	-0.36	0.43
	18-55	<18 (scholar)	-0.172	0.167	0.555	-0.56	0.22
		>55 (elderly)	-0.140	0.167	0.680	-0.53	0.25
	>55 (elderly)	<18 (scholar)	-0.033	0.168	0.979	-0.43	0.36
		18-55	0.140	0.167	0.680	-0.25	0.53
waiting 20 - 30 mins	<18 (scholar)	18-55	0.193	0.122	0.254	-0.09	0.48
		>55 (elderly)	0.205	0.123	0.219	-0.08	0.49
	18-55	<18 (scholar)	-0.193	0.122	0.254	-0.48	0.09
		>55 (elderly)	0.012	0.122	0.995	-0.27	0.30
	>55 (elderly)	<18 (scholar)	-0.205	0.123	0.219	-0.49	0.08
		18-55	-0.012	0.122	0.995	-0.30	0.27
waiting more than 30 mins	<18 (scholar)	18-55	-0.020	0.063	0.948	-0.17	0.13
		>55 (elderly)	0.080	0.064	0.422	-0.07	0.23

	18-55	<18 (scholar)	0.020	0.063	0.948	-0.13	0.17
		>55 (elderly)	0.100	0.063	0.259	-0.05	0.25
	>55 (elderly)	<18 (scholar)	-0.080	0.064	0.422	-0.23	0.07
		18-55	-0.100	0.063	0.259	-0.25	0.05

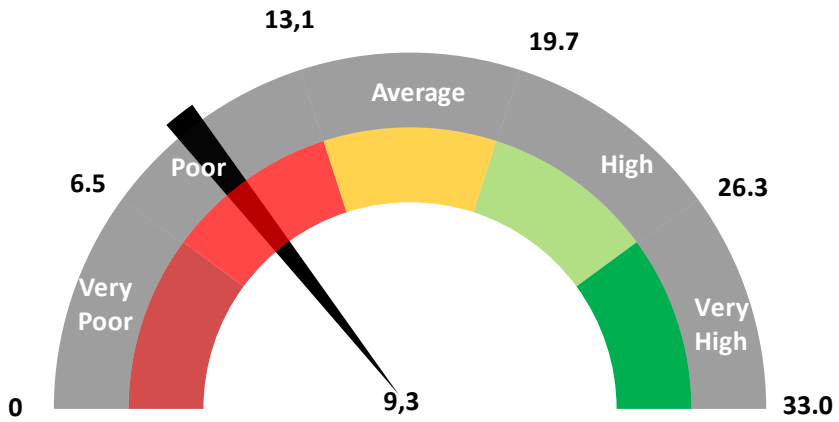
APPENDIX H – SPREADSHEET MODEL

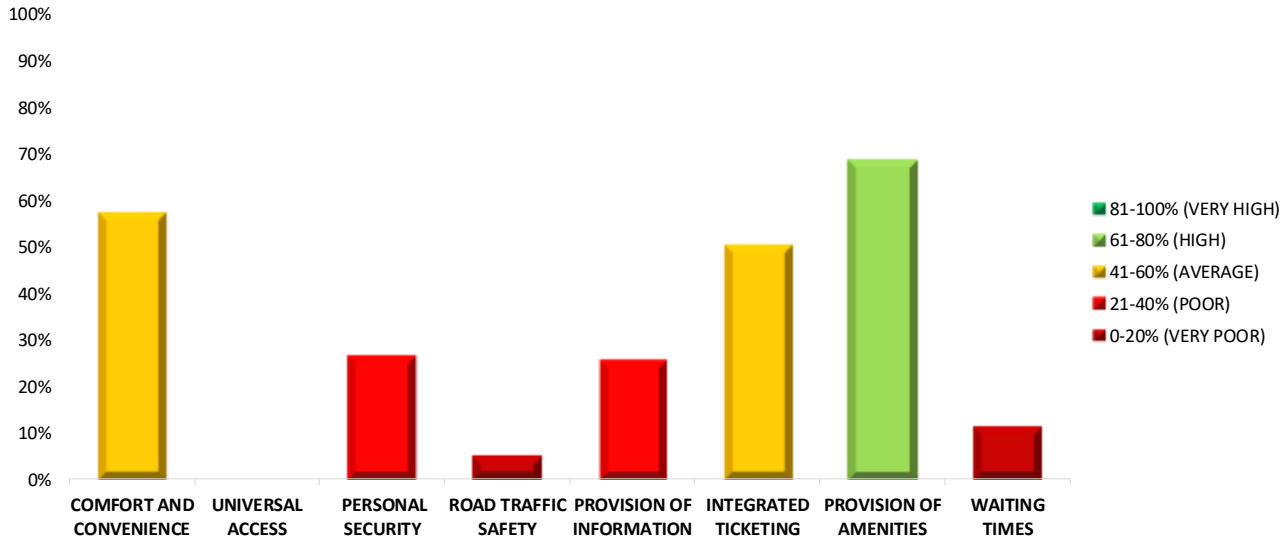
Name of Facility:	ISIPINGO	
Date of Audit:	2019/10/22 (6:30 -7:30)	
COMFORT AND CONVENIENCE	Seating	No
	Shelter	Yes
	ablutions	Yes
	Description of level of overcrowding	Excessive overcrowding
	Observations of percentage of passengers experiencing the following walking distances and comfort levels:	
	Short walking distance – comfortable < 400m	80%
	Medium walking distance – acceptable level of comfort 400-800m	15%
	Long walking distance – unacceptable level of comfort >800m	5%
UNIVERSAL ACCESS	Provision of ramps/ lifts as an alternative at facilities with stairs	No provision
	Provision of railings along ramps	No provision
	Tactile surfaces	No provision
	Lowered kerbs/ ramps at crossing points	No provision
	Audible traffic signals crossings	No provision
PERSONAL SECURITY	Provision of lighting:	Good/ adequate lighting provided
	CCTV camera monitoring	No
	Police/ security guards	No
	Emergency help point	No
ROAD TRAFFIC SAFETY	Provision of safe crossing	Unmarked or unprotected crossing (based on observed pedestrian desire line)
PROVISION OF INFORMATION	Provision of timetables/ routes	Yes
	Provision of fares/ cost of travel for trips	No
	Provision of Directional signage/ way-finding/ facility layout map	No
	Provision of Information on service delays/ disruptions	No
INTEGRATED TICKETING	Fare integration across modes	No
	Card system for at least one mode of travel	Yes
PROVISION OF AMENITIES	Retail/shopping	Yes
	Food	Yes
	ATM's/ banks	No
WAITING TIMES	Observation of percentage of passengers with the following average waiting times	
	0 minutes – 10 minutes	0%
	11 minutes – 20 minutes	0%
	21 minutes – 30 minutes	70%
	more than 30 minutes	30%

CRITERIA	ELEMENTS	ELEMENT WEIGHT	ASSIGNED AUDIT SCORE	ELEMENT SCORE
COMFORT AND CONVENIENCE	Seating	0,221	0	0
	Shelter	0,218	1	0,218
	ablutions	0,192	1	0,192
	Description of level of overcrowding	0,185	0	0
	Description of walking distance and comfort level	0,184	0,875	0,161
UNIVERSAL ACCESS	Provision of ramps/ lifts as an alternative at facilities with stairs	0,168	0	0
	Provision of railings along ramps	0,182	0	0
	Tactile surfaces	0,213	0	0
	Lowered kerbs/ ramps at crossing points	0,222	0	0
	Audible traffic signals crossings	0,215	0	0
PERSONAL SECURITY	Provision of lighting:	0,263	1	0,263
	CCTV camera monitoring	0,247	0	0
	Police/ security guards	0,244	0	0
	Emergency help point	0,246	0	0
ROAD TRAFFIC SAFETY	Provision of safe crossing	Weighting not used	0	0
PROVISION OF INFORMATION	Provision of timetables/ routes	0,253	1	0,253
	Provision of fares/ cost of travel for trips	0,253	0	0
	Provision of Directional signage/ way-finding/ facility layout map	0,239	0	0
	Provision of Information on service delays/ disruptions	0,255	0	0
INTEGRATED TICKETING	Fare integration across modes	0,500	0	0
	Card system for at least one mode	0,500	1	0,5
PROVISION OF AMENITIES	Retail/shopping	0,358	1	0,358
	Food	0,33	1	0,33
	ATM's/ banks	0,312	0	0
WAITING TIMES	Observation of average passenger waiting times	Weighting varies per time range	0,112	0,112

CRITERIA	RELATIVE IMPORTANCE WEIGHT	CRITERIA SCORE	RELATIVE IMPORTANCE WEIGHT * CRITERIA SCORE
COMFORT AND CONVENIENCE	4,773	0,571	2,725383
UNIVERSAL ACCESS	4,481	0	0
PERSONAL SECURITY	4,690	0,263	1,23347
ROAD TRAFFIC SAFETY	4,291	0	0
PROVISION OF INFORMATION	3,896	0,253	0,985688
INTEGRATED TICKETING	2,947	0,5	1,4735
PROVISION OF AMENITIES	3,455	0,688	2,37704
WAITING TIMES	4,495	0,112	0,50344

ISIPINGO

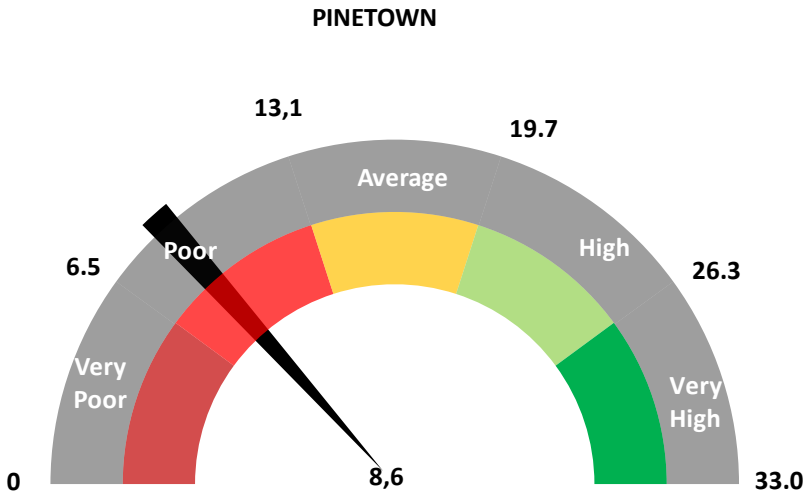


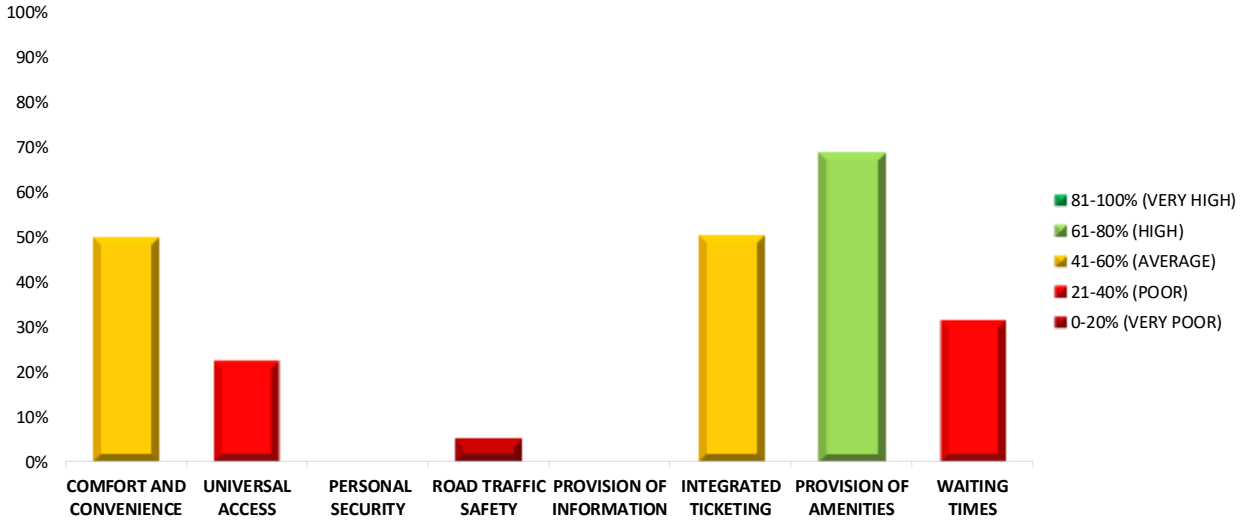


Name of Facility:	PINETOWN	
Date of Audit:	2019/10/23 (6:30 -7:30)	
COMFORT AND CONVENIENCE	Seating	Yes
	Shelter	No
	ablutions	Yes
	Description of level of overcrowding	Excessive overcrowding
	Observations of percentage of passengers experiencing the following walking distances and comfort levels:	
	Short walking distance – comfortable < 400m	10%
	Medium walking distance – acceptable level of comfort 400-800m	70%
	Long walking distance – unacceptable level of comfort >800m	20%
UNIVERSAL ACCESS	Provision of ramps/ lifts as an alternative at facilities with stairs	No provision
	Provision of railings along ramps	No provision
	Tactile surfaces	No provision
	Lowered kerbs/ ramps at crossing points	Good/ adequate provision
	Audible traffic signals crossings	No provision
PERSONAL SECURITY	Provision of lighting:	No lighting provided
	CCTV camera monitoring	No
	Police/ security guards	No
	Emergency help point	No
ROAD TRAFFIC SAFETY	Provision of safe crossing	Unmarked or unprotected crossing (based on observed pedestrian desire line)
PROVISION OF INFORMATION	Provision of timetables/ routes	No
	Provision of fares/ cost of travel for trips	No
	Provision of Directional signage/ way-finding/ facility layout map	No
	Provision of Information on service delays/ disruptions	No
INTEGRATED TICKETING	Fare integration across modes	No
	Card system for at least one mode of travel	Yes
PROVISION OF AMENITIES	Retail/shopping	Yes
	Food	Yes
	ATM's/ banks	No
WAITING TIMES	Observation of percentage of passengers with the following average waiting times	
	0 minutes – 10 minutes	0%
	11 minutes – 20 minutes	40%
	21 minutes – 30 minutes	40%
	more than 30 minutes	20%

CRITERIA	ELEMENTS	ELEMENT WEIGHT	ASSIGNED AUDIT SCORE	ELEMENT SCORE
COMFORT AND CONVENIENCE	Seating	0,221	1	0,221
	Shelter	0,218	0	0
	ablutions	0,192	1	0,192
	Description of level of overcrowding	0,185	0	0
	Description of walking distance and comfort level	0,184	0,45	0,0828
UNIVERSAL ACCESS	Provision of ramps/ lifts as an alternative at facilities with stairs	0,168	0	0
	Provision of railings along ramps	0,182	0	0
	Tactile surfaces	0,213	0	0
	Lowered kerbs/ ramps at crossing points	0,222	1	0,222
	Audible traffic signals crossings	0,215	0	0
PERSONAL SECURITY	Provision of lighting:	0,263	0	0
	CCTV camera monitoring	0,247	0	0
	Police/ security guards	0,244	0	0
	Emergency help point	0,246	0	0
ROAD TRAFFIC SAFETY	Provision of safe crossing	Weighting not used	0	0
PROVISION OF INFORMATION	Provision of timetables/ routes	0,253	0	0
	Provision of fares/ cost of travel for trips	0,253	0	0
	Provision of Directional signage/ way-finding/ facility layout map	0,239	0	0
	Provision of Information on service delays/ disruptions	0,255	0	0
INTEGRATED TICKETING	Fare integration across modes	0,500	0	0
	Card system for at least one mode	0,500	1	0,5
PROVISION OF AMENITIES	Retail/shopping	0,358	1	0,358
	Food	0,33	1	0,33
	ATM's/ banks	0,312	0	0
WAITING TIMES	Observation of average passenger waiting times	Weighting varies per time range	0,312	0,312

CRITERIA	RELATIVE IMPORTANCE WEIGHT	CRITERIA SCORE	RELATIVE IMPORTANCE WEIGHT * CRITERIA SCORE
COMFORT AND CONVENIENCE	4,773	0,4958	2,3664534
UNIVERSAL ACCESS	4,481	0,222	0,994782
PERSONAL SECURITY	4,690	0	0
ROAD TRAFFIC SAFETY	4,291	0	0
PROVISION OF INFORMATION	3,896	0	0
INTEGRATED TICKETING	2,947	0,5	1,4735
PROVISION OF AMENITIES	3,455	0,688	2,37704
WAITING TIMES	4,495	0,312	1,40244

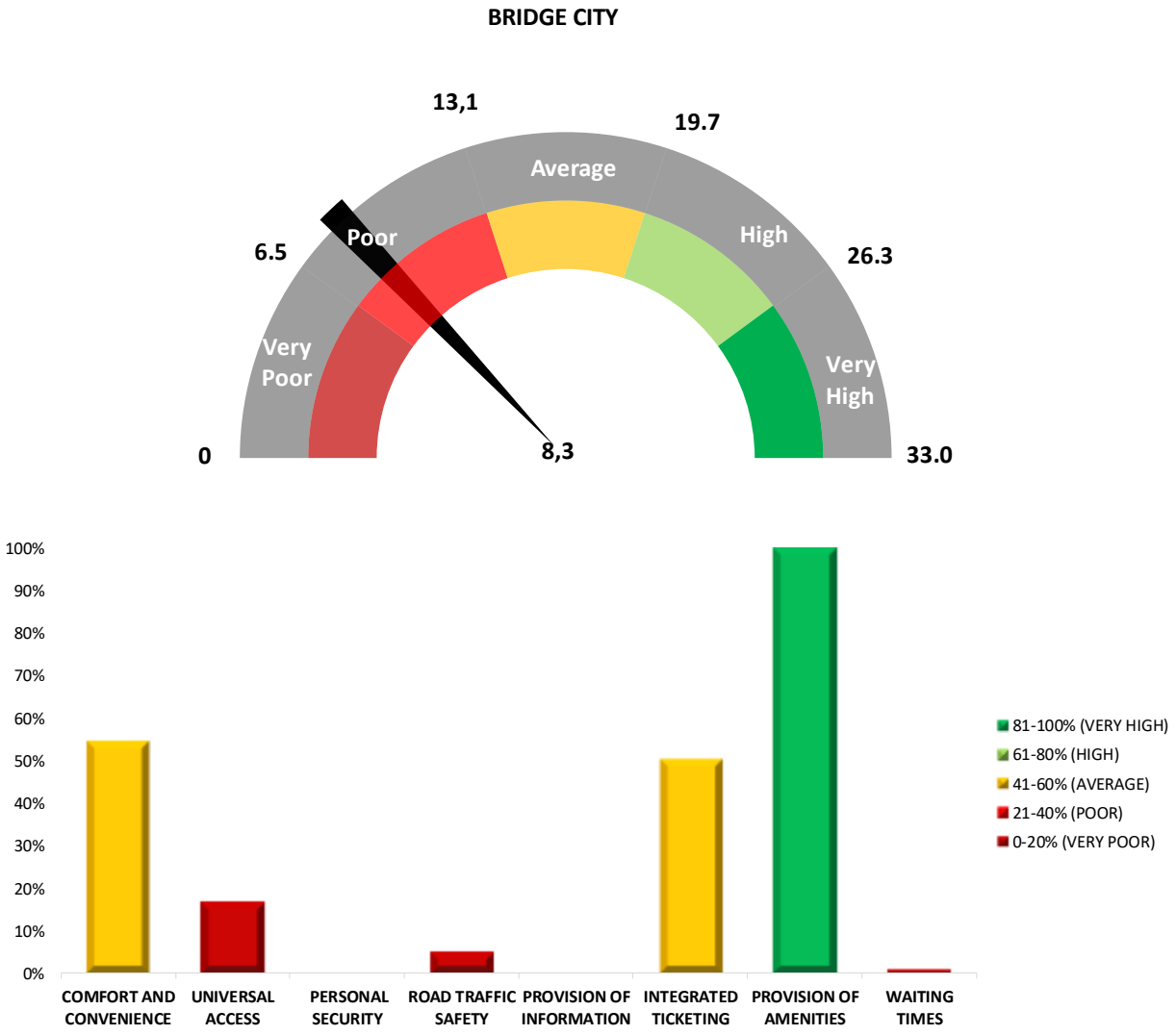




Name of Facility:	BRIDGE CITY	
Date of Audit:	2019/10/24 (6:30 -7:30)	
COMFORT AND CONVENIENCE	Seating	No
	Shelter	No
	ablutions	Yes
	Description of level of overcrowding	Little/ no overcrowding
	Observations of percentage of passengers experiencing the following walking distances and comfort levels:	
	Short walking distance – comfortable < 400m	80%
	Medium walking distance – acceptable level of comfort 400-800m	20%
	Long walking distance – unacceptable level of comfort >800m	0%
UNIVERSAL ACCESS	Provision of ramps/ lifts as an alternative at facilities with stairs	Good/ adequate provision
	Provision of railings along ramps	No provision
	Tactile surfaces	No provision
	Lowered kerbs/ ramps at crossing points	No provision
	Audible traffic signals crossings	No provision
PERSONAL SECURITY	Provision of lighting:	No lighting provided
	CCTV camera monitoring	No
	Police/ security guards	No
	Emergency help point	No
ROAD TRAFFIC SAFETY	Provision of safe crossing	Unmarked or unprotected crossing (based on observed pedestrian desire line)
PROVISION OF INFORMATION	Provision of timetables/ routes	No
	Provision of fares/ cost of travel for trips	No
	Provision of Directional signage/ way-finding/ facility layout map	No
	Provision of Information on service delays/ disruptions	No
INTEGRATED TICKETING	Fare integration across modes	No
	Card system for at least one mode of travel	Yes
PROVISION OF AMENITIES	Retail/shopping	Yes
	Food	Yes
	ATM's/ banks	Yes
WAITING TIMES	Observation of percentage of passengers with the following average waiting times	
	0 minutes – 10 minutes	0%
	11 minutes – 20 minutes	0%
	21 minutes – 30 minutes	5%
	more than 30 minutes	95%

CRITERIA	ELEMENTS	ELEMENT WEIGHT	ASSIGNED AUDIT SCORE	ELEMENT SCORE
COMFORT AND CONVENIENCE	Seating	0,221	0	0
	Shelter	0,218	0	0
	ablutions	0,192	1	0,192
	Description of level of overcrowding	0,185	1	0,185
	Description of walking distance and comfort level	0,184	0,9	0,1656
UNIVERSAL ACCESS	Provision of ramps/ lifts as an alternative at facilities with stairs	0,168	1	0,168
	Provision of railings along ramps	0,182	0	0
	Tactile surfaces	0,213	0	0
	Lowered kerbs/ ramps at crossing points	0,222	0	0
	Audible traffic signals crossings	0,215	0	0
PERSONAL SECURITY	Provision of lighting:	0,263	0	0
	CCTV camera monitoring	0,247	0	0
	Police/ security guards	0,244	0	0
	Emergency help point	0,246	0	0
ROAD TRAFFIC SAFETY	Provision of safe crossing	Weighting not used	0	0
PROVISION OF INFORMATION	Provision of timetables/ routes	0,253	0	0
	Provision of fares/ cost of travel for trips	0,253	0	0
	Provision of Directional signage/ way-finding/ facility layout map	0,239	0	0
	Provision of Information on service delays/ disruptions	0,255	0	0
INTEGRATED TICKETING	Fare integration across modes	0,500	0	0
	Card system for at least one mode	0,500	1	0,5
PROVISION OF AMENITIES	Retail/shopping	0,358	1	0,358
	Food	0,33	1	0,33
	ATM's/ banks	0,312	1	0,312
WAITING TIMES	Observation of average passenger waiting times	Weighting varies per time range	0,008	0,008

CRITERIA	RELATIVE IMPORTANCE WEIGHT	CRITERIA SCORE	RELATIVE IMPORTANCE WEIGHT * CRITERIA SCORE
COMFORT AND CONVENIENCE	4,773	0,5426	2,5898298
UNIVERSAL ACCESS	4,481	0,168	0,752808
PERSONAL SECURITY	4,690	0	0
ROAD TRAFFIC SAFETY	4,291	0	0
PROVISION OF INFORMATION	3,896	0	0
INTEGRATED TICKETING	2,947	0,5	1,4735
PROVISION OF AMENITIES	3,455	1	3,455
WAITING TIMES	4,495	0,008	0,03596



APPENDIX I – AUDIT FORM TEMPLATE

Name of Facility and location:
Date of Audit:
Name of person undertaking Audit:

1. COMFORT AND CONVENIENCE			
1.1 Seating	yes	no	
1.2 Shelter	yes	no	
1.3 ablutions	yes	no	
1.4 Description of level of overcrowding	Excessive overcrowding	Moderate overcrowding	Little/ no overcrowding
1.5 Description of walking distance and comfort level	% of passengers observed experiencing short walking distance – comfortable (<400m)	% of passengers observed experiencing medium walking distance – acceptable level of comfort (400-800m)	% of passengers observed experiencing long walking distance – unacceptable level of comfort (>800m)

2. UNIVERSAL ACCESS			
	Good/ adequate provision	Poor provision or existing infrastructure in disrepair	No provision
2.1 Provision of ramps/ lifts as an alternative at facilities with stairs			
2.2 Provision of railings along ramps			
2.3 Tactile surfaces			
2.4 Lowered kerbs/ ramps at crossing points			
2.5 Audible traffic signals crossings			

3. PERSONAL SECURITY			
3.1 Provision of lighting:	Good/ adequate lighting provided	Poor lighting/ existing lighting frequently out of order	No lighting provided
3.2 CCTV camera monitoring	yes	no	
3.3 Police/ security guards	yes	no	
3.4 Emergency help point	yes	no	

4. ROAD TRAFFIC SAFETY				
4.1 Provision of safe crossing	Underground or overhead pedestrian crossings (no ped-vehicle conflict)	Signalised pedestrian crossing	Unsignalized marked pedestrian crossing	Unmarked or unprotected crossing (based on observed pedestrian desire line)

5. PROVISION OF INFORMATION		
5.1 Provision of timetables/ routes	yes	no
5.2 Provision of fares/ cost of travel for trips	yes	no
5.3 Provision of Directional signage/ way-finding/ facility layout map	yes	no
5.4 Provision of Information on service delays/ disruptions	yes	no

6. INTEGRATED TICKETING		
6.1 Fare integration across modes	yes	no
6.2 Card system for all travel	yes	no

7. PROVISION OF AMENITIES		
7.1 Retail/shopping	yes	no
7.2 Food	yes	no
7.3 ATM's/ banks	yes	no

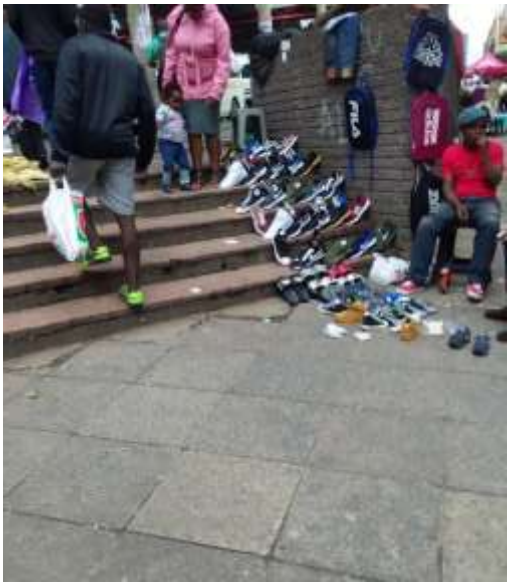
8. WAITING TIMES				
8.1 Observation of average passenger waiting times	% of passengers observed waiting 0 minutes – 10 minutes	% of passengers observed waiting 11 minutes – 20 minutes	% of passengers observed waiting 21 minutes – 30 minutes	% of passengers observed waiting more than 30 minutes

APPENDIX J – PHOTOGRAPHS OF ISIPINGO, PINETOWN AND BRIDGE CITY FACILITIES

ISIPINGO

Damaged loading aisles. Bins on the islands reduce the effective width and cause obstruction to passengers.	Pedestrians crossing in-between traffic
	
Shelter doesn't offer complete protection	Passenger walking with heavy shopping bags
	

PINETOWN

Trolley boy assisting passenger to mini-bus taxi with her shopping	No railing along stairs. Informal traders use this area, hindering passenger movements
	
Retail available in vicinity of rank	Passenger vehicle conflict
	

BRIDGE CITY

No shelter on rooftop facility. Trolley boy waiting to assist passenger with taking shopping to mini-bus taxi	Rank is shared with shopping Centre parking – increasing pedestrian-vehicle conflict
	
Retail, fast-food and banking facilities provided for	The loading islands have very high kerbs which is challenging for the elderly passengers and passengers with limited mobility to step up onto.