ICT-ENABLED PUBLIC TRANSPORTATION SYSTEMS BASED ON TRAVEL PATTERNS AND TRAVEL BEHAVIOUR CONSTRUCTS: THE CASE OF BLOEMFONTEIN AND GABORONE

by

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DECLARATION

I declare that the work in this thesis, submitted to the Central University of Technology, is my own original work, which has never been submitted to any other institution. Resources used in research towards this thesis have been acknowledged in citations and references.

30 June 2023

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NDAKHONA BASHINGI **DATE**

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ABSTRACT

Efficient public transportation is promoted as an alleviator of urban transportation problems for reasons of social, economic and environmental sustainability. Over the years, the development of information communication technologies (ICT) has been studied and promoted as a solution to many problems of urban sprawl, including urban transportation. In efforts to make transportation in urban areas more sustainable, the use of public and non-motorised transportation is endorsed over the use of private vehicles. However, the attractiveness of public transportation is limited by factors such as affordability and the users' level of desperation. Private vehicles offer the efficiency, reliability, comfort and freedom that the public transportation systems lack. It is suggested that ICT, which are envisaged to improve the attractiveness of public transportation by improving accessibility to travel information and limiting the need to travel, be incorporated into the public transportation systems to create ICT-enabled public transportation systems.

Information communication technologies can be used to assist and improve travel. It could change travel patterns and influence sustainable travel behaviour by providing platforms for planning, information and payment, as well as essentially increasing the effectiveness of public transportation and increasing its overall appeal. The attractiveness of public transportation would catalyse a modal shift from private to public transportation. It would also improve travel time, specifically those portions of time usually spent waiting for, and in, public transportation.

Spatio-temporal concerns about trips taken when using public transportation, including the number of trips caused by the inaccessibility of transportation services, time spent on travelling and waiting, as well as trip flow within an urban area all contribute to a disinterest in the use of public transportation. Therefore, public transportation planning that takes into consideration the desired extended socioeconomic sustainability was investigated. Travel behaviour and patterns in the cities of Bloemfontein, South Africa, and Gaborone, Botswana, were explored to identify trends and ways in which ICT could be incorporated to promote sustainable travel patterns, behaviour and ICT-enabled public transportation systems.

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The research was divided into two studies, both using data gathered through questionnaire surveys conducted in Bloemfontein and Gaborone. The first study was focused on reviewing the socioeconomic factors influencing travel within the cities. The present state of public transportation based on users' experiences and perceptions was assessed. Land-use for areas of residence and regular travel, travel distance, and transportation accessibility were also examined to determine spatial influences on travel and accessibility. Accessibility of transportation was assessed in terms of distance and time travelled regularly, as well as the modes of transportation used. Modal split and factors influencing the choice to use a mode of transportation were also determined. Thereafter, private vehicle usage, its influences, and various possibilities of modal shift were evaluated. The influence of ICT on current travel behaviour and patterns, as well as possibilities for the use of ICT in travel and improving the sustainability of public transportation systems were also assessed. The analysis showed the need for ICT to improve public transportation, as well as to increase ridership. However, private vehicle use is still prevalent, and users are not willing to shift modes, unless there are specific improvements implemented in the public transportation systems.

The main focus of the second study was on travel patterns and the use of ICT by public transportation users. Geographical trip origins and destinations of individual public transportation users were analysed to identify travel patterns and trip formations. The analysis showed a concentration of destinations for work trips in the central areas of both cities and the dispersions of residential areas. Most public transportation trips originate from less affluent areas of the cities, ending in the city centres and areas of mixed land-use. Access to ICT is high, but its usage for travel purposes is uncommon among public transportation users in both cities. Activities based on ICT performed during travel are not travel-related, but mostly of a social and entertainment nature. Furthermore, substituting ICT for travel, thereby reducing the need to travel, is attractive to public transportation users, but currently, there are limited structures in place for most regular activities, education and work purposes.

Based on the analysis of the results of the study, guidelines and recommendations for sustainable public transportation are presented in this study. Inclusive transportation planning to accommodate all demographics of the study areas, land-use zoning

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measures that promote transportation accessibility, as well as measures and considerations for integrating ICT are suggested. Policy considerations for future public transportation systems, as well as guidelines for ICT-enabled public transportation are also offered in the study.

Keywords: Public transportation, travel patterns, travel behaviour, land-use, ICT-enabled public transport, information communication technologies

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PUBLICATIONS FROM THIS RESEARCH

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LIST OF ABBREVIATIONS AND ACRONYMS

ALS	Area Licence Scheme
ANPR	Automatic Number Plate Recognition
ASI	Avoid-Shift-Improve
ATIS	Advanced Traveller Information Systems
BLR	Binary Logistic Regression
BRT	Bus Rapid Transit
BWP	Botswana Pula
DCO	Downtown Congestion Pricing
DOI	Diffusion of Innovations
DOT	Department of Transport
DRTS	Department of Road Transport and Safety
ERP	Electronic Road Pricing
GB	Gigabyte
GIS	Geographic Information Systems
GHG	Green House Gas
GPS	Global Positioning System
GT	Green Transportation
IBL	Interstate Bus Lines
IPET	Individual Persuasive Eco-Travel Technology
IPTN	Integrated Public Transport Network
ITS	Intelligent Transportation Systems
ITU	International Telecommunication Union
Mb	Megabyte
NDP	National Development Plan
NMT	Non-Motorised Transportation
MaaS	Mobility as a Service
MSA	Moving South Africa
OD	Origin-Destination
OECD	Organisation for Economic Co-operation and Development
PT	Public Transportation
RSA	Republic of South Africa
SADC	Southern African Development Community
ST	Sustainable Transition

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STI	Sustainable Transport Indicators
TAM	Technology Acceptance Model
TIS	Traveller Information Systems
TNC	Transport Networking Company
TPB	Theory of Planned Behaviour
TTM	The Transtheoretical Model
UN	United Nations
USSD	Unstructured Supplementary Services Data
UTAUT	Unified Theory of Acceptance and Use of Technology
V2I	Vehicle-to-Infrastructure
V2G	Vehicle-to-Grid
V2V	Vehicle-to-Vehicle
VSL	Variable Speed Limit
VTBC	Voluntary Travel Behaviour Change
WCED	World Commission on Environmental Development
ZAR	South African Rand

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CHAPTER 1: OVERVIEW OF THE STUDY

1.1 Introduction

Transportation systems are a vital element to the functionality of cities across the globe. The efficacy of transportation networks determines the potential and reliability of a city's social and economic growth. Transportation connects land uses and functions within a city by transferring commodities and people from one place to another, allowing socioeconomic progress and daily operations that enable the cities' functions to take place. Cascetta (2013:1) describes transportation systems as a "*combination of elements and their interactions, which produce the demand for travel within a given area and the supply of transportation services to satisfy this demand"* (Cascetta, 2013). Growth in population numbers and consequently, the corresponding functions of urban areas led to increased human activity, which in turn, intensified the need for transportation. Transportation forms an integral, yet challenging part of the urban environment where the continued development of vehicles, construction of transportation infrastructure, growth in demand for transportation, as well as the need to create transportation systems that equally serve all of society are expansive. The provision of equitable mobility and accessibility, and facilitating travel behaviour that promotes socio-economic and environmental sustainability are some of the challenges faced by transportation systems. The Brundtland Report implies that it is important to fulfil the needs of the poor. Therefore, public transportation should be affordable and accessible to poorer communities to be deemed sustainable (WCED, 1987). As there is often poor infrastructure in the less advantaged areas of cities, public transport is often also limited in such areas. This forces the city's poor to walk longer distances to reach designated public transportation terminals or use informal public transportation.

This research provides a theoretical foundation for public transportation systems in Southern African cities through the application of ICT. First, the study explored the concepts of travel behaviour and travel patterns and thereafter, it explored the application of ICT in public transportation. The research shows the current state of travel. It also incorporates travellers' needs, interests and expectations to predict their practicality for inclusion in ICT-enabled public transportation systems. In this chapter, the concepts that are fundamental to the study are outlined, including the crucial

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characteristics of travel patterns, travel behaviour and ICT-enabled public transportation systems in the areas selected for the study.

1.1.1 Public transportation systems

The function of transportation systems is to provide individuals with mobility and access to activities, places and services through spatio-temporal engagements (Miller, 2018; Ravensbergen et al., 2021). According to Hall, Le-Klähn and Ram (2017), public transportation refers to transportation services operating on fixed and non-fixed routes, offered to the public. UN-Habitat (2018:8) defines public transportation as "*shared passenger transportation services that are available to the general public and which are provided for the public good".* Daganzo and Ouyang (2019:1) describe that the purpose of public transportation is to economically enable efficient movement of passengers in large numbers from origin to destination. The system is considered less detrimental to the environment because it serves many passengers at a time, reducing the number of vehicle-kilometres (Daganzo and Ouyang, 2019:2). Abdallah (2017:13) highlights that since sustainability principles are based on not compromising future generations' needs, the negative consequences of fossil fuel use that are perpetuated by the dominance of private vehicle use can be solved by public transportation.

Road public transportation provides alternative transportation to private vehicle travel and it is a much-needed service to individuals who do not have access to personal transportation. It is expected to meet the demands of all by being economical, efficient and less detrimental to the environment; hence, the continued improvement to meet the rising travel demand. To accommodate the expanding population numbers, the increasing demand for travel, and the congestion levels, first-world countries have developed high-speed passenger trains, Bus Rapid Transit systems, and park and ride infrastructure. Developed countries also encourage travellers to use bicycles or e-bikes. Improvements in public transportation have been in the form of vehicular structure, improving the services offered, reduced waiting and travel times, and providing real-time travel information. However, in developing countries, the demand for private vehicle ownership is expected to increase (Daly et al., 2014), while some cities' public transportation systems are still using conventional methods of transporting passengers on standard buses and minibus taxis, thus making their services less desirable. There is widespread dissatisfaction with passenger transport in South Africa as the system is insufficiently customer-orientated and inefficient

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(Department of Transport, 2016). Generally, public transportation is unsafe, but minibus taxis are riskier as their drivers often ignore the safety of passengers by speeding, stopping illegally at intersections where there are no bus stops to pick up or drop off passengers, and they frequently disregard traffic signs and rules (Madejski et al., 2014).

Technological advancements and more exposure have facilitated the adoption of new technologies in several areas, including transportation. For example, Vuchic (2007) summarised significant events in the evolution of technologies in urban public transportation from the 1600s' Hackney coaches in London, to the 1888 electric streetcar lines in Virginia, and in 1899, the motorbuses in London. This progressed in 1962 to fully automated rapid transit lines in New York, in 1972 to computer-controlled rapid transit systems of San Francisco, and between 1993 and 2002, fully automated full-size metro lines in Lyon, Paris and Singapore. The noticeable change from vehicle types, automation to incorporation of computers and intelligent transportation systems (ITS) into systems is apparent. However, ITS are applied in a number of urban transportation systems. They use road transportation technology to monitor and regulate traffic, and provide real-time information. The use of ICT in transportation is expected to grow in the future (Gössling, 2017). Using the International Telecommunication Union (ITU)'s concept of sustainable areas (ITU, 2014:12), transportation systems should be connected with ICT to be deemed sustainable.

ICT in public transportation has mostly benefited service providers rather than customers. It includes ticketing systems for revenue management, automated vehicle location for monitoring and accountability, and data management systems for administrative purposes (Scholz, 2016). Using technology to benefit public transportation users will increase the system's sustainability by encouraging a shift away from the public's reliance on private vehicles and towards drawing more people to public transportation. However, the emphasis should not be just on technology; people's social behaviour and its impacts should also be researched, as they play a key part in travel preferences. It is critical to integrate the intricacies of travel behaviour in the research of sustainable transportation.

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1.1.2 Travel behaviour and travel patterns

Travel behaviour is concerned with performing activities in different places, at different times and moving from one place to another, which encompasses human emotions, feelings, attitudes, and perceptions, as well as beliefs (Goulias, Davis and McBride, 2020:2). Regular travellers make decisions about travel on a daily basis. These travel-based decisions include where to travel to, what mode of transportation to use, travelling times, and activities during travel and where the trip begins and ends. Travel behaviour also contributes to the sustainability of a transportation system. Regular choices, reasons and habits displayed in the way people travel, frequency of travel, and mode of travel all create patterns for the transportation system. Steg (2007:59) examined sociocultural and psychological variables influencing vehicle use, and concluded that owning a car is more appealing than using any alternative forms of transportation (Steg, 2007).

Pre-determined locations based on a city's land-use and zoning practices all influence travel behaviour. Other influences are the sequence of activities as determined by the individual or dictated by their social condition, their location of residence, places of work, education, shopping or entertainment, and the modes of transportation available to users, vehicle ownership and time.

Travel behaviour generates ingrained travel patterns that travellers carry with them every day. Travel patterns are "*patterns formed by trips over a period of time, such as a day*" (Kitamura, 2001:1). Kitamura defined urban activity patterns as the link between human activities in areas of the city, and spatial and temporal patterns (Kitamura, 2001:1). Cascetta emphasises that the social and economic components of a system in a geographical area interact differently, based on the level of intensity (Cascetta, 2013:1). Geographical variables and urban land-use zoning influence mobility and accessibility, and thereby affect both time and space. Location of residences, transportation networks, and public transportation terminals affect how people move and access different parts of the city or beyond.

Public transportation might be considered a mitigating solution towards achieving sustainable travel; however, it is not without its drawbacks. Problems encountered by public transportation users range from socioeconomic to psychological issues, and the

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lack of offering addressing personal preferences. Walters (2013) claims that Southern African transportation systems lack technological involvement.

1.1.3 ICT-enabled public transportation

The progression of the "smart evolution" has raised questions on sustainability, and how the growth in these ICT aspects will sustain the cities' urban characteristics, quality of life and economic growth (Black and Van Geenhuizen, 2006; Bhat and Pendyala, 2012). ICT is thought to have an impact on individuals' travel behaviour and the patterns of both private and public transportation travel worldwide. ICT usage is recognised as improving transportation network performance, the reliability of travel times, and leading to changes in travel behaviour. This may also lead to the reduction of externalities, such as unreliability and congestion (Pendyala and Bhat, 2012), induced by an increase in private vehicles on the roads. ICT has also been used as a tool to draw people from private vehicle usage towards public transportation usage to achieve sustainable mobility (Strömberg et al., 2016) by providing information on the internet, on information displays, and by offering improved travel information and personalised travel planners, persuading people to change their travel behaviour.

The use of ICT-based solutions has the potential to promote a shift from private vehicle use to the use of public transportation, and to influence sustainable travel behaviour and generally improve the state of public transportation in cities. Black and Van Geenhuizen (2006:41) depicted the unsustainability of the current transport patterns as a function of traffic volumes, as the increased numbers of vehicles on the roads lead to more vehicles/kilometres travelled, more car accidents, increased fuel consumption, as well as road network congestion. Sustainable travel is also based on socioeconomic as well as environmental factors, such as affordability, energy efficiency, safety, pollution, and equity (Miller, Witlox and Tribby, 2013).

ICT is used in public transportation logistics by operators, the ITS used by cities' transportation departments and by public transportation customers through mobile applications (Alessandro, Sara and Riccardo, 2011). Some uses of ICT include customer feedback to operators and driver communication systems (Mulligan, 2007; Goh and Fraser, 2012; Gössling, 2017). Potentially, the use of ICT could improve the efficiency of public transportation through digital technologies, without necessarily building new physical infrastructure and where properly executed, may alleviate congestion (Mulligan, 2007; Snellen and de Hollander, 2017; Abejide, Adedeji and

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Mostafa-Hassan, 2018). The role of ICT in road public transportation has already greatly improved the reliability and effectiveness of passenger transportation services. Example are the use of smart cards for fare payment in major cities such as Cape Town, London and Melbourne, and the use of mobile phone payment methods, such as Lipa-Na-Mpesa in Kenya. Another example is online booking and payment for bus seats through service providers' web portals on computer and mobile application based platforms, and real-time information provision through Dynamic Message Signs at public transportation terminals, through social networks and alert text messages. These are some examples of consumer-based satisfactory technologies in public transportation. Public transportation service providers have also been able to keep track of their vehicles through Automatic Vehicle Location (AVL) for safety and security reasons, and also provide real-time information to customers (Barabino, Di Francesco and Mozzoni, 2015; Gilmore and Reisbergen, 2015).

1.1.4 Public transportation systems in Southern Africa

Southern African countries include Zimbabwe, Zambia, Botswana, Lesotho, Mozambique, Swaziland, South Africa, Malawi, Namibia and Angola. Most cities in Southern Africa are growing rapidly, and people with different income levels are found in these cities – high income, middle and low income and the urban poor. Rapid population growth also means that there are increased road congestion levels and travel times as a result of more vehicles being on the roads and the high demand for transportation. The perception of public transportation has suffered as a result of political instability in countries such as Zimbabwe and Angola, and the limited availability of bus services, the poor infrastructure and overcrowding of the limited buses available (Vines and Weimer, 2011; Bonga and Sithole, 2020). Most minibus taxis making up the transportation systems are privately owned. Bus services, such as Zimbabwe's ZUPCO (Zimbabwe Passenger Company) and Mozambique's Transportes Publicos De Maputo (TPM), are state owned, while in some countries, there are partnerships between the minibus taxi owners and the state, in that some transport services are privately owned or subsidised by the government (Mbara, 2006; Walters, 2013).

It was noted in the Brundtland Report that it is necessary to meet the needs of the poor and, therefore, that public transportation should be affordable and accessible to

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poorer communities in order to be considered sustainable by all sections of the population (WCED, 1987). Since there is often poor infrastructure in less advantaged areas of the cities, public transportation is often very limited in such areas, resulting in longer walking times for the city's poor when they want to reach legitimate public transportation stops or to use informal public transportation.

Comparing local transportation systems with those of cities in both developed and developing countries with better transportation systems, Bloemfontein and Gaborone's systems are poor. Cities in developed countries, for example London and Beijing, have advanced, highly accessible public transportation systems comprising underground rail, light rail, road-based and Non-Motorised Transportation (NMT) modes. ICT-enablement is highly embedded in these systems, evident through easily accessible online information, smart payment and ticketing systems, and information display systems in vehicles and at public transportation platforms.

In developing countries, cities such as Dar es Salaam have BRT systems (Joseph et al., 2022), while Nairobi has a system of buses, minibuses and taxis. However, Nairobi also has a distinct application of ICT in transportation through the Mpesa payment system. The cities of Johannesburg, Pretoria and Cape Town in South Africa have better, integrated public transportation systems compared to other countries in Southern Africa. Public transportation in most cities in Southern Africa consists of buses, minibuses and saloon cabs and, in bigger cities, such as Johannesburg and Cape Town, railway services are also available. The City of Cape Town has harnessed the ICT-enabled MyCiti rapid transit system with a smartcard ticketing system, real-time information availability, a mobile application and journey planning platform. This is in stark contrast to the lack of technological involvement observed by Walters (2013) in the current state of public transport in Bloemfontein and Gaborone.

1.2 Background to the Problem

Growing concerns about undesirable aspects of public transportation are highlighting the gradual shift away from public to private transportation use in many cities. There is increasing car ownership in South Africa and Botswana (Mokonyama and Venter, 2007; Statistics Botswana, 2017b) and in both cities that were examined in this study. The need to own private vehicles could be a result of social standing (car ownership) or essential extremities, such as the lack of accessibility to amenities (Mokonyama

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and Venter, 2007). Increasing levels of car ownership pose a threat to sustainable transportation and the environment; hence, it is necessary for sustainable public transportation to address and overcome some urban transportation issues. Public transportation has been studied as a way to promote sustainable urban transportation, based on factors, such as its high occupancy, speed, and convenience. These beneficial factors are taken for granted in most developed countries. However, public transportation systems in Southern African countries are not at the same level of operation, organisation or efficiency. Thus, it is necessary for developing countries in Southern Africa to address and mitigate the urban transportation problems. High levels of private car ownership are linked to increased traffic volumes, congestion, and increased emissions, which will lead to ongoing and even increasing issues of unsustainability in future if no mediation measures are put in place (Luke, 2018). A modal shift to public transportation has been suggested as a way to reduce the volume of private vehicles on the roads. The purpose of a modal shift to public transportation is to promote sustainable travel patterns and behaviour. It is necessary to attract far more people to public transportation and discourage the use of private vehicles. ICT-enabled public transportation systems could be used to assist in this process.

How people travel, their modes of travel and decisions related to their movement from one place to another, as well as the frequency of their travel are influenced by various factors. Low use of public transportation translates into low demand, which will lead to low levels of profitability of the systems. Reasons given by users include factors, such as the lack of public transportation services and, in some cases, the poor quality of the public transportation service (Luke, 2018). Poor quality services in public transport are attributed to unreliability and the lack of safety, among other factors. Dissatisfaction with the systems has played a major role in travel behaviour and travel patterns. Mode choice is also an important contributory factor towards travel behaviour.

The incorporation of ICT into most aspects of urban life includes the inclusion in the transportation systems, and this could also influence travel behaviour and patterns (Black and Van Geenhuizen, 2006). ICT has been incorporated into transportation systems to improve efficiency, monitor travel, assist traffic control, and improve communication systems within a transportation system, and for transactions within the transportation system. ICT is important both in private and public passenger

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transportation. The use of ICT for GPS, mapping, directions, payments, entertainment and general information dissemination in transportation influences individuals' travel behaviour (Black and Van Geenhuizen, 2006; Mokhtarian and Tal, 2013; Thomopoulos, 2015). Employment of ICT in public transportation can be leveraged to improve the system and create demand for public transportation, based on efficiencies created by the availability of ICT. Therefore, there is a need to study the existing travel patterns and how ICT could affect travel patterns and individuals' travel behaviour. This study also examined whether ICT increases or decreases the need to travel. There are high levels of congestion on the roads in Bloemfontein and Gaborone, which are caused by increased numbers of vehicles on the roads, especially at peak travel times. So far, there is a lack of effective ICT solutions and platforms in these cities, and therefore, public transportation, which could offer a solution to some of the congestion problems, is not effective and does not fulfil everyone's transportation needs.

ICT and a modal shift have been an ongoing topic of investigation in efforts to promote sustainable transportation. In areas where there is increased ownership and use of private vehicles and low efforts to promote the use of public transportation, incorporation of ICT in the transportation systems has been hypothesised to be a possible way to encourage a shift from the use of private transportation to public transportation.

1.3 Problem Statement

Efficient public transportation systems are a necessity to support the continuously expanding population numbers in the major cities. However, in cities where public transportation does not meet the mobility and accessibility needs of the people, they tend to use private vehicles. Increasing car ownership and the poor state of public transportation networks hinder all attempts to achieve sustainable mobility patterns. Because of its high occupancy, speed, and convenience, public transit has been explored as an urban transportation option. This is especially effective in most developed nations. Southern African road public transportation networks are not as interconnected, well-organised or efficient as those in developed countries. They are also often not well-maintained. Thus, there is a need for the creation of efficient public

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transportation systems to attract private vehicle users and provide them with a reliable and convenient alternative method of mobility. However, such conversion is hindered by the poor-quality services in public transport, the high levels of unreliability and the lack of safety, among other factors. Dissatisfaction with the public transport system has played a major role in creating unsustainable travel behaviour and travel patterns. To reverse such unsustainable move, it is crucial to first identify the specific negative factors regarding the public transportation system. As there is currently a limited use of ICT for public transportation in the two selected cities, there exists a knowledge gap in research on the use of ICT for public transportation. This is in the contexts of conventional methods of public transportation, creating new digital platforms, data and technologies that will enable the existing public transportation systems to improve their services and better fulfil the users' needs. This should improve commuters' experiences. It is hypothesised that ICT-enabled and integrated transportation systems will assist in shaping a better understanding of the future of mobility that works for individual travellers and communities (Zhao et al., 2020).

International, and some local transportation systems have utilised ICT to increase efficiency, monitor travel, help traffic control, improve communication systems, and facilitate transactions. Most developing nations lack the technology breakthroughs to generate and analyse travel data. This study investigated the travel patterns and their influence on public transportation in Bloemfontein and Gaborone. It also examined ICT as a driver of shifting travel habits and a key component of public transportation sustainability. Spatio-temporal factors impacting travel were also examined as metrics for ICT-enabled public transportation, as the adoption of ICT was assumed to be able to be leveraged to improve road public transportation systems, generating demand for public transportation based on the efficiencies produced by ICT availability. Therefore, the feasibility of deploying ICT-enabled road public transportation systems to stimulate travel behaviour modification was examined in this study.

The purpose of this study was to examine the current trends in travel patterns of people in the study areas to develop empirical models and simulate the impact of using ICT in public transportation systems on travel behaviour and the consequent impact on the travel patterns of people on the cities' transportation systems. This led to the identification of problems within the public transportation systems and a review of the best attributes of private transportation with which public transportation systems must

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compete to attract private vehicle users. This will be essential in the search for solutions for a successful modal shift, and the transition from conventional public transportation systems to ICT-enabled public transportation systems.

1.4 Research Aim and Objectives

The research sought to create a contextual understanding of ICT-enabled public transportation systems applicable to cities in the developing world where transportation systems are yet to adapt to the global trends of technological advancements in road public transportation. A holistic approach, seeking solutions to public transportation problems was developed, which first explored the existing state of passenger transportation in Bloemfontein and Gaborone. Current travel behaviour, travel patterns and the level of ICT use in travel and public transportation were established.

The research aimed to explore opportunities for ICT-enabled public transportation systems in Bloemfontein and Gaborone, creating an understanding of socioeconomic influences and issues in public transportation. The study explored existing theoretical concepts on travel behaviour, technology and spatio-temporal theories, exploring the relationship between geography and travel patterns, and technology adoption. The study was guided by the research questions:

1. What is the impact of urban characteristics of the cities of Bloemfontein and Gaborone on travel behaviour and patterns?
2. How can ICT-enabled public transportation systems contribute to sustainable public transportation?

The specific objectives were to:

a) Develop a theoretical review based on existing literature to create contextual understanding of concepts and how their application can contribute to ICT-enabled road public transportation systems.
b) Explore the current travel behaviour and travel patterns of people in the study areas.
c) Examine the geographical relationship between road public transportation users' travel patterns and land-use.

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d) Examine the influence of various contributors towards ICT-enabled road public transportation systems.
e) Identify major socioeconomic, infrastructural, environmental and technology-related indicators that would influence ICT-enabled road public transportation.
f) Develop a set of guidelines and a framework for sustainable road public transportation systems in the study areas.

1.5 Hypothesis

The hypothesis of the study was framed as follows:
The provision of ICT can improve accessibility and quality of public transportation services, creating opportunities for ICT-enabled public transportation and subsequently contribute towards improved mobility and accessibility to public transportation in developing cities.

1.6 Study Area

The study focuses on two Southern Africa cities; Bloemfontein, South Africa, and Gaborone, Botswana. Both are medium-sized cities with relatively conventional public transportation systems, and both cities have the capacity to grow and accommodate future urban development trends. The backgrounds of each study area are detailed in sections 1.6.1 and 1.6.2 below.

1.6.1 Bloemfontein

Bloemfontein is South Africa's legislative capital, the capital city of the Free State Province and the biggest city within the Mangaung Metropolitan Municipality (MMM). The city is geographically located in central South Africa at 29°07'S and 26°13'E.

The map of Bloemfontein is presented in Figure 1.1.

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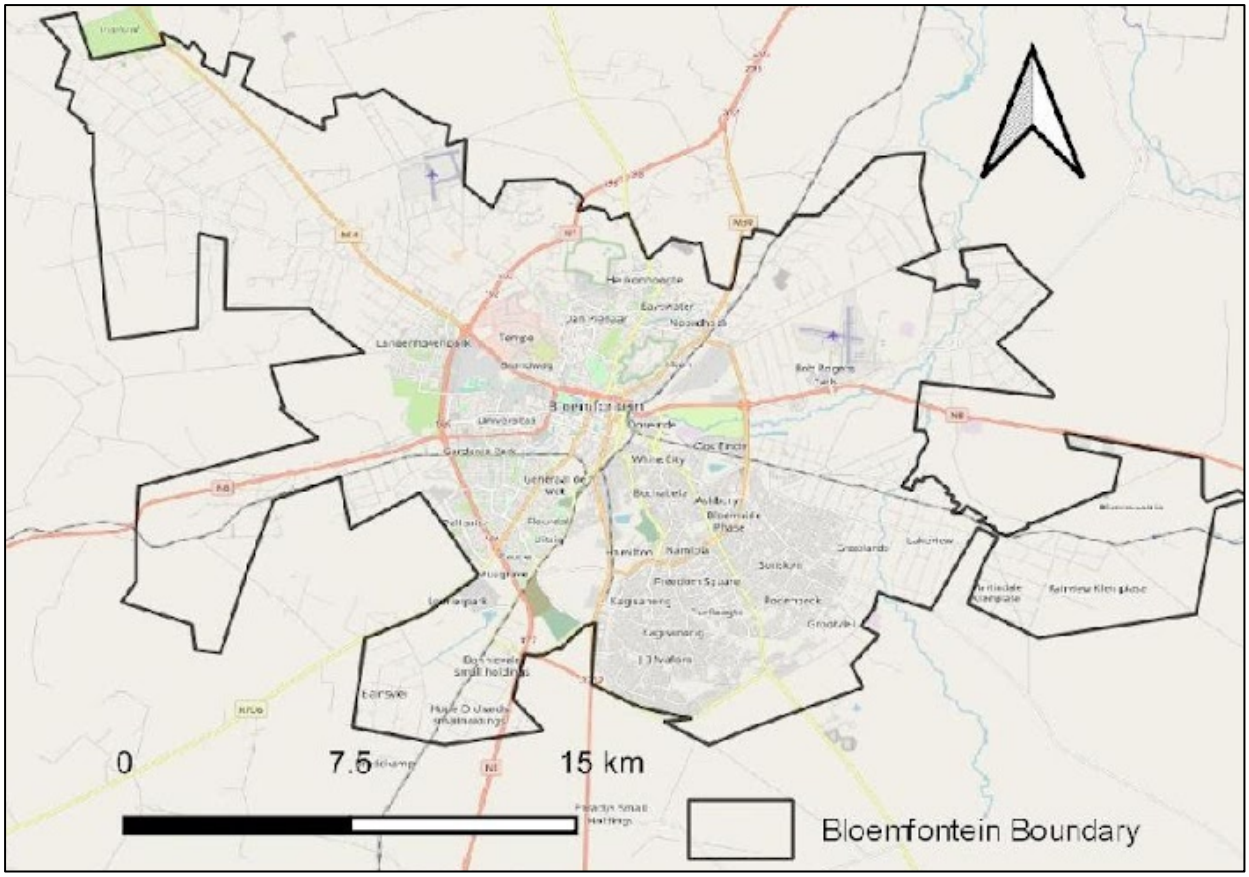

Figure 1.1: Map of Bloemfontein

Source: OpenStreetMap

Socioeconomic conditions

According to the United Nations' World Population Prospects of 2019, the city's population grew from 363 000 in 2001 to 462 000 in 2011 and to 567 000 in 2020. The population was projected to grow by 1.94% to 578 000 in 2021 (United Nations Department of Economic and Social Affair, Population Division, 2019). The Bloemfontein city centre has evolved into a mixed land-use area, with commercial and residential sections coexisting. The city is also quickly expanding, with new residential, commercial, and mixed-use developments recently finished and others still under construction. There is also a rapid increase in illegal land occupation, especially in the poor areas of the city, along the public transportation routes and in areas far from the city centre where many are searching for job opportunities (Toba et al., 2012). Due to South Africa's political history of racial segregation, Bloemfontein has residents living in settlements and suburbs based on their economic status, with the majority of the city's poor and middle-income citizens living in the south-eastern parts of Bloemfontein and travelling, on average, 15 km to the city centre for jobs (Mangaung Local

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Municipality, 2010). The city's economy is sustained mainly through commercial activity. Agricultural and industrial activities also contribute to the city's economy.

The state of transportation in Bloemfontein

The city's extensive road network includes two major national highways, the N1 and the N8, as well as provincial roads. The roads in the city, which include major arterial roads, are mostly minor arterial roads and local streets, and these are mostly paved roads that are utilised by both private and public transportation vehicles. Some roads, especially streets in low-income residential and informal areas, are unpaved, limiting any access by public transportation for the residents. Transportation infrastructure in the city is inadequate. The inadequacy of transportation via roads and its support systems is highlighted in the Mangaung IDP of 2019/20, which points to inadequacy of access and the poor quality of roads. It also alludes to the need for future implementation of low-carbon transportation, the promotion of public transportation, the upgrading of the transportation infrastructure and investment in green technology (Mangaung Metropolitan Municipality, 2019). Inadequacies in infrastructure across cities have also been attributed to the country's political history by Toba et al. (2012), who also noted the disparities in the upkeep of roads between the northern, more affluent areas and southern, low-income parts of the city.

There exists an unutilised minibus taxi rank in the Central Business District (CBD), which has resulted in on-street taxi ranks in the CBD. Even though the city's road network is lowly maintained, there have been recent attempts at improving the road network, visibly the upgrading and maintenance of Moshoeshoe Road, one of the main roads connecting the south-western areas of the city to the city centre. Figure 1.2 shows the city of Bloemfontein's road network.

Buses and minibus taxis are the most regularly utilised road public transportation vehicles. Buses and taxis operate on routes as shown in Figures 1.3 and 1.4. However, taxi routes are not regulated or fixed, compared to those followed by buses.

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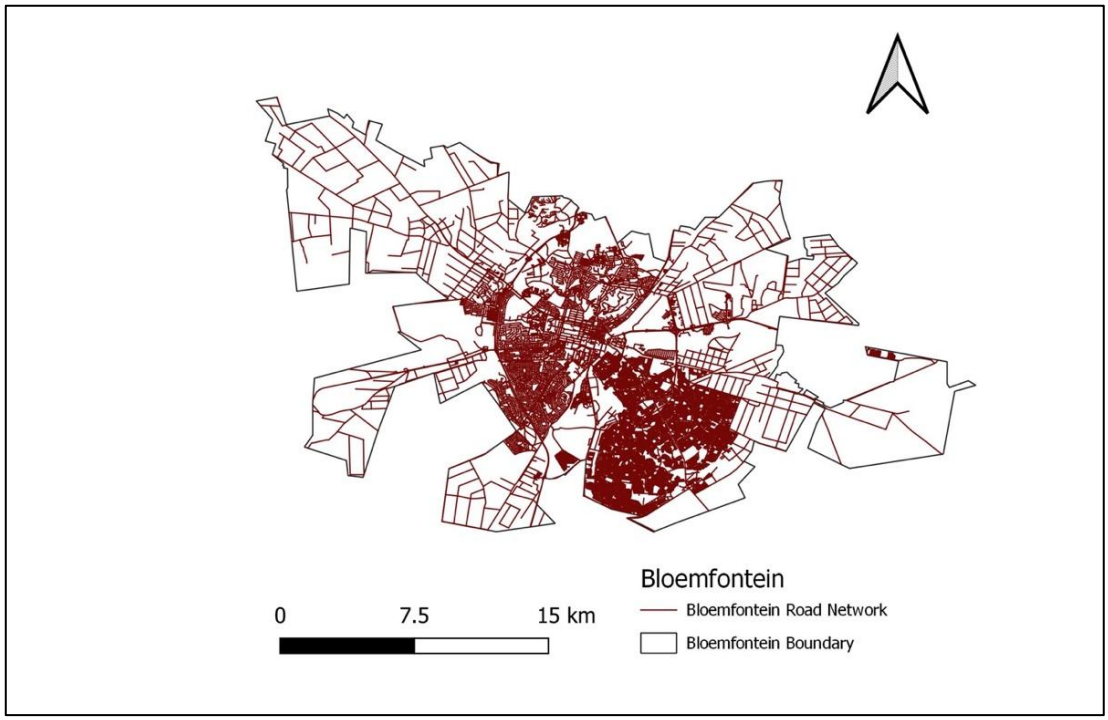
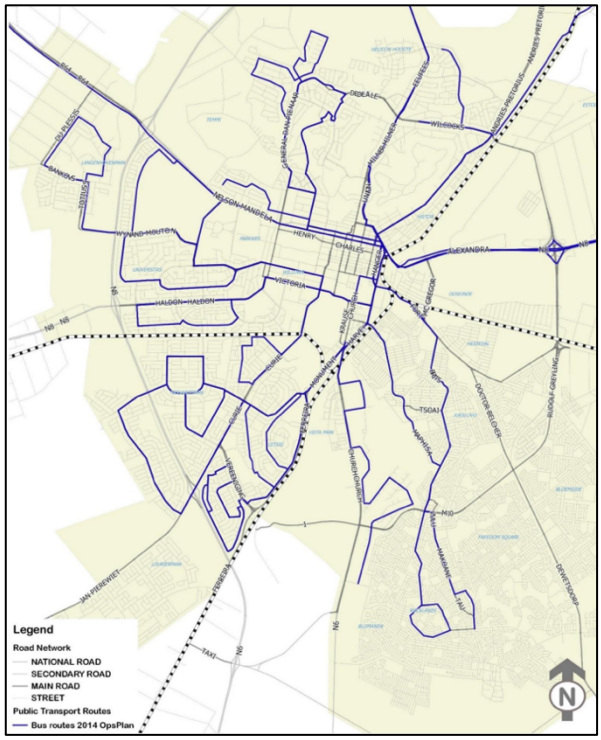


Figure 1.2: Bloemfontein Road Network



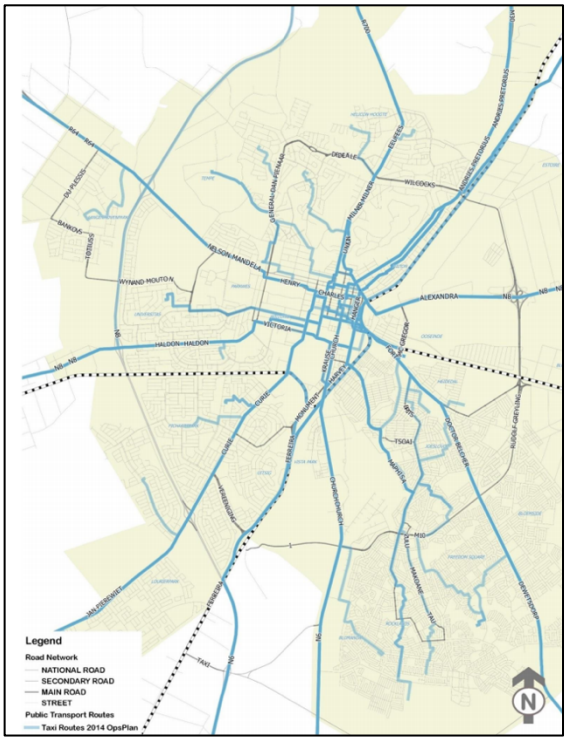


Figure 1.3: Bloemfontein Bus Routes **Figure 1.4: Bloemfontein Taxi Routes**

Source: Mangaung Metropolitan Municipality (2016)

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Passenger transportation in Bloemfontein

Passenger transportation in Bloemfontein is characterised by private vehicles, public road transportation and walking. There is a prevalent use of private vehicles for trips for different purposes. Table 1.1 shows the modal split between public and private modes of transportation in Mangaung, which includes Bloemfontein. It shows that there is a high usage level of taxis in the southern parts of the city (Mangaung, which includes but is not limited to Rocklands, Turflaagte, Bloemanda, Freedom Square, Rodenbeck). Table 1.1 also shows the high usage level of private vehicles in the north-western and north-eastern parts of the city, such as Dan Pienaar and Langenhoven Park. Affluent areas in the southern parts of the city, namely Pellisier, Fichardt Park, and Ehrlich Park recorded a 71.9% private vehicle usage.

Table 1.1: Modal split of road passenger transportation in Mangaung

Reporting Zone	Bus	Taxi	Company transport	Lift Club	Car	Walk all the way	Other
Central	5.6%	21.5%	0.0%	0.6%	29.0%	42.1%	1.2%
Oranjesig	1.0%	7.5%	0.0%	1.8%	73.6%	16.1%	0.0%
Mangaung	6.8%	54.7%	0.7%	4.3%	14.1%	18.6%	0.7%
Airport/Estoire	9.8%	19.2%	2.3%	1.8%	64.0%	2.5%	0.3%
Naval Hill/Bayswater	1.7%	13.9%	1.4%	2.6%	54.9%	25.0%	0.5%
Tempe/Dan Pienaar	6.3%	5.7%	1.5%	0.9%	78.0%	7.0%	0.6%
Langenhoven Park/Woodlands	12.7%	8.7%	0.5%	1.5%	71.1%	3.9%	1.6%
Universitas	3.6%	18.4%	0.2%	0.0%	50.4%	26.6%	0.7%
Pellissier/Fichardt-Ehrlich Park	3.5%	8.9%	0.8%	2.0%	71.9%	10.8%	2.1%
Thaba Nchu	14.7%	60.0%	0.4%	3.7%	8.0%	12.8%	0.3%
Botshabelo	19.1%	35.9%	1.9%	1.6%	9.0%	31.6%	0.9%
N-E Rural	1.2%	23.0%	3.6%	3.6%	37.4%	30.1%	1.0%
N-W Rural	7.2%	29.1%	2.7%	0.8%	26.7%	33.5%	0.0%
S-W Rural	2.5%	22.2%	0.6%	4.2%	52.4%	17.0%	1.1%
S-E Rural	9.0%	28.3%	0.0%	1.7%	39.5%	18.0%	3.5%
Naledi	5.9%	19.3%	0.6%	0.8%	17.7%	52.4%	3.3%
Mangaung Municipality	**10.1%**	**39.6%**	**1.1%**	**2.8%**	**22.8%**	**22.6%**	**0.9%**

Source: MMM Citywide Integrated Public Transport Plan 2015 – 2036

Public transportation vehicles are in the form of buses, minibus taxis, sedan taxis and on-demand taxi services. Public transportation is dominated by buses and minibus taxis. Bus services are run by Intestate Bus Lines (IBL), a government-subsidised bus company that operates in Bloemfontein. In the Mangaung Local Municipality, it is estimated that R80-million was spent on transportation subsidies (Mangaung Local Municipality, 2010; Mangaung Spatial Development Framework, 2010).

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Minibus taxis are privately owned and operated by individuals or private companies. These vehicles have a 15-seaters and 22-seater carrying capacity that ferry passengers from bus ranks, bus stops and non-designated stops along their routes. IBL buses have a larger carrying capacity and operate from the Interstate Bus Rank in the CBD and designated bus stops along their formal routes. Bus tickets are purchased prior to boarding buses and fares are loaded into bus tags, which are used to access the bus. Taxi fares are paid in cash to the taxi drivers during trips.

Concerns over the state of public transportation in Bloemfontein have been raised by Toba et al. (2012), citing poor infrastructure, lack of time adherence, lack of security and inaccessibility. The city's road and passenger transportation systems are insufficiently developed to enable ICT-integrated public transportation. In relation to ICT-enablement, there are just a few devices and applications available, such as basic entertainment devices that include music and DVD-players, GPS and tracking systems in some vehicles, and the recently-installed ticketing machines in some buses. For most projects, there is insufficient transportation infrastructure to meet the needs of all, such as non-motorised transportation facilities, or bicycle lanes and public transportation amenities (Department of Transport, 2016).

1.6.2 Gaborone

Gaborone is the capital city of Botswana, a landlocked, developing Southern African country bordered by South Africa, Zimbabwe, Zambia and Namibia. Botswana is described as a middle-income economy, while its capital city Gaborone is considered one of Southern Africa's fastest growing cities (Cavric and Keiner, 2004; African Economic Outlook, 2012). Gaborone is geographically located in the south-eastern part of Botswana, positioned at 24°39'29"S and 25°54'44"E.

The map of Gaborone is provided in Figure 1.5.

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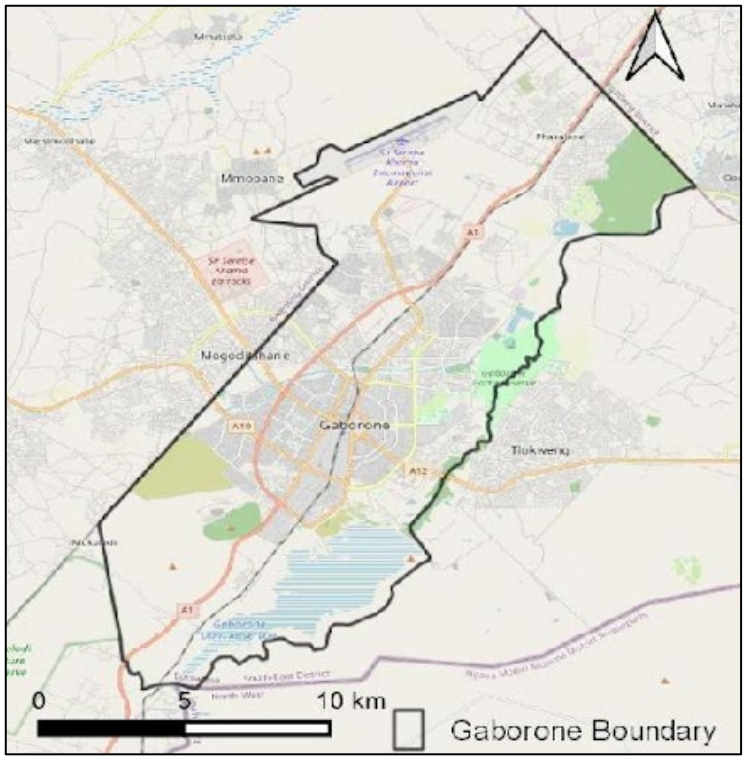

Figure 1.5: Map of Gaborone

Source: OpenStreet Map

Socioeconomic conditions

Gaborone is considered Botswana's most urbanised and industrialised area (Sebego and Gwebu, 2013). The population of Gaborone rose from 186 000 in 2001 to 231 626 in 2011, and to approximately 232 000 in 2017 (Statistics Botswana, 2017a). According to the preliminary results of the 2022 population census, Gaborone has a population of 244 107 (Statistics Botswana, 2022). As the largest city in the country, Gaborone has earned the capacity to host most of the country's infrastructural and urban growth. Cavric and Keiner (2004) lamented the evident disparity between urban and rural areas in developing countries such as Botswana. The government's infrastructure development is evident in metropolitan areas, since it was prioritised owing to economic need and economic justification (Lionjanga and Raman, 1990:6). Botswana's Gross Domestic Product (GDP) was expected to grow by 4.2% for the year 2022 (African Development Bank Group, 2022). The economy of Gaborone is dominated by commercial activity, significant public service employment, and private sector employment in the industrial and service sectors.

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The state of transportation in Gaborone

This rapid growth is straining the city's resources, including transportation, as the city has witnessed a rapid increase in car ownership. Increased car ownership in Gaborone is hypothesised to the influx of cheaper imported cars (Ranko and Bolaane, 2011), which are more affordable for people with an average income. The city's rapid growth makes long-term development somewhat challenging in economic and financial terms. In addition, previous land-use zoning failures resulted in unequal distribution of developments and segregation of residential areas based on economic status, and the scattering of commercial zones across the city. Industrial areas are the exception, as they are located in one zone in Gaborone and some on the outskirts of the city. The city's road network consists of 444.6 km of tar road, 153 km of gravel, 40.7 km of gravel roads and 21.7 km of interlocking brick roads (Statistics Botswana, 2019).

The Gaborone City Council (2009:15), through the Gaborone City Development Plan (1997 – 2021), stated its goal as being to:

> "*provide safe, functional, convenient and cost-effective circulation and transportation systems in the city*". Some of the set objectives to achieve this goal were to "*provide for the development of an efficient and cost-effective rail and road mass transit system in the city*" and to "*encourage non-motorised transport in the city through provision of walkways and bicycle routes*".

The city's road public transportation system is dominated by combis and taxis, which are not integrated for a mass transit system. There have been proposals to introduce buses with a carrying capacity of 25 passengers to reduce the number of combis on the roads (Gaborone City Council, 2009:99). However, there is a lack of sufficient infrastructure for both motorised and non-motorised transportation, while private vehicle use is surging.

Figure 1.6 shows the road network of the City of Gaborone, while Figure 1.7 shows the main public transportation routes used by minibus combis. Figure 1.8 shows the ongoing developments of the road network, proposed interchanges and an outer ring road surrounding the City of Gaborone. Road public transportation vehicles operate on the main trunk roads and some secondary roads, while saloon taxis occasionally use lower-order streets to designated households, based on a demand-response basis.

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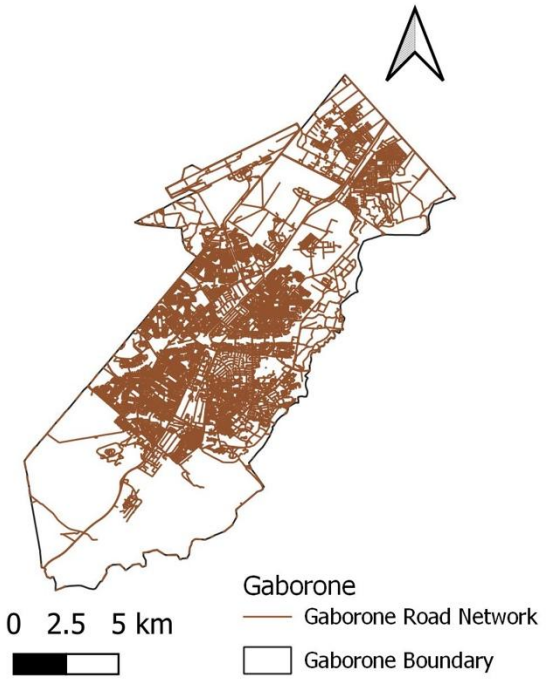

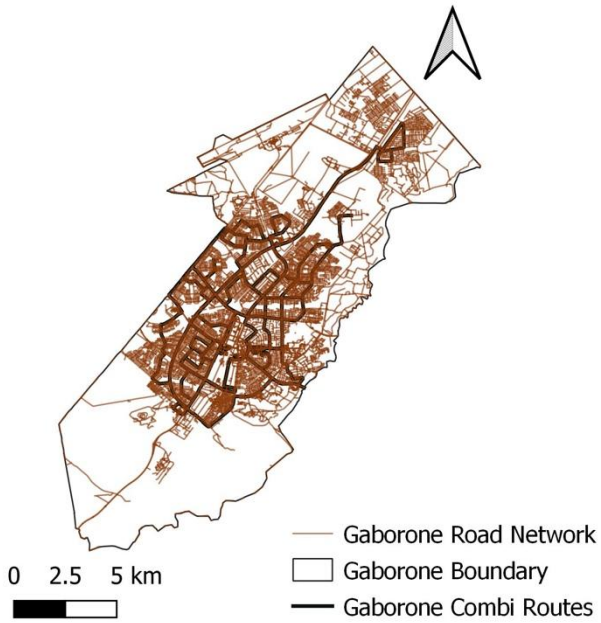

Figure 1.6: Gaborone Road Network **Figure 1.7: Gaborone Combi Routes**

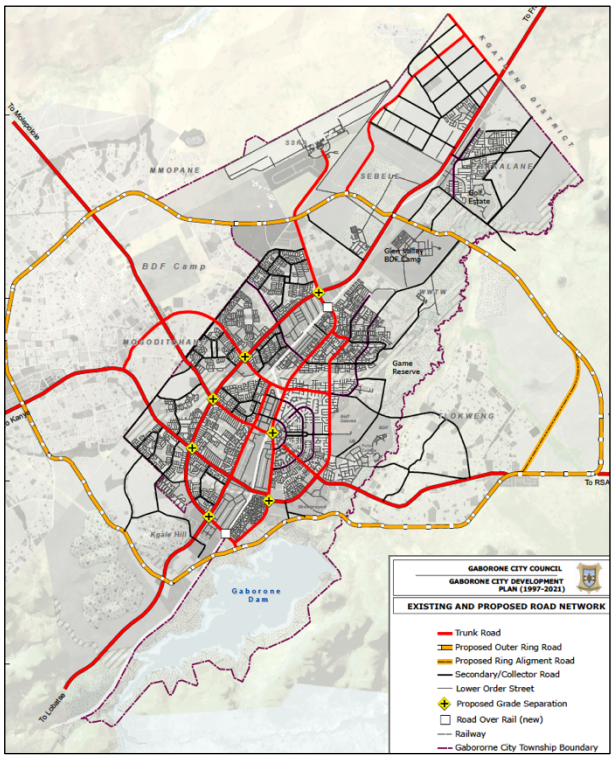

Figure 1.8: Ongoing Road Network developments in the City of Gaborone

Source: Gaborone City Council (2009:107) Gaborone City Development Plan (1997 – 2021)

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Passenger transportation

Passenger transportation in Gaborone is dominated by high volumes of private vehicles and public transportation usage. Keiner and Cavric's (2006) study found that at the time of their study, the preferred mode of travel was private cars and public transportation was less popular, while peak time congestion was a norm (Keiner and Cavric, 2006; Ranko and Bolaane, 2011). Between 2016 and 2017, licenced vehicle ownership rose from 500 316 to 527 901, an increase of 5.5%, and recorded growth of 9.7% on national car stock between 2008 and 2017 (Statistics Botswana, 2019:5). Thus, increased traffic congestion is caused by growing car ownership, inefficiencies in the public transportation system, and insufficient road infrastructure to accommodate the increased number of vehicles on the roads (Ranko and Bolaane, 2011). Public transportation systems within the city are comprised of 15-seater minibuses known as "combis" as designated by the Department of Roads Transport and Safety (DRTS), and 5-seater taxis. Ranko and Bolaane (2011) referred to Gaborone as having an inefficient infrastructure, one that was inadequate and unappealing.

Passengers in combis (minibus taxis) paid a fee of P3.50 per trip, while taxi users paid P4/trip, until fares increased in April 2018 to P4 per combi and P5 per taxi trip. In August 2020, public transportation passenger fares were revised again , resulting in a modification to prices based on the Road Passenger (Permits) Act (Cap. 69:03) to take effect from September 2020. The new fares were set to be P5/trip by combi and P6/trip by taxi (Government of Botswana, 2020, Government Notice No. 341 of 2020). Combi operation was dependent on the availability of passengers (collective demand basis), which should not to be confused with demand-responsive transportation services. Combi passengers do not actively request transportation services from the service providers. Instead, a person wishing to take a trip waits at a bus stop, until such time when a combi that is already en-route becomes available. Subsequently, trip-makers gather or queue at taxi ranks for available combis or taxis. This systems does not operate on a fixed schedule (Maphale, Sereetsi, Moreri and Manisa, 2015). According to Maphale et al. (2015), there are no policies promoting the use of public transportation in Botswana, while a previous study by Sebego and Gwebu (2013) highlighted the lack of regulation of some aspects of the urban shadow of the City of Gaborone.

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1.7 Summary

Buses, minibus taxis and saloon car taxis make up the road public transportation systems in both cities, Gaborone and Bloemfontein. This study focused on the prevalent forms of transportation in each city, which are buses and minibus taxis in Bloemfontein, and minibus combis and saloon taxis in Gaborone. Batty et al. (2015:110) state that several modes of public transportation are required to establish an integrated, accessible and inclusive public transportation system, but "*at the core, must be a higher capacity and higher efficiency mode*". Several modes do exist in the two cities; however, there is a lack of integration of the modes, as each of the available modes operates independently. Minibus taxis, combis and taxis are owned by individual operators and small businesses that are affiliated to different taxi associations. Buses in Bloemfontein are operated by a private company and subsidised by the government. It is under these circumstances that integration of modes is unattainable. In terms of carrying capacity, buses are the means with higher carrying capacity available in Bloemfontein, while combis are the largest alternative available in Gaborone.

1.8 Outline of the Study

The study comprises seven chapters, which are outlined as follows:

Chapter 1: Introduction

The first chapter introduced the study and study concepts, providing the background to and the basis for the study. The chapter further described the study areas and the state of road public transportation in both study areas. The research design of the study is illustrated in Figure 1.9 below, followed by details of the remainder of the chapters.

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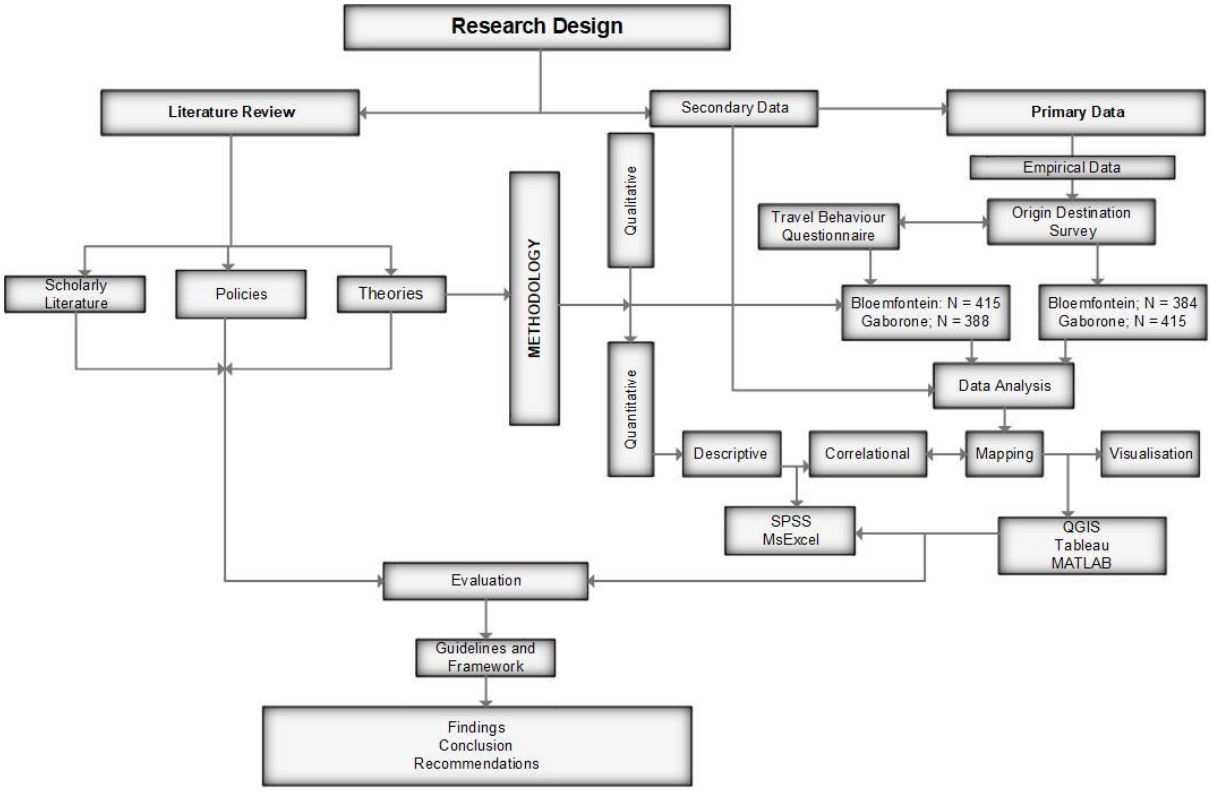

Figure 1.9: Research Design

Chapter 2: Literature Review

The chapter reviews existing literature on the background of transportation sustainability, ICT and its application in transportation systems and their role regarding towards the creation of ICT-enabled public transportation systems. The chapter also reviews existing transportation, technology and sustainability policies. The last section of the chapter explores and contextualises existing theories applicable to public transportation, spatio-temporal factors influencing travel patterns and travel behaviour, as well as the adoption and utilisation of technology.

Chapter 3: Research Methodology

In Chapter 3, the research methods used to fulfil the aim and objectives of the study are described and explained.

Chapter 4: Results Analysis and Discussion

In this chapter, the results of the study are presented and discussed, based on data collected through a questionnaire.

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Chapter 5: Results, Analysis and Discussion of Travel Patterns

In this chapter, results are presented and discussed, based on data collected through a questionnaire to obtain trip origins and destinations.

Chapter 6: Guidelines and Framework for Sustainable, ICT-enabled Road Public Transportation Systems

The chapter uses the findings of the study, the literature review and a synthesis of theories to propose guidelines and a framework for sustainable public transportation adaptation in Southern African cities.

Chapter 7: Summary, Conclusion and Recommendations

In this chapter, the researcher brings together concepts from the preceding chapters, draws conclusions and presents recommendations on how the results and findings of the study can be applied to accommodate concepts that promote ICT-enabled public transportation systems in the current transportation systems.

References

The sources of literature used in this study are listed in this section.

Appendices

The section contains samples of the data-gathering tools, and important tables and pictures not included in the main body of the data presentation and analysis.

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CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Information Communication Technologies (ICT) have developed significantly, leading to their deployment and incorporation in many aspects of life, often as a catalyst to internal processes. The developments have led to ICT being used either as a substitute for activities and processes, or as a tool to improve or speed up these activities and processes (Kramers, Höjer and Lövehagen, 2014; Chugh, Wibowo and Grandhi, 2016). The growing level of adoption of technology and advancements in ICT are being leveraged in urban areas towards attaining sustainable development goals. ICT is also explored and utilised by different sectors of the urban environment in order to discover its potential for environmental, socioeconomic and infrastructural sustainability (Elias and Krogstie, 2017b, 2017a).

The contribution of ICT towards road transportation systems is evident in their application into Intelligent Transport Systems (ITS), Traveller Information Systems (TIS), payment systems and even communication systems used by transportation operators and users. The ITS use advanced ICT to integrate transportation infrastructure, vehicles and users to improve the productivity of a transportation system. In its broader state, ITS is concerned with the integration of components of transportation systems; traffic infrastructure with advanced driver assistance, freight management and tracking systems, toll management, and fare systems and cooperative systems. Angelidou et al. (2015) identified the four most common ITS domains as being the smart grid, revenue management, and intelligent inter-modal transport units and rail networks. A smart grid is focused more on electric vehicles (EV), in which ICT plays a huge part in creating the intelligent charging systems. It, provides real-time information exchange between vehicles and the grid through the use of applications such as EV booking, payment, charging, fleet management systems, grid management, Vehicle-to-Grid (V2G) and Vehicle-to-Infrastructure (V2I) connectivity.

New technologies used in ITS have made it possible for public transportation vehicles to have priority on the roads, reducing travel time and chances of being delayed on

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congested roads (Pojani and Stead, 2015a). Incorporating ICT to attract different groups of people to use public transportation has also been one of the innovative approached that have been tried to make public transportation more attractive and more sustainable (Konrad and Wittowsky, 2018).

The immense influence ICT has on transportation is highlighted by Gössling (2017), in stating the various ways ICT could draw interest to sustainable transportation by either substituting travel or increasing travel demand. This statement echoes previous research by Banister (2008:75), who stated that the use of ICT to reduce the need to travel through substitution of trips and the opportunity for flexible travel patterns highlighted the potential for ICT use in transportation in efforts towards sustainable transportation (Banister, 2008). The ability of technology to improve transportation by reducing transportation costs, stimulating travel and making travel more convenient has been investigated in various studies as efforts to address transportation sustainability (OECD, 1996; de Almeida Guimaraes and Leal Junior, 2017). These studies showed similarities in their enthusiasm towards the potential effects of ICT on transportation.

Further, increased relevance of ICT in transportation is attributed by Gössling (2017) to technological advancements on the internet and web-based platforms, smartphone technologies, mobile applications and the rapid growth of social media and networking platforms. In the review of ICT and transportation behaviour, focusing on passenger transportation, the relationship between ICT and transport revealed that there is a growing importance of ICT for transportation systems, while acknowledging the undeniable accompanying implications to travel behaviour (Gössling, 2017). By influencing travel demand and mode choice, ICT impacts sustainability. ICT facilitates travel by easing the use of public transportation, by providing accessibility, increasing reliability, and providing travellers with a real choice (Gössling, 2017).

Even though the impact of technology on travel and urban transportation was predicted in earlier research as being achievable, with significant visible impacts and influence on sustainability, most of the predictions have not been accurate (Black, 2010; Lane, 2019). It was envisaged that tele-commuting would reduce urban travel significantly over the past two decades, while communication technology would reduce

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the need for, and amount of, personal travel (Black, 2010). Gössling (2017) states that the important role played by ICT in transport behaviour will increase over time, rendering ICT an instrumental asset towards sustainable transportation systems. In concluding the review, Gössling acknowledges that resistance to change is a possibility, given the involvement of lifestyles and identities. Therefore, social and psychological effects of ICT advancements and innovations need to be monitored (Gössling, 2017).

2.1.1 Defining sustainable transportation

Numerous studies have made attempts to define sustainable transportation by using the environment as the dominant entity that needs to be sustained; the main beneficiary of sustainability. An earlier study by Jordan and Horan (1997:72) defined sustainable transportation as "*transportation services that reflect the full social and environmental costs of their provision; that respect carrying capacity; and that balance the needs for mobility and safety with the needs for access, environmental quality, and neighbourhood liveability*". One study in sustainable transportation that recognises social issues as both impacted by and impactful to transportation's sustainability is a summary paper by Button and Nijkamp (1997). The authors encouraged a perspective that would encompass *"the need for competitive efficiency, the need for geographical accessibility and social equity for all, and the need for environmentally sustainable development*" in consideration for modern transport and mobility (Button and Nijkamp, 1997:216). Sustainable transportation does not only concern itself with environmental protection, but takes into account economic aspects of transportation (Gudmundsson, 2004:36).

One significant narrative towards the study of sustainable transportation, with respect to environmental sustainability, was the emergence of Green transportation (GT). GT is concerned with eco-friendly transportation, which has less negative environmental and subsequently health impacts than the existing forms of transportation services (Chiras, 2010; Shah et al., 2021). GT is characterised by reduced risk, traffic congestion and pollution, accident prevention, enhanced energy, resource sustainability, safety and security assurance, and optimised travelling speed and traffic flow (Shah et al., 2021). The key parameters to using GT for sustainable mobility are

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still attributed to environmental, social and economic outcomes. Chiras (2010) asserted that solutions towards GT should make sense from social, economic and environmental perspectives, otherwise they should not be considered.

Most of the attempted definitions were based on the concept of sustainable development as defined by the Brundtland Report by WCED (1987). Similarities in these attempts were the attribution of sustainability to meeting the needs of the present without denying future generations to satisfy their needs. Such studies included those by Gudmundsson (2004); Goldman and Gorham (2006); Schiller, Bruun and Kenworthy (2010); and Shah et al. (2021). The study by Goldman and Gorham, however, acknowledged the ambiguity and seeming inexactness or broad nature of the word "sustainable" (Goldman and Gorham, 2006:262). Shah, Pan, Lee, Kim, You, Zheng and Chiang (2021:2) define sustainable transportation as:

> *"…the ability to meet the mobility needs of today's society in such a way that the environment is least polluted and the mobility needs of the next generation are not impaired*".

Gudmundsson (2004:36) argued that to define sustainable transport, the question might not be clear of what it is that should be sustained and in what respect should it be sustained, before making an assertion that requirements are there to fulfil a sustainable transportation system. Gudmundsson also raised a question as to how far the transportation systems were from satisfying sustainable transportation requirements (Gudmundsson, 2004:36).

Goldman and Gorham (2006) interrogated and classified the many previous attempts made to define sustainable transportation, using three categories, the first being the school of thought that defines sustainability as a policy pathway by suggesting policies towards a more sustainable society. The second category based sustainability as an end-state vision (Goldman and Gorham, 2006:263), and the last one saw sustainability as a system-based vision (Goldman and Gorham, 2006:264). Schiller et al. (2010:2) had previously defined a sustainable transportation system as one that allowed for an equitable, safe access regarding the basic needs of individuals and society, while remaining harmonious with the health of the people and that of the ecosystem for generations. It is an affordable, efficient system that offers flexibility in mode choice, while supporting a vibrant economy. Further, a sustainable transportation system limits

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emissions and waste, it allows for minimal use of non-renewable energy, while reducing the levels of renewable resources to a sustainable yield level, and the use of land, as well as limiting noise production (Schiller, Bruun and Kenworthy, 2010).

Black (2010:10) on the other hand, defined a sustainable transportation system as *"one that provides transport and mobility with renewable fuels, while minimising emissions detrimental to the local and global environment and preventing needless fatalities, injuries and congestion*".

Most of the problems caused by transportation are the result of people's dependence on cars, which is largely linked to the high energy consumption by private transportation (Schiller, Bruun and Kenworthy, 2010). Hence, some studies have focused on sustainability to tackle problems caused by increased motorisation. One study, linking sustainability problems to high private car use, was conducted by Dimitriou (2006), who attempted to evaluate the progress towards sustainability of three Asian cities' urban transportation, highlighting the unfortunate plight of middle-sized cities copying trends set by larger cities, instead of initiating "*bold and innovative solutions*" (Dimitriou, 2006:1086). This approach often led to similar issues associated with rapid motorisation (Dimitriou, 2006).

In the quest to define sustainable transportation, some studies proposed sets of indicators that would be used to measure sustainability. One such study was a study by Nicolas, Pochet and Poimboeuf (2003). The study suggested economic, social and environmental indicators that would be applicable to urban transportation and mobility in the case of Lyons and its surrounding areas. Also notable in the study was the set on services and organisation of urban mobility indicators, which were classified under the mobility dimension (Nicolas, Pochet and Poimboeuf, 2003). The indicators suggested under the three main dimensions of sustainability; economic, social and environmental indicators were elaborated. Economic indicators were classified as cost to the communities; and under this category, the authors described the annual cost to residents of the area due to mobility within the zone. The second category of economic indicators was expenditure to participants, which were further divided into expenditure by households, companies and public authorities. Household-related indicators would be annual average expenditure for urban mobility per person, while for companies,

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this would be costs of employee parking spaces, subsidies such as company cars, and possible taxes to the company. Finally, for public authorities, economic indicators would be the annual expenditure for investments and operates per resident (Nicolas, Pochet and Poimboeuf, 2003). Social indicators included factors, such as vehicle ownership, distance travelled and expenditures associated with urban mobility, which are amounts for transport, either public or private and share of the household income spent on urban mobility. The environmental indicators started with air pollution as both a local and global issue. Air pollution indicators were listed as energy consumption and carbon emissions per resident, levels of nitric acid and nitrite, hydrocarbons and particles. Other considerations were space consumption for mobility purposes per individual consumed in travelling and parking, as well as space consumed by transportation infrastructure. Other indicators included but not measured were noise intensity levels and risk of accident (Nicolas, Pochet and Poimboeuf, 2003:199). Gudmundsson's study on sustainable transport and performance indicators reviewed indicators as presented by past literature and concluded that indicators should not only be used to provide definitions to complex issues, such as sustainable transportation (Gudmundsson, 2004).

Following the studies by Nicolas, Pochet and Poimboeuf (2003) and Gudmundsson (2004), Banister (2008) authored the sustainable mobility paradigm, which attempted to create an understanding of reasons that influence the effective implementation of sustainable mobility measures. For sustainable mobility to be achieved, there needs to be an approach that requires the need to reduce travel, while encouraging a modal shift, reducing trip lengths, as well as encouraging the efficiency of transportation systems (Banister, 2008:75). The author further suggested four elements towards the achievement of a sustainable mobility paradigm (Banister, 2008:77), "*making the best use of technology, including investment in technology in transport modes, information systems and in the transport system itself, and in giving industry directions on priorities*" (Banister, 2008:78).

Banister (2008) noted that it would be important to take into consideration that for this to be achieved, behavioural change and consideration for increasing occupancy levels would be essential. The second element is concerned with the external costs of transportation being presented as the actual costs of travel, which will help in reducing

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the number of trips, reducing trip distance, and changing the modal split, while promoting more efficient vehicles. Third, integrating of land-use development is essential to support short travel distances, and improving the level of proximity. Banister (2008:78) described the last element towards sustainable mobility as the importance of clearly targeted personal information, which will influence the acceptability of sustainable mobility.

In conclusion, the authors expressed the need for sustainable transportation in developing countries to avoid further negative environmental impacts. Such sustainable transportation would be achieved by prioritising modal share between NMT and public transportation in the development process.

Sustainable urban transportation has been described as one of the pathways to achieving sustainable urban areas (Bibri and Krogstie, 2017). It requires non-motorised transportation, walking and the reduced use of cars as methods to achieve sustainability. Bachok et al. (2014:554) describe transportation as a "*gateway to sustainable accessibility*", while Gouda and Masoumi (2017) recommend the use of active transportation or non-motorised transportation measures, such as walking and cycling. The sustainability of this form of mobility is associated with ease of accessibility, reduced congestion, energy conservation and cheaper infrastructure. Dimitriou (2006) stated that the attempt to solve rapid motorisation and transportation problems by building more roads was not effective and a setback to sustainable development efforts. On the other hand, Lane (2019:6) argues that "*modes of transportation are not inherently unsustainable; instead, it is the intensity and frequency of use that makes a mode unsustainable".* Public transportation is suggested as one way to achieve sustainable transportation, because it can reduce traffic volume and solve traffic congestion (Bachok et al., 2014).

Sustainable transportation therefore will be defined for this study as transportation that provides efficient movement for goods and people with minimum negative environmental, social and economic impacts while simultaneously reducing the need for travel and promoting modal shift.

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2.1.2 Sustainable public transportation systems

Efforts to make transportation sustainable have drawn attention to public transportation systems in urban areas as they face the greater part of accessibility and mobility challenges. Public transportation modes are considered to be environmentally friendly because they contribute less emissions than the very high number of private vehicles (Kii and Hanaoka, 2003; Dirghahayani, 2013; WWF, 2016). The high carrying capacity of most public transportation modes have the potential to contribute positively towards sustainability. Passenger rail transportation and Bus Rapid Transit systems are more effective in larger cities, as they can carry more people with less or no dead mileage (Pojani and Stead, 2015a). Car travel promotes spatial barriers and isolation from social interactions, and leads to increased pollution, which are very common aspects in urban areas because of the high percentage of car ownership (Zhao and Zhang, 2018; Chen et al., 2019). Most cities with effective public transportation in the developed world have improved their environmental sustainability by improving their public transportation infrastructure and fleet (Kennedy et al., 2005; Commission of the European Communities, 2007; Rodrigue, 2020). However, these developments required a long-term commitment to policies to provide fast, reliable and seamless public transportation services. Acknowledgements are further made by Pojani and Stead (2015b:7791) that although the uptake of BRT as a solution to mobility problems is advantageous, it has not always brought effective sustainable solutions, which can be attributed to issues such as rushed implementation, financial constraints, overloaded occupation and infrastructure deterioration in developing countries (Pojani and Stead, 2015b).

Instrumental towards achieving sustainable mobility such as Mobility as A Service (MaaS) and Avoid-Shift-Improve are envisaged to promote sustainable travel by avoiding the need to travel, creating a shift from personalised vehicles to NMT and public transport, increased public transportation usage, as well as promoted innovation technology (Shah et al., 2021).

One significant study in the field of sustainable urban transportation is by Pojani and Stead (2015), in which the authors state that *"effective road public transport is central to economic growth of developing cities" (Pojani and Stead, 2015:7789).*

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Pojani and Stead (2015:7789) further highlight the existence of inadequacies in road-based public transportation systems in the developing world, detailing their inability to fully serve mobility needs of populations they are meant to serve.

People are central to road passenger transportation systems as the developers, users, operators, owners, consumers of a service in public transportation. Transportation demand is characterised by a need, usually involving an activity; for example, work, school, and health needs, at specific locations distributed over space in rural and urban contexts. Therefore, effective transportation systems should satisfy all needs in both urban and rural contexts through different socioeconomic developments (Ortúzar and Willumsen, 2011). The need for transportation is also characterised by zonal population characteristics, because different population groups need to travel to different types of destinations at different times of the day (Farber et al., 2015). Transportation supply, on the other hand, is characterised by virtue of transportation being a service, which "*must be consumed where and when it is produced*" (Ortúzar and Willumsen, 2011:4). Essentially, meeting mobility and accessibility needs of the public creates a sustainable public transportation system.

Mobility and accessibility: Public versus private transportation

Mobility is linked to human activities and land-use, and is focused on making more trips instead of longer trips (OECD, 1996; Rodrigue, 2020), while accessibility involves integrating land-use and transportation system interactions with social perspectives for transportation planning (Boisjoly and El-Geneidy, 2017). Accessibility can be defined as a function that enables people to reach their destinations and perform activities (Boisjoly and El-geneidy, 2017). Schiller, Bruun and Kenworthy (2010:16) emphasised the importance of access by stating that access profoundly impacts the quality of urban life. Public transportation accessibility relies on the quality of service and ease of access of the public transportation service by users (Yatskiv and Budilovich, 2017).

Mobility and accessibility are associated also with supply and demand of transportation. Demand for public transportation is higher than its supply because transport is not equally accessible by everyone because of limited routes, poor infrastructure and spatial characteristics. Transportation supply is high for private

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vehicle users, making mobility easy and providing increased accessibility to transportation and various areas of the city. Socioeconomic and sociocultural factors influence mobility in urban areas (Ahmad and Puppim de Oliveira, 2016), so accessibility in residential and commercial areas should be given priority (Wang, Han and de Vries, 2019).

Accessibility can be measured in two ways, using person-based or infrastructure-based measurements. Infrastructure-based measurements apply to the level of satisfaction of users with the public transportation network, while the person-based measurements apply to the accessibility of the network and commercial speed of the regional public transportation system (Yatskiv and Budilovich, 2017). Geographical contexts of cities play an enormous role in transportation sustainability, based upon their modification to accommodate transportation networks through which accessibility is enabled and dictated. "*Degrees of access to transport networks affect social patterns at all levels of spatial aggregation"* (Button and Nijkamp, 1997:215).

Even though private transportation detracts from effective sustainability measures, it provides better accessibility and boosts mobility, compared with public transportation (OECD, 1996). To improve the accessibility and mobility of public transportation, some countries have adopted methods such as the demand-responsive public transportation services, and using ICT such as the internet and mobile phones to improve flexibility (Commission of the European Communities, 2007). The mobility needs of most people living in developing countries are not met by public transportation (Pojani and Stead, 2015). Sustainable transportation in an area should be inclusive and provide mobility and accessibility to everyone, as well as being environmentally friendly.

2.2 Travel Behaviour and Patterns

The main focus of research in sustainable transportation has been on sustaining the environment, in which sufficient recognition and study of travel behaviour has been neglected (Anagnostopoulou, Bothos, Magoutas, Schrammel and Mentzas, 2018). This exclusion led to the implications of policies and recommendations based on earlier research being ineffective (Garcia-Sierra, Bergh and Miralles-Guasch, 2015).

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Reasons for the ineffectiveness of these policies could be that researchers providing insights into travel behaviour relied on only a few theories. Conventional research on travel behaviour is based on utility theories, assuming that individuals make conscious decisions, based on the evaluation of the alternatives in terms of cost, time and effort (Heinen, 2016). Travel behaviour is also influenced by the travel choices that households face daily when planning their trips (Cheng, Chen, Wen, Wu and Hou, 2014; Garcia-Sierra, Bergh and Miralles-Guasch, 2015).

Garcia-Sierra, Bergh and Miralles-Guasch (2015:292) explain long-term travel choices and deem them to be "*long-term commitments*", because they strongly determine daily travel behaviour. The factors include residential location, employment location, location of place of study, and travel mode limitations, such as driver's licence and car ownership. In addition to their influence on long-term travel decisions, these factors influence short-term, daily choices.

Table 2.1: Travel choices for individuals and households

Set of travel choices	
Long-term choices	**Short-term choices**
Residential and employment locations Driver's licence Car ownership and car purchasing	Destination Departure time Route Travel mode

Source: Adapted from: (Garcia-Sierra, Bergh and Miralles-Guasch, 2015).

Choices of travel behaviour create continuous, embedded travel patterns, which travellers instil in their daily lives. Travel patterns are determined by different social, economic and environmental factors. Figueroa, Sick Nielsen and Siren (2014) indicate that there is a significant difference in travel patterns for older and younger adult populations, as the older population has a decreased travel demand and limited mobility. Travel behaviour and patterns also change according to weather and climatic conditions. ICT becomes more relevant to transportation in instances such as floods, because travellers need travel information and, once the flood passes, the need for information by travellers lessens (Zheng, Lee, Saifuzzaman and Sun, 2015). ICT assists people who are new in an area to make travel decisions as they travel and receive information about transportation availability in an area, they update their

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mental representation of the built environment, which might affect their travel activity decisions (Cenani, Arentze and Timmermans. 2012). There are different travel patterns for people who use public transportation on a daily basis than for private vehicle users. Travel behaviour and patterns are also determined by travel demand in relation to transportation supply (Farber et al., 2015).

Travel patterns often follow individuals' daily activity logs. Smart card and social network information about public transportation users has been used to track and trace people's travel patterns over time (Goulet-langlois, Koutsopoulos and Zhao, 2016). Medina (2016) conducted a data inference study on primary activity patterns, using public transportation smart card data and a household travel survey. Based on the study, it was found that weekday workers used public transportation more during the week, this is reflected by their use of smart cards (Medina, 2016). In another study. Kumar et al. (2016) observed multi–modal trips, using origin-destination pairs in a multimodal environment, based on each traveller's records of shared mobility. The influence that travel behaviour and patterns can have on the sustainability of transportation options clearly shows that negative outcomes are caused by the way people choose to travel. Changing travel behaviour is more effective when aiming to mitigate the negative impacts and output of transportation, as it can have greater positive effects and eliminate the need to reduce the impact and output of car-based transportation (Heinen, 2016; Anagnostopoulou et al., 2018). Change in travel behaviour, in favour of more environmentally friendly behaviours, can also be linked to the use of persuasive technologies (Anagnostopoulou et al., 2018).

Increasing the economic status (for both developed and developing countries) resulting from factors such as reduced household sizes, improved healthcare, more women being employed in full-time jobs, and improved family income, has led to people becoming more knowledgeable and exposed to better information and technology. This increased access to mobile technology led to a rapid increase in demand for long- and short-distance travel (Pendyala and Bhat, 2012). Daily activities (work, study, leisure and household activities) have an impact on travel behaviour and patterns (Sanchez, Isabel and González, 2014). Social demographics, such as gender, age, occupation, and household responsibilities and activities, influence travel times, the number of trips, choice of mode and distances travelled. Behaviour change

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is one of the necessary steps towards achieving the modal shift towards sustainable transportation (Andersson, Winslott and Adell, 2018).

2.2.1 Behavioural change: A shift towards public transportation

A modal shift from private transportation to public transportation has been recommended in various studies as the solution to urban transportation problems, such as congestion on the roads, thus contributing towards environmental sustainability (Dell'Olio, Ibeas and Cecin, 2011; Gunay, Akgol, Andreasson and Terz, 2016; Anwar and Yang, 2017; Conti, 2018; Urbanek, 2021). Increasing levels of car ownership is seen as one of the main reasons for unsustainable transportation patterns. Therefore, it has been concluded in many studies that switching the mode from private to public transportation can remedy the situation and improve environmental sustainability by reducing carbon emissions (Conti, 2018; Amatuni, Ottelin, Steubing and Mogollón, 2020). Kim (2019) argues that traffic congestion has a greater negative social impact and less impact on time. However, inconvenience resulting from traffic delays can cause discomfort at the time it occurs, which should not be disregarded in the discussion (Kim, 2019).

Given the many unsatisfactory factors associated with public transportation, especially in developing countries, a shift to public transportation has proven to be difficult to achieve. Considering the different societal, environmental and economic dynamics related to car ownership, as well as the unsatisfactory state of public transportation, the shift is difficult to achieve without offering some form of incentives (Zhu, Wang, Chen and Reed, 2020). Abou-Zeid and Ben-Akiva (2012) conducted an experiment that attracted car users to public transportation during the study period through offering them free transportation and some rewards, which was successful only for the time that these incentives were offered. However, people using private transportation have to face the reality that costs associated with car travel go beyond fuel costs and include costs associated with depreciation of the vehicle, repairs, services and insurance (Urbanek, 2021). Thus, the costs associated with public transportation are low in comparison to the costs of private transportation.

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Findings of other research indicated that the provision of financial incentives to employees by their companies could influence their choice of travel mode (Conti, 2018; Ghimire and Lancelin, 2019). In a recent study, Zhu et al. (2020) developed an incentive system in which the travel behaviour of individuals was identified, and incentives were provided based on their personal preferences. The goal of the system was to influence individual travel choices by using reward points as incentives. However, the positive effect on changing travel behaviour of financial incentives alone might not be enough (Ghimire and Lancelin, 2019). In studies carried out at the Massachusetts and in Switzerland where incentives (free tickets for a certain period) were provided to ascertain whether habitual car users would switch to public transportation, other factors might have contributed to the decisions by participants to switch mode (from private to public). These factors included demographic characteristics, travel attributes, transportation policies, social influences, and psychological factors such as satisfaction, attitudes and perceptions (Abou-zeid and Ben-akiva, 2012). Roselló, Langeland and Viti (2016:12) concluded that the concept of sustainable development itself should already incentivise a shift from private modes to collective (public) modes. Such conclusion was based on the energy savings incurred using collective modes of travel per individual trip compared with individual modes of travel. However, many other factors influenced the individuals' behaviour.

Change from private to public transportation is also a psychological issue, as most people associate car ownership and use with social status. While public transportation is considered to be a means for the low-income and lower middle-class groups, private vehicles are considered to be a transport means for the upper-middle and higher-income groups. Emotional and psychological readiness and evaluation of the effects of psychological influences on modal shift must be taken into consideration (Abou-Zeid and Ben-Akiva, 2012). A preference for cars and the lack of willingness to switch to public transportation should be expected (Urbanek, 2021).

Public transportation, cycling and walking have become unattractive options for most people and they have resorted to the convenient use of cars, which are more valuable and utilitarian in social terms (Banister, 2008; Garcia-Sierra et al., 2015). Ellison et al. (2017:83) observe that travel mode characteristics, such as "*the perceived inconvenience of public transport, poor frequencies, the need to travel to multiple*

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destinations, the inability of public transport to accommodate impromptu decisions" hinder mode switching from car to public transport. Banister (2008) also stated that dependence on cars has become a difficult process to reverse. However, Batty, Palacin and González (2015) emphasise that modal shift from private to public transportation is essential, stating that if the increased use of private vehicles over public transportation continued in future, this would lead to even higher levels of congestion and air pollution in urban areas (Batty, Palacin and González-Gil, 2015). Ahmad and Puppim de Oliveira (2016) advise that social inclusion, health and environmental improvements are some of the that could be used to motivate a shift from private modes to sustainable modes of transportation. Social exclusion can be a result of limited mobility in cases where individuals or communities have limited access to basic services and resources, owing to the lack of access to private vehicles or public transportation (Roselló, Langeland and Viti, 2016).

The findings of previous research on modal shift have indicated the need to develop seamless, accessible, high-capacity, zero emissions models of sustainable urban transportation and to promote a modal shift from private to public transportation, especially high-capacity transportation modes (Batty, Palacin and González-Gil, 2015). In order to encourage a modal shift, improving the quality and attractiveness of public transportation will be essential, while discouraging the use of private cars has been proposed as a further option (Batty, Palacin and González-Gil, 2015; Ahmad, Puppim and Oliveira, 2016). Rodrigue (2020) proposes factors that could lead to a change of transportation mode, based on comparative advantages, lower costs, time gained by avoiding traffic congestion, and a high level of service, comfort and reliability. The higher the comparative advantages over one mode, the more incentive there is to switch modes (Rodrigue, 2020). Growth in demand for the mode with more advantages will therefore lead to reduced preference for the other mode.

The process of modal shift involves decision-making by travellers and service providers, and the consideration of intrinsic factors affecting passengers and providers. It also involves the extrinsic factors relating to policies, regulations and costs, which are usually controlled by governments or collective bodies of service providers (Rodrigue, 2020). For people to be influenced successfully to choose public transportation over their private vehicles, it is necessary to understand what makes

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public transportation attractive or unattractive to users (Batty, Palacin and González-Gil, 2015). However, private vehicle users might be willing to carry the costs of private travel instead of spending longer times on public transportation travel (Urbanek, 2021). More people could be encouraged to use a public transportation system that provided attractive factors, such as safety, cleanliness and convenience. Urbanek (2021) indicates that the lack of proper connections, insufficient frequency and longer travel times are some of the factors that are regarded as obstacles to regular use of public transportation. Urbanek (2021) concludes that strategies to achieve a modal shift should focus more on improving the quality of public transportation. Public transportation users expect to derive satisfaction from the service (Dell'Olio, Ibeas and Cecin, 2011), including reduced waiting times, and improved cleanliness and comfort.

Technological features, such as Wi-Fi and game stations in public transportation vehicles and other public transportation platforms, such as bus terminals, also attract users (Batty, Palacin and González-Gil, 2015). ICT can be used to promote a modal shift because user-generated data, such as social network data, mobile phone data and smart card data have "*the potential to improve the understanding of travellers' patterns and mobility preferences*", including the choice of mode, travel times and purpose of the trip (Gkiotsalitis and Stathopoulos, 2015). Individuals' personal travel logs, derived from social networks and smart phone data, can be used to create origin-destination matrices, which provide data such as time travelled, mode used, the duration of the trip, origin, destination and waiting times. This data, matched with location and the AVL of public transportation vehicles, can be used to evaluate the reliability of public transportation services (Carrel, Lau, Mishalani, Sengupta and Walker, 2015).

2.2.2 Impacts of ICT towards travel behaviour

Travel behaviour and perceptions towards the current systems together with possibilities for technological interventions will ultimately shape the future of road public transportation systems. Earlier research which suggested lack of technological involvement in Southern African transportation systems by Walters (2013), is still relevant. However, availing technology in the systems will still require human participation, which in itself is influenced by behaviour. The concept of travel behaviour

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encapsulates the reasons why people travel the way they do, take the routes they take, and use the mode they use. Decisions associated with travel, in the past and currently, have not been favourable to the concept of sustainability – environmentally, socially and economically. Although it can be difficult to pinpoint what influences behaviour, studies in social sciences and engineering have linked travel behaviour to various demographic factors. Travel behaviour has been linked to social factors such as gender, employment status and occupation; economic factors such as travellers' income; and environmental and infrastructural factors such as travel distance, transportation infrastructure and land-use (Papagiannakis, Baraklianos and Spyridonidou, 2016; Feng et al., 2017). Gender had an influence on choice of mode as women were more likely than men to use public transportation (Feng et al., 2017). Among other reasons for change in travel behaviour are an increase in financial resources, more specialised destinations, and choices of transport mode available to the people. Technological efficiency is also crucial in behavioural change (Banister, 2008).

Past research has also focused on the direct impact of ICT on travel behaviour (Mokhtarian and Tal, 2013; Ben-Elia et al., 2014), as it has been thought that ICT affects the general travel behaviour of people using any modes of transportation. Research has focused on the impact of ICT on travel where people's physical activities are now being replaced by virtual activities (Pawlak, Polak and Sivakumar, 2017; Song, Preston and Ogilvie, 2017). Instead of travelling to work, or to official meetings, shops, making social visits to friends and so forth, people have resorted to working from home on their computers, engage in online shopping, social networking and video calls. At the same time, ICT in transportation has also been used to improve efficiency and convenience as a cost-effective source of entertainment through gaming (Amelung-Herzogenrath, Troullinou and Thomopoulos, 2015). However, use of ICT is not always possible, affordable and accessible and, in some instances, a person is required to travel in order to access ICT. In cases where affordability is an obstacle, employment of frugal technologies can bridge the financial gap. Frugal technologies are supposed to cater for novelty and improvement, so the increased access to mobile phones and other cheaper technologies has the potential to be incorporated into public transportation to satisfy people's needs to use the internet affordably (Zhang, 2018; Hossain, Simula and Halme, 2016). However, the price sensitivity of frugal technology

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users is an important factor in the use of frugal innovations (Hossain, Simula and Halme, 2016). Innovative and affordable technologies deployed in public transportation through the use of mobile phones include USSD technologies, and mobile banking and payment platforms, such as Kenya's Mpesa system (Hossain, Simula and Halme, 2016; Howell, van Beers and Doorn, 2018), but their diffusion might be hindered by a lack of appropriate business models (Howell, van Beers and Doorn, 2018). Users might be more willing to adopt familiar technologies instead of entirely new systems (Lucas et al., 2016).

Strömberg et al. (2016) used the diffusion of innovations theory in a trial for sustainable change in travel behaviour and concluded that people want to change and have positive attitudes towards innovations, but it appears to be difficult to transform their attitudes and intentions into a sustained practice. At the same time, the advancement of ICT is perceived to be influencing travel behaviour internationally. The influence prevails in both travel by private or public transportation and is associated with providing people with travel flexibility in terms of where, when and how to travel (Yuan, Raubal and Liu, 2012; Pawlak, Polak and Sivakumar, 2017; Zhao, Koutsopoulos and Zhao, 2018). Flexibility in travel is partially influenced by individualisation (Roselló, Langelang and Viti, 2016: 8), as travellers expect transportation to fulfil their personal distinctive demands. E-hailing and demand-responsive transportation can be attributed to this individualisation. Mobile ICT, such as transportation applications, e-hailing services and location geo-tagging on social media, are examples of how technological advancements are shaping people's activity travel patterns and social interactions, as they make it possible for people to use the time spent on public transportation more productively (Pendyala and Bhat, 2012; Hilty, Aebischer and Rizolli, 2014). This can be done by way of automotive technologies and navigation systems providing instant travel information, such as alternative routes, preferred destinations, nearby recreation and leisure areas. Technologies used in ITS lead to optimised performance of transport networks, improved reliability of travel time and changes in travel behaviour that might reduce externalities such as congestion, pollution, and carbon emissions (Pendyala and Bhat, 2012).

Some of the direct effects of ICT on travel include ICT replacing existing travel, which might create new travel patterns in the long term, as ICT becomes embedded into

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people's lifestyles (Banister, 2005). On a quest to promote sustainable transportation through sustainable travel behaviour, Meloni et al. (2014) studied the use of technology to pilot a Voluntary Travel Behaviour Change (VTBC) program, which would automate tasks such as capturing, processing and delivering information. Based on the study's findings, a dynamic method was proposed that would automatically send direct, instant, clear, persuasive information or advice to mobile devices and result in a smartphone application called IPET (Individual Persuasive Eco-Travel Technology). Research has found that positive travel behaviour can be encouraged by use of persuasive normative behaviour, including switching from private car use to using modes that are more sustainable (Piras et al., 2021). The study found that people's positive attitudes towards public transportation led to increased chances and intention to use sustainable travel means instead of driving a private car (Piras et al., 2021). However, it was not established whether the positive intention was also converted into the appropriate behaviour in a sustainable manner.

Banister (2005) indicated that some of the effects of ICT on transport include a modal shift in favour of public transportation. Travellers' options and requirements are fundamental to a successful modal shift from private to public transportation (Batty et al., 2015). To provide better alternatives to private transportation, it is necessary to address reliability, flexibility, convenience, safety and other requirements previously fulfilled by privately owned vehicles (Brög, Erl, Ker, Ryle and Wall, 2009; Meloni et al., 2014; Batty et al., 2015).

2.3 ICT-enabled Public Transportation Systems

Advances in information technology have been developed into innovations used in transportation systems. ICT has enabled better public transportation, and innovation in ICT has continued to improve the public transportation systems, thereby increasing the use of ICT (Funk, 2015). Earlier technologies used in public transportation included route design systems used by planners, scheduling used by transportation operators and automated fare collection (Vuchic, 2007). These were followed by improved ticket machines replacing the need for cash for bus fares, computer- and web-based booking of tickets and, most recently, smart cards, mobile applications and provision of real-

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time data through social networks and internet-based platforms (Commission of the European Communities, 2007; Ellison et al., 2017; Bounie, Adoue, Koning and L'Hostis, 2019). Smart cards were intended to improve the convenience of using public transportation, while also offering options on modes of travel by being used in areas where co-modality was available in public transportation (Ellison, Ellison, Greaves and Sampaio, 2017). Smart cards also removed the need for users physically to buy paper tickets, thus saving time when boarding or disembarking. These developments also benefited operators because their time and resources were saved.

Revenue management is used mainly in air transportation, which does not mean that the ICT functions cannot be applied to other transportation sectors, such as capacity and demand forecasting, over-booking and capacity management. Ticketing, through smart cards and other fare structures in public transportation are an integral part of revenue management (Scholz, 2016). Intelligent inter-modal transport units can refer to seamless transportation systems, including all available modes of public transportation in an area operating under one ICT-enabled process and system. These are considered to have the potential to improve efficiency, productivity, profitability, safety and security in the system, because they are seamless and lead to low environmental impacts and improved quality control (Angelidou et al., 2015). The importance of the accessibility and convenience of information about public transportation included the importance of promoting and marketing public transportation, which is essential to help people make pre-trip decisions (Le-klähn, Gerike and Hall, 2014).

Among other properties, ICT systems in public transportation should be user-friendly, efficient and secure (Scholz, 2016). Some systems utilised by public transportation companies include planning the trips, dispatching vehicles, operational controls, passenger information, ticketing and evaluation (Scholz, 2016). These systems involve several ICT-based processes that interact seamlessly with each other to create a successful IT system that supports passengers' experiences, as well as the service provision by the operators. Thus, it is pertinent for integrated public transportation, comprising information and fare systems, to provide a seamless service that then increases efficiency (Jansson, Andreasson and Kottenhoff, 2016:33).

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Advanced technologies have been used in most public transportation options to provide and disseminate information, and to manage revenue and public transportation fares. These provisions have led to general improvements and ease of access to public transportation. However, the developments in such technologies are still to be achieved in many countries, and their application could improve the efficiency of road public transportation in Southern African cities. In light of the recent Covid-19 pandemic and its impact on travel patterns and behaviour, Shah et al. (2021:3) suggested the uptake of technology advancements to strengthen the transportation systems.

2.3.1 Defining ICT-enabled road public transportation systems

It is well established that ICT is an enabling technology, when properly used, that can be leveraged to improve communication between people, increase productivity, help towards the provision of better services and connect people (Guermazi and Satola, 2005; Choudrie, Tsatsou and Kurnia, 2018). Even though it is evident that ICT has been an important factor of development, it is similarly apparent that with such advancements, ICT will continue to make an impact on the interactions between customers and service providers (Breidback, 2018). Similarly, there will be continued interactions between ICT and infrastructure. Leveraging technology for support, analysis and improvement of transportation services, together with the innovative use of ICT and adapting it to any changes within the systems to meet public transportation users' needs is essential to attain a fully ICT-enabled public transportation system.

ICT-enabled road public transportation systems require the synergy between:

i. Transportation infrastructure, referring to the bus ranks, taxi stations, terminals and bus stops serving the public transportation systems, especially buses and minibus taxis in the context of Bloemfontein, and combis (minibus taxis) and 5-seater taxis in the context of Gaborone;
ii. Vehicular components of the system (public transportation vehicles);
iii. Geographical and spatial characteristics, such as location, distance and the interaction between these characteristics and travel;
iv. People, which considers the sociopolitical as well as the economic interaction: stakeholders, users, operators, governing bodies, transportation authorities and government;

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v. Technology: The enabling device (ICT), including people's interaction with the technologies, which will be based on technological awareness, accessibility, interest, affordability, and willingness to use and purpose.

Therefore, ICT-enabled public transportation systems refers to a public transportation services system that fulfils individual travellers' mobility, and accessibility needs, and is integrated with ICT to create a synergetic, interactive, socioeconomically equitable system with improved efficiency.

2.4 Towards ICT-enabled, Road Public Transportation: A Policy Perspective

Transformation of cities' urban systems is often led by government authorities through directives and policies. Key regulatory and management decisions regarding transportation are made by governments through policies (Rodrigue, 2020). It is for this reason that poor policymaking and implementation have been regarded as the main contributors to a lack of development, with some attributions ascribed to political authority and the lack of political will. One such example is the assertion by Schiller, Bruun and Kenworthy (2010) that most of the negative impacts of transportation are a result of the lack of integrated planning, poor policy and the exclusion of effective public participation. Continued development of policies is required to adapt to new and emerging problems in transportation. Stopher and Stanley (2014) suggest that there was ample room for the introduction of new technologies in urban transportation based on policy, while Hensher (2019) claims that technological advancement and social change caused by accessible information has the potential to disrupt transport policy. It is necessary to understand travel behaviour in order to improve the effectiveness of transportation policy (Dijst, Rietveld and Steg, 2013).

To achieve fully functioning ICT-enabled public transportation systems, policy should be directed at socioeconomic and environmental aspects of transportation. However, priority should be given to public transportation and supporting policies. Public transportation is promoted as a solution to the problem of unsustainable transportation by virtue of it offering high occupancy and the perceived solution to traffic congestion. To support the shift to successful ICT-enabled public transportation, policies should

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address various issues currently hindering the adoption of public transportation, and create policies that promote the assimilation and integration of ICT. Environmental matters associated with traffic congestion and increased car use, the vital reduction of the current dependence on fossil fuels and the elimination of carbon emissions, and wasteful land-use, as well as ICT adoption are some of the issues that can be addressed by the appropriate effective policies that would eventually lead to reduced private vehicle use and increased public transportation use.

Inclusivity of public transportation and proposed ICT solutions should be extended to all societal groups through the relevant policy to ensure equity and access. The effective attainment of ICT-enabled road-based public transportation systems will rely on progressive policymaking. ICT-enabled road public transportation systems should offer an efficient mobility of people and better accessibility, both to the system and to activities. The transportation policy both of South Africa and Botswana was based on prepositions discussed below.

2.4.1 South African policy premise

The initial concept of transportation policy in post-apartheid South Africa is based upon the vision to:

> "*…provide a safe, reliable, effective, efficient and fully integrated transport operations and infrastructure, which will best meet the needs of freight and passenger customers in improving the level of service and cost in a fashion that supports government strategies for economic and social development, while being environmentally and economically sustainable"* (Republic of South Africa, Department of Transport, 1996).

The goals of the policy to support the vision included enabling access to transportation systems in ways that satisfy customers' choice criteria. Thus, transportation systems were planned to minimise mobility constraints, while maximising service and providing options for choice of mode. Flexible transportation systems that were responsive to passengers' needs and provided online information were suggested as ways to minimise these constraints (Republic of South Africa, Department of Transport, 1996). Integrated efforts were to improve safety, security, reliability, quality and speed of transportation in line with standards of international best practice. Investments were to be made into the transportation infrastructure or transportation systems in ways that

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would satisfy social, economic and strategic investment criteria. However, concerns of conflicts between providing improved levels of service and reducing infrastructure costs were raised in the policy (Republic of South Africa, Department of Transport, 1996). The policy implied that the goals of the transportation system were to create an integrated transportation and information system that would enable seamless, efficient and transparent passenger logistics. Public transportation was recognised as a basic human need for which government wished to ensure efficient provision, so the equity of the system was essential for sustainability. The policy aimed to ensure affordability of public transportation, and to promote safety, security and reliability. It also aimed to provide readily accessible information to public transportation users and ensure public transportation services that would address the needs of all users (Republic of South Africa, Department of Transport, 1996). The environmental provisions of the policy were to promote the efficient use of energy and modes of transportation that emitted less pollution. Regarding modal shift, policies prioritising public transportation over private transportation, especially at peak times, were proposed.

Moving South Africa (MSA) is an initiative by the Department of Transportation to improve sustainable transportation by the year 2020. The aim was to provide an effective and sustainable urban transportation system in South Africa. The system would be planned and regulated at the lowest possible government level and also, based on competition, operated by the private sector to reduce system costs and improve the services. This would contribute towards meeting customers' needs and national transportation objectives for user cost, travel times, choice and safety (Department of Transport, 1999). This initiative takes the satisfaction of public transportation users into consideration in order to achieve sustainability (Department of Transport, 1999). The strategies proposed for the initiative included legislation to enable the restructuring of the public transportation system in an effort to achieve sustainability. The objectives towards sustainability were linked to a sustainable system to enable funding and flexibility, which facilitates the achievement of the national sustainability goals, while also meeting customers' needs. National goals, which were stipulated as measures of a sustainable public transportation system, were set for the system to be accessible to all, while minimising costs and travel time. Customer needs, which were to be prioritised for a sustainable public transportation system, were affordability, reduced travel time, convenience, and freedom of choice,

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safety and comfort (Department of Transport, 1999). The initiative proposed that for a public transportation system to achieve sustainability, customers' needs and national goals had to be met (Department of Transport, South Africa, 1999).

ICT integration for sustainability was also outlined in the South African National Land Transport Act (2009), which stated that integrated planning is essential for integrating public transportation services that would integrate modes, cost efficiency and service quality. The Act states that the respective minister may make regulations relating to the requirements for an integrated fare system, ensuring compatibility between fare structures and levels of technology. Electronic fare collection and ticketing systems may also be put into regulation by the minister, and the systems are to be controlled by provinces and municipalities in partnership with operators or alone (Republic of South Africa, 2009).

2.4.2 Botswana policy premise

The aim of Botswana's National Integrated Transport Policy were to:

> *"…increase the quality and accessibility of transport services, replace or modernise transportation equipment in all modes of transportation, substitute travel demand with communications where possible, increase the use of new technologies, reduce harmful emissions by 20% by the year 2025 and 30% by 2036 and increase renewable energy in transport by 10% each decade"* (Ministry of Transport and Communications, 2011).

The policy aimed to ensure that transport supply was responsive to customers' needs by recognising that transportation had been viewed previously as the supply of transportation instead of being user oriented. The impact of high car ownership levels on traffic congestion in cities resulted in reduced efficiency of public transportation and increased operational cost for public transportation. It was also recognised in the policy. The objectives of the passenger transport policy were to attend to social needs by *"increasing public transportation patronage, reducing the use of private cars in urban areas, reducing social exclusion, prioritising public transportation projects and supporting poverty elimination*" (Ministry of Transport and Communications, 2011:16).

To improve accessibility, integrated land-use and transport planning were proposed in the policy to promote close consensus on the communities' needs, to optimise locations of amenities and services to reduce travel time and costs, and to give

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preference to compact urban development. The policy was also to ensure sustainable mobility by improving road safety, safeguarding the environment, managing traffic, encouraging the reduction of vehicle ownership, and managing travel demand. The establishment of the Gaborone Transport Authority (GTA) was proposed in the National Transport Policy to lead policymaking for, and regulation of, multimodal road transportation activity in Gaborone. The GTA was expected to reduce transport costs, improve the environment and reduce energy costs, produce better quality public transportation and reduce road accidents.

Non-Motorised transportation (NMT) was also catered for in the policy under its objectives to increase trips by NMT, improve the safety for NMT users, increase modal split in favour of walking and cycling, and reduce conflict between NMT and motorised transportation. Regarding embracing new technologies, the barrier caused by the lack of research resources in Botswana was acknowledged in the policy. The government's vision to solve transportation problems by embracing new technology and exploiting synergies that already existed between transport and communications was promoted (Ministry of Transport and Communications, 2011:28).

2.5 Tailoring Policy towards ICT-enabled Road Public Transportation

The goals of the policies in both countries were to promote sustainable public transportation, but the present state of the public transportation systems is evidence of the lack of fulfilment of the policy goals. Transportation policies, formulated at different levels of government, influence public transportation operations. In Bloemfontein, public transportation routes, pricing and operational parameters, such as vehicle types and carrying capacity, are managed and co-ordinated by the Provincial Department of Transport, while in Gaborone, they are managed by the Department of Road Transport and Safety. Public transportation is guided generally by transportation policies created to organise and enable human movement efficiently and systematically. There is a need for a shift in the operational policies to focus mainly on improving the efficiency of the public transportation systems.

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A greater focus in these policies has been on sustainability; hence, environmental, social and economic aspects that would eventually contribute to sustainability are propagated throughout the policy objectives, using terms such as inclusion, congestion elimination, emission reduction, NMT promotions and modal shift. ICT-enablement of public transportation operations was not given much attention. Hence, there is a need for policies that explicitly detail processes on how to achieve sustainable public transportation, by reinforcing the existing policies to include ICT as an enabler. In drafting new policies to govern sustainable cities distinctively, transportation systems should be created with the knowledge and awareness of the factors that influence choice of mode and social behaviour relating to travel. To promote sustainability, detrimental behaviours should be recognised, and policies should offer counter alternatives. In-depth understanding of travel behaviour can influence policy (Ko, Lee and Byun, 2019). Effective transportation policies depend on the consideration of traffic patterns, household income, modal split, and transportation supply, as well as the objectives of the policy (Agarwal, Ziemke and Nagel, 2019). The implementation of these policies can also affect travel behaviour and associated activities (Xu, Yang and Zhang, 2019). Important secondary and social effects can emanate further from appropriately designed public transportation policies (Nunes, Pinheiro and Brito, 2019).

Transition to efficiency-based policies requires governments and policymakers to undergo capacity building in order to coordinate transformative action and implement policies to fruition (Glaser, te Brömmelstroet and Bertolini, 2019). The following section discusses the existing policies and how they could promote public transportation. It further reviews ICT policies and how they may be leveraged to impact transportation for ICT-enabled public transport.

2.5.1 Policies promoting a shift from private vehicle use to public transportation

The influence of the use of cars on travel patterns is undebatable. Banister (2005:11) relayed that in the developed world, travel patterns were influenced by the use of car (Banister, 2005). However, a shift from private transportation reinforced by policy would be more effective in achieving sustainable road public transportation. Policies promoting modal shift include measures to draw passengers away from other modes of transportation to environmentally friendly modes, as well as measures to attract

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passengers to other modes (Hrelja, 2019). Promotion and discouragement of the use of specific modes can be enhanced by offering incentives, taxation for the use, or frequent use, of the undesired modes, informative outreach programmes, and extra charges for using and parking some modes in certain areas or for a certain period of time. The Green Transport Strategy (GTS) proposes a modal shift to reduce traffic congestion and improve transport efficiency through spatial, temporal and economic efficiency, and especially, to achieve a 20% shift from private passenger transportation to public transportation and other eco-friendly modes in a period of 5 to 7 years (Department of Transport, Republic of South Africa, 2018:25). The communications strategy to support GT focuses on promoting the awareness of a modal shift towards public transportation, NMT as well as introducing efficient vehicle technologies, emphasises that feasibility of the GT strategy will require a transparent, open communication with all stakeholders to encourage their involvement in and compliance with modal shift plans.

The Botswana National Integrated Transport Policy plans to achieve a 30% modal shift from private cars to public transportation by the year 2025 (Ministry of Transport and Communications, 2011).

2.5.2 Policies discouraging excessive car use

Excessive car use is a problem for sustainable urban transportation, as it promotes traffic congestion and increased emissions. To eliminate problems associated with increasing car ownership, policies should be introduced to discourage such private car use. Vehicle and driving restriction policies have been formulated in cities to try to effect a modal shift from private to public transportation modes. Policies to reduce traffic congestion, road accidents and pollution, and related suffering have been enforced in cities through congestion pricing (Cipriani et al., 2019). Road users or drivers are charged, based on the areas where they drive, the time of day and the types of vehicles. Congestion pricing, specifically Downtown Congestion Pricing (DCP) can be applied in the CBDs of crowded cities (Lehe, 2019). Downtown or CBD areas are usually the most congested during the day, as they are the places where businesses and some of the busiest transportation nodes in cities are located. Traffic flow is also often constrained, with vehicles parking in undesignated areas along the streets. Charging for prolonged parking and driving in these areas discourages drivers

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from spending more time there than necessary or even from driving into the CBD areas at certain times of the day. Congestion charging can be implemented through various schemes, such as the Area Licence Schemes (ALS), which involve varying charges for types of vehicles in an area at a certain time, and Electronic Road Pricing (ERP) in which vehicle IDs are detected electronically at pavement control points in charging zones and bills are sent to the drivers. Other schemes adopted include toll rings and toll gates where vehicles are charged when entering an area. Automatic Number Plate Recognition (ANPR) cameras are another method implemented to assist drivers being charged for contributing to congestion in some areas (Lehe, 2019).

The purpose of charges based on vehicle types or models is to reduce carbon emissions and favour eco-friendly vehicles over the older models that produce higher emissions (Cipriani et al., 2019). The South African Green Transport Strategy: 2018 – 2050 has a medium-term goal for travel demand management by developing regulation policies and congestion charges, which will be the responsibility of local government (Department of Transport, Republic of South Africa, 2018:55). Collaborations between the local governments and the Department of Transport to develop regulatory frameworks for congestion charges and taxing in high traffic volume areas and CBDs will be employed (Department of Transport, Republic of South Africa, 2018:30).

Congestion reduction was a short-term need under Botswana's National Integrated Transport Policy, which was envisioned to be attained by 2016. It is also listed under the public passenger transport sector policy. It states that congestion, caused by increasing car ownership in the city, impacts public transportation's efficiency and operating costs (Ministry of Transport and Communications, 2011). To address this, stringent measures that would favour public transportation where it is negatively impacted by private vehicles, will be promoted (Ministry of Transport and Communications, 2011:5). Further steps will be taken to charge and restrict private vehicle in cities and encourage the use of the most appropriate mode of travel by the year 2030 (Ministry of Transport and Communications, 2011:5).

However, discouraging the use of private cars should be met with equally efficient road public transportation systems. Restriction of car use has had a positive effect on the

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volume of public transportation passengers, but it did not have a visible effect on modal split (Zhang, Long and Chen, 2019). Private vehicle users might be discouraged from driving by prompting them to use the mode of public transportation with the next best efficiency. The attractiveness of public transportation in terms of reliability, comfort, cost, safety and overall efficiency should be able to attract and retain private vehicle users, although convenience remains a strong factor in favour of private vehicle use.

2.5.3 Policies promoting non-motorised transportation

Non-Motorised Transportation is considered a necessity in Africa (Vanderschuren, 2012). It is considered one of the most environmentally and economically sustainable modes of travel where walking and cycling are encouraged for sustainable cities. NMT can uplift the urban poor from the unsustainable burden of long-distance and high-cost travel (Vanderschuren, 2012). It is therefore crucial to accommodate NMT through policy.

The South African Non-Motorised Transportation Policy (2008) states that NMT will be a "*sustainable and stimulant*" transportation mode within an integrated and efficient transportation system towards the achievement of socioeconomic development (Republic of South Africa Department of Transport, 2008). The vision of the policy was to ultimately meet the mobility needs of NMT users and those of marginalised communities by providing a "*safe, secure and reliable*" transportation system. Among the objectives towards attaining its mission, the policy highlighted the integration into transportation and spatial planning together with the recognition of NMT as a safe, essential and standardised mode of transportation. Hence, the integration of NMT with road public transportation would be utilised at the trips between home and public transportation access points (Republic of South Africa, Department of Transport, 2008:31). NMT is also promoted as a measure towards GT by the South African Green Transport Strategy: 2018 – 2050 (Department of Transport, South Africa, 2018:55). For successful use and support of NMT, there should be legislation to guide the development of accessible and NMT-friendly road infrastructure. Research has found that some factors preventing the use of NMT in Gaborone include the lack of facilities (Pal, 2012). Policy provisions for adequate NMT infrastructure are needed. The promotion of NMT can be reinforced through congestion pricing, no-drive zones, and driving penalty charges. However, affordable NMT methods are not sustainable with

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regard to the time and convenience factors. Walking consumes more time, even though it is the cheapest mode of transportation, so it is much more suitable for travel over short distances. Also, having to change several buses or minibuses/taxis to reach one's final destination consumes a lot of time, as does having to walk to a bus stop, then inculcating the time on the bus, and finally having to walk again to one's destination. This also raises the inconvenience factor of having to combine various modes of transport.

2.5.4 Land-use and policies

Land-use and zoning have undeniable implications for travel behaviour. Zoning and urban planning policies influence land allocation, population density and land-use, which have an impact on travel time, travel distance and mode of travel. A study by Gössling Schröder, Späth and Freytag, (2016) that reviewed aerial imagery and calculated the area of spaces consumed by transportation infrastructure. It established the necessity of repurposing or reallocation of urban transportation spaces to create sustainable urban areas (Gössling et al., 2016). The study further suggested that the reallocation of space would make cycling popular (Gössling et al., 2016:674).

Zoning practices for transportation infrastructure should promote accessible transportation platforms, and walkable and cycle-friendly mobility. Planning of residential areas should also include the consideration of users of public transportation by catering for short walking distances and waiting times for all residents of an area. An integrated land-use must prioritise providing sufficient space for transportation, road networks, routes, terminals for sustainable transportation. Provision of enough space for ranks will eliminate constant upgrades, or the demolition of existing infrastructure to create space for expansion of ranks and terminals.

The South African National Land Transportation Act of 2009 states that transportation and land-use planning must be integrated. The contents of integrated transport plans must be prepared by planning authorities and handed over to members of the executive councils (Republic of South Africa, 2009). The Act provides for change and intensification of land-use with approval from the planning authorities that have the power to approve or decline the proposals (Republic of South Africa, 2009). Future land-use changes are considered by legislation. Therefore, it is upon the authorities to

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improve public transportation facilities and infrastructure to accommodate ICT-integrated public transportation. It is the responsibility of the Government of Botswana to construct, maintain and rehabilitate public transportation infrastructure (Lionjanga and Raman, 1990). In relation to land-use, the National Integrated Transport Plan for Botswana acknowledges the impact poor physical planning has had on transportation planning, especially the provision of transport infrastructure. Therefore, the policy aims to safeguard land to be used for future transportation infrastructure developments (Ministry of Transport and Communications, 2011) by preserving land for future roads infrastructure developments and increase the utility of road reserves. The policy aims to take efforts towards acquiring land for upgrading existing and creating new transport routes through for public consultation (Ministry of Transport and communications, 2011:53).

Land-use and zoning practices promoting road public transportation are needed to facilitate integration, and as a first step, the integration of public transportation modes and NMT. Distribution of land for facilities is the responsibility of government. Therefore, government should cater for infrastructure improvement, creating platforms for inter-modal and co-modal passenger transportation. Safe parking facilities for bicycles and private vehicles at public transportation terminals would also improve the use of public transportation. Zoning policies constricting parking can also be employed to reduce private vehicle traffic, users' reliance on car usage and ultimately, by creating space for sustainable means of transport (Al-Fouzan, 2012).

2.5.5 ICT policies

Policies promoting the use of ICT in transportation, accommodating virtual activities, such as online working and studying, can also influence the integration of ICT into public transportation. However, for such policies to be successful, multi-sector participation is required. Labour and education lawmakers, working with the communication sectors, should all be involved in the development of ICT policies. These policies could include ICT safety and security policies.

The South African White Paper's policy on a digital society is set to have a single strategy to ensure diffusion of ICT as an enabler in areas of the economy, such as the energy and transport sectors. It further highlights the enabling abilities of ICT, which

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can be opimised through “speeding up delivery, providing support analysis, building intelligence, creating new ways for sharing, learning and engaging (South Africa, Department of Telecommunications and Postal Services, 2016:114). The goal towards a digital society, once attained, will see members of society with access to mobile technologies and digital infrastructure allowing them unlimited access to information and services. Ensuring digital access and inclusion for all will be instrumental towards ICT-enabled public transportation. The role of ICT towards the country’s development will be by reducing spatial exclusion and enabling global participation. The White Paper further discusses the role of ICT towards industrialisation and reindustrialisation of sectors, including the transportation sector, which is among those highlighted as important towards the growth of the ICT sector (Department of Telecommunications and Postal Services, South Africa, 2016).

Botswana’s 2007 National Policy for ICT Development (Maitlamo, 2007) states the national ICT vision of social, economic and cultural development that would place the country as a globally competitive, knowledge and information society, a goal that would be attained by effectively using ICT (Republic of Botswana, Ministry of Communications, Science and Technology, Botswana, 2007). However, the policy document did not explicitly distinguish objectives towards transportation development through the use of ICT. However, Botswana’s most recent development plan (NDP 11: April 2017. – March 2023) provides ICT support towards the country’s ICT strategies for various sectors, such as water, agriculture and employment creation. The transportation sector is not explicitly listed as one of the priority areas. Development within the transportation sector focuses mainly on road network improvements and facilitation of road safety programmes to assist in the country’s economic growth of other sectors towards achieving sustainable development (Ministry of Finance and Economic Development, 2020).

Botswana’s National Integrated Transport Policy states that electronic communications are impactful in the transportation sector and are expected to reduce the need for travel; hence, affecting transportation demand. To attain this, the ministry is to develop and assimilate new technologies and also encourage the transportation sub-sectors to harness the incorporation of new technologies in their planning.

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The use of ITS to provide information to travellers in an effort to enable them to make informed decisions, encouraging home-based working, and replacing travel by using technology are some of the measures proposed to manage travel demand according to Botswana's Integrated Transport Policy that are bound to promote ICT in transportation (Ministry of Transport and Communications, 2011:25 - 26). The policy plans to embrace new technology to increase the application of technology and thus, solve transportation problems, gain positive economic benefits generated by the introduction of new technology and further exploit collaborations between transport and communications. An initiative started to include new technologies, such as ITS, into the National Transport Multi-Annual plan (Ministry of Transport and Communication, 2011: 28 – 29).

The importance of policy towards creating an ICT-enabled environment and the emphasis on the role of policymakers to create an enabling environment cannot be downplayed (Guermazi and Satola, 2005). Government policy and regulation impacts the way ICT services and infrastructure are developed and ultimately put to use; hence, it is important to align policy with technological advancement and the potential development prospect (Guermazi and Satola, 2005).

2.6 A Review of Theories Informing ICT-enabled Road Public Transportation Systems

2.6.1 Introduction

Integration of ICT into public transportation is intersectional. The intersectionality is evident in the fundamental contributions of theories by various scholars relating to the different aspects contributing to the study.

First, transportation and transportation systems are highly influenced by spatial and geographic features, as they are determined by the natural state of an area. Transportation networks, routes and nodes are represented by and located within the spaces they occupy. Geography dictates the flow of movement and connectivity within

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transportation networks' topological features. The topology of elements in transportation systems creates spatial and temporal interdependencies that subsequently contribute to the way in which people travel. The relationship between locations, structures of settlements, land-use, and the built environment determines transportation demand, cost, accessibility, and connectivity, as well as travel behaviour and patterns.

2.6.2 Spatial and travel behaviour theories

2.6.2.1 Time geography (Hägerstrand, 1970)

Key to the spatial or geographical aspect of travel patterns and behaviour is the Time Geography by Hägerstrand (1970). The theory states that limitations of time and tasks that exist in physical entities dictate and predetermine travel behaviour and activities' geographical distribution. Therefore, a person will be at a single place or physical location at any given time to perform limited activities. Travel, which also requires time, is then required for the individual to move from one place to another to perform another task. The theory further explains the interaction of different people's paths, which ultimately create a bundle of paths, ultimately leading to spread effects. The interdependence of bundles is a result of people, materials and information having to move from place to place in an orderly fashion.

Hägerstrand's take on bundles applies to today's travel by public transportation where individual travellers are not at liberty to control the flexibility of their trips and activities. Realising that individuals are not at liberty to establish their own paths, they are limited by capability, coupling and authority constraints. Road public transportation operates within legislation by government and governing bodies, and rules and regulations are set by public transportation operating entities and associations. These bodies set operational procedures, which may be constrictive to individual travellers. In reference to technology as a substitute to travel, Hägerstrand mentioned television screens in boardrooms instead of face-to-face meetings as a divergent idea. At that time, the potential for tele-activities was still at conception stage. The theory also recognises that telecommunication allows for "*people to form bundles without losing time in transportation*" (Hägerstrand, 1970:15).

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The relationship between geography and travel behaviour was detailed by Golledge and Stimson (1997), providing an insight into spatial behaviour. The decision-making process relating to geography and the physical environment was analysed by Golledge and Stimson (1997) as a motivated response process that involves: (i) seeking out information (*information search*). Information about the problem is sought and enough information is attained to move to determine (ii) behaviour-space perception. Behaviour-space perception, as described by Golledge and Stimson (1997), requires an individual's cognitive map to potentially decide on a destination. The cognitive map is structured in a spatial context in one's memory as "*an image or survey type of representation of a segment of the task environmen*t" (Golledge and Stimson, 1997:33). The cognitive map sets out and assesses the potential paths an individual could follow to a destination using minimal distance, time, effort, turns or even maximising on aesthetics (Golledge and Stimson, 1997). The next step would be (iii) activating the cognitive map, which entails the transference of the cognitive map to the working memory by the identification of behaviour-space attributes and dimensions. The application of a set memory determines factors such as time, distance and constraints to prospective travel in order to make a decision. Finally, the (iv) movement imagery creates a travel plan that envisions factors that may be barriers to travel constrained by sociocultural factors (Golledge and Stimson, 1997). In this envision, movement from origin to destination is also imaged, including the mode of travel. The authors emphasised the importance of socioeconomic factors towards the mode choice and availability by aligning travel plans with household needs and other household members' schedules to finally make the travel decision.

The authors also deciphered the motivated act, which involves the choice act whereby after decision-making, an individual's decisions between origin and destination are based on information about linkage, direction, frequency and intervals. Provisional trial behaviour is the follow up behaviour once information is obtained where the individual now makes a translated choice into the spatial setting, repeating the choice to create repetitive learned behaviours. Finally, in the feedback and evaluation stage, after these repetitions, satisfaction is evaluated. Satisfactory trials are then turned into habits, developing stable travel plans concerning paths and destinations.

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2.6.3 Theory of activity patterns

Chapin (1974) considered that understanding individuals' daily routines will allow for aggregated activities and provide for policy interventions based on regular activity patterns of groups of individuals (Chapin, 1974). Further, the theory-based activities on four determining factors, which are propensity, opportunity, appropriate situation, and the environmental context in which the activity is undertaken. First, the theory takes into account the activities related to propensity and distinguishes between motivating and constraining factors influencing activity patterns. Motivating factors are the reasons for performing or undertaking an activity whereas the constraining factors are pre-set conditions for a particular activity. Second, opportunity is determined by compatibility of the physical surroundings for activity as well as accessibility of activity location and the quality of the activity. Third, an appropriate situation is determined by appropriate timing and appropriate circumstances. Appropriate timing is determined by whether the individual performed other activities earlier, had prior commitments or adhered to institutional schedules. Appropriate circumstances are determined by the right people, props and factors such as weather conditions. Lastly, the environmental context under which activities are performed involves socioeconomic and cultural standings, as well as intrinsic factors, such as attitudes, level of satisfaction and reactions.

Every person taking a trip has a reason to travel, or the need to travel to perform activities, which are motivating factors. Such activities may be work, school, shopping, family obligations, entertainment, and so forth. Conditions beyond each individual's control refer to personal characteristics that end up dictating the feasibility of the travellers' activities.

2.6.4 Behavioural theories

The trans-theoretical model

The Trans-theoretical Model (Prochaska and DiClemete, 1982) was developed in psychotherapy studies of behavioural change. It is applicable to changes in individuals' behaviour. This theory follows six steps to behavioural change; (i) pre-contemplation, (ii) contemplation, (iii) preparation, (iv) action, (v) maintenance, and (vi) termination. Prochaska and DiClemente (1982:280) acknowledged that choice is a result of several

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options available to an individual and if only one option is available, the individual has no choice as to what to do. This applies to mode choice, in instances where an individual has alternative modes or no alternatives to choose from. Captive travellers, who use only modes available to them are also represented in this theory.

Theory of planned behaviour

The Theory of Planned Behaviour by Ajzen (1991:182) is based on individuals' intention to apply certain behaviour at a specific time and place. The theory takes into consideration the intent based on attitude, subjective norms or perceived behavioural control. Its main focus is "*the individuals' intention to perform a given behaviour*" (Ajzen, 1991:181). The plan to perform a certain action or undertake a certain behaviour is the focal point. However, the varying degree of intentions as per situation presented determines the importance of the intentions and the perceived behavioural control (Ajzen, 1991). Further, subjective norms, among them social pressure, also play a part in the end decision or action. This comprises the perceived approval or disapproval of a behaviour by society; hence, it contributes to behavioural change or lack thereof.

The concept of subjective norms justifies the behaviour by a cluster of people. In regard to travel behaviour, for instance in Gaborone, cycling as a regular mode of travel for regular work or school trips is not a common practice. Private car and public transportation use is the norm. Even if a person is willing to shift mode from either travel by public transport or private vehicles to cycling to work, this subjective norm might hinder their actual change in behaviour. Similarly, the shift from using a private vehicle to public transportation may be influenced by subjective norms. The societal basis of status, expectations and negative connotations would deem the move from private vehicle to public transportation as downgrading; hence, lowering social status.

Theory of routine mode choice decisions

The Theory of Routine Mode Choice Decisions by Schneider (2013) proposes a five-step theory, illustrating elements that influence the mode choice decision-making process. In an attempt to increase sustainable transportation, the proposed framework focuses on shifting regular travel by car to travel by NMT methods (walking and bicycle). In a broader approach, the theory is a description of the decision-making process pertaining to mode choice for regular travel. The theory outlines a five-step

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mode that reflects the choice decision-making process where the first four steps refer to socioeconomic factors influencing the response to each of the other steps. The first step is 'awareness and availability', which states that having a mode of transport readily available and being aware of such availability is necessary for mode choice decision-making. The second step refers to the need for 'basic safety and security'. It is essential for any available mode to be safe from accidents and secure from crime. The third step refers to 'convenience and cost'; this step emphasises the importance of spending minimal time, effort and money for travel. The fourth step refers to 'enjoyment'; this step shows the importance of physical, mental and emotional wellbeing when choosing a mode of travel, aspects that highlight that it is crucial that travellers should be enjoying their travel. It is in this study that the author also noted that while travellers were enjoying a mode of travel, this alone did not guarantee their continued regular use of the mode. The second, third and fourth steps to the theory can be applicable either simultaneously or in differing orders. The fifth step, 'habit', states that repetition of use of a certain mode breeds habitual behaviour; therefore, people using a certain mode on a regular basis were likely to consider the mode as their normal, regular form of travel (Schneider, 2013).

The study proposed a theory of Routine Mode Choice Decisions, which promotes walking and cycling. The first step to this theory is awareness and availability where the modes of travel available to the traveller and which they have the opportunity to select from, are stipulated. It is necessary to raise awareness among travellers that they have an option to choose any mode they want. The following three elements are clustered as situational trade-offs. The second to fourth elements to the model are basic safety and security, convenience and cost, and enjoyment. These three clustered elements can be used concurrently or in no specific order or sequence. The fifth element is habit, which emphasises the repetitive mode choice behaviour.

The author concluded this study by emphasising the need for implementation of strategies promoting walking and cycling at all stages of the decision-making process (Schneider, 2013). It should be noted that the strategy proposed for promoting cycling and walking can be implemented on a short-term basis, while others may take longer to be implemented (Schneider, 2013:134).

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2.6.5 Theories relating to technology integration

Information is essential to travel decision-making, as information technologies can ease the interactions between transportation systems and their stakeholders, users and operators. Even though this is the case, acceptance of such technologies by individuals, governing bodies and from a public transportation operation's perspective is vital and a precursor to their adoption into public transportation systems. Even though suggestions and recommendations for the uptake of technology as a solution to public transportation problems are possible, the decision to use these technologies still lies with the people involved in the process, the public transportation users, the operators, and the governing bodies. Acceptance of ICT is a human factor, based on findings using the Technology Acceptance Model (Davis, 1993; Davis and Venkatesh, 1996; Lee, Kozar and Larsen, 2003; Venkatesh, Morris, Davis and Davis, 2003). The uptake of technology develops from the relevant users' decisions, which involves planning and will-power. User acceptance of technologies has been studied intensively through acceptance models and theories such as the Theory of Planned Behaviour, the Technology Acceptance Model, Innovation Diffusion Theory and Social Cognitive Theory (Venkatesh et al., 2003). Venkatesh et al. (2003:427) defined the basic concept of user acceptance models as being based on individuals' reactions to using technology, their intention to use technology, and the actual use of the technologies.

Technology acceptance model (TAM)

The model focuses on how the users will accept technology, once a technology has been disseminated, based on its usefulness and its ease of use (Davis, 1989). The perceived usefulness of the technology and how easy it is to use influences the overall attitude and ultimately, whether that technology is accepted or not. Davis (1989:333) stated that the perceived usefulness of a technology was significantly related to usage of the technology, while ease of use of a technology did not have a strong relationship with the actual usage of the technology. This implies that users are likely to endure difficulties when using a technology, as long as there is the expectation of an improved functionality. In developing the model, the relationship between acceptance by users, perceived usefulness, perceived ease of use, attitude towards technology and the actual usage behaviour was examined (Davis, 1993; Davis and Venkatesh, 1996).

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This was the result of the rapid changes in ICT over a short period of time, which can lead to uncertainties in investments by users (Davis and Venkatesh, 1996).

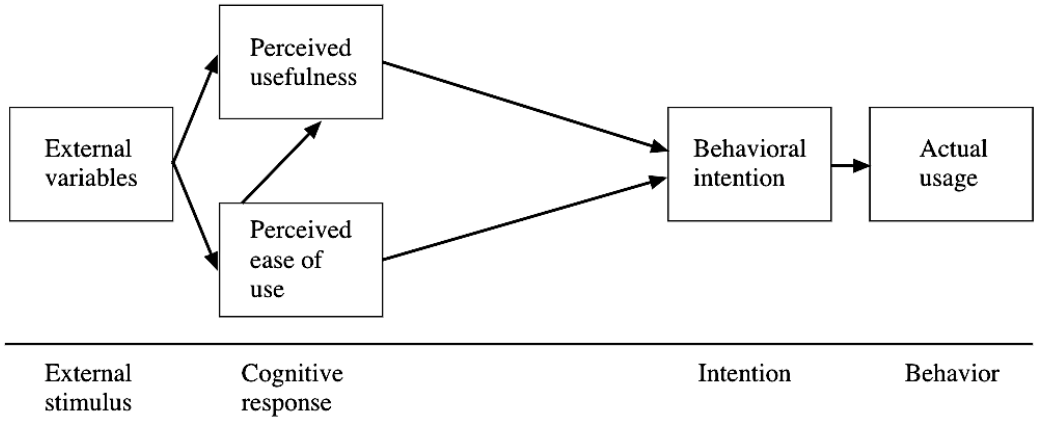

Figure 2.1: Technology Acceptance Model

Source: (Davis and Venkatesh, 1996)

This model is based on the users' willingness to accept technology, based on its perceived usefulness and perceived ease of use. People are likely to use technologies that have the potential to be useful, improve their lives, and are easy to use. Psychological influences also play an integral part in the acceptance of new technologies, because the intention to use has the potential to predict actual usage, while acceptance refers to the positive adoption of, and the decision to use a technology (Davis and Venkatesh, 1996; Taherdoost, 2018). Although individuals make most of the decisions about travel, technology acceptance is also determined by organisations. Organisational decisions play a large part in transportation systems, because transportation companies and governing bodies formulate and institute various decisions and policies.

Wallace and Sheetz (2014) propose a model of software measure used, based on the TAM, which incorporated several perceptions to the perceived usefulness of a technology. These perceptions, including life cycle applicability, language independence, prescriptiveness and validity, are deemed desirable in terms of measuring acceptance of software. The research further suggests that training and education are vital to improve the awareness of software measures, which would improve potential technology adopters' knowledge of strengths and weaknesses of the technology (Wallace and Sheetz, 2014). TAM has also been applied in social media

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usage (Rauniar, Rawski, Yang and Johnson, 2014), noting that utilitarianism of social media is determined by the perceived usefulness and trustworthiness. However, acceptance of such platforms by managers should not only be based on opportunities but the risks posed (Rauniar et al., 2014). The relationship between technology interventions in public transportation, and their success and failures are explainable by the TAM framework. Recent transportation studies in technology acceptance towards mobility and disruptive transport technologies, based on the TAM, examined the adoption of urban air mobility and vehicle sharing (Al Haddad et al., 2020; Efthymiou, Chaniotakis and Antoniou, 2020; Burghard and Scherrer, 2022). The disruptive technology model, based on the TAM can be extended by including the perceived reliability of automation, vehicle safety, locus of control, as well as past experience with automation (Al Haddad et al., 2020).

Diffusion of innovation theory

Based on the rate or speed at which innovation or technology dissipates, the theory acknowledges the slow and continuous process of technology diffusion (Hall and Khan, 2003; Rogers, 2003). The process of diffusion of innovations involves the innovation that is to be diffused, the communication channels it follows, time and the social system (Rogers, 2003). From the time an individual is introduced to a technology, the time involved in the individual's decision-making process whether to adopt a technology or reject it, contributes to the diffusion of the technology. However, it is essential to note that the process can also encompass adopting a technology at a specific moment or at a later stage (Hall and Khan, 2003). Social structure plays a significant role in diffusion, and it is this structure that ultimately dictates whether innovation diffusion is facilitated or hindered (Rogers, 2003). Rogers stresses that with diffusion comes societal change (Rogers, 2003). Once technologies are adopted and embraced in transportation systems, their diffusion would lead to entrenchment, which then becomes the norms and part of everyday travel. The innovation in this regard will be the ICTs, irrespective whether these are new or existing technologies introduced in public transportation. These can be in the form of software, applications, new online systems, or even using cellular phones for purposes related to travel. Conveyance of information about the ICTs through different channels to create awareness of these innovations takes place thereafter, moving the message from individual to individual.

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Once this information reaches an individual, then the decision-making process is activated as to whether to accept or reject a technology. Time is involved in this process, which consists of knowledge, persuasion, decision, implementation and confirmation (Rogers, 2003). The social system, in this case the public transportation system's stakeholders, users, operators, drivers, taxi associations, or governing bodies, will affect each individual's acceptance. It will also affect policy implementation by governing bodies, the technology roll-out and power of operators to accept the technologies in their business. The power held by government and regulatory institutions and their effect on diffusion is emphasised by Hall and Khan (2003) and Rogers (2003). Hall and Khan (2003) highlighted the importance of socioeconomic development, as well as geography and culture towards diffusion whereas Rodgers, Singhal and Quinlan (2009), acknowledged the role of multi-media and personal methods of communication as important channels, concluding that there should be a focus on organisations and communities, instead of focusing mostly on individual adopters of technology (Hall and Khan, 2003; Rogers, Singhal and Quinlan, 2009).

Unified theory of acceptance and use of technology (UTAUT)

The theory determines how likely a new technology is to succeed once adopted. Chances of success for technologies diffused into the public transportation systems can be forecasted using this theory as a foundation. Venkatesh, Morris, Davis and Davis (2003) developed the Unified Theory of Acceptance and Use of Technology (UTUAT), based on preceding models and theories on technology acceptance, among them DOI, TAM and TPB. After reviews and comparisons of these existing theories, the UTAUT was formulated. It was determined that performance and effort expectancy, social attitudes, as well as facilitating conditions would influence behavioural intention. However, factors such as gender, age, experience, as well as voluntariness of use of technology influence the relationship between these constructs and behavioural intention (Venkatesh et al., 2003; Momani, 2020). The UTAUT is considered a base for technology acceptance studies. It was extended by Venkatesh, Thong and Xu (2012), who formulated the UTAUT2, which added price value, habit and hedonic motivation as constructs to the existing UTAUT (Venkatesh, Thong and Xu, 2012, Korkmaz et al., 2022), relating the extension to customer use. This extension emphasises the enjoyment of the use of technology, the financial cost to

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customers, as well as the intentionality of use of technology created by habit. Based on the presumed potential stagnant level of user acceptance, and research based on the UTAUT, Venkatesh, Thong and Xu (2016) propose a framework for technology use and acceptance that incorporates individual attributes as low level contextual factors and environmental, organisational and location attributes as high-level contextual factors.

2.7 Summary

It is important for transportation systems to evolve at the same speed as the development of the urban areas' other functions. Transportation is the backbone of the functionality of urban areas, as it provides accessibility. This, in turn, leads to economic and social growth, as well as spatial dispersion of activities (Jahromi, Meneses and Moreira, 2014). Hidalgo and Huizenga (2013:67) attributed the development of transportation sectors in the developing world to compulsion by economic and social development. It is in the same respect that transport is recognised as an enabler, facilitator and catalyst for socioeconomic development, making it a unifier of human development and the environment, necessitating ICT integration as part of the cities' transport evolution. Socioeconomic development of countries and cities is guided by governments through policy. As countries develop, their policies have also been amended to accommodate this development or growth relative to global trends and direction. In recent times, they have focused on sustainable development. Policy-making has to involve stakeholders; the community and private sector must be consulted to allow for integration of information by the stakeholders at different levels, ensuring concise solutions (Shamsul Haque and Mudacumura, 2006:9).

Eliasson and Proost (2015:99) state that effective strategies for efficient transportation rely on "*attractive public transportation, walkability, compact land-use planning and restrictions on car use",* further suggesting that the strategies could be complemented by technologies that increase traffic safety and reduce transportation costs (Eliasson and Proost, 2015). The integration of technology into policy-based measured towards attaining ICT-enabled public transportation is essential. There needs to be a strong focus towards updating policies that fully appreciate the ever-growing transformational

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power of technology and leverage this fact to create direct policies for integration. Moreover, even though larger cities are criticised for their contribution towards unsustainability, there are suggestions that smaller- and medium-sized cities could offer solutions to sustainability, as they still hold the potential for transformation (Pojani and Stead, 2015a). Cities in the developing world are experiencing urbanisation at a rapid rate (Banister, 2005:14). They should exploit this potential for growth as opportunity for ICT integration through policy.

The theoretical framework for characterising ICT-enabled road public transportation is based on the interaction between geography, travel behaviour and technology acceptance. Travel is primarily a function of movement in spatial and temporal features. ICT-enabled public transportation is foremost dependent on spatio-temporal factors, location and time, that predetermine origins and destinations, and travel time. These factors also dictate accessibility of transport and activity locations. Second, it is a function of social and human behavioural factors relating to the need to and purpose of travel, and the ultimate decisions made to move from origin to destination for a specific purpose. The decision-making process includes mode choice and time of travel. IC technologies are brought into the process as an enabler of travel and catalyst to the decision-making process. On its own, the use of ICTs is a function of a myriad of decision-making processes by individuals and organisations. The acceptance of technologies for transportation purposes will depend on users' acceptance of the technologies and their willingness to use them. Differentiation between individual use of technologies, devices and applications and multiple use, or organisational use of technologies should also be made. Rogers (2003:1) had noted that it was difficult to get a new idea adopted, even though the advantages of that idea were obvious. Essentially, to shape future mobility by using ICT and other sustainable mobility prospective solutions, the users have to accept such technologies. Acceptability, not only of ICTs, but that of car-sharing, is crucial to the development of efficient public transportation systems. Shared mobility that can be facilitated by ICT, though considered a way to reduce the number of vehicles on the roads if well diffused, is not easily acceptable, due to factors such as the lack of convenience and ease of use (Burghard and Scherrer, 2022).

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2.8 Synthesis

Technological advancements have undeniable effects on transportation development and have thus, trickled down to individual travel decision-making and travel behaviour. There exists research from around the world, based on public transportation and ICT in transportation; however, there are limited studies focusing on Southern African cities and ICT-enabled public transportation.

The focus of urban studies has been shifted to encompass transportation studies, and the concern of public transportation has changed from automated vehicles to how to move people around efficiently and conveniently. Passenger transportation, both private and public, is available to move people from one place to another, but questions exist as to how public transportation systems can best be leveraged to fulfil the transportation needs of people in an efficient manner. The demand for travel must be met by the provision of sufficient means of travel, which the public transportation has not been able to fulfil. However, many underlying problems still exist within the public transportation systems, which many potential users find unattractive. Even though public transportation is often affordable, the inefficiency, unreliability and lack of safety are some of the factors that discourage people from using these systems. As studies continue to be undertaken to find ways to attract more users to public transportation, the inclusion of ICT has been considered. ICT in public transportation is considered from two perspectives or possibilities: As a substitute for travel, or as a way to enhance public transportation. However, the areas being studied have minimal use for ICT in transportation and for travel-related purposes. Travel activities and modes are still conventional. Successful studies on travel patterns have been made possible by ICT and ITS, which enable tracking of vehicles, payment by cards and sourcing information from cities about travellers and transportation operators.

The slow progress in the development of infrastructure in Southern African cities limits the procurement of improved vehicles that support the use of advancing technologies. Studies emerging from other countries and cities are made possible by the availability of data and continuously improved research. Therefore, technology has made it possible for travel studies involving data about passenger travel to be accessible and attainable easily.

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Socio-political influence on transportation cannot be ignored, as it is rooted in policy implementation and implementation depends on political will. Transportation policies that influence progress towards sustainable ICT-enabled public transportation have been proposed, but they are seldom implemented. It is well established by the policies for both countries that there is a need to keep up with the ongoing development in technology, while keeping a steadfast guard on sustainable transportation development. It is also evident through existing policies that there is recognition of the lack of sustainability caused by increased volumes of cars and the concurrent high level of dependency on private car use, and the resulting high congestion levels, and increased emissions from the transportation systems. The lack of ICT integration is also noticed by these policies and put forward as a possible catalyst. All these factors can be assisted by providing the necessary infrastructure, clean, reliable, efficient and sufficient public transportation, which may be reinforced by ICT to improve their efficiency.

Although research on ICT in transportation exists, there have been no studies conducted in Bloemfontein and Gaborone, which has resulted in a geographical gap in travel studies. More attention is still needed in the field of ICT for sustainable transport (Zhao et al., 2020). There was limited research conducted in the fields of public transportation and land-use, or the incorporation of ICT into the public transportation systems of either of these two cities, on which this study is focused. Therefore, new knowledge was created in this study on travel behaviour, travel patterns, social influences of public transportation and ICT usage in Bloemfontein and Gaborone.

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CHAPTER 3: METHODOLOGY

3.1 Introduction

The research methods and procedures used in this study to address and fulfil the stated objectives and the aim of the study are explained in this chapter. The research methodology explains the processes undertaken to fulfil the research objectives and the rationale behind the processes. A positivist epistemological approach was adopted for this study. This approach was selected to evaluate the factors influencing the behaviour and decision-making of individuals, and their possible impacts on a larger scale (Hofer and Bendixen, 2012). Positivist epistemology was employed, using quantitative survey statistics to quantify, explain and predict individual behaviour. Positivism was initially linked to the need to obtain valid knowledge through measurement and quantification, but this was developed to include the articulation of coherent perspectives on human spatial behaviour (Couclelis and Golledge, 1983; Khanna, 2018). According to Golledge (2006), epistemology has also influenced behavioural research in an effort to explain the undertaking of spatial actions. In this type of behavioural research, "*spatial thinking and reasoning to explain human actions and activities in different environmental settings*" are used (Golledge, 2006:75). Kitchin (2006) discussed the place of positivism in geography and behavioural approaches, highlighting that positivism in spatial geography is supported by Geographical Information Systems (GIS) paired with quantitative geography.

The same approach was applied in both contexts of this study to review individual travel behaviour and spatial decision-making, respectively. It is of fundamental importance to understand why people travel the way they do in order to forecast future travel behaviour and where possible, mitigate negative impacts on more sustainable travel behaviour, or remove the barriers to successful shifts in behaviour.

Prior to the data collection, an extensive literature review was conducted to establish the background of the study. The literature review consisted of three sections; scholarly literature, and a review of theories and policies, which were detailed in Chapter 2 of the thesis.

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3.2 Literature Review

An intensive review of existing data was crucial to this study. The different types of literature are discussed below:

3.2.1 Scholarly literature

Literature sourced from books, journal articles and conference papers was used to establish an understanding of existing knowledge. Ravitch and Riggan (2016:29) define a literature review as "*a synthesis of research literature about a particular topic".* A literature review can be used either to simply refer to the process of reading scholarly material, which is the process of conducting a literature review, or as the product of writing about the scholarly literature presented as a chapter in academic writing reports (Ridley, 2012; Harris, 2020). It offers an understanding of already existing knowledge through extensive referencing to existing research and theories related to the topic of study (Ridley, 2012). The literature review serves a number of purposes, some of its functions as described by Ridley (2012) are that (i) it serves as a background to the study, (ii) it provides an overview of the context of the study, (iii) it discusses theories and concepts underpinning the study, (iv), it can be used to introduce relevant terminology and detail the context in which the terminology is applied in the study, (v) it provides a description of related research and discusses how the study addresses the research gap, or (vi) it provides evidence of problems, which the study intends to address (Ridley, 2012:24).

Existing literature related to the topic and key concepts of the study was sourced from published books, journal articles, conference papers, reports, and news reports. It was then systematically detailed and its contribution to the study structurally discussed.

3.2.2 Review of policies

A review of legislative documents pertaining to public transportation and technology adaptation and use was conducted to establish the status quo. Policy documents often include future plans by government on how existing problems and new developments will be addressed. Karppinen and Moe (2021:10) state that policy documents are "*statements that are intended to communicate political action*". They articulate plans on how governments intend to achieve their goals. In stating that there are blurred lines between documents and literature, Karppinen and Moe (2012:5) suggested that

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the policy documents remain a form of literature. The context in which the policies were formulated, their intended purpose and the impact the policies have had was also reviewed.

Similar to any other sector operating in a country, the transportation sector is overseen by various government structures through policy. Sustainability and technological advancements have been part of governments' agendas for decades. Governments have formulated policies to promote sustainability, leverage technology and operate transportation systems. This study reviewed the policies to establish what action followed the formulation of such policies and what is yet to be done to fulfil these policies' goals. The study used these policies in conjunction with scholarly literature to suggest new policy direction to address and create sustainable public transportation systems that employ the use of ICT.

3.2.3 Theoretical review

A review of various theories provides a platform for generalising on the basis or said theories to create a direction for the study. Anfara and Mertz (2014) ascertain that theories may guide the methodology of a study, while Ravitch and Riggan (2016) conclude their discussion on where theory comes from by stating that theory may be presented as a formal relationship, as the researcher's belief or as a hunch held by the researcher. A review of theories and theoretical models was conducted to contextualise the current study. Contextualising the study by using theories controls possible subjectivity (Anfara and Mertz, 2014; Adom, Hussein and Agyem, 2018). The study thus employs a review of a combination of theories from various backgrounds, forming constructs that explain the status quo of current travel behaviour, patterns, technology use and adoption, and the reasons for the current status. The interconnectedness of these explanations, constructs and views guided the current study. Hence. the direction for the study was birthed through varying perceptions that ultimately built a relationship of these multiple constructs. However, sentiments by Anfara and Mertz (2014) are worth noting that acknowledge that there was no theory that could perfectly create a perfect interpretation of what was being studied.

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3.3 Data Collection

3.3.1 Secondary geographical data

Secondary geographical data was derived from OpenStreetMap (OSM) plugin in QGIS (Saha and Frøyen, 2021). Shapefile data of each city's road network was obtained from OSM. The road network data was merged with primary geographical data for accessibility analysis, based on distance and time using the road networks.

3.3.2 Primary data

Primary data was gathered using questionnaires, which consisted of closed and open-ended questions. Applying mixed methods for this study allowed for open-ended or qualitative responses to compensate for the numerical data, while the quantitative data justified and validated experiences and opinions. For these reasons, the study took advantage of the strengths of both methods. Creswell and Clark (2011) described mixed methods research as integrating at least one qualitative method with qualitative methods and vice versa. Similar assertions are made by Clark and Ivankova (2015). The research drew on the strengths from both qualitative and quantitative enquiries, as both methods compensated for each other's shortcomings (Kumar, 2014). The need to fulfil the research objectives through multiple research phases as described by Creswell and Clark (2011:11) also influenced the integration of various methods into the study.

Mixing qualitative and quantitative inquiry in the research tools was important for this study, as Bonsall (2009) suggested that the use of a combination or various methods in travel studies reduced bias. Moreover, research methodology research shows that mixed methods can be employed to establish a theoretical stance (Creswell and Clark, 2011:10). The theoretical background of the current study prompted the need for both qualitative and quantitative data, as it drew from various fields, which are systematically integrated to provide an understanding into the research questions. Quantitative and qualitative data was collected and analysed concurrently to address the research problem posed in the study.

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3.3.3 Qualitative data

Qualitative aspects of a study seek to enquire on narratives by investigating the experiences of individuals (Clark and Ivankova, 2015). There has been criticism towards the subjectivity of qualitative data in the past, for example, by Borman, Le Compte and Goetz (1986), who highlighted that qualitative research often lacks objectivity. Some criticisms of qualitative research pointed to a lack of validity and empirical surety (Borman, LeCompte and Goetz, 1986). In this study, the qualitative data obtained from open-ended questions put into context the participant's perceptions, views and understandings of constructs to the researcher.

3.3.4 Quantitative data

Quantitative methods are based on data that can be countable. They employ the use and analysis of numerical data into statistics and percentages to study a phenomenon (Mishra and Alok, 2011). These methods explore relationships between variables represented in standardised numerical data using descriptive and inferential methods. Descriptive data determines the characteristics of a subject, variable or a group and describes the present circumstances as they are (Dulock 1993; Mishra and Alok, 2011). An elaborate definition of descriptive research by Dulock (1993:1) utilised purposes to define descriptive research. The purposes were to describe the facts and characteristics, provide an accurate portrayal of characteristics and portray the characteristics of individuals, a population group, or of an area of interest and to discover the relationship between variables (Dulock, 1993). Correlation was used to further describe the data. According to Seeram (2019), correlational research seeks to facilitate prediction and explanation of the relationship between variables. Correlation coefficients are used to describe the magnitude and direction of the relationship between quantitative variables (Bellini and Rumrill, 2009). Boslaugh (2013) defined inferential methods as those that characterise and make general decisions for a population, based on information drawn from the sample. Inferences make a judgement about unknown circumstances, based on truths that are already known. The study employed binary probit regression analysis to draw inferences on the relationships between coded quantitative variables.

Two subsequent questionnaires, using the methods described above, were developed and used for primary data collection in each study area. An overview of each

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questionnaire, providing detailed discussions of the research parameters, is detailed in Sections 3.4 and 3.5. The data collected was analysed as discussed in Section 3.6.

3.4 Overview of the Travel Behaviour Survey

The questionnaire focused on travel behaviour and covered a broad spectrum of socioeconomic aspects, travel patterns and behaviour, and data about use of ICT. The aim of the paper-based questionnaire survey was to identify the social factors influencing transportation and travel and ascertain the level of ICT diffusion in the respective communities. The study was aimed at both public and private transportation users who travelled frequently to perform activities.

The relevance of this questionnaire to the study was informed by Bonsall (2009), who highlighted the importance of socioeconomic characteristics towards sustainable travel studies. It is the basis of understanding why people travel the way they do; the financial ability and car ownership, mode of travel relative to activities, the location of activities relative to residential areas, travel times, trip durations and perceptions of travellers towards congestion.

Questionnaire surveys were conducted between August 2017 and January 2018 in Bloemfontein, South Africa, and between September 2017 and February 2018 in Gaborone, Botswana. Simple random sampling of participants was used. Given the populations of each city, a sample of 384 or more, based on a 95% confidence level and allowing for a 5% margin of error were deemed adequate. Therefore, the final sample sizes of 415 and 388, respectively, were obtained in Bloemfontein and Gaborone. Although participants were not selected based on areas or neighbourhoods where they resided, the study noted that some areas had higher representation than others. Figures 3.1 and 3.2 show the areas of both cities where the participants resided.

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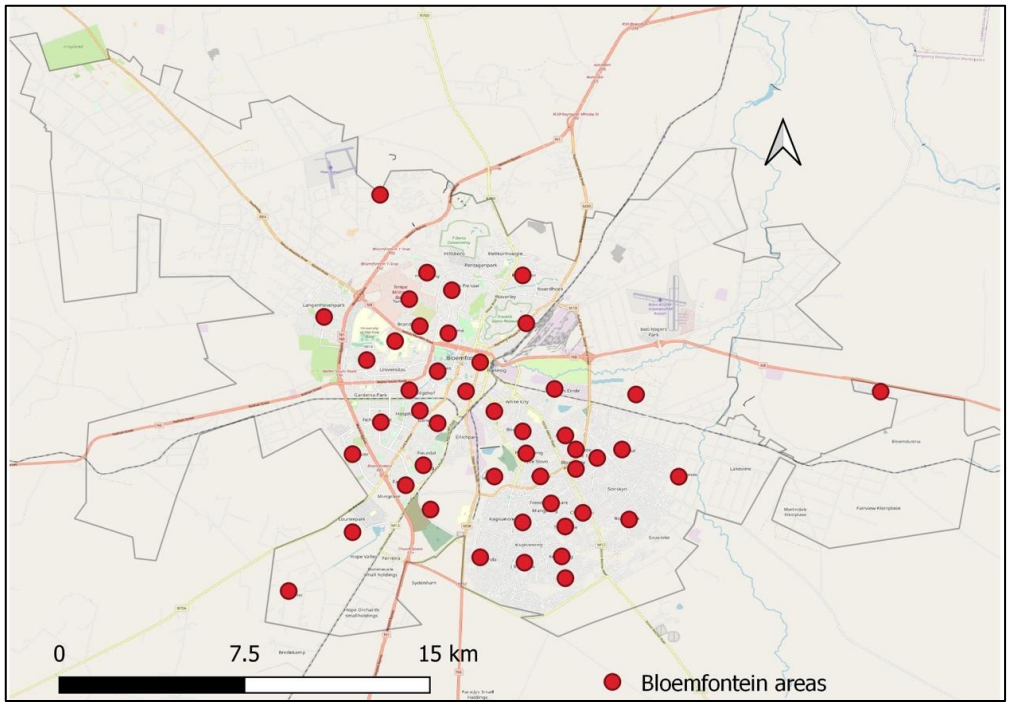

Figure 3.1: Bloemfontein Areas

Figure generated on OpenStreetMap on QGIS

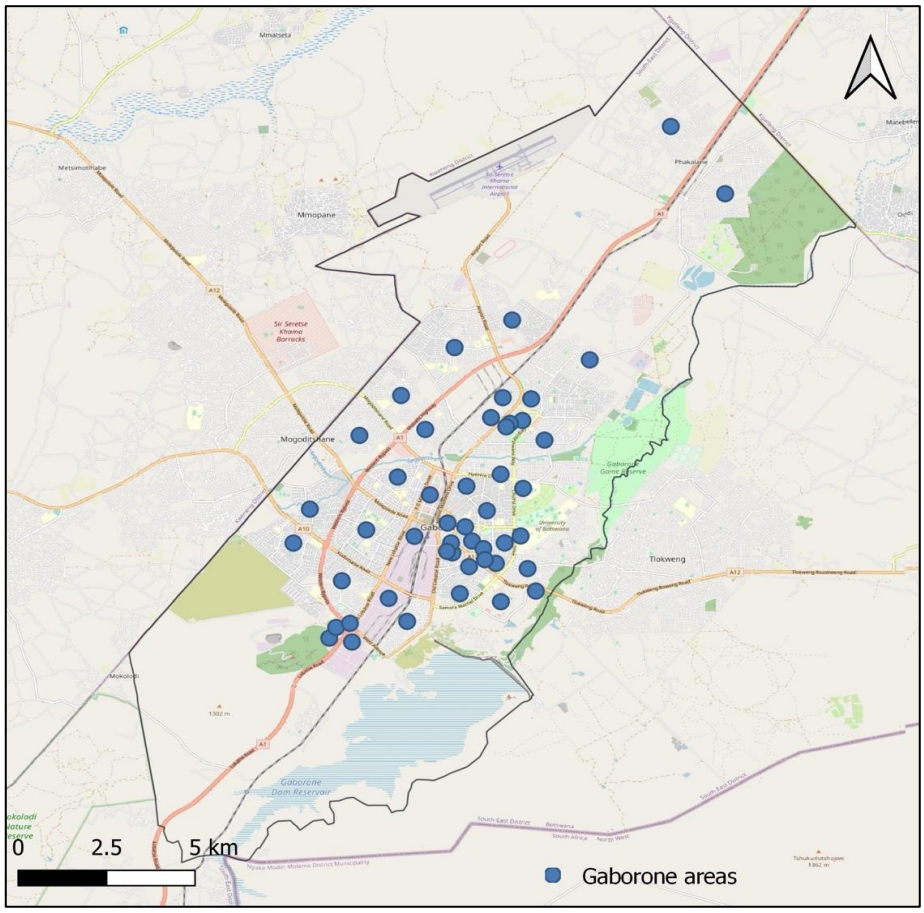

Figure 3.2: Gaborone Areas

Figure generated on OpenStreetMap on QGIS

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First, to obtain the demographic characteristics of participants, they were asked to indicate their age group, gender and type of occupation. Demographic characteristics are essential in transportation studies as they often influence the way people travel, and specifically, their choice of mode and times of travel. An in-depth overview of the survey questionnaire is detailed further in the Sections 3.4.1 – 3.4.6 below:

3.4.1 Assessment of land-use and spatial travel characteristics

The purpose of this section was to evaluate the current state of spatial characteristics and zones of land-use in the selected cities.

Spatial data included geographical information about suburbs of residence and suburbs where the participants carried out specified activities, such as work, school, religious, recreational, or shopping, and so forth.

a. Locations where the participants resided and spent most of their days, and their perceptions of land-use were explored. Accessibility and mobility between residential areas and areas of work and study were assessed, using availability of direct public transportation as a measure.
b. Locations where participants performed activities were also assessed to determine the travel patterns and human movement within the study areas.

3.4.2 Assessment of modal split

In this section, the various modes of travel used for activities and the frequencies with which they were used were assessed.

a. Mode of transportation used for activities and frequency with which each mode was used were assessed to understand the composition of vehicles on the roads at given times.
b. Factors influencing choice of mode were also assessed to understand why travellers used certain types of transportation.

   Cronbach's reliability analysis was used to test the internal consistency of the attributes. Andrew, Pedersen and McEvoy (2011:202) described the purpose of Cronbach's Alpha as measuring how well a set of variables measures a single construct. Values of 0.7 are considered desirable whereas above 0.9 may not be desirable (Andrew, Pedersen and McEvoy, 2011).

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3.4.3 Assessment of travel time, distance and congestion

Accessibility of transportation services and activities is essential to sustainable transportation. Time and distance are used as spatial measures of accessibility. The following were assessed:

a. Distance travelled per person was assessed to understand the spatial accessibility of the most common activities, i.e., home, school and work.
b. Travel time between these places was assessed to evaluate time spent at stops, in-vehicle, and total time spent travelling per day. Travelling time spent on delays was also evaluated.

   Traffic congestion was assessed by requesting participants to rate their perceptions of the level of congestion during their trips, using a Likert scale ranging from 1 (no congestion at all) to 5 (extremely congested). Congestion contributes greatly to travel time. Delay times were also assessed to understand the levels of congestion further. Assessment of delays in traffic, how long the delays lasted, and the frequency of trip delays depicted the state of congestion in the study area.
c. Cronbach's Alpha was used to measure the reliability of the scale towards determining the general congestion.
d. The cost of travel for public transportation and private vehicles was assessed because monetary cost contributes to the sustainability of transportation.

3.4.4 Assessment of public transportation problems

Participants were asked to select the problems they have encountered from a list of options of common problems in public transportation vehicles. They were asked also to indicate how the problems were resolved. The responses in this section provided insight into the current state of public transportation and provided a foundation for new solutions to problems in public transportation to create a more sustainable environment within the system, as well as ideas on how future issues could be avoided or mitigated in a new sustainable system.

It was essential to explore the general perceptions of public transportation systems by both public and private transportation users in the quest to create a better system. Positive perceptions provide the basis of what to include in the aims of creating

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sustainability, while the negative perceptions provide insights into how the system can be improved. Modal shift depends mainly on improvements made to the public transportation system to attract private vehicle users. Therefore, understanding problems within the public transportation system would allow decision-makers to eliminate the problems and create a more conducive and attractive public transport environment, which might then attract more users.

3.4.5 Assessment of private vehicle use and possibilities of modal shift

Private vehicle users play an integral part in the debate about sustainable passenger transportation. Over the years, private vehicles have been considered to be one of the major causes of congestion and emissions, attributable to their increasing numbers and low passenger occupancy. Understanding the activities undertaken by travellers and the consequences of the activities is essential in achieving environmental sustainability (Bonsall, 2009). The author also recognised the importance of the adoption of sustainable travel patterns by individuals either as a personal choice or as a result of societal demands and placed the emphasis on these patterns' importance regarding available data on change of attitudes and behaviour. Understanding the reasons why people choose private vehicles over public transportation, as well as factors that would attract them to use public transportation would assist in better planning of a public transportation system that caters for those who have the option to use their own vehicles. In this section, the reasons why people use public transportation and whether they would be willing to shift to public transportation were investigated, as well as the improvements they would like to see in public transportation to encourage modal shift.

3.4.6 Assessment of the use of ICT in public transportation and travel

The effects of ICT on travel by public transportation were evaluated. Data on the use of "communications media" and by extension, ICT, using factors such as time, type of technology, frequency of use, time of use as well as costs of the technology are useful towards the study of travel mode sustainability (Bonsall, 2009).

The people in both study areas have not experienced the use of advanced ICT in public transportation within the cities. Thus, any experience with ICT in transportation will be based on the use of such technologies when in other cities. Views and sentiments may also be based on secondary information through literature and various

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forms of media showing the state of ICT in other countries and cities. The assessment was therefore based on the possibilities of adaptation to ICT in public transportation and the potential uses at three stages of making a trip. In addition, the prospective impacts of ICT on travel and an understanding of sustainability, as affected by use of ICT, were assessed as follows:

a. ICT use at different stages of a trip:
   Incorporating ICT into transport required an understanding of the usefulness of ICT components to prospective users before undertaking a trip, during the trip and after completing the trip.
b. ICT influence on travel:
   To understand the current state of ICT use in transportation in order to determine the level of ICT penetration in transport, as well as the awareness level of users.
c. ICT for sustainability:
   To understand the participants' understanding of sustainability and the importance of ICT in achieving sustainability.

3.5 Overview of the Public Transportation Origin-destination Survey

The questionnaire was a public transportation trips origin-destination survey, which focused on the geographical composition, spatial and temporal characteristics of public transportation trips and the use of ICT by public transportation users. The questionnaire was used to record the characteristics of the participants' most regular trips, ICT-based activities performed during the trips, as well as satisfaction with the public transportation services. The necessity to focus on public transportation users only stems from the relevance of public transportation to the study; to observe travel patterns of road public transportation users.

Data collection exercises were carried out at public transportation terminals, ranks, and bus stops to access public transportation users. These locations were strategically targeted, based on the concentration of public transportation activity. Therefore,

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regular public transportation users were accessible at these areas. A final sample size of 384 was used in Bloemfontein and 415 in Gaborone. These sample sizes were based on a 95% confidence level and 5% margin of error, which is adequate, based on each city's population numbers. Survey samples were collected from randomly selected users of public transportation. Individuals were approached at these locations, and their consent to participate in the study was requested. When consent was given, the survey was conducted.

The areas where data collection exercises were performed, are shown in Figures 3.3 and 3.4 below.

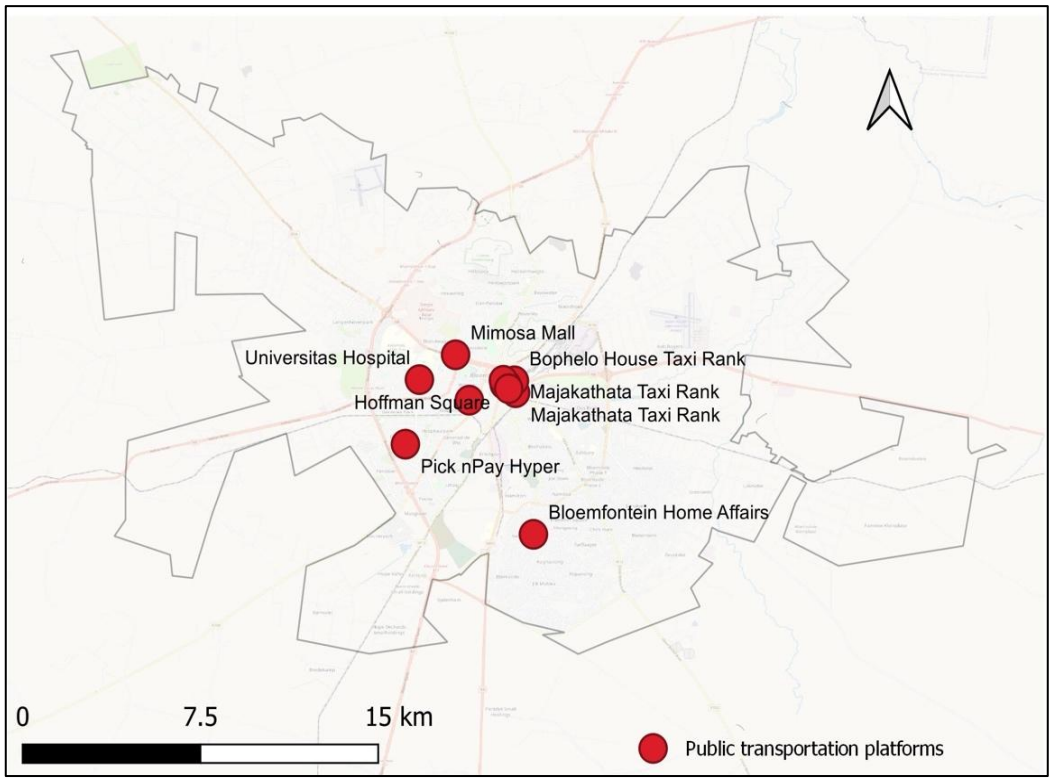

Figure 3.3: Bloemfontein public transportation prevalent areas

Figure generated on OpenStreetMap on QGIS

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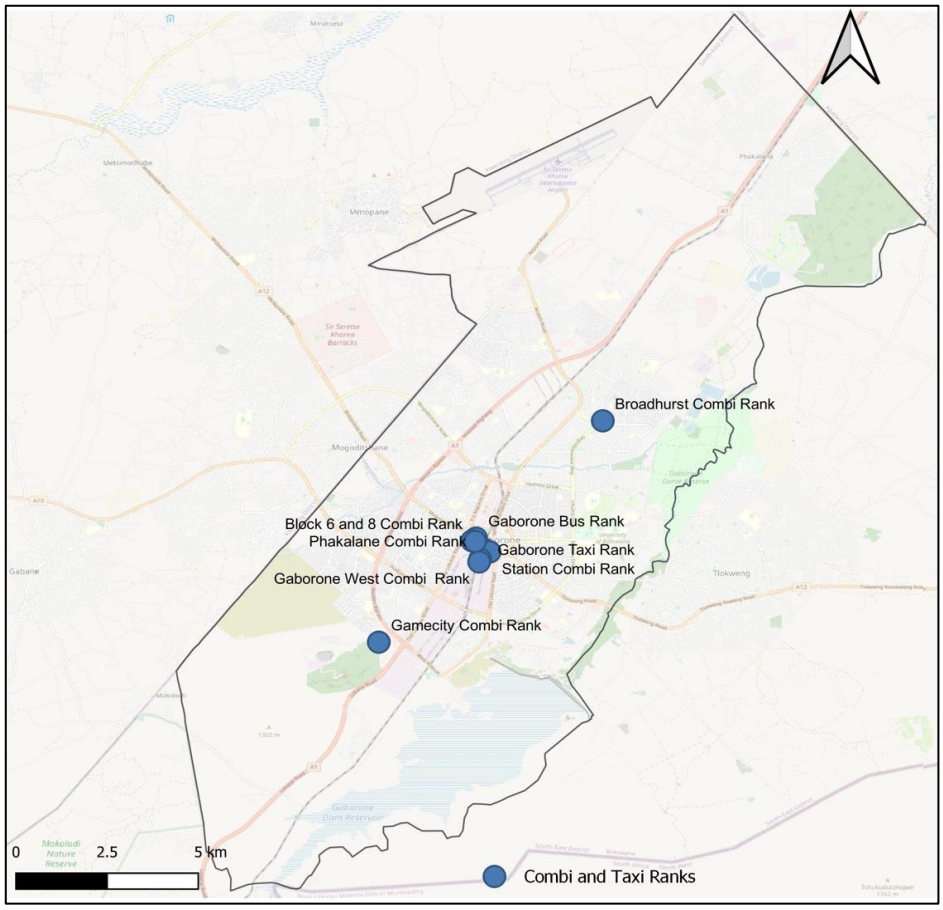

Figure 3.4: Gaborone public transportation prevalent areas

Figure generated on OpenStreetMap on QGIS

Choice-based sampling, which, according to Ortúzar and Willumsen (2011), entails population stratification, based on the result of the choice process, was used for the study. The method justified the use of public transportation users as the sample population (Manski and Lerman, 1977). Simple random sampling was also used to sample the public transportation users. Simple random sampling is one of the most interesting sampling methods used for transport modelling, according to Ortúzar and Willumsen (2011), who asserted that most accepted sampling methods for modelling are based on random sampling. As participants were randomly chosen, the study noted underrepresentation or a lack of representation of some areas. This can be attributed to the use of private vehicles and lack of access to public transportation by people living in those areas.

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The survey was divided into sections as follows:

3.5.1 Trip characteristics

Data about trip characteristics were gathered, including geographical locations where trips originated and terminated, travel times, trip cost, mode of travel, and trip purposes.

a. Spatial characteristics:

   Coordinates for the origins and destinations for all trips taken by participants on the day were recorded. The destinations were bus stops, bus terminals or points along roads where the users waited for, or alighted from, public transportation. Maps showing these locations were created to identify public transportation nodes and assess the general human movement in the cities. Google Maps was used to identify the geographical location of origins and destinations. The locations of origins and destinations shows flow of movement of people and helps identify a concentration of locations that can be identified as public transportation nodes.

b. Temporal characteristics:

   Times when trips were made were assessed, including the departure time from origins, arrival time at destinations, the duration of each trip and total time spent travelling. This data was used to identify peak and off-peak times, as well as the availability of public transportation at certain times of the day.

c. Mode of public transportation:

   The mode of public transportation used was assessed.

d. Trip purpose:

   The reasons for undertaking trips were assessed.

3.5.2 Use of public transportation

The focus of this section was to collect data on the frequency of public transportation use, the period of public transportation use, and future use of public transportation. The frequency was assessed according to the number of days per week that the users' most regular trips were taken. The periods over which the users had been using public transportation and whether they would continue to use public transportation in future

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were also assessed. The retrospective questions in this regard enabled the study to acquire data on past activities and associated change over certain period of time.

3.5.3 Use of ICT

The focus of this section was on the current use of ICT by public transportation users, the influence of ICT on travel by public transportation, and the possibilities of ICT substituting some travel by public transportation. Stopher (2009) emphasised that the surge and growing prevalence of technologies was likely to impact travel and change the way travel and communication interacted. Data collected comprised the activities performed by participants during the trip, participants' usage of and types of devices used during public transportation trips, usage of other ICTs during travel and whether travellers would substitute travel with ICT alternatives. The assessment of ICT usage determined the current state of ICT's impact on travel and the prospects for future ICT-enabled public transportation. The use of ICT during public transportation trips and how ICT influenced regular travel activities were also explored.

3.6 Data Analysis Tools and Techniques

Statistical analysis of primary data was conducted using the Statistics Package for the Social Sciences (SPSS 22) and presented using Microsoft Excel. Quantitative data, which was in the form of multiple responses, single responses or open-ended numerical responses, was analysed statistically using SPSS. To analyse the qualitative data, thematic and content analysis was applied. Qualitative data obtained from both questionnaires in the form of continuous and open-ended responses, was grouped into themes and coded to reflect the common themes of the responses. Subsequently, the responses were analysed statistically to establish significant percentage occurrences by using SPSS. Pairwise deletion was used to eliminate missing data from the analysis of each variable (Warner, 2012).

3.6.1 Descriptive data analysis

Descriptive statistics were used to identify characteristics of groups of the samples, using frequency distribution and percentages, and present summaries of characteristics. This data is presented in tables, charts and graphs.

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3.6.2 Inferential data analysis

Inferential data analysis, using correlation and binary probit regression, was used to generalise and explain the relationships of variables as predicted by the coefficients. The samples were analysed by applying probabilistic approaches and conclusions drawn based on the probabilities and the relationships between variables.

Pearson's correlation

Pearson's correlation tests were conducted to establish the relationship between congestion and trip duration variables. Below is the Pearson's correlation equation:

$$r = \frac{\sum(x_i - \bar{x})\,(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Where:

$$r = correlation\ coefficient$$

$$x_i = values\ of\ x\ variable$$

$$\bar{x} = mean\ of\ the\ x\ variable\ values$$

$$y_i = values\ of\ the\ y\ variable$$

$$\bar{y} = mean\ of\ the\ y\ variables$$

Binary probit regression

Probit regression was used to model the relationship between different ICT-related binary variables (decision variables) and different independent variables. The dependent variables were selected, based on their possible influence on an ICT-enabled public transportation system. This type of regression analysis is used to model a relationship between one or more independent variables and a binary dependent variable (Flury and Riedwyl, 1988; Scott, Hosmer and Lemeshow, 1991). Binary probit regression is applied to determine factors that would influence the use of ICT for public transportation-related purposes. The binary assessment was based on the outcome of whether an event occurs or does not occur, determined by the probability of choice. Probit models are part of the Discrete Choice Models that are used when individual choice is involved. Discrete choice models are used to postulate the probability of individuals choosing a given option as a function of their socioeconomic characteristics and the relative attractiveness of the presented option (Ortúzar and Willumsen, 2011).

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Travel demand and choices are based on decision-making by individual travellers. The homogeneity of collective public transportation users was used in the study to determine the probabilities of the use of ICT in public transportation.

The binary probit regression equation below was applied:

$$Pr(Y = 1|X_1, X_2, \dots, X_k = \Phi\ (\beta_0 + \beta_1 + X_1 + \beta_2 X_2 + \cdots + \beta_k X_k)$$

Link of actual y to estimated y: $f(X) = \Phi(1 + e^{-X})$

Where:

$$Pr\ Pr\ = Probability$$
$$Y = Binary\ response\ (Yes = 1\ or\ No = 0)$$
$$X = independent\ variable$$

$$\Phi\ (\cdot) = cumulative\ standard\ normal\ distribution\ function$$

The following tests were conducted to measure the association between the variables, in each probit test model:

a. Wald Test

This test is used for significance testing for each independent variable.

$$z = \frac{\hat{\beta}}{SE\ (\hat{\beta}\ )}$$

Where:

$\hat{\beta} = Estimated\ logit\ coefficient$

$$SE\ (\hat{\beta}\ )\ = Standard\ error$$

b. Chi-Squared tests

Chi-squared statistics determine the goodness-of-fit of the model and its variables. The statistic is used to compare variations in data to determine whether they are caused by chance or the variables being tested.

The equation below was applied:

$$x^2 = \sum \frac{(O_i - E_i))^2}{E_i}$$

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Where:

$$O_i = Observed\ data$$
$$E_i = Expected\ data$$

Where:

$O_I = Observed\ data.$

$E_i = Expected\ data.$

Chi-Squared tests are used to validate a null hypothesis that the variables used in the models are independent or an alternative hypothesis that the variables are not independent.

Reliability and normality testing

Skewness and kurtosis tests were used to test for normality of data used for probit regression before analysis. The use of skewness and kurtosis was informed by researchers who suggested acceptable skewness and kurtosis normality ranges. An acceptable range of skewness values is between -3 to +3, while a kurtosis range of values from -7 to +7 for samples over 300 is acceptable (West, Finch and Curran, 1995; Kim. 2013).

3.6.3 Geographical data analysis

Tableau Maps was used to present the geographic data (vector routes, connecting origins and destinations) collected in the form of coordinates using Google Maps. The presentation enabled visualisation and analysis of origins and destinations. The data showed the origins and destinations for each individual traveller's trips. The data was grouped further into different areas within the study areas to create analysis zones, based on the movement of public transportation users in and out of the areas.

Tableau

Tableau Desktop 2021.4 was used for spatial data visualisation. Trip origins and destination data was analysed to create a vector course connecting the origin to destination of each public transportation user's trip. The resultant vectors were presented in Tableau, mapped on an OpenStreetMap layer and presented in Section 5.7.1.

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QGIS

QGIS is a Geographical Information Systems (GIS) platform that is freely available. QGIS Desktop 3.24.0 was used for geographical data analysis, mapping and visualisation (Westra, 2014: Saha and Frøyen, 2021).

Determining accessibility of areas using QGIS

Accessibility analysis of locations within both study areas was done using QGIS. This includes OD matrix measuring the distance between locations as well as visualising accessibility of the locations within specific time and distance. Analysis of accessibility of both study areas was based on the time and distance.

Determining public transportation trips origins and destinations using QGIS

First, activity location data, which showed the frequencies of participants performing activities in a specific location was visualised by using QGIS. Geographical coordinates data of origins and destinations was also mapped on QGIS to determine the locations of public transportation access by the participants.

Graphical visualisation of trip origins and destinations using MATLAB

MATLAB R2022a, a mathematical data analysis and graphical software program was used for further visualisation and analysis of origin-destination location and time data. The trip origins and destinations coordinates were plotted on 3D graphs using MATLAB. The x-axis represented longitudinal coordinates, z-axis represented the latitudinal coordinates, and the y-axis represented the departure or arrival time at the origin or destination.

Determining location of activities using QGIS

Areas in both cities, which participants indicated as places of residence relative to the areas where they performed activities, were mapped using central point coordinates. The coordinates identifying each location were then plotted on QGIS and maps were created. Thereafter, the statistics indicating the percentages of participants performing activities in each area were reflected.

Determining travel patterns

Coordinates for each participant's trip saved in Ms Excel files were converted to CSV files. Point data layers were then created on QGIS, producing maps showing all origins and destinations of participants' trips. MATLAB was used to visualise the relationships

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between trip origins and destination locations with time of travel in three-dimensional plots.

3.7 Conclusion

This chapter provided a detailed procedure and the methods applied to gathering primary and secondary data used in the study. It further provided the background and reasoning behind the methods. Using mixed research methods, resulting in descriptive and inferential data, complement both the data and the results obtained. After presentation and analysis of the data, the study provides guidelines and a framework for ICT-enabled public transportation in the Southern African cities of Bloemfontein and Gaborone. The following chapters are a presentation and analysis of the data collected, using the methods elaborated on this chapter.

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CHAPTER 4: RESULTS, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter contains the analysis, results and the discussion of the findings obtained from the questionnaire surveys in two study areas (Bloemfontein, South Africa and Gaborone, Botswana). The questionnaire surveys were focused on private transportation users and public transportation users. The results include social aspects, land-use characteristics and their influence on travel and travel behaviour, as well as the introduction of ICT into public transportation systems to improve the efficiency of public transportation systems in both study areas.

4.2 Background and Demographic Characteristics

This section contains a description of the demographic characteristics of the 415 participants in Bloemfontein and 388 participants in Gaborone. Table 4.1 shows the demographics and background information of the study's participants. Age, gender and occupation influence the way people travel, their behaviour, decision-making and travel patterns. Age has a potential influence on the mode of travel, especially for older and much younger people who use public transportation because they do not have a driver's licence or a car, or are not able to afford private vehicles. Age influences the ability and interest in using ICT technologies, and plays a role in technology awareness, use, travel substitution by ICT, and activities performed while travelling. This is possibly the case, because younger people are more technologically aware than older people and have grown up with many facets of ICT in their environment. Age also affects the mode of transportation used, considering younger people without driver's licences and older people who are unable to drive, and who, in most cases, are dependent on public transportation systems.

Even though, in both surveys, more men responded to the questionnaires than women, gender was not found to have any significant influence on travel and use of ICT. Occupation or employment status was found to have a significant influence on travel times, number of trips per day, and frequency of trips. Full-time students and

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full-time employees travel more frequently compared with unemployed people, part-time workers and pensioners.

Table 4.1: Background and demographic characteristics

Characteristics		Percentage of participants in each group			
		Bloemfontein (N = 415)		Gaborone (N = 388)	
Age	18-25	34,7	N =144	43,0	N = 167
	25-35	40,2	N = 167	37,4	N = 145
	36-45	16,9	N = 70	15,5	N = 60
	46-55	7,2	N = 30	4,1	N = 16
	55+	1,0	N = 4	0	
Gender	Male	54,5	N = 226	46,6	N = 181
	Female	45,5	N = 189	53,4	N = 207
Occupation	Student	29,2	N = 121	33,0	N = 128
	Part-time employee	13,5	N = 56	7,5	N = 29
	Self-employed	7,0	N = 29	11,9	N = 46
	Full-time employee	38,3	N = 159	41,0	N = 159
	Unemployed	6,7	N = 28	5,9	N = 23
	Student and part-time employee	5,3	N = 22	0,8	N = 3

4.2.1 Monthly income

In this section, participants' monthly income and the number of vehicles available in their households were investigated. Monthly income influences choice of travel mode and ICT access, which ultimately influences vehicle ownership and knowledge of ICT. Table 4.2 shows the monthly income of participants from Bloemfontein and Gaborone.

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Table 4.2: Monthly income

Bloemfontein (N = 415)			Gaborone (N = 277)		
Amount (ZAR)	**Percentage**		**Amount (BWP)**	**Percentage**	
R0 -R 2500	36,9	N = 153	P0 -P2500	63,2	N = 175
R2500 - R5000	25,5	N = 106	P2500 - P5000	11,6	N = 32
R5000 - R10 000	13,3	N = 55	P5000 - P10 000	15,2	N = 42
R10 000 - R30 000	22,4	N = 93	P10 000 - P30 000	9,7	N = 27
R30 000 - R50 000	1,7	N = 7	P30 000 - P50 000	0,4	N = 1
R50 000+	0,2	N = 1			

*ZAR 13.87 = 1 USD / BWP 10.63 = 1 USD (25 May 2021)

Table 4.2 shows the monthly income of 415 participants in Bloemfontein. The mean income of the participants was R 7 808.01, while a median of R4 000 was recorded. Low incomes ranging from total lack of income to R500 per month were also recorded. A maximum of R55 000 per month was recorded. Most of the participants (36.9%) reported earning a monthly income of R0 to R2 500.00, while 25.5% earned R2 500 to R5000; 13.3% had an income of between R5 000 and R10 000.00; 22.4% earned between R10 000 and R30 0000; 1.7 % earned between R30 000 and R50 0000, while only 0.2% earned over R50 000 per month.

It is immediately apparent that there are broad inequalities in income in Gaborone. Table 4.2 shows that a large percentage (63.2%) of the participants had a monthly income of less than P2 500.00, while 11.6 % earned P2 500.00 to P5 000.00 per month, and 15.2% earned P5 000.00 to P10 000.00 on a monthly basis. Only 9.7% had monthly incomes exceeding P10 000 but less than P30 000.00. Only 0.4% reported a monthly income in excess or R30 000. The mean monthly income of individual participants living in Botswana was P4 210.45, with a median income of P1 420.00, which was the result of a large percentage of participants being tertiary students, who earned a standard monthly allowance of P1 420.00. The lowest monthly income recorded was P500.00. A significant percentage of full-time employees did not provide their monthly income; hence, the lower number of participants reporting their

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income. The low levels of income were attributed to the basic minimum wage in the Botswana Government's Employment Act, which was set at P3.21 per hour for domestic service work and P700.00 per month for workers in the agricultural sector (Government of Botswana, 1985).

South Africa has a higher minimum wage than Botswana. This was evident from the data presented in Table 4.2, showing larger percentages of people in Bloemfontein earning more than R5 000.00 per month, compared with the majority earning below P2 500.00 in Botswana, which was equivalent to R3 600.00.

Household income influences vehicle ownership and mode of transportation used. Low-income groups use public transportation as captive users. People earning higher incomes have greater chances of owning their own vehicles or, depending on the number of high-income earners in a household, multiple vehicles.

4.2.2 Vehicle ownership

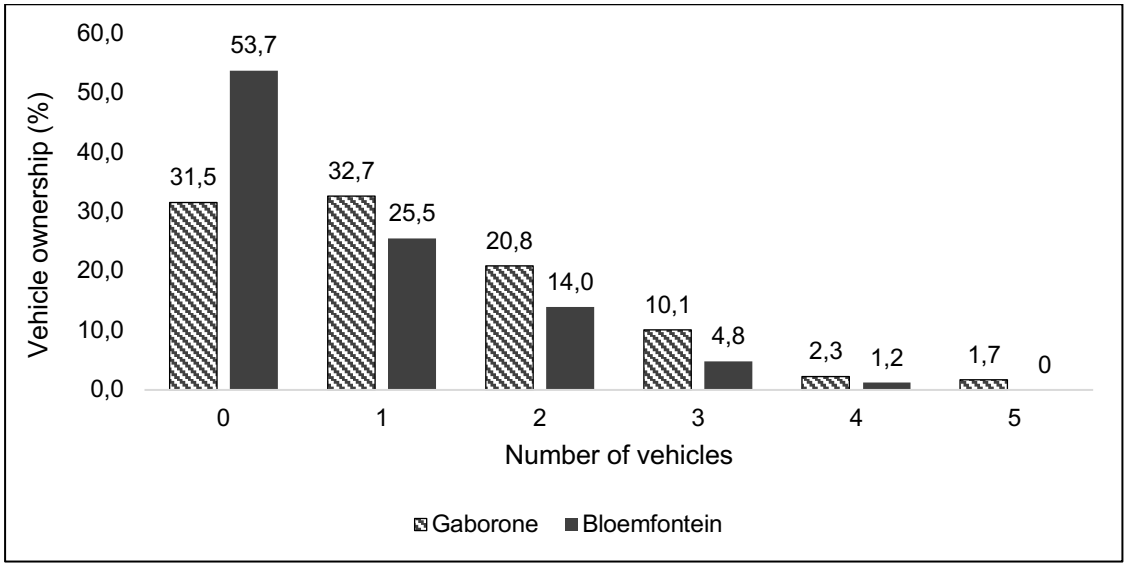

Figure 4.1: Percentage of vehicles per household

The number of vehicles per household in both cities is presented in Figure 4.1. In Bloemfontein, there were more participants from households without vehicles than those with vehicles. Specifically, 53.7% of households reported having no vehicle, compared with 46.3% of participants from households with one or more vehicles. Only 31.5% of participants in Gaborone came from households without vehicles, compared with 68.5% from households with at least one vehicle.

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Also, 53.7% of participants in Bloemfontein did not have any vehicles in their household, compared with 31.5% in Gaborone. Owning 1 or 2 vehicles per household was common in both areas, with participants from car-owning households indicating that 25.5% and 32.7%, respectively, were from one-car households in Bloemfontein and Gaborone, while 14% and 20.8%, respectively, were from two-car households in Bloemfontein and Gaborone. Insignificant percentages of participants came from households owning six or more vehicles. Interestingly, despite the lower personal incomes that were recorded in Gaborone, vehicle ownership was higher there. This question was focused on the household apart from the individual participants, because the vehicle in a household might not have belonged to the participant. Vehicles are cheaper in Gaborone than in South Africa, because of the influx of second-hand car imports from Asia and the United Kingdom. Second-hand car imports are not permitted in South Africa, under the International Import Trade Administration Act, Act 71 of 2002 (Republic of South Africa, 2003). Younger participants, students, and those with lower monthly income indicated that they did not own vehicles. Most of the students from various towns and villages moved to cities, such as Bloemfontein and Gaborone, and lived in households that might have included roommates of the same age ranges, also with no vehicles. The lack of vehicles in households meant that the participants and members of their households were likely public transportation or NMT users.

4.3 Spatial Characteristics and Land-Use Zoning

The focus of this section was on the land-use and spatial characteristics of areas where activities were performed.

4.3.1 Spatial characteristics

It is imperative for the study of transportation and mobility to embrace the role of land-use and accessibility, which meant that the spatial characteristics of the study areas were central to this section, as they affected travel and time. First, the zones in which participants resided and spent their workdays were explored. Coordinates of the centre of each area were acquired and used as the geographical representation of the area. Statistical data showing percentages of participants residing and spending their workday in each area are presented in Appendix Table 1 and Appendix Table 2.

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4.3.2 Location of activities in Bloemfontein

Participants were asked to indicate the areas of their city where they performed activities. The activities they provided were shopping, educational activities, sporting activities, work, recreational activities, religious activities, and entertainment activities at clubs and stadiums. The percentages of activity in each area were plotted against the areas' central coordinates to create visual distinction between areas of residence and areas where activities were performed. The results are presented in Figures 4.2 to Figure 4.5 and presented in frequency graphs in Appendix Figure 1 to Appendix Figure 18.

Figure 4.2 below shows the names of the geographical zones in the Bloemfontein study area, while Figure 4.3 shows the percentage distribution of participants by areas in which they resided and those in which they spent their days.

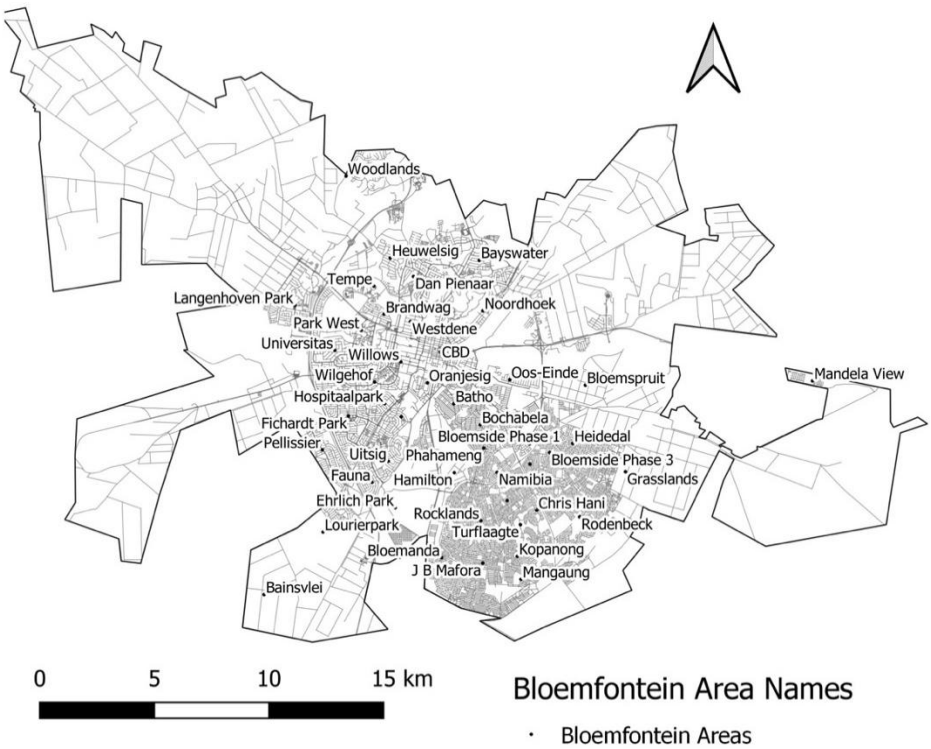

Figure 4.2: Bloemfontein areas names

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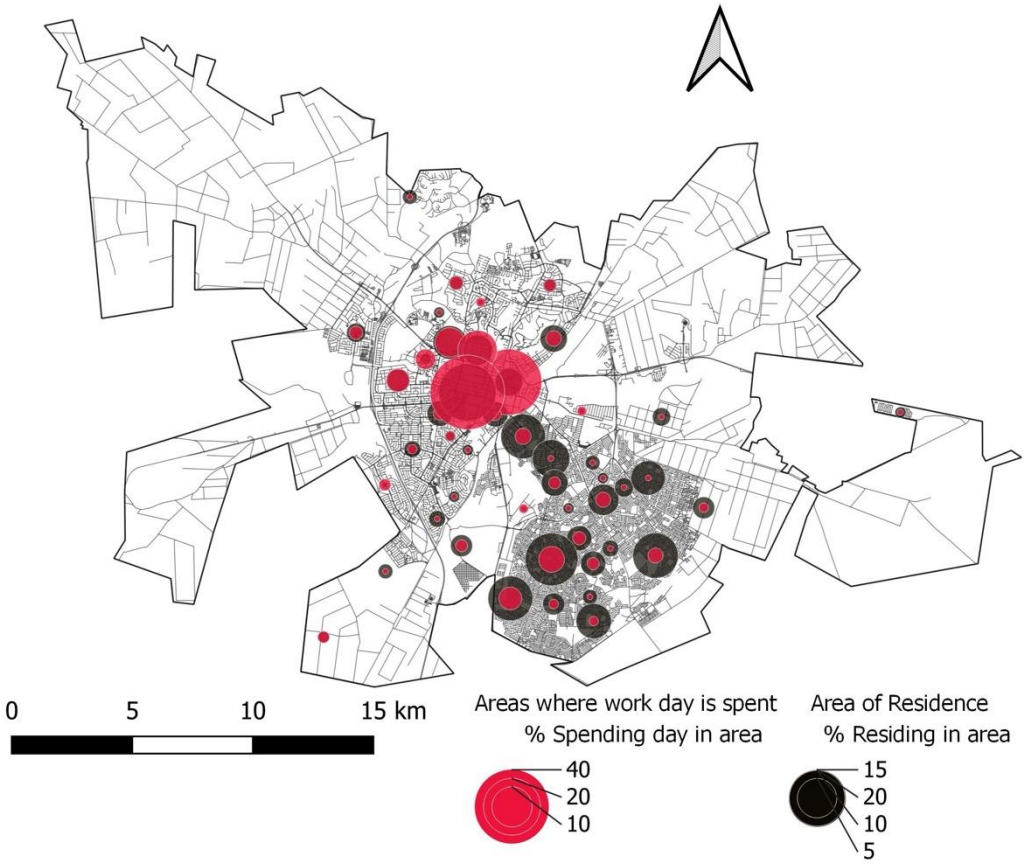

Figure 4.3: Bloemfontein areas of residence and areas where participants spent their day

Figure 4.3 shows that residential areas in Bloemfontein were scattered around the city, and some of the participants resided in areas outside of the city. Significant numbers of participants resided in areas in the south-eastern parts of the city. There was also an indication of residences in areas such as the CBD, which is mostly a commercial area, which makes them mixed land-use areas. Large numbers of participants were attracted to the CBD, as well as to Westdene, Willows and Park West, because that was where they spent the workday. Locations where participants performed specific activities, are presented in Figure 4.4 and Figure 4.5.

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Figure 4.4: Location of activities in Bloemfontein

Figure 4.4 illustrates the distribution of socioeconomic activities performed on a regular basis against the areas of residence and areas where the regular workday is spent by participants.

Public services

Areas where participants accessed public services, banking facilities, educational facilities, and shopping activities are visualised against the participants' areas of residence and areas where participants spent the day. Overall, 73% of participants accessed public services in the CBD, 13.5% in Rocklands and 3.6% in Willows. The remainder of the participants accessed public services in Westdene, Brandwag, Heidedal and Fauna. Postal services and services offered by the government, such as payment facilities for water and electricity utilities and social grants, are offered in

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locations in the CBD area and Rocklands. Other public services are offered at municipal offices located in the CBD, the Bram Fischer Building, and the post office located in the CBD. The Department of Home Affairs, which deals with immigration and labour, has offices that are located in Rocklands. The results indicated that there was significant movement from other areas of the city to the CBD and Rocklands areas generated by public service activities.

Banking activities

Areas where participants indicated that they carried out banking activities or accessed banking facilities, were mapped in relation to residential areas. Most banking activities (55.7%) occurred in the CBD area, and 12.3% participants performed their banking activities in Willows, while 9.1% banked in Westdene. Brandwag and Rocklands also attracted 6.3% and 4.7%, respectively, of the banking activity. In contrast, 2.6% of the participants did their banking online, which is not represented on the map in Figure 4.7. Movement for banking purposes is also generated in other areas and ends most often in the CBD area. The Willows and Westdene areas have significant traffic generated by banking.

Shopping activities

Most of the participants (52.5%) performed shopping activities in the CBD area, while 13.1% shopped in Willows, 11.6% in Westdene, and 5.9% in Brandwag. Other areas attracting significant shopping activity were Rocklands and Heidedal. The implication of the results was that there was high travel demand for shopping originating from all areas of the city and terminating in the CBD, Rocklands, Willows and Westdene areas. A concentration of shopping activity in these areas generated movement towards the city centre. This movement originated from all other areas of the city. Shopping activity indicated in other areas might also have generated travel within the zones or even to other zones, but it was of less significance.

Educational activities

Of the 214 participants who were pursuing education and who travelled to and from educational centres, 53.3% were in the Willows area, 23.4% in the CBD area, 5.1% in Universitas and 3.7% in Park West. Considering that the participants to the study were people over the age of 18, who are often in the last stages of basic education and in tertiary institutions, it is to be expected that they would be located in the Willows, CBD, Park West/Universitas and Rocklands areas, as most tertiary institutions and colleges

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are located in these suburbs. The Central University of Technology, Pearson's Institute of Higher Education and the Midrand Graduate Institute are located in Willows. Park West/Universitas accommodates the University of the Free State. Various vocational training centres are also located in the CBD area, such as the Motheo Technical and Vocational Education College, Damelin and Jeppe College. Educational activities generate significant demand for travel to a few areas of the city in which institutions of learning are located. Travel generated by educational activity originates from all areas of the city; therefore, there will be regular movement between areas of residence and the CBD, Willows and Universitas areas.

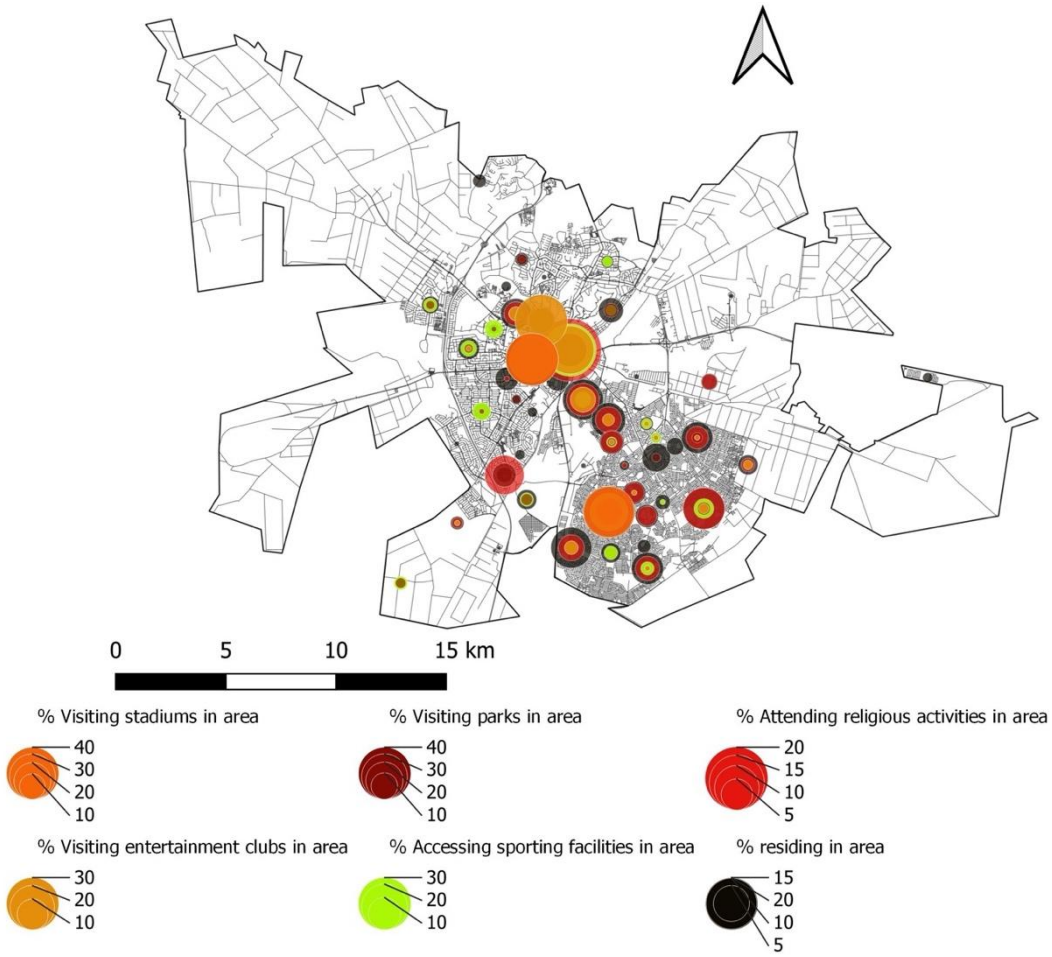

Figure 4.5: Location of leisure and social activities in Bloemfontein

Figure 4.5 is a visualisation of areas where participants accessed various leisure and social activities. These activities include visits to religious activities, stadiums, parks,

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sporting facilities, and clubs for entertainment purposes. They are mapped against the areas of residence to visualise the need to travel for activities.

Stadiums

A total of 38.8% of the participants used the stadium in Willows, while 37.3% used the stadium in Rocklands and 1.5% used the stadium in Heidedal. The remainder of the participants indicated that they used stadiums in areas of the city that do not have any stadium facilities, which made their responses invalid. The city of Bloemfontein has three stadiums: the main stadium, Free State Stadium, is located in Willows; the Dr Rantlai Petrus Molemela Stadium is situated in Rocklands, and the Clive Solomon Stadium is located in Heidedal. Tertiary education institutions, such as the University of the Free State and Central University, also have their own stadiums. Travel to stadiums is generated from other areas of the city and ends in only three areas, which are Heidedal, Rocklands and Willows. Stadium visits happen only when there are competitive sporting activities, so trips generated by the activities are not frequent.

Entertainment clubs

Most of the clubs visited (27.8%) were located in Westdene, followed by 23.6% in the CBD area and 20.4% in Willows. Other areas located in the southern part of the city where visits to clubs were noteworthy, were Rocklands (8.3%) and sports locations with 6%. The remainder of the participants went to clubs located in Brandwag (1.9%), Bochabela (1.4%) and Thaba Nchu (1.4%). Other locations received less than 1.0% of participants for clubbing and entertainment activities. Westdene, Willows and the CBD areas are home to the city's most popular entertainment clubs. Club visits generate a significant demand for travel, as significant clubbing activities happen in only a few areas of the city. Travel between other areas of the city to the CBD, Westdene, Willows, Rocklands and Batho (sports) areas for entertainment purposes is highly likely.

Religious activities

The results showed that more participants (19.3%) visited religious centres located in the CBD area of Bloemfontein, while 8.2% of participants visited centres located in Rocklands and Willows, respectively, and 7.6% of participants visited centres located in Fauna. From the results, it was evident that religious centres in the city are located

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within communities. These results could also imply that people travel from their own areas of residence to other locations for religious purposes.

Parks

A large portion (39.1%) of the participants went to parks located in Willows, 16% in the CBD area, 9.1% in Westdene, and 5.3% in Rocklands. King's Park, located in Willows, is one of the famous and most frequented parks of Bloemfontein, accessed from all over the city. It is located in a busy area, in the vicinity of the Free State Stadium, Loch Logan Waterfront, and the cricket stadium. The origins of trips generated by visits to parks are distributed among many zones in the city, which implies that inter-zonal trips occur between most of the areas in the city to the CBD, Willows and Westdene areas. The origins of other trips to visit parks could be within areas of residence.

Sports facilities

Only 32.4% of the total participants indicated that they participated in sporting activities. Figure 4.8 shows areas in Bloemfontein where the participants performed these activities. The CBD, Willows and Rocklands attracted the most sporting activity. Specifically, 26.1% of participants went to the CBD, 21.1% went to Willows, and 14.1% of participants went to Rocklands for their sporting activities. Percentages of sporting activity are shown also in other areas, which are mostly residential. Although minor, the results were important, because they indicated that sporting activities were distributed across the city and not only limited to the busiest areas.

Non-professional sporting activities performed by individuals for exercise and leisure, such as cycling, soccer and athletics, might not need travel to specialised facilities. These activities are performed in neighbourhoods, on roads, and public grounds without the need for trips using a vehicle. Therefore, social sporting activities do not generate significant inter-zonal trips.

Other unspecified activities

Participants were asked further to indicate areas of the city where they performed other important activities not provided in the questionnaire. The results obtained showed that 40% of the participants performed such activities in Rocklands, and 20% in Brandwag, Turflaagte and Willows, respectively. Only 1.2% of the total participants responded to this question, thus the results were not representative of the entire sample.

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Summary of activity locations in Bloemfontein

In summary of the location of activities in Bloemfontein, the results above showed that most human activity took place in the CBD area. The spatial distribution of activities indicated that the CBD, Willows, Westdene, Brandwag and Rocklands were the areas where most activities were concentrated. Shopping and banking were carried out often in shopping malls, making them major generators of the demand for travel to zones with shopping malls. The CBD-Willows-Westdene areas are high-activity areas, as they were indicated as the places where most participants spent their days, making them major transportation nodes, attracting regular visitors.

4.3.3 Location of activities in Gaborone

Location of activities in Gaborone are presented in this section. First, the areas within the City of Gaborone are represented in Figure 4.6, showing the names of the areas. Areas of residence and areas where participants spent their days are illustrated in Figure 4.7, which also shows the percentage of participants residing or spending their day in each area. Figures 4.8 and 4.9 show areas where participants performed specific socioeconomic and recreational activities within the city.

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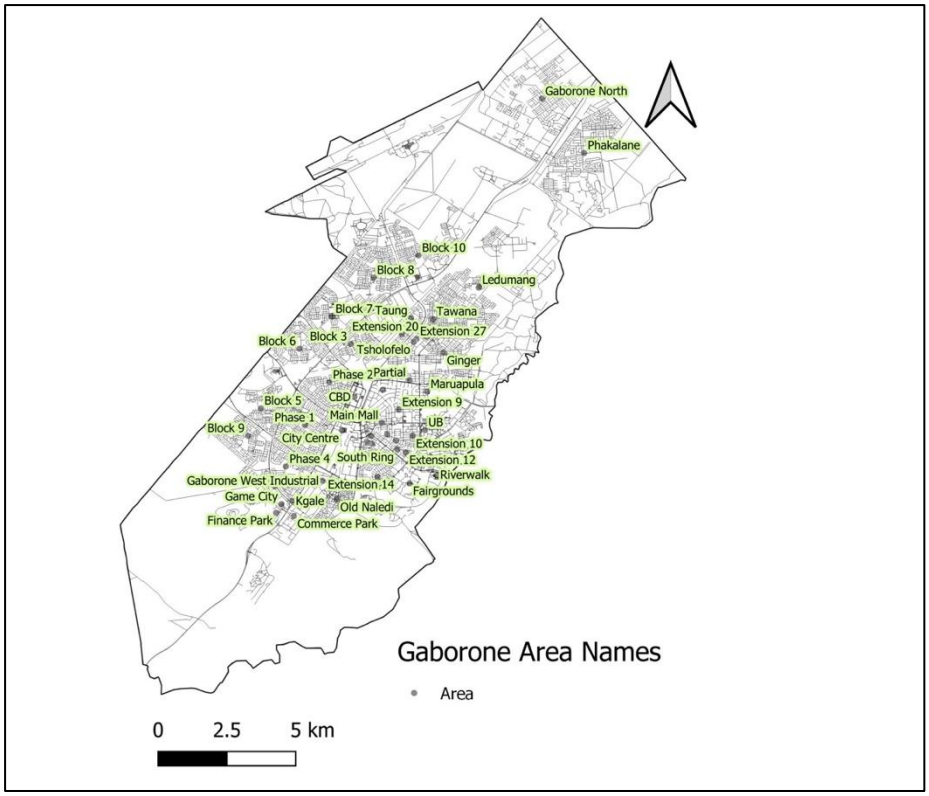

Figure 4.6: Gaborone Area names

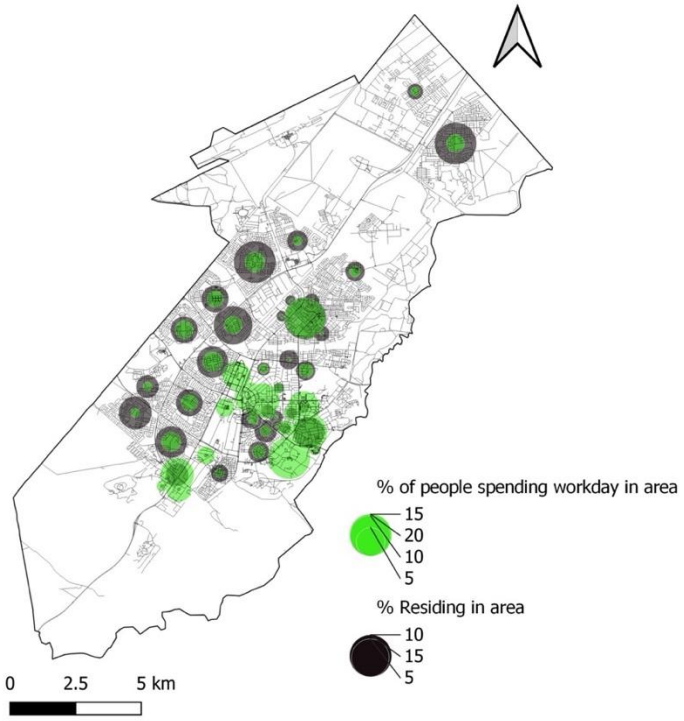

Figure 4.7: Areas of residence and areas where participants spent the day in Gaborone

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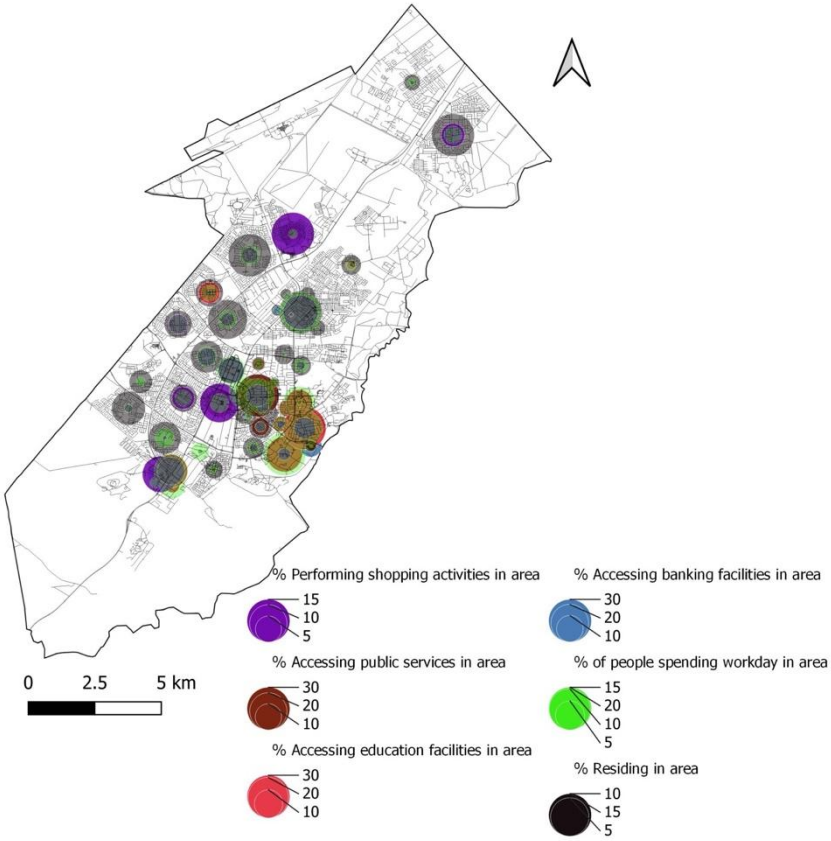

Figure 4.8: Location of socioeconomic activities in Gaborone

Figure 4.8 shows the distribution of shopping, banking, and education facilities, and public service facilities in Gaborone as follows:

Shopping

The results showed a scattered distribution of shopping centres. Shopping locations were characterised by low percentages of visits by participants distributed across different areas of the city. More participants (12.3%) shopped in Riverwalk, followed by 9.4% in Game City, and 5.6% of participants shopped in Kgale View. Two main shopping centres located in Kgale View are the adjoined Kgale Mall and Game City shopping centres. A further 9.3% of participants shopped in Block 10, which is where the Airport Junction Mall is located, and which 1.3% of participants indicated as their regular place of shopping. Assuming that all people who shop in Block 10 use this mall, a combined total of 10.6% of the participants shopped in Block 10.

The city centre attracted 7.5% of participants for shopping, while the CBD attracted 4.8% of their shopping activity. The CBD is located opposite the city centre and is

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home to the Square Shopping Centre, while the city centre accommodates a small number of shopping centres and street hawkers. In addition, 3.4% of participants indicated that they shopped in Railpark, which is also located in the city centre, while 8.6% of the participants shopped in the Broadhurst area, and 3.7% shopped in Main Mall, 4% shopped in Phakalane, 3.4% in Village and 2.4% in Block 6. The results indicated a distribution of shopping areas across many areas in the city, but there were more common areas for shopping, such as Game City, Riverwalk, Block 10, Broadhurst and the city centre. This implied that traffic generated by shopping activity would be evident also in most of these areas.

Banking

Main Mall attracted 26% of the participants' banking activities, 9.3% were performed in Game City, 8.5% in the city centre and 7% in Riverwalk. Most of the banking institutions in Botswana have branches in Main Mall, confirming the results obtained. Banks also have offices and branches in shopping malls, and ATMs in high-activity areas such as the city centre. Trips for the purpose of visiting banking facilities and institutions terminate in shopping centres and malls where most banks and ATMs are located. The spread of facilities across a significant number of zones ensures that the facilities are accessible.

Education

Only 46.9% of the total participants completed this section. The largest percentage (22.3%) indicated that they attended educational centres located in Village, and 8.7% of the participants attended the University of Botswana, which is located in Village. In addition, 15.5% received their education in Fairgrounds, 12.6% in Kgale View, 5.8% in Block 7, and 2.9% in Block 6.

The results accurately depicted the location of tertiary education centres in Gaborone. The University of Botswana is located in Village, Botswana Accountancy College is in Fairgrounds, Botho University is located in Kgale View, and Limkokwing University of Creative Technology and Balsago University are both located in Block 7, while ABM and GIPS Colleges are located in Block 6. The distribution of educational institutions across the city also implies that there is movement generated from all over the city to these areas. Regular movement of vehicles, including private and public transportation, is to be expected in areas that host learning institutions.

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Public services

The results showed that 26.2% of the public service activities used by participants were in Main Mall, 11.3% in Broadhurst, and 11% in the city centre. Post offices, libraries, council offices, foreign embassies and consulates, as well as the central police station are all located in Main Mall. Broadhurst and the city centre also accommodate police stations, post offices and courts.

Travel for public services originates from different areas of the city and terminates mostly in the Main Mall area. As public services are offered most days of the week, most of the traffic in the area could be generated solely by people seeking services. The availability of public services in other areas means that there is also movement caused by the need for people to travel in and out of an area for such services or within the area to access the services.

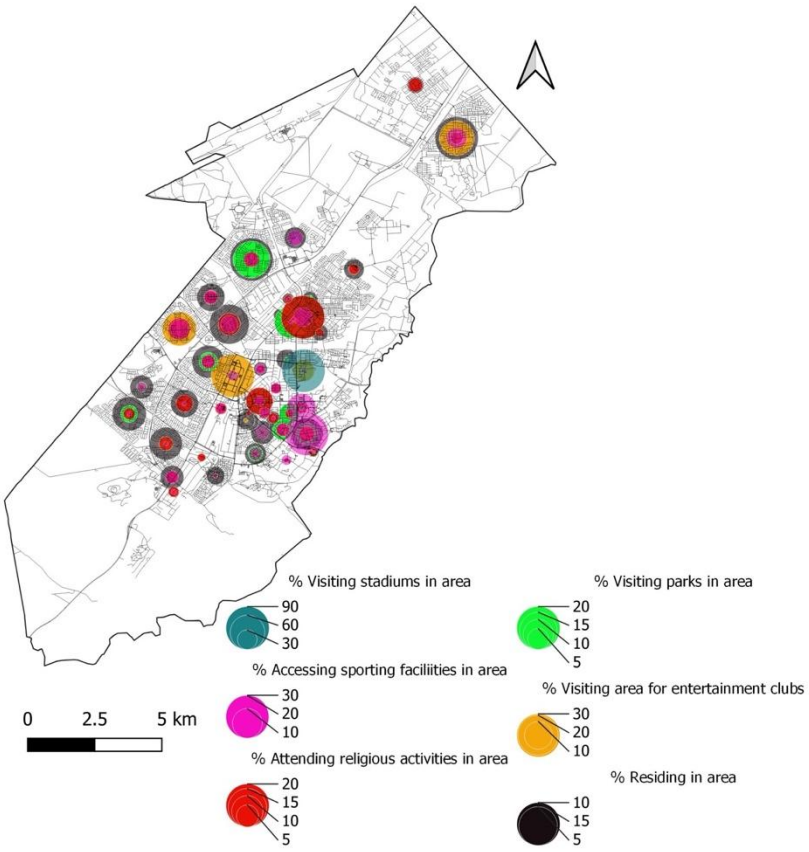

Figure 4.9: Location of social and leisure activities in Gaborone

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Figure 4.9 shows areas where participants performed sporting activities in relation to their areas of residence.

Sporting

Most of the participants (20.3%) took part in sporting activities in Village and at the University of Botswana (9.8%), while 7% of sporting activities occurred in Mogoditshane. The University of Botswana (UB) is located in Village. Military barracks with sporting facilities open to the public are located in Mogoditshane, confirming the higher percentage of participants whose sporting activities occurred in the area. Facilities for sporting activities are also spread across the city in a number of areas, generating travel within and across zones. Trips for sporting activities originate from most areas of the city to UB and Village, as they offer advanced sporting facilities.

Stadiums

The only two stadiums in the city are the University of Botswana (UB) Stadium and the National Stadium. The National Stadium was used by 83.1% of the participants, while 16.9% used the University of Botswana Stadium. Trips for stadium visits begin in most areas of the city and terminate only in two places, the National Stadium and the University of Botswana Stadium. Most events occurring in the stadiums are occasional, so stadium visits are likely to generate traffic in the areas on certain days at certain times.

Parks

Overall, 19.6% of the participants went to Broadhurst to visit parks, 14.4% went to Block 8, while 10.5% visited parks in Tsholofelo. The results also showed that there are parks in locations such as Village, Main Mall, Extension 10, 12 and Block 5, which were also frequented by a noteworthy percentage of participants. There are parks in most residential zones in Gaborone, but most of them are not functional because of vandalism and the lack of maintenance. The zones indicated as being visited regularly for parks were those where the parks were in good condition and safer. The results indicated that most trips generated by park visits would terminate in Broadhurst, Block 8 and Tsholofelo. The low percentages recorded of park visits in other areas could mean that there are parks in those areas that are not frequently visited and they are not well maintained. The demand to travel for park visits is low.

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Religious centres

More participants (18.2%) went to Broadhurst for religious activities, followed by 10.1% who went to Tlokweng, 7.5% went to Main Mall, 5.5% attended religious activities in Tlokweng, and 6.2% in Mogoditshane. A total of 79.4% of all participants answered this question. This could have been because people have different or no religious affiliations. People in Gaborone also travel to nearby villages and towns for religious services, such as Lobatse, which is approximately 80 km from Gaborone, Kopong, which is about 20 km from the city, and Tlokweng, which shares its border with Gaborone. Smaller percentages of participants attending religious activities in a number of areas indicated that religious institutions are not concentrated in specific areas of the city, but are spread across zones. Therefore, trips generated by religious activities are also distributed across the city. Religious activities often occur on specific days of the week, thus travel demand for religious purposes is time-specific.

Entertainment clubs

It is evident that most clubs frequented by the participants were located in the CBD (22.9%), Phakalane (15.2%) and Block 6 (14.6%) areas. Mogoditshane, Main Mall and Broadhurst were also indicated as zones where a noteworthy number of participants visited social clubs. These results did not indicate necessarily that these zones had more clubs. Each zone could have one popular club, which attracts more patrons to the zone. Travel demand generated by entertainment activities is inter-zonal.

Summary of activity locations in Gaborone

In summary of the location of activities in Gaborone, the city centre, the CBD area, Main Mall, Broadhurst and Kgale are high-activity zones. They attracted most shopping, entertainment, work and educational trips. Areas outside the city, such as Tlokweng and Mogoditshane, also generated travel activity. These areas are residential for a significant part of the population who regularly commute in and out of the city. There is dispersion both in areas of residence and areas in which the participants spent their day. The map shows that there is less density compared with Bloemfontein. The pattern shows that both places of residence and places of work are scattered throughout the city. The city's land-use zones are loosely defined, leading to random developments all over the city. However, there are areas in which

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commercial activity is concentrated, such as Fairgrounds, Kgale, Broadhurst, and the CBD.

In both study areas, some participants spent their days in their areas of residence. Mixed land-use areas provide for residential and other commercial, educational, and agricultural activities. In areas dominated by agricultural activity, provision is often made to accommodate workers, so the participants' place of residence and the area in which they spend their day are similar. Furthermore, with some participants being unemployed and self-employed, working from home and spending most of the day at home is common practice.

4.3.4 Land-use perceptions

Participants were asked to indicate the land-use of the areas in which they resided and spent their workdays. The results are presented in Figure 4.10 (Bloemfontein) and Figure 4.11 (Gaborone). The land-use of a zone influences the population density, traffic flow in and out of the area, and travel patterns. People's regular trips are likely to begin in areas of residence and end in industrial and commercial zones.

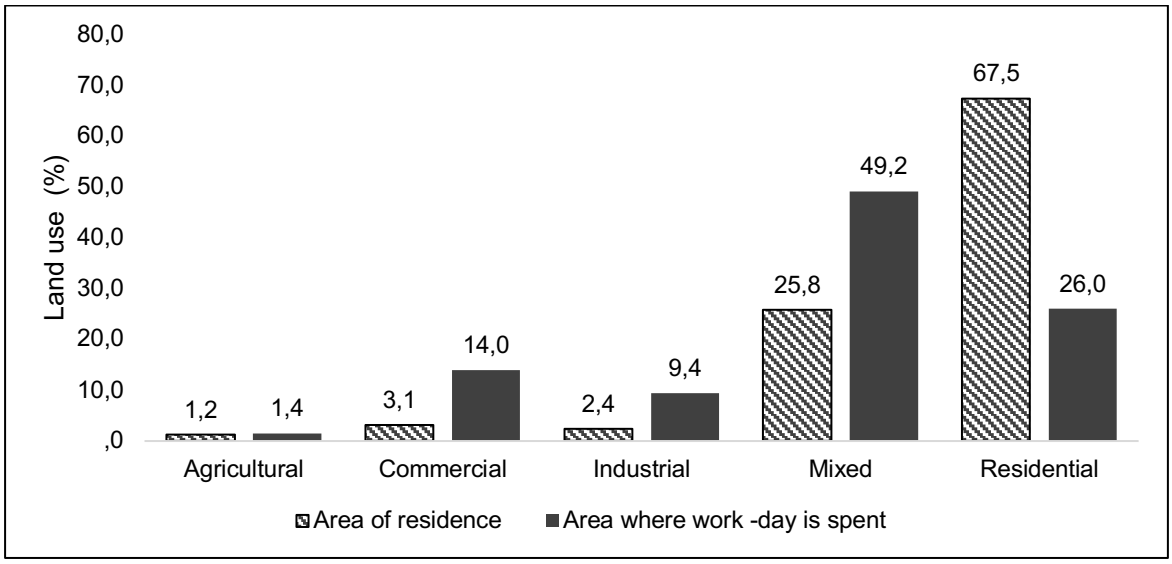

Figure 4.10: Percentage land-use as perceived by participants in Bloemfontein

The results from the Bloemfontein study (Figure 4.10) showed that 67.5% of the participants' areas of residence were commonly residential, while 25.8% indicated that they resided in mixed land-use areas, and 2.4% resided in mostly industrial areas. In addition, 3.1% and 1.2%, respectively, indicated that their area of residence was commercial or agricultural. A further 14% of participants spent most of their workdays

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in commercial areas, 9.4% in industrial areas, 49.2% in mixed land-use areas, and 26% in residential areas. Only 1.4% of the participants reported spending their workdays in agricultural areas.

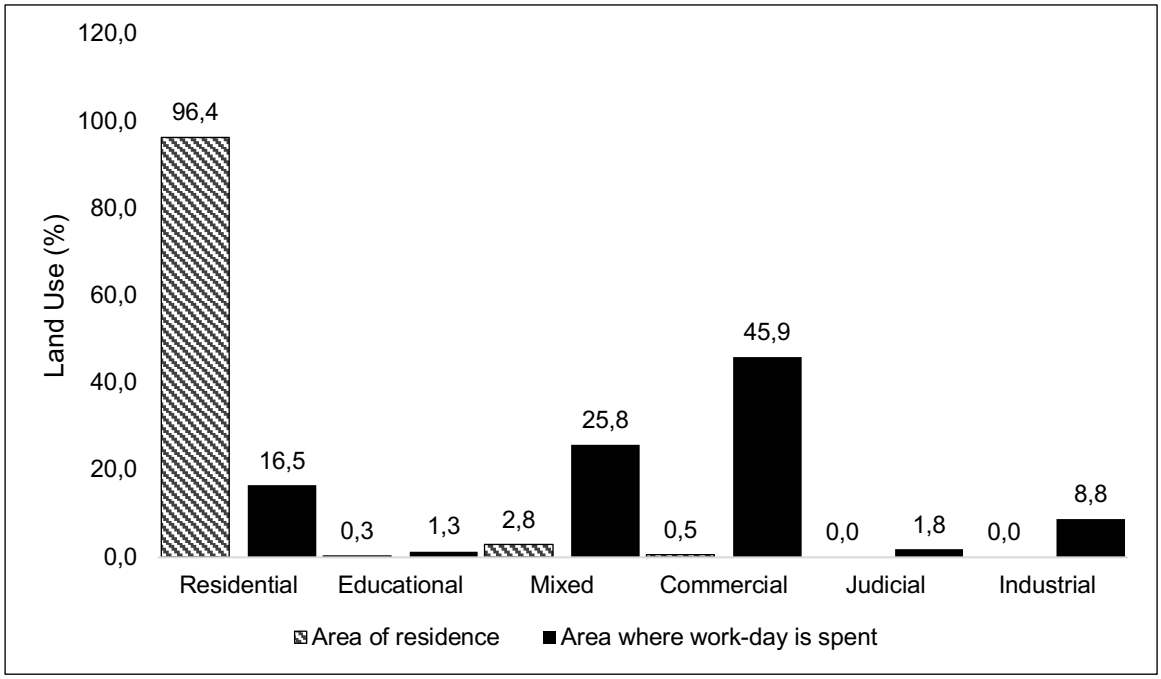

Figure 4.11: Percentage land-use as perceived by participants in Gaborone

The results obtained from Gaborone (Figure 4.11) showed that 96.4% of participants lived in residential areas, 0.3% in educational areas, 2.8% in mixed land-use areas, and 0.5% in commercial areas. The results showed also that places where participants spent most of their workdays, were 16.5% residential, 1.3% educational institutions, 25.8% mixed land-use areas, 45.9% commercial areas, 1.8% judicial land, and 8.8% industrial areas.

Land-use affects people's ability to reach places with ease. Public transportation is likely to be more visible in residential areas with higher population densities than it is in low-density areas. Characteristics and facilities within an area attract human movement and activity. Land-use also affects the times of day when there is increased activity and traffic in a zone. Travellers move between residential, mixed land-use and commercial/industrial areas for work, school and most activities performed during the day. Therefore, residential, mixed land-use and commercial areas attracted more human movement compared with other land uses in both cities in the study area.

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Increased human movement indicates an influx in vehicular movement. Therefore, increased traffic and human movement can be expected more in residential, commercial and mixed land-use areas compared with other areas. Prioritisation of accessibility and mobility between these land-use areas is therefore essential.

4.4 Transportation Accessibility

This section focuses on the accessibility of transportation in both the areas. First, access to public transportation is presented, followed by the access to other modes of transportation and modal split among the various modes.

4.4.1 Public transportation accessibility

Availability of public transportation between residential areas and areas of high-economic activity promotes accessibility. Connectivity by means of public transportation promotes interaction between people and the areas, while limiting the constraints associated with multiple trips. Direct trips create opportunities for people to move with ease between their respective residential areas and the areas where they spend most of their day for work, education or recreational purposes. The availability or lack of direct transportation for public transportation users in both cities is shown in Figure 4.12.

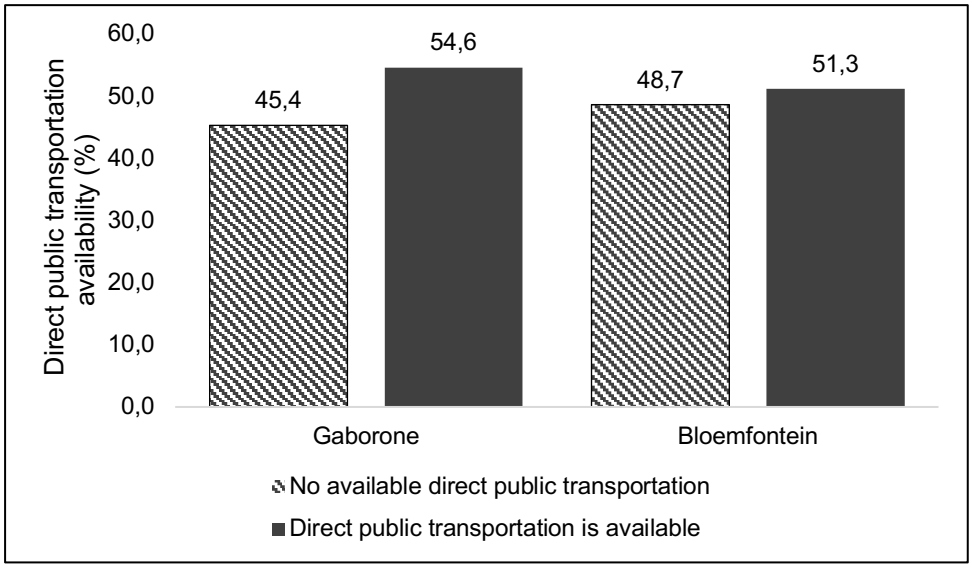

Figure 4.12: Percentage access or lack of access of participants to direct public transportation services

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To determine the accessibility of public transportation between residential areas and areas where participants mostly spent their day, availability of direct public transportation was evaluated. Direct transportation would mean a single trip from home to work, school, shopping and performing any other activities, and one trip back home. Lack of direct transport would mean that the participants would take more than a single trip to get from home to their place of work, school, shopping, and so forth. Transportation services provide mobility between these areas. The availability of direct public transportation between areas means improved mobility and accessibility. Direct public transportation from the area of residence to the area where most of the day is spent indicates improved accessibility characterised by single trips.

Participants were asked whether they had access to direct public transportation from their areas of residence to areas where they spent their days. Figure 4.12 shows the availability or lack of direct public transportation. Specifically, 54.6% (N = 212) of the participants in Gaborone had access to direct public transportation from residential areas to areas where they spent their workday. On the other hand, 45.4% (N = 176) in Gaborone did not have access to direct transportation. In analysing the origins and destinations of direct public trips, it is evident that people residing in Block 3 (5.2%), Block 8 (7.5%), Broadhurst (10.4%), Village (5.2%), Mogoditshane (4.2%), and Tlokweng (17.9%) had access to direct public transportation trips. More direct public transportation trips terminated in Broadhurst (11.8%), Commerce Park (4.7%), Fairgrounds (8%), Government Enclave (4.2%), Kgale View (7.5%), Main Mall (8.5%), University of Botswana (4.7%), and Village (7.5%).

The lack of direct public transportation is noticeable in residential areas such as Block 7 (4.5%), Block 3 (5.7%), Phakalane (8.5%), Phase 2 (4.5%), and Phase 4(5.7%). There is also a noteworthy lack of direct transportation to the CBD (6.8%), Fairgrounds (14.2%), Government Enclave (7.4%), Main Mall (5.1%), Kgale View (5.1%), Village and UB (8.1%). These results are evidence to the lack of integration of transportation services and land planning in the city. People residing in a single area could have different, opposing experiences regarding the public transportation accessibility. These results also address the importance of bus stop locations and geographical planning of public transportation routes.

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Results from Bloemfontein indicated that 51.3% (N = 213) of participants in Bloemfontein had access to direct public transportation from their places of residence to the zones where they spent their days, while 48.7% (N = 202) did not have access to direct public transportation services. Significant lack of direct public transportation was notable in participants residing in Batho, Freedom Square, Phelindaba, Phase 2 (2.5%), Bloemanda (5.9%), Bochabela (5%), Heidedal, Oranjesig (3%), Phase 2 and Rocklands (3.5%), and Willows (13.9%). Areas of the city where participants spent most of their day that had a notable lack of direct transportation were Brandwag (6.9%), CBD (14.9%), and especially, Willows (42.1%).

Participants residing in Bloemanda and Bochabela (4.2%, respectively), Brandwag (5.2%), CBD, Phahameng (2.8%), Hillside View (2.3%), Rocklands (8.5%), Sports (5.6%), Westdene (3.8%), and some residents in Willows (7.5%) had access to direct transportation to the areas they spent the workday. On the other hand, 38% of the people with access to direct public transportation spent their day in the CBD, 10.3% in Westdene, and 24.9% spent their day in Willows.

Similar to Gaborone, Bloemfontein results indicated that people living in the same suburb may have different interactions with the public transportation system, characterised by the lack of access or or the lack of an easy access. However, even while participants might have had access to direct public transportation from suburb to suburb, they might have to walk long distances within the suburbs to access transportation. Therefore, availability of direct public transportation does not directly reflect accessibility of services.

Participants who had direct public transportation were asked which modes of public transportation were available to them. Table 4.3 shows that taxis were directly available to 75.5% of the participants in Bloemfontein, while combis were directly available to 88.7% of the participants in Gaborone. In addition, 13.3% and 11%, respectively, of participants in Bloemfontein had direct access to buses and cabs, while 9.9% and 1.4%, respectively, had access to taxis and cabs in Gaborone.

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Table 4.3: Available modes of transportation

Bloemfontein		Gaborone	
Mode available	**Percentage**	**Mode available**	**Percentage**
Taxi	75.5	Combi	88.7
Bus	13.3	Taxi	9.9
Cab	11	Cab	1.4

Table 4.4: Modes of public transportation accessible to socioeconomic groups - Bloemfontein

		Mode of public transportation available as direct transportation (N = 210)			
		Taxi	Bus	Cab	Sedan Taxi
Demographic characteristics		N = 259	N = 28	N = 23	N = 0
Age of Participants	18-25	77,3%	10,6%	12,1%	0,0%
	26-35	71,9%	17,7%	10,4%	0,0%
	36-45	82,9%	8,6%	8,6%	0,0%
	46-55	75,0%	8,3%	16,7%	0,0%
	55+	100,0%	0,0%	0,0%	0,0%
Participants' monthly income in ZAR	R0 -R 2500	83,5%	12,7%	3,8%	0,0%
	R2500 - R5000	77,8%	9,3%	13,0%	0,0%
	R5000 - R10 000	74,1%	18,5%	7,4%	0,0%
	R10 000 - R30 000	63,8%	14,9%	21,3%	0,0%
	R30 000 - R50 000	33,3%	33,3%	33,3%	0,0%
	R50 000+	0,0%	0,0%	0,0%	0,0%
Occupation	Student	77,0%	13,1%	9,8%	0,0%
	Part-time employee	85,7%	10,7%	3,6%	0,0%
	Self-employed	100,0%	0,0%	0,0%	0,0%
	Full-time employee	67,4%	18,0%	14,6%	0,0%
	Unemployed	90,9%	0,0%	9,1%	0,0%
	Student and part-time employee	62,5%	12,5%	25,0%	0,0%

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Table 4.5: Modes of public transportation accessible to socioeconomic groups - Gaborone

Demographic characteristics		Mode of public transportation available as direct transportation (N = 213)			
		Taxi	Combi	Bus	Cab
		N = 21	N = 189	N = 0	N = 3
Age of Participants (N = 388_	18-25	11,2%	86,7%	0,0%	2,0%
	26-35	9,3%	89,3%	0,0%	1,3%
	36-45	9,4%	90,6%	0,0%	0,0%
	46-55	0,0%	100,0%	0,0%	0,0%
	55+	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in BWP (N = 277_	P0 -P2500	10,7%	87,4%	0,0%	1,9%
	P2500 - P5000	7,1%	92,9%	0,0%	0,0%
	P5000 - P10 000	5,3%	94,7%	0,0%	0,0%
	P10 000 - P30 000	11,1%	88,9%	0,0%	0,0%
	P30 000 - P50 000	0,0%	0,0%	0,0%	0,0%
	P50 000+	0,0%	0,0%	0,0%	0,0%
Occupation (N =388)	Student	7,7%	89,7%	0,0%	2,6%
	Part-time employee	5,9%	94,1%	0,0%	0,0%
	Self-employed	17,9%	82,1%	0,0%	0,0%
	Full-time employee	6,6%	92,1%	0,0%	1,3%
	Unemployed	33,3%	66,7%	0,0%	0,0%
	Student and part-time employee	0,0%	100,0%	0,0%	0,0%

Taxis are commonly accessible to people in all income groups. Minibuses, commonly referred to as “taxis” in Bloemfontein and “combis” in Gaborone, are the most accessible mode of public transportation in both cities. The capacity of minibuses makes shorter loading periods possible for vehicles operating in high-density residential and commercial areas. Their carrying capacity also reduces losses owing to dead mileage, enabling them to carry enough passengers without waiting long times for the vehicle to reach full capacity with passengers. Five-seater sedan taxis in Gaborone are not available directly from places of residence to work or school, because they are not available in all areas of the city. Also, sedan taxis cost more than combis, which means people might choose combis in preference to sedan taxis for affordability reasons. Most bus routes starting from residential and commercial areas end at a bus rank at a central location on the route where passengers then change buses to those going to their destination. This explains the lack of direct trips from areas of residence to areas of work or school.

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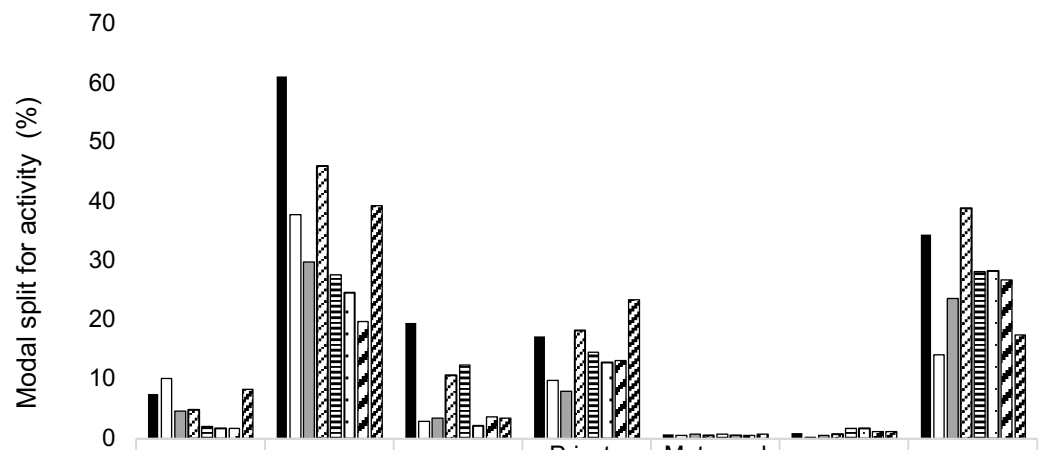
Cabs are the least used mode because of their operational policies as demand-responsive public transportation, meaning that they are available only to people who request them. Therefore, using their availability to measure the accessibility of other modes of public transportation would not be valid.

4.4.2 Modal split and non-motorised transportation

Data on the use of available modes of both motorised and NMT for travel to perform various activities are presented in this section. Modal split is influenced by user preferences and accessibility of modes. Figure 4.13 shows that taxis, walking and private vehicles were the most used modes of transportation. Walking is common among students who live in areas around universities, enabling them to walk to campus. Walking is also a common leisure and recreational activity.

Modal split in Bloemfontein

Figure 4.13 shows the modal split between activities in Bloemfontein.



	Bus	Taxi	Cab	Private Vehicle	Motorcycle	Bicycle	Walking
Shopping	7,6	61,1	19,5	17,3	0,7	1	34,5
Work	10,2	37,8	2,9	9,8	0,5	0,2	14,1
School	4,6	29,8	3,4	8	0,7	0,5	23,7
Personal	4,9	46	10,7	18,2	0,5	0,7	38,9
Leisure	2	27,7	12,4	14,6	0,7	1,7	28,2
Sporting	1,7	24,6	2,2	12,9	0,5	1,7	28,3
Sightseeing	1,7	19,8	3,7	13,2	0,5	1,2	26,8
Family Obligations	8,3	39,3	3,4	23,4	0,7	1,2	17,5

Figure 4.13: Percentage of participants using given modes of transportation for each activity in Bloemfontein

The majority of shopping trips were made by taxi (61.1%), followed by 34.5% trips made by walking, 19.5% trips made by cab, and 17.3% shopping trips by using private

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vehicles. Only 7.6% of the trips were made by bus. Work trips were made mostly by taxi (37.8%), while 14.1% were made by walking, 10.2% by bus, and 9.8% by using private vehicles. Furthermore, 2.9% of work trips were made by cab, and only 0.5% and 0.2%, respectively, of trips to work are made by using motorcycles and bicycles. Taxis were used by 29.8% of participants to make trips to school or educational institutions and 23.7% walked to school. In addition, 4.6% of students caught a bus to school, while 3.4% used a cab. Only 0.8% of participants went to school in private vehicles. Motorcycles and bicycles were the least common modes of transportation used for travelling for all activities.

Taxis were the most used transportation method, but this might have been influenced by their accessibility instead of user preference. Taxis are inconvenient and unreliable, but affordable. Public transportation users travelled by taxi, because they had no other choice. Low bus usage was influenced by the lack of bus services in some areas of the city. Although subsidised by the government and cheaper than taxis, buses did not attract more users. Cabs were only available on-demand and were costlier than all modes, which explains their low usage.

Modal split in Gaborone

Figure 4.14 shows the modal split for activities in Gaborone. Combis and private vehicles were the most used modes of transportation. Specifically, 44.2% of participants used combis for shopping trips, while 41.3% used private vehicles. A further 16.2% walked to the shops, 11.6% used cabs, and 11.1% used sedan taxis. None of the participants used motorcycles or bicycles for shopping trips.

Travel to work was dominated by combis and private vehicles. In particular, 31.8% of participants used combis for work trips, while 28.4% used private vehicles. Only 4.4% and 4.1%, respectively, walked or used taxis. School trips were also dominated by the use of combis and private vehicles, with 35.4% of trips being made by combi, 15.8% by using private vehicles, 6.2% by sedan taxi, and 2.6% by cab.

Personal trips were trips made to perform miscellaneous activities not listed in the questionnaire. In all, 48% of these trips were undertaken by using combis, 36.4% by

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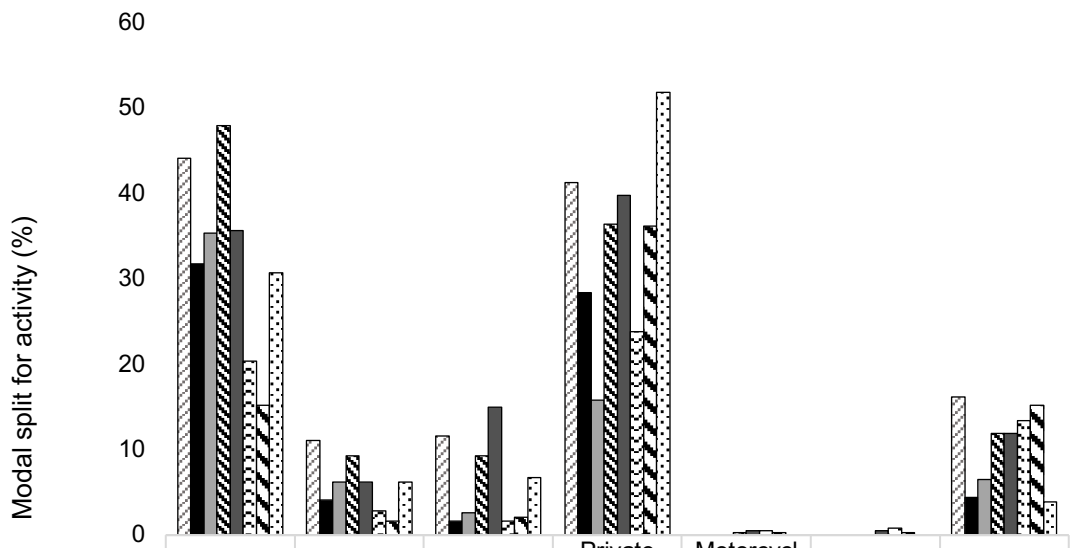
using private vehicles, 11.9% by walking, and 9.3% by using sedan taxis and cabs, respectively.

Most of the participants used private vehicles in preference to combis to travel for leisure, sport, sightseeing and travel for obligatory family activities. Private vehicles were used to make 39.8% of participants' leisure trips compared with 35.7% trips made by combi; 23.8% of sporting trips were made by using private vehicle compared with 20.4% made by combi; 36.2% of sightseeing trips were made by using private vehicles compared with 15.2% made by combi; and 51.9% of trips for family obligations were made by using private vehicles compared with 30.7% made by combi. Cabs were used mostly for leisure trips compared with other activities, with 15% of participants using cabs for leisure trips, and 6.7% using cabs for family obligations.



	Combi	Taxi	Cab	Private vehicle	Motorcycle	Bicycle	Walking
Shopping	44,2	11,1	11,6	41,3	0	0	16,2
Work	31,8	4,1	1,6	28,4	0	0	4,4
School	35,4	6,2	2,6	15,8	0	0	6,5
Personal	48	9,3	9,3	36,4	0,3	0	11,9
Leisure	35,7	6,2	15	39,8	0,5	0,5	11,9
Sporting activities	20,4	2,8	1,6	23,8	0,5	0,8	13,4
Sightseeing	15,2	1,6	2,1	36,2	0,3	0,3	15,2
Family obligations	30,7	6,2	6,7	51,9	0	0	3,9

Figure 4.14: Percentage of participants using given modes of transportation for each activity in Gaborone

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The distribution and split of modes of transportation among activities showed that the combi was the most used mode of transportation for the majority of activities in Gaborone, followed by the use of private vehicles. Although the use of combis was common for travel to perform most activities, the use of private vehicles for family obligations was higher than the use of combis. The use of private vehicles is convenient and flexible compared with public transportation, but the prevalent use of combis could be a result of affordability.

Other available modes of public transportation, including sedan taxis and cabs, were used less compared with combis. The only activities for which cabs were used most were leisure activities. Sedan taxis, as the only other alternative, non-demand-responsive public transportation, were not available, did not operate in all areas of the city and cost more than was charged for the use of combis.

Walking was less common than the other modes of travel, and could have been used by people living near areas where they performed activities for convenience and affordability purposes. The results also indicated the limited use of motorcycles and bicycles. There is no infrastructure dedicated for the use of the two modes in Gaborone – although motorcycles use the same infrastructure as cars, bicycles are not catered for by the city's infrastructure.

Modal split frequency

The results of the distribution of mode use over periods of time provided in the questionnaire are presented this section. For each mode, participants were asked to select the frequency with which they used the different public, private and NMT options. The results obtained in Bloemfontein are shown in Figure 4.15, and the results obtained in Gaborone are shown in Figure 4.16.

The results in Figure 4.15 indicated that 79.5% of the participants did not use private cars. Of those who used private vehicles, 8.2% indicated that they used them daily, while 3.4% used their cars only once a week. In addition, 5.5% of the participants used the car 2-3 times a week, while 1.4% and 1.9%, respectively, used their cars on weekends and once a month.

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Car sharing was not common in Bloemfontein, as indicated by the results, showing that 89.4% of participants did not use car sharing, while only 1.4% used car sharing every day, of which 3.1% and 2.9%, respectively, travelled by sharing rides once a week and for 2-3 days a week. A further 3.1% of the participants used car sharing once a month. None of the participants used car sharing on weekends.

The frequency of bus use indicated by the participants was that 80.2% did not use the bus, while 7.7% used the bus on a daily basis. A further 5.3% used the bus once a month, 2.4% used it 2-3 days a week and on weekends only, respectively, and 1.9% of the participants used the bus once a week only.

Taxis were the most commonly used mode of transportation, with only 22.9% of participants indicating that they did not use taxis and 50.4% used taxis daily. In addition, 11.1% of the participants used taxis 2-3 days a week, while 7.5% used taxis once a week. Furthermore, 3.9% and 4.3%, respectively, of the participants used a taxi on weekends only and once a month.

Motorcycles were the least common mode of transport used in Bloemfontein. A total of 98.6% of the participants did not use motorcycles, while only 0.5% used them once a month. Only 0.2% of the participants used motorcycles daily, once a week, 2-3 days a week and on weekends.

Walking was the second most common mode of travel, with only 27.7% of the participants indicating that they did not walk, while 61.9% of the participants walked daily, and 4.6% walked 2-3 days a week.

The use of bicycles was not common and could not compete with the use of taxis and walking. Specifically, 95.9% of the participants did not use bicycles. Only 0.5% and 0.7% of the participants used bicycles daily and on a weekly basis, respectively. Also, 2.2% used bicycles 2-3 days a week, while 0.7% used bicycles once a month only, and none of the participants used bicycles only on weekdays.

Cabs are a demand-responsive method of public transportation. Consequently, 81% of participants did not use cabs. However, 12% of participants used them once a

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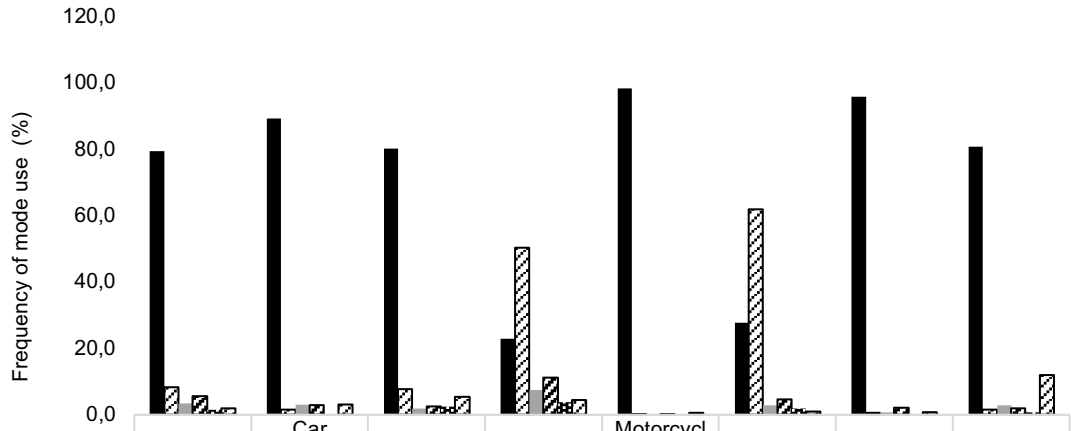
month, 2.9% once a week, 1.9% 2-3 days a week, and only 1.4% of the participants use cabs daily. Only 0.7% of the participants used cabs only on weekends.



	Car	Car Sharing	Bus	Taxi	Motorcycle	Walking	Bicycle	Cab
Do not use mode	79,5	89,4	80,2	22,9	98,6	27,7	95,9	81,0
Daily	8,2	1,4	7,7	50,4	0,2	61,9	0,5	1,4
Once a week	3,4	3,1	1,9	7,5	0,2	2,9	0,7	2,9
2 -3 days a week	5,5	2,9	2,4	11,1	0,2	4,6	2,2	1,9
Weekends only	1,4	0,0	2,4	3,9	0,2	1,9	0,0	0,7
Monthly	1,9	3,1	5,3	4,3	0,5	1,0	0,7	12,0

Figure 4.15: Percentage of frequency of use of modes of transportation by participants in Bloemfontein

The results in Figure 4.15 indicated that taxis and walking were the most frequently used modes of transportation. Walking was the most common, non-motorised mode of travel. Trips by public transportation typically begin with walking from a place of origin to the bus stop, and end with another walking trip from the bus stop to the destination. Walking trips, to carry out lunch-hour shopping and errands might occur during the course of the day, but these were not the main trips made by the participants. Therefore, walking might be used in combination with trips by public transportation. However, all-inclusive trips to work, from origin to destination, might still account for most of the walking trips. People living closer to work, school and shopping areas might walk regularly – walking being the most convenient way for them to reach places.

Figure 4.16 shows the results obtained for the same parameters in Gaborone. The frequency of private vehicle use showed that 45.6% of the participants did not use private cars, while 28.4% used private cars daily. Furthermore, 10.3% of participants

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used private vehicles only once a week. In addition, 8.2% and 4.6%, respectively, of participants used private vehicles 2-3 days a week, or on a monthly basis, and only 2.8% used private vehicles only on weekends.

Car sharing modes were used rarely, with 83.5% of the participants indicating that they did not use them. A further 5.3% of participants used car sharing only once a month or 4.6% once a week. Only 2.6%, 2.3% and 1.3%, respectively, used car sharing 2-3 times a day, every day and only on weekends.

Combis, being the most popular choice of transport in Gaborone, consequently had the lowest percentage of not being used compared with other modes. Only 23.5% of the participants did not use combis. Most of the participants who used combis did so daily (56.7%). A further 7.5% of the participants used combis 2-3 days a week, while 5.7%, 3.9% and 2.8%, respectively, used combis once a month, once a week, or only on week days.

Taxis were used on a daily basis by 8.5% of the participants, and 9% on a monthly basis. A further 7% and 6.2%, respectively, used taxis only 2-3 days a week or once a week, while 2.1% of participants used taxis only on weekends.

Walking was also a common mode of travel in Gaborone. Only 38.1% of the participants did not walk, while 42% walked daily, and 9.3% walked 2-3 days a week. Respectively, 4.6%, 4.1% and 1.8% walked weekly, only on weekends, or once a month.

Most cab users used cabs once a month (17%). A further 3.1%, respectively, used cabs once a week or only on weekends. A further 2.1% and 1.8%, respectively, used cabs daily and 2-3 days a week, while the majority of participants (72.9%) did not use cabs.

The use of bicycles was not common in Gaborone. A total of 97.9% of the participants did not use them, while 0.3% used them once a week. In addition, 1.3% of participants used bicycles once a month, while 0.3% reported using bicycles 2-3 days a week and on weekends only. None of the participants used bicycles on a daily basis.

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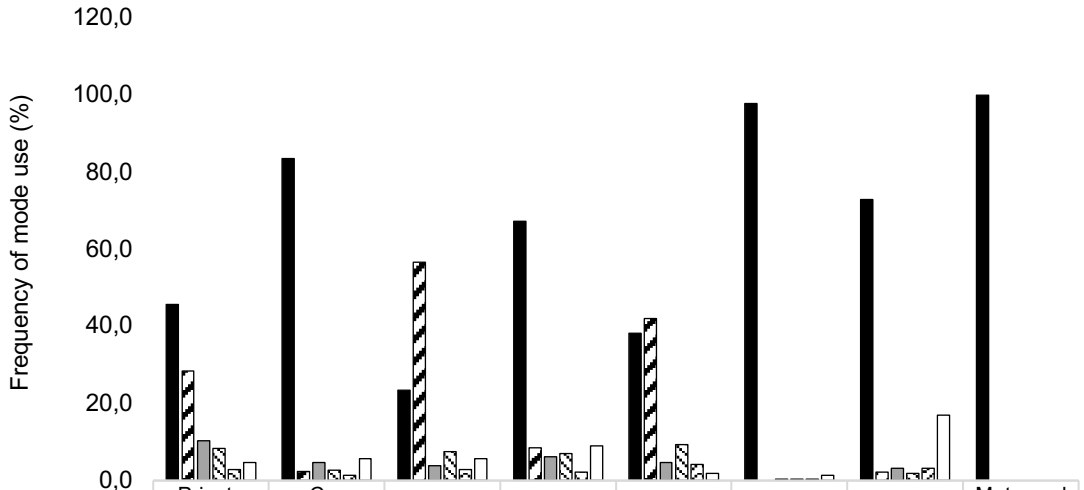
Motorcycles were the least common mode of transportation, as none of the participants used them.



	Private Vehicle	Car Sharing	Combi	Taxi	Walking	Bicycle	Cab	Motorcycle
Do not use mode	45,6	83,5	23,5	67,3	38,1	97,9	72,9	100,0
Daily	28,4	2,3	56,7	8,5	42,0	0,0	2,1	
Once a week	10,3	4,6	3,9	6,2	4,6	0,3	3,1	
2 -3 days a week	8,2	2,6	7,5	7,0	9,3	0,3	1,8	
Weekends only	2,8	1,3	2,8	2,1	4,1	0,3	3,1	
Monthly	4,6	5,7	5,7	9,0	1,8	1,3	17,0	

Figure 4.16: Percentage of frequency of use of modes of transportation by participants in Gaborone

Figure 4.16 shows the frequency of mode used by the participants in Gaborone. Combis, walking and private vehicles were the most frequently used modes of transportation. Specifically, 56.7% of participants used combis, 42% walked, and 28.4% used private vehicles on a daily basis. Motorcycles were never used, while only a few participants ever used a bicycle (2.1%). Cab usage was also very low and rarely used compared with other modes. Only 17.0% of the participants used cab services on a monthly basis, and 2.1% daily, while 72.9% of participants did not use cab services at all.

Taxis, combis, walking and private vehicles were the most commonly used modes of transportation in both cities. Taxis or combis were the cheapest modes of public transportation in Bloemfontein and Gaborone, respectively. These modes, while they were both affordable and accessible, were the least convenient, safe, or reliable.

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Based on the dissatisfaction among public transportation users with the lack of safety or comfort regarding combis and taxis, it can be assumed that most of the people using these modes were captive users. Students and people making short-distance trips tended to walk, as it is the most affordable way to travel. Lack of use of motorcycles and bicycles as regular transportation modes might be because of the lack of infrastructure, costs associated with owning motorcycles, and a lack of interest in using these modes.

The frequency with which the various modes were used also showed that walking and taxis were frequently used modes: more walking and taxi trips were made daily, while cabs were used at best only on a monthly basis.

The use of private vehicle was prominent in Gaborone for all activities and was far more frequent than in Bloemfontein. The use of private vehicles stems mostly from the need for convenience and flexibility rather than affordability.

Discussion of trip formations by mode

This section is a schematic discussion of typical trip compositions by various modes. Figures 4.17 to 4.19 are typical presentations of formations of trips by different modes. These formations can be used to interpret flexibility, accessibility of mode, and convenience.

Trips by private vehicle, bicycle, walking and cabs are typically easier to undertake and totally at the discretion of the user as to when to make use of these modes, when to leave and arrive at the destination. The difference in these trips lies within the traveller making the decision to undertake a trip and performing the task without third-party involvement for private vehicles, cycling and walking. The trip-making process is between the traveller and the mode, whereas there is involvement of a third-party, which is the cab operator, cab driver or company, when using demand-responsive modes.

Trips by public transportation are more complicated compared to the other modes, while the complications are of varying degrees, depending on the number of trips per journey and the need to buy tickets or have cash available, among other

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considerations. Typical trips begin by a walk from the original point of departure to the point of access for public transportation vehicles, for example, the bus terminal or bus stop. This is followed by waiting times, which also vary depending on area, availability of vehicles, capacity at which the available vehicles are already carrying and the time of day.

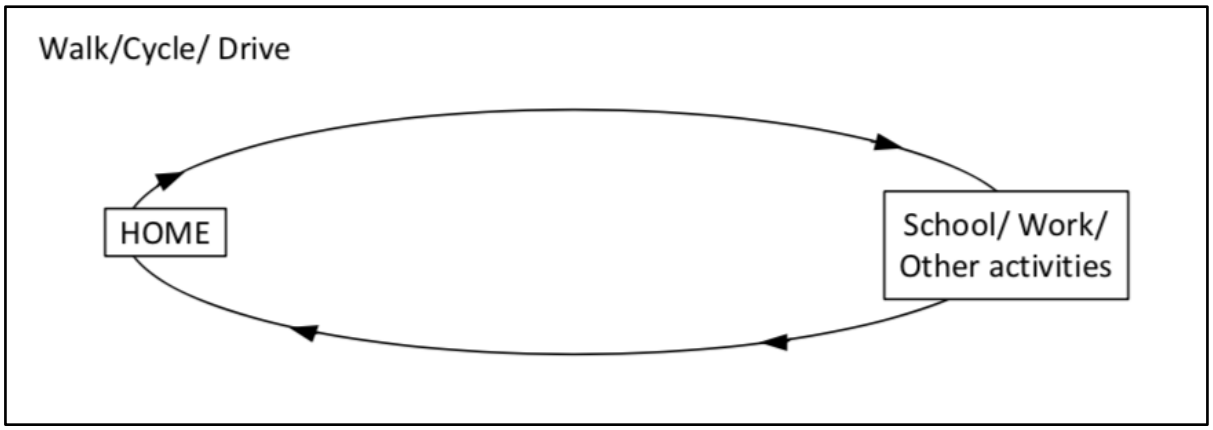

Figure 4.17: Typical formation of trips by private vehicle, cycling, motorcycle or walking

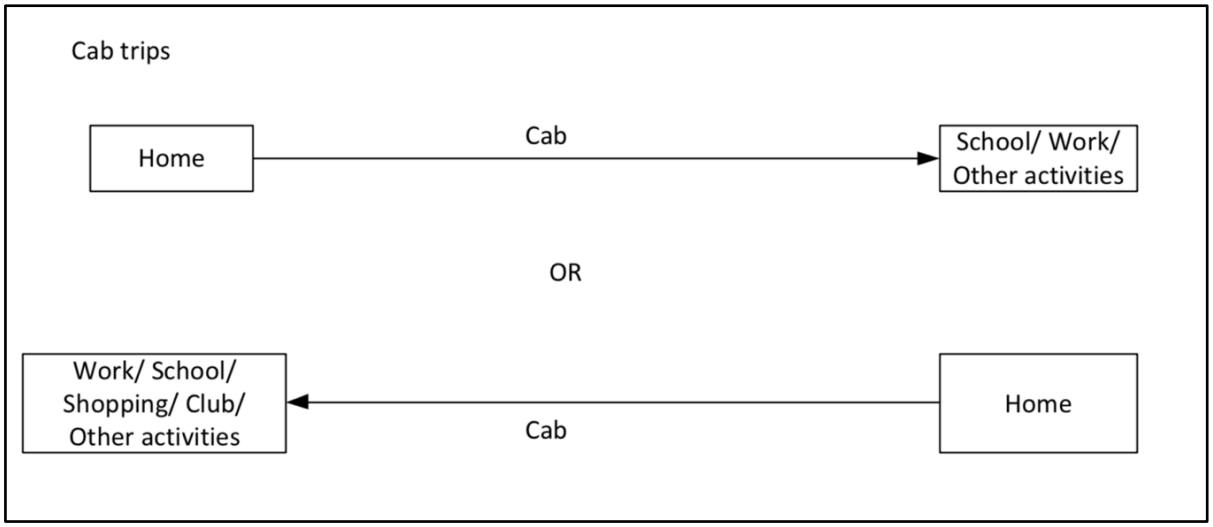

Figure 4.18: Typical formation of trips by cabs and demand-responsive public transportation modes

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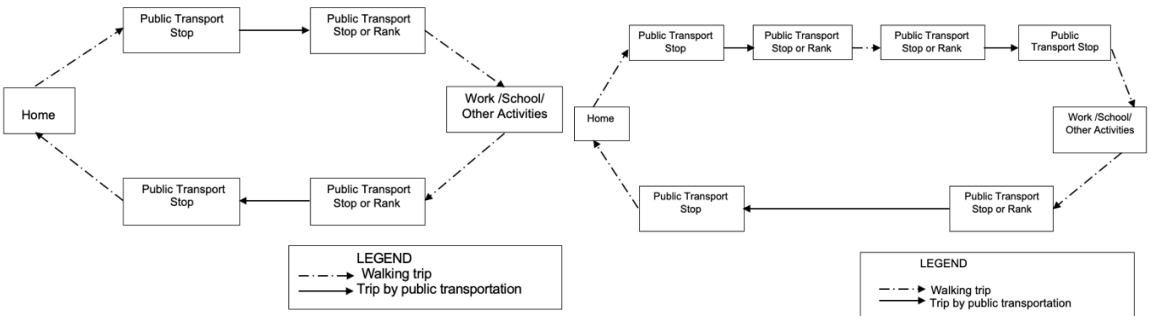

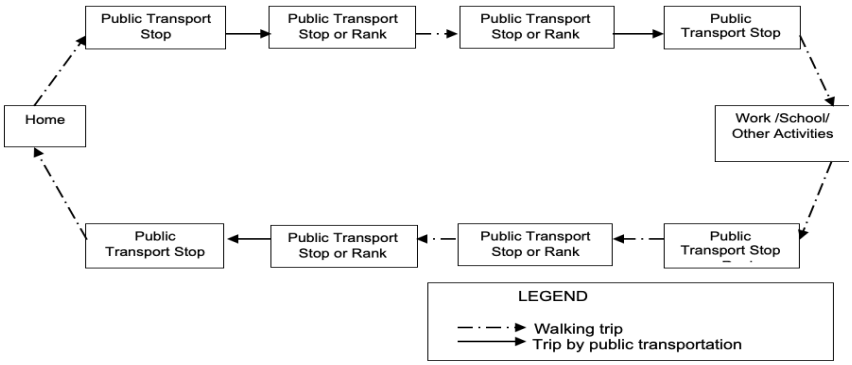

a. Two-trip formation

b. Three-trip formation

c. Four-trip formation

Figure 4.19: Typical formation of trips by public transportation (taxi, bus, combi)

4.5 Accessibility by Distance

In the following section, accessibility in terms of distance travelled and travel time spent on regular trips between home, school and work is presented. The variables measured in this section were: Distance and time spent walking to bus stops, travelling from the bus stops to school or work, from home to school or work, as well as the modes of transportation used. Walking distance to access bus stops is presented in Figure 4.20.

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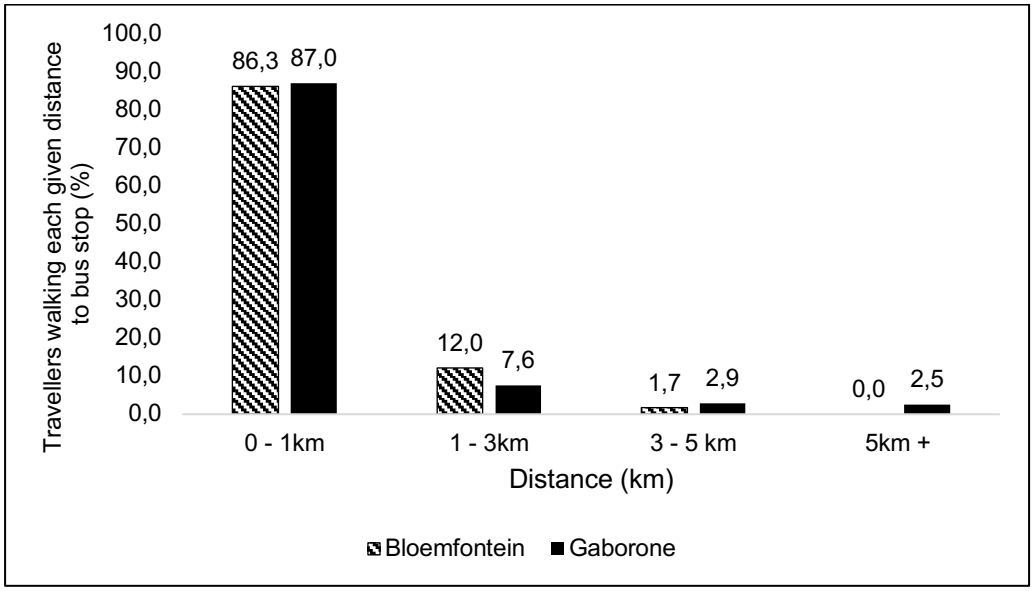

Figure 4.20: Percentages of distances walked by participants to bus stops

Figure 4.20 shows the distances walked by participants to bus stops in the relevant cities. In Bloemfontein, 86.3% of participants walked for a kilometre or less, while in Gaborone, 87% walked the same distance. Furthermore, 12% and 7.6%, respectively, walked distances of more than 1 km, but less than 3 km in Bloemfontein and Gaboron, while 1.7% and 2.9%, respectively, walked for distances between 3 km and 5 km. In Gaborone, 2.5% of the participants walked distances of over 5 km to the bus stop, while none of the participants in Bloemfontein had to walk distances of over 5 km.

There were similarities in walking distances, as the results indicated that most people in both areas walked distances of less than 1 km to the bus stop. This implied that bus stops were accessible at minimal walking distances. However, some of the participants, who walked more than a kilometre and up to five kilometres, did not have easy access to transportation infrastructure and public transportation services, as they spent considerably more time walking before they were able to access public transportation.

4.5.1 Accessibility in Bloemfontein by distance

The distance travelled from the bus stop to school or work, from school or work going home, as well as the average distance travelled from home to school or work in Bloemfontein is shown in Figure 4.21. Figure 4.22 shows accessibility of areas in

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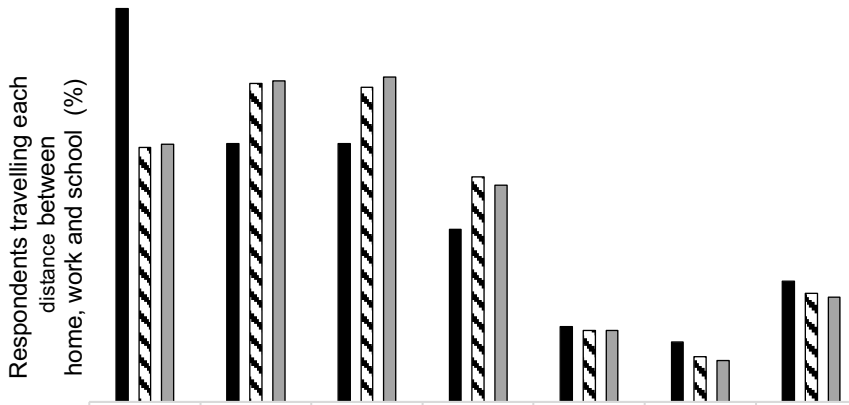
Bloemfontein within a 25 km distance from areas of residence, while Figure 4.23 is a visualisation of the shortest distances between the areas.



	0 - 1km	1 - 5km	5 - 10km	10 - 15km	15 - 20km	20 -30km	30km+
Bus stop to school/ work	29,4	19,3	19,3	12,9	5,6	4,5	9,0
School/ work - Home	19,0	23,8	23,5	16,8	5,3	3,4	8,1
Home to school/ work	19,3	24,0	24,3	16,2	5,3	3,1	7,8

Distance

Figure 4.21: Percentage of distances travelled to school work and home by participants in Bloemfontein

Distances travelled by participants in Bloemfontein are shown in Figure 4.21. A total of 29.4% of participants travelled a distance of less than 1 km from the bus stop to school or work, while 19.3% travelled distances between 1-5 km and 5-10 km, respectively. A further 12.9% of participants travelled distances between 10-15 km, while 5.6%, 4.5% and 9%, respectively, travelled distances of 15-10 km, 20-30 km and over 30 km from bus stops to schools or work.

Participants were asked also to indicate the distances they travelled from home to school or work, and from school or work going home. These two parameters were separated, because people might travel using different routes for the two trips. It was reported that 19% of participants travelled for less than a kilometre from school or work going home, and 19.3% were travelling from home going to school or work. A further 23.8% travelled for 1-5 km from school or work going home, and 24% travelled the same distance when travelling from home to school or work. A further 23.5% travelled distances between 5-10 km from school or work going home, and 24.3% travelled the

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same distance from home going to school or work. In addition, 16.2 % of participants travelled distances between 10-15 km from school or work going home, and 16.2% travelled the same distance from home going to work or school. These figures indicated that it was logical that there was hardly any difference between the distances travelled between home and school/work and the reverse travel.

At the same time, 5.3% travelled 15-20 km both from home to work or school and school or work to home, while 3.4% travelled 20-30 km from work or school going home, compared with 3.1% travelling the same distance from home going to school or work. Distances of over 30 km were travelled by 8.1% of the participants going home from work or school, compared with 7.8% who travelled the same distance from home going to school or work. These are potentially people travelling from outside the city or travelling from areas along the borders of the city. Again, there were no significant differences between the circular travelling patterns.

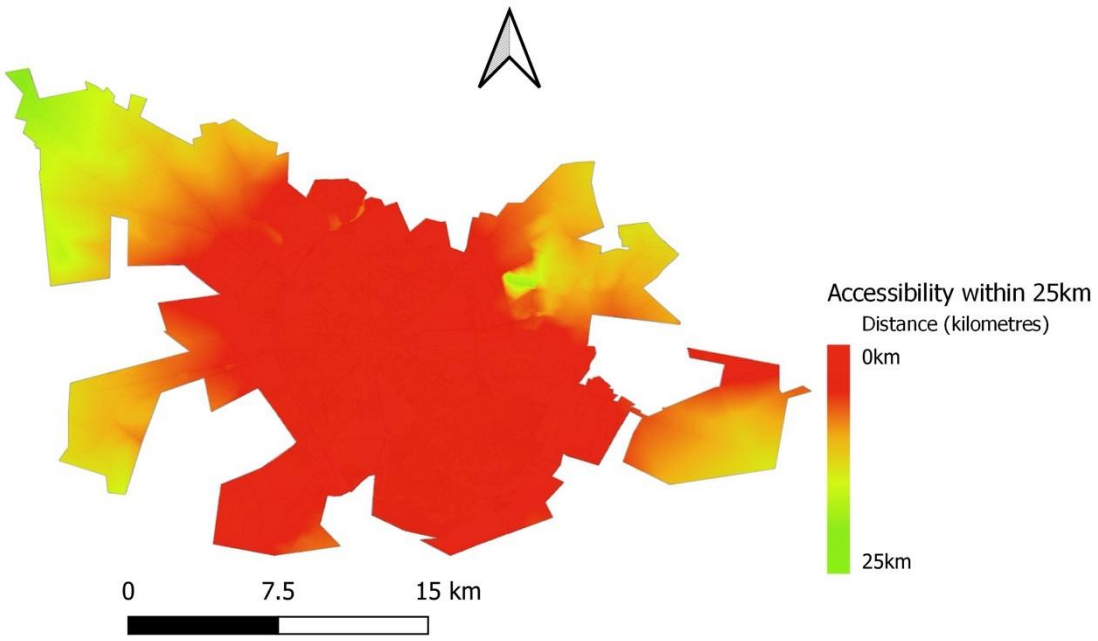

Figure 4.22: Accessibility of Bloemfontein areas within 25 km distance

Figure 4.22 shows accessibility within a 25 km radius within the city of Bloemfontein. Most areas of the city are accessible within a geographical distance of 25 km or less from areas of residence. Highly accessible areas within shorter distance are

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represented in high-density, by intense red colour, which gradually changes to lighter colours as the distance increased, which equates to decrease in accessibility. Hence, the least accessible areas are presented by fading to lighter yellow and neon green colours. Most areas within the city are accessible within a 25 km radius, with areas in the southern, and central parts of the city being most accessible. Some areas in the further north-western, south-western and north-eastern parts of the city are the least accessible. To further determine accessibility of each area to other areas by distance, an OD matrix was developed and this is presented in Figure 4.23 and the shortest and longest distances are shown in Table 4.4.

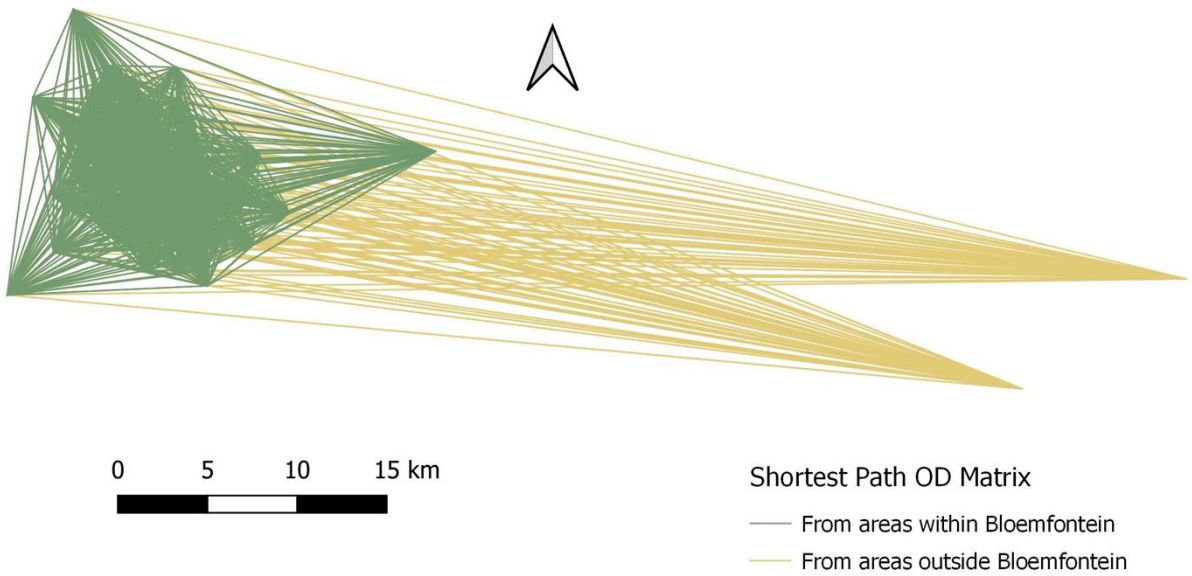

Figure 4.23: Shortest past OD Matrix connecting Bloemfontein areas

Table 4.6: Nearest and furthest distance

	Origin	Destination	Distance (km)
Nearest	Ashbury	Bloemside Phase 1	0.989
	Hospitaal Park	General De Wet	1.214
	Phahameng	Bochabela	1.268
	Turflaagte	Chris Hani	1.284
Furthest	Langenhoven Park	Mandela View	26.475
	Mandela view	Woodlands	26.810
	Pellissier	Mandela View	26.855
	Lourier Park	Mandela View	28.094
	Bainsvlei	Mandela View	32.774

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The shortest travel distances between any two areas in the city of Bloemfontein are 0.989 km between Ashbury and Bloemside Phase 1; 1.214 km between Hospitaal Park and General DeWet; 1.268 km between Phahameng and Bochabela; and 1.284 km between Turflaagte and the Chris Hani settlement. There are few areas accessible in over 25 km distances, with such distances ranging from 25.775 km to a maximum of 32.775 km. These areas include Bainsvlei, Lourier Park, Mandela View, Langenhoven Park, Pellissier and Woodlands. Furthest distances between any areas are 32.774 km, 28.094 km, 26.855 km, 26.810 km, and 26.475 km, respectively, between Mandela View and Bainsvlei, Lourier Park, Pellissier, Woodlands and Langenhoven Park.

The CBD area of Bloemfontein, which attracts more travel, is accessible within shortest distances of 2.218 km from Oranjesig and the furthest area is Mandela View of 18.022 km; Mangaung location of 16.396 km; and Bainsvlei of 14.965 km. The CBD is accessible to the remaining areas within the city within a distance of less than 12.271 km.

The distance from areas in Bloemfontein and areas outside of the city where some participants performed activities, Botshabelo and Thaba Nchu, were also determined. The shortest distance from Thaba Nchu to areas in Bloemfontein range between 65.632 km to a maximum of 74.279 km. The distances between Botshabelo and Bloemfontein areas have both the shortest and the longest distances, ranging between 45.687 km and 66.354 km, depending on the exact place of departure and the destination.

4.5.2 Accessibility in Gaborone by distance

Accessibility of home, school and work by distance is shown in Figures 4.24, while accessibility of areas in the City of Gaborone that are reachable within a 20 km distance is shown in Figure 4.25. The shortest routes between areas within Gaborone and those outside Gaborone, but those that are contributing to regular activity travel, are shown in Figure 4.26.

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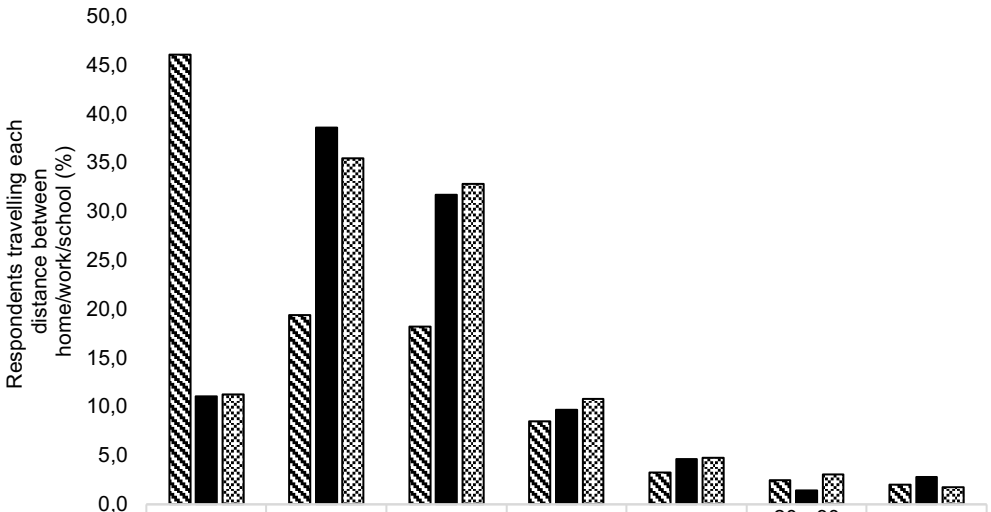

	0 - 1km	1 - 5km	5 - 10km	10 - 15km	15 - 20km	20 - 30 km	30+ km
Bus stop to school/work	46,2	19,4	18,2	8,5	3,2	2,4	2,0
Home to School/Work	11,1	38,7	31,8	9,7	4,6	1,4	2,8
School / Work to Home	11,3	35,5	32,9	10,8	4,8	3,0	1,7

Figure 4.24: Percentage of distances travelled to school, work and home by participants in Gaborone

Figure 4.24 shows distances travelled by participants in Gaborone from their respective bus stops to work or school, and to and from home and school or work. Specifically, 46.2% of the participants travelled distances of less than 1 km from the bus stops to school or work. A further 19.4% of the participants travelled distances of between 1-5 km from the bus stop to school or work, whereas 18.2% and 8.5%, respectively, travelled 5-10 km and 10-15 km. The remaining 3.2%, 2.4% and 2%, respectively, travelled distances of 15-20 km, 20-30 km and more than 30 km from the bus stop to school and work.

The distances travelled between home and place of work or school indicated that 11.1% of participants travelled a kilometre or less from home to school or work, and 11.3% travelled the same distance from school or work going home. Furthermore, 38.7% travelled distances of 1-5 km from home to school or work, compared to 35.5% who travelled the same distance from work or school going home. This difference in distance should be noted, as it implies a different route being taken when travelling home.

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In addition, 31.8% travelled 5-10 km from home to school or work, while 32.9% travelled the same distance from work or school going back home, and 9.7% travelled 10-15 km to work or school compared with 10.8% travelling 10-15 km from school or work going home.

Fewer participants (4.6% and 4.8%, respectively) travelled 15-20 km from home to school or work and from school or work going home. A further 1.4% of participants travelled distances of between 20-30 km to work or school, compared with 3% who travelled 20-30 km when going home from school or work. In addition, 2.8% of participants travelled distances of over 30 km to work or school, while 1.7% travelled the same distances from school or work going home.

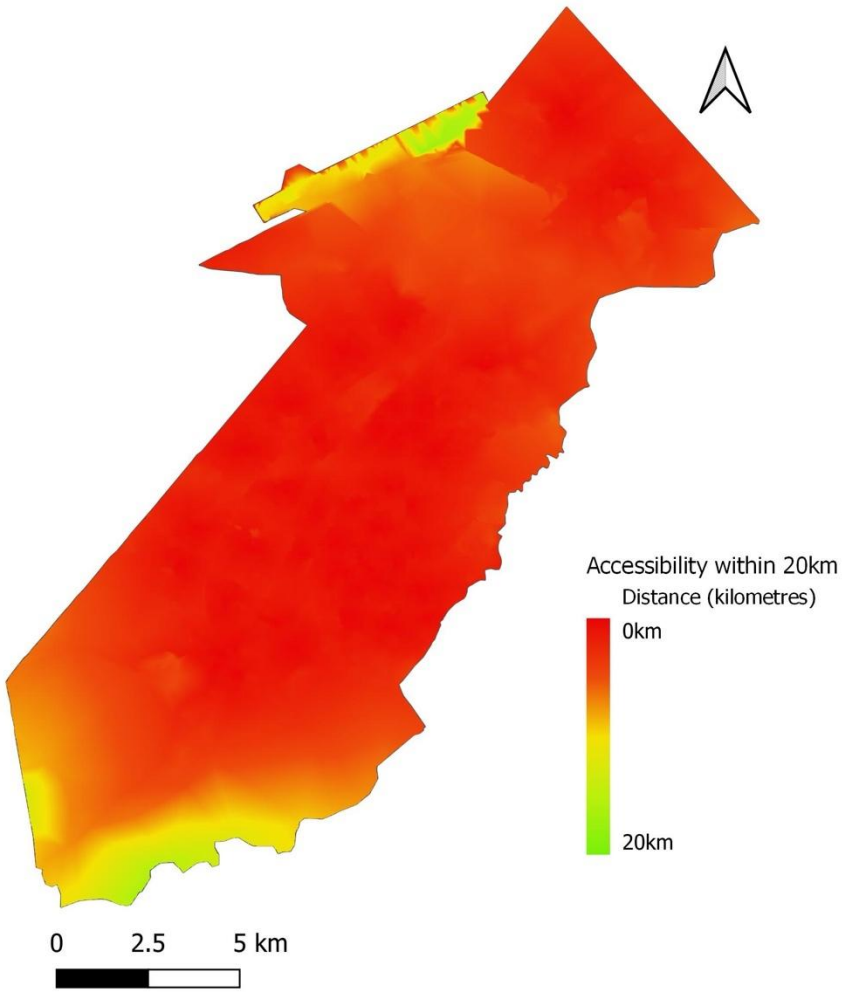

Figure 4.25: Accessibility of Gaborone areas within 20km distance

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Figure 4.25 shows accessibility of areas within a 20 km radius. The easier and more accessible an area is, the higher the colour intensity on the map. The least accessible areas are located in the north-western parts of the city towards the airport, as well as the southern part of the city. These areas, especially the airport area, have low residential density.

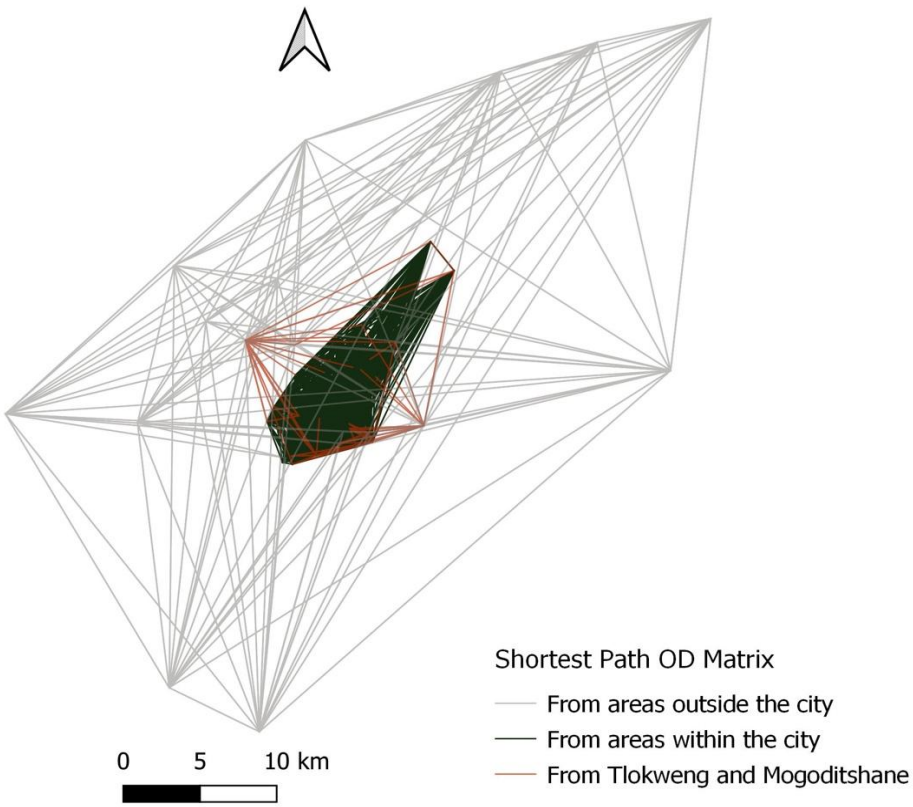

Figure 4.26: Shortest path OD matrix connecting Gaborone area

Table 4.7: Nearest and furthest areas by distance in Gaborone

	Origin	Destination	Distance (km)
Nearest	Extension 27	Tsholofelo	0.207
	White City	New Canada	0.469
	Extension 2	Extension 4	0.572
	South Ring	Extension 4	0.787
Furthest	Phakalane	Commerce Park	20.344
	Gaborone North	Kgale	20.899
	Game City	Gaborone North	21.598
	Gaborone North	Commerce Park	21.878

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Finance Park	Gaborone North	21.993

Figure 4.26 shows the shortest routes between zones within and outside of Gaborone where participants either resided or performed activities, and which contributed to regular travel in the city. The furthest and shortest distances are shown in Table 4.5. Shortest distances were measured between close, densely located lower-middle-class residential areas located near the city centre. Furthest distances were measured between areas in the northern residential areas of the city and the commercial areas in the far south of the city.

Distances between areas in the outskirts of the city, such as Tlokweng, Mogoditshane and areas within Gaborone showed that Tlokweng is closest to the Riverwalk area, a distance of 5.33 km. The furthest distance between Tlokweng and areas within Gaborone is 19.9 km, between Tlokweng and Gaborone North. Areas in Gaborone are accessible within a radius of less than 10 km from Mogoditshane and Gaborone North, which is accessible within a 20.1 km radius from Mogoditshane. Areas outside Gaborone, such as Boatle and Ramotswa further south of Gaborone, Bokaa and Mochudi to the north, Mogoditshane, Gabane, Gakutlon north-west of Gaborone, and Tlokweng also contribute to travel within the city. The distances between Kumakwane and Mochudi are 70.893 km, between Mochudi and Boatle 65.9 km, Ramotswa and Pilane 64.05 km, and 55.6 km between Boatle and Bokaa.

4.5.3 Accessibility by time

This section assessed the time taken to reach bus stops, school, work and home in both study areas. The results showing the time taken travelling from home to the bus stop, from the bus stop to school, work and home and back are presented in Figure 4.27 and Figure 4.29. Figure 4.28 and Figure 4.30 show the accessibility of areas in both cities within one hour.

Accessibility of Bloemfontein, based on time

Time spent travelling between home, the bus stop, school or work was evaluated and the results from Bloemfontein are shown in Figure 4.27, which shows the walking distances travelled by users between their homes, work areas and schools to the bus stop. Accessibility was further assessed by determining the time taken to travel by vehicle from a central point of an area to other areas within the city, which is shown in Figure 4.28.

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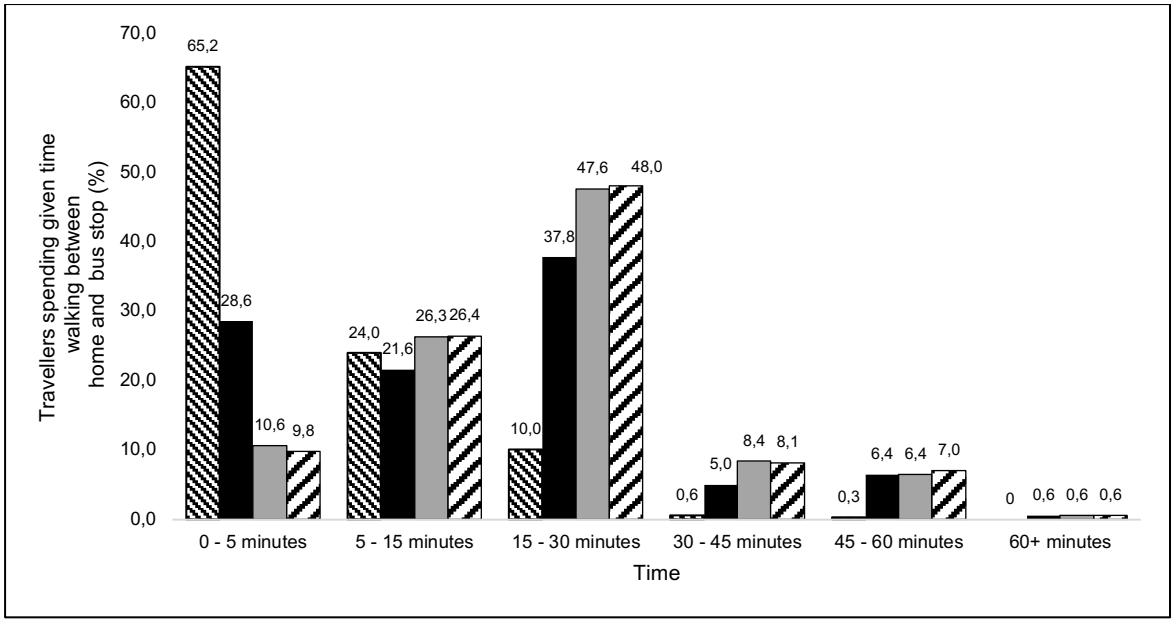

Figure 4.27: Percentage of given times spent travelling between bus stop, school and home by participants in Bloemfontein

It is evident from Figure 4.27 that most participants (65.2%) in Bloemfontein spent 5 minutes or less walking from home to the bus stop, while 24% spent between 5 and 15 minutes and a further 10% spent between 15 and 30 minutes walking to the bus stop. Only 0.6% and 0.4% spent 30 to 45 minutes and 45-60 minutes, respectively, walking to the bus stop.

Results obtained from assessing travelling time between the bus stop and work or school showed that only 28.6% of the participants spent less than 5 minutes travelling from the bus stop to their workplace or school, whereas 21.6% spent between 5 and 15 minutes, a further 37.8% spent 15 to 30 minutes to travel there, while 5% and 6.4%, respectively, spent 30 to 45 minutes and 45 to 60 minutes travelling there. Finally, only 0.6% spent over an hour travelling between the bus stop and their workplace.

Travelling time between school or work and home recorded that 10.6% of participants spent less than 5 minutes, 26.3% spent between 5 and 15 minutes to travel that distance. 47.6% which is majority of the participants spent 15 to 30 minutes. On the other hand, 8.4% and 6.7%, respectively, spent between 30 to 45 minutes and 45 to 60 minutes on getting there. Only 0.6% spent longer than an hour on that travelling distance. These results are close to those obtained from assessing travelling time between home to school and work, where 9.8% and 26.4%, respectively, spent less

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than 5 minutes, and 5 to 15 minutes on this travel. Another 48% spent 15 to 30 minutes, while 8.1% and 7%, respectively, spent 30 to 45 minutes and 45 to 60 minutes on such trips. Lastly, only 0.6% spent over an hour travelling from home to school or work. The results indicate that most people reach their destinations within an hour. Figure 4.28 presents the accessibility of the city within an hour.

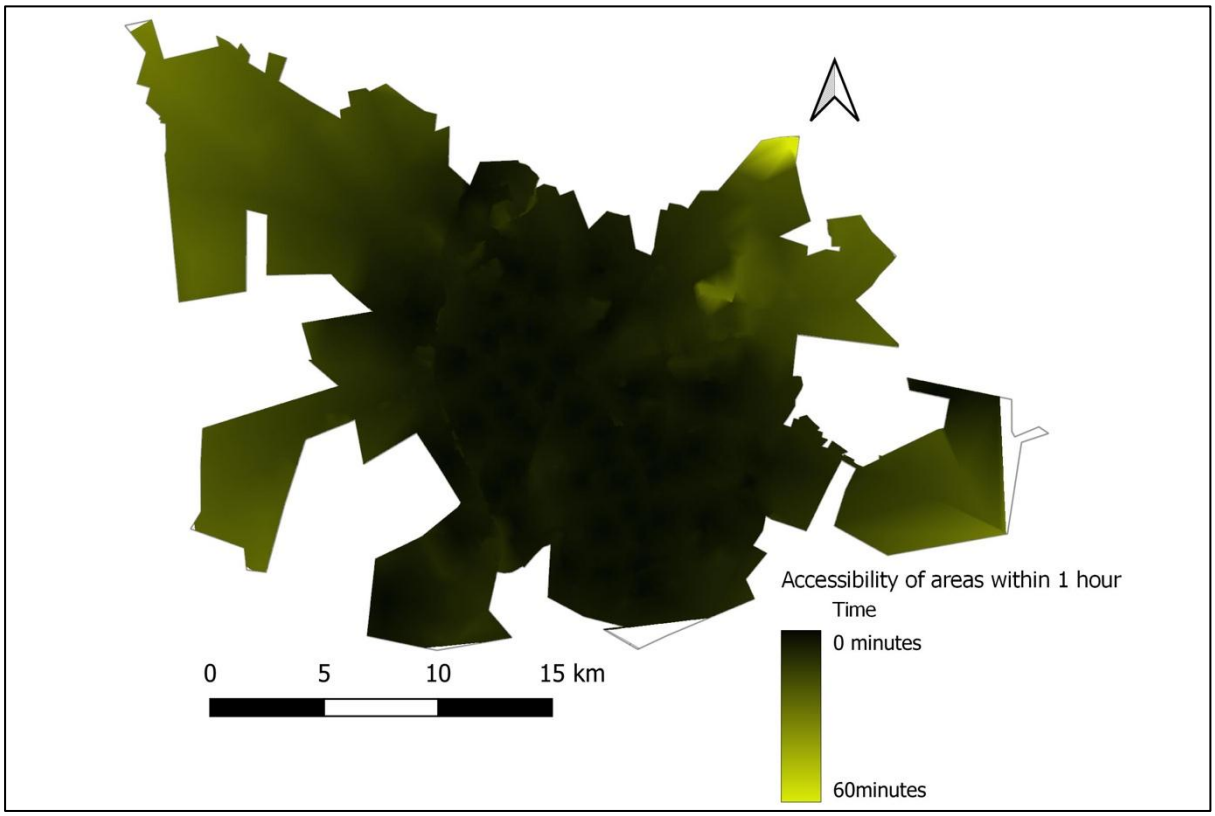

Figure 4.28: Accessibility of areas in Bloemfontein within one hour

Figure 4.28 shows the accessibility of various areas of Bloemfontein within 1 hour at 50 km/hr. Most of the residential areas and the commercial, centrally located areas are accessible in less than 60 minutes. Most of the areas are accessible within 30 minutes and others in 45 to 60 minutes. Similar to the measured accessibility by distance, areas on the north-western parts of the city were least accessible or accessible in longer time taken, as the limited accessibility to these areas could be associated with inadequate road networks in the area. The results demonstrate that most areas of the city are accessible within an hour, validating the results in Figure 4.27.

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4.5.3.1 Accessibility of Gaborone based on time

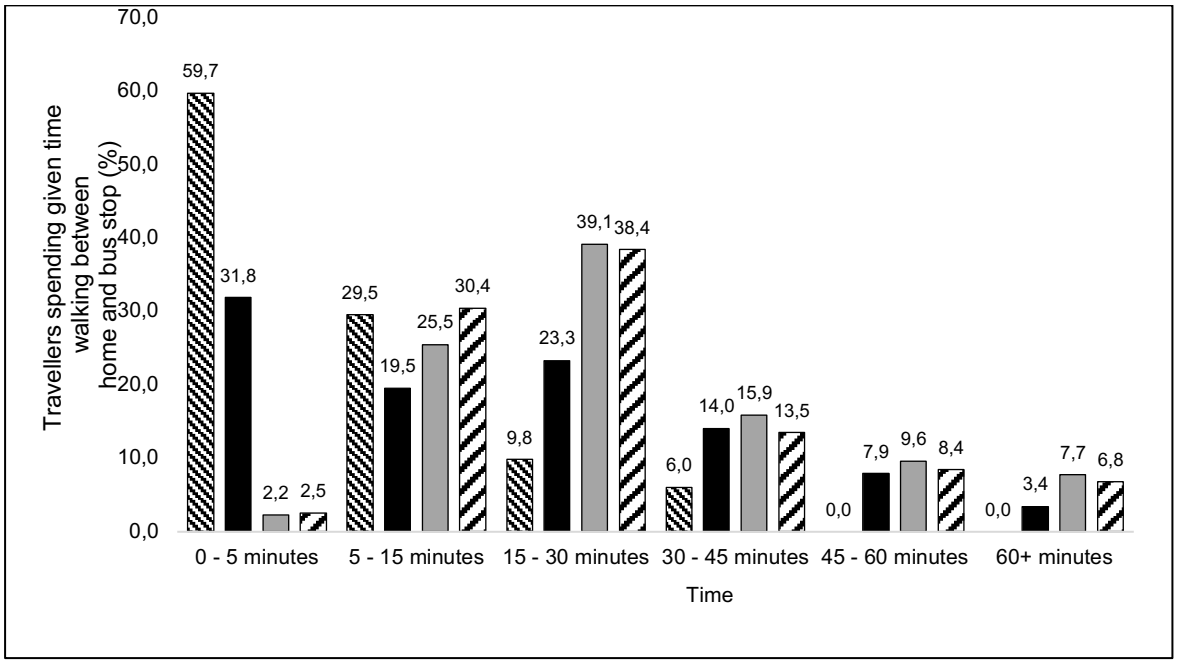

Figure 4.29: Percentage of given times spent travelling between bus stop, school and home by participants in Gaborone

Figure 4.29 shows the duration of travel between home and bus stop, work place and school in Gaborone. The results showed that 59.7% of the participants spent 5 minutes or less walking from home to the bus stop, while 29.5% spent more than 5 minutes, but less than 15 minutes walking to the bus stop. A further 9.8% spent 15 to 30 minutes and 6% spent 30 to 45 minutes to get to the bus stop. None of the participants spent more than 60 minutes walking to the bus stop.

The results of assessing duration of travel from the bus stop to school or work showed that 31.8% of the participants spent 5 minutes or less, while 19.5% spent 5 to 15 minutes to get there. A further 23.3% spent 15 to 30 minutes and 14% spent 30 to 45 minutes to get there, while 7.9% spent 45 to 60 minutes travelling from the bus stop to school or work and lastly, 3.4% spent over an hour.

Trips from home to school or work, and from school or work going home were also evaluated. The results showed that 2.2% of participants spent 5 minutes or less on the trip home compared with 2.5% who spent 5 minutes or less on the trip from home to school or work. A further 25.5% of participants spent 5 to 15 minutes on trips from

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school or work going home and 30.4% spent 5-15 minutes on trips from home to school or work. Most of the participants (39.1%) spent between 15 and 30 minutes travelling from home to school or work and 38.4% spent between 15 and 30 minutes travelling from work to home. Furthermore, 15.9% of participants spent 30 and 45 minutes travelling home, compared with 13.5% who spent the same time travelling from home to school or work. A further 9.6% and 8.4%, respectively, spent between 45 and 60 minutes travelling from school or work going home and from home going to school or work. Also, 7.7% and 6.8%, respectively, spent more than 60 minutes on trips going home from school or work and trips going to school or work from home.

Accessibility of areas within Gaborone within an hour was analysed further and the results are shown on Figure 4.30 below.

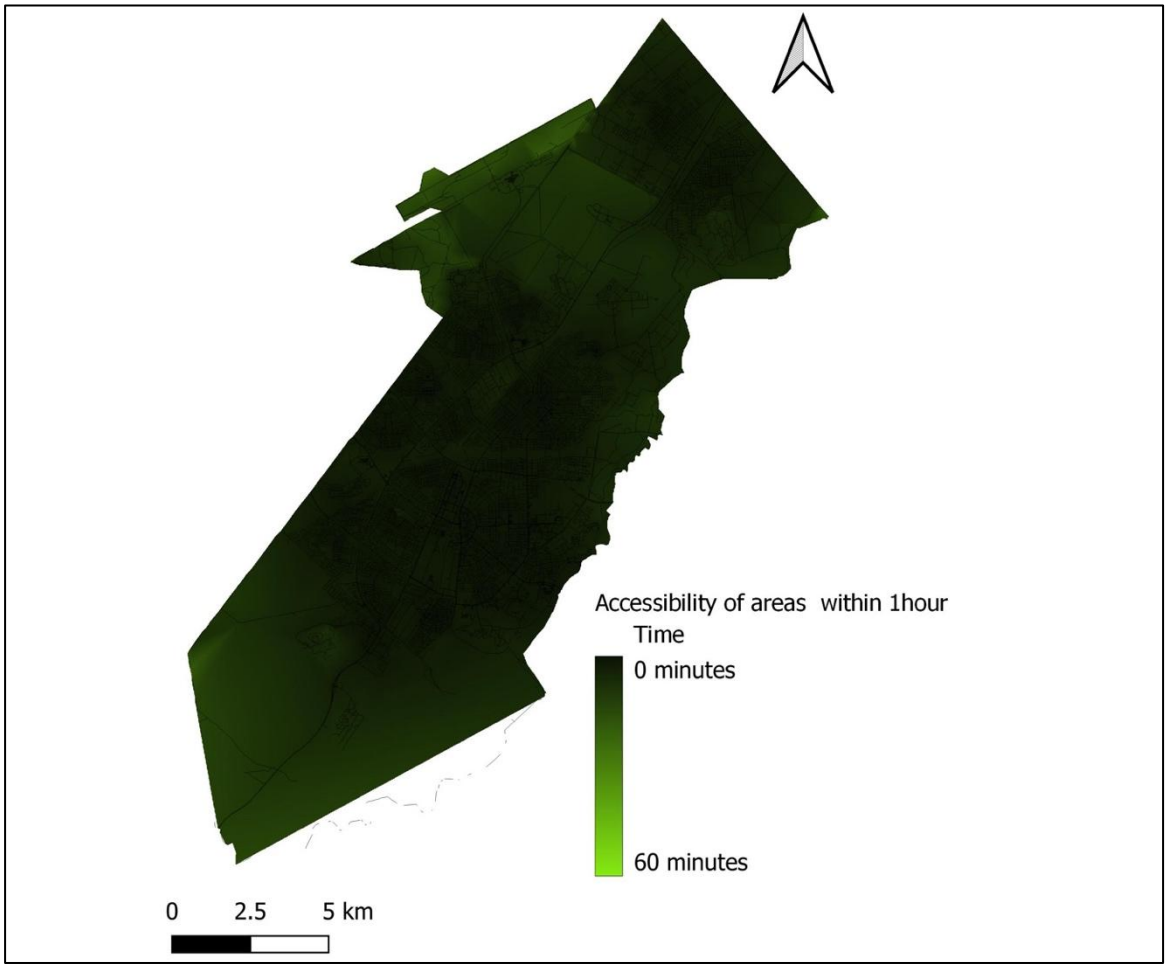

Figure 4.30: Accessibility of Gaborone areas within one hour

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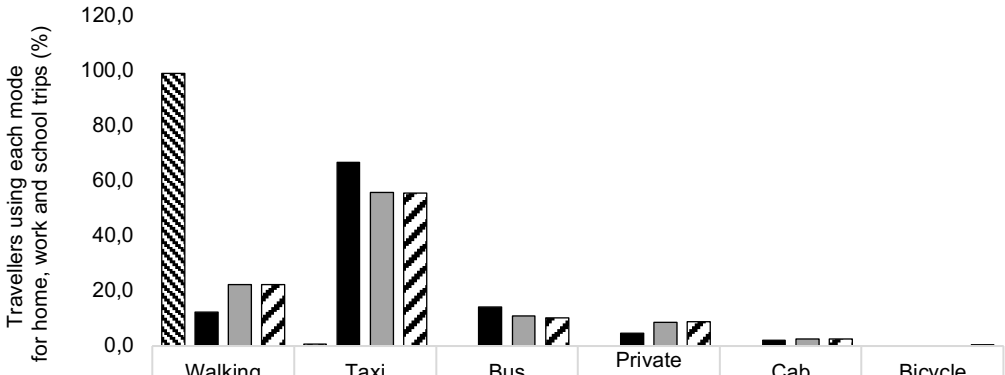
Figure 4.30 shows areas of Gaborone that are accessible within 60 minutes. The map shows that most areas within the City of Gaborone are reachable within an hour, confirming that most people spent less than an hour travelling between homes, school and workplaces within the city. Areas that were not reachable within an hour could be attributed to road network limitations, especially in the north-western end of Gaborone.

Overall, the results indicated that most of the participants in both cities spent less time on trips to the bus stops where these were generally walking trips for distances less than a kilometre from the participants' homes. Differences in durations for trips from home to work or school and trips from school or work going home could have been the result of travelling on different routes, using different modes of travel for each trip and possible differences in traffic congestion levels at the different times of day when these trips were undertaken. The analysis shows that both cities have high accessibility and travellers are able to reach their destinations within the city in an hour.

4.5.4 Accessibility by mode of travel

Modes of transportation used to travel between home, school and work in Bloemfontein are shown in Figure 4.31, while Figure 4.32 shows modes of travel in Gaborone.



	Walking	Taxi	Bus	Private vehicle	Cab	Bicycle
Home to Stop	99,3	0,7				
Bus stop to school/ work	12,3	66,9	14,2	4,6	1,9	
School/ work - Home	22,3	55,8	11,0	8,5	2,4	
Home to school/ work	22,4	55,8	10,3	8,8	2,4	0,3

Mode

Figure 4.31: Percentage of participants using modes of travel between home, school and work in Bloemfontein

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Figure 4.31 shows the modes of travel used by the participants in Bloemfontein for trips from home to the bus stop, bus stop to school or work, from school or work going home and from home to school or work. A total of 99.3% of the participants walked from their homes to the bus stop, while 0.7% indicated that they took taxis to the bus stop. Most of the participants travelled by taxi from the bus stop to their place of work or school, while 14.2% travelled by bus. A further 12.3% walked to school or work, and 1.9% travelled by cab. None of the participants travelled to school or work by bicycle.

Taxis were used by 55.8% of the participants to go from home to school or work and from school or work to home, respectively, while 22.3% and 22.4% walked from school or work going home and from home going to work or school. Furthermore, 11% and 10.3% of the participants travelled by bus from school or work going home and from home to school or work, respectively. In addition, 8.5% and 8.8% of the participants used private vehicles going home from school or work and from home going to school or work, respectively, while 2.4% used cabs for both trips.

Taxis and walking were the modes of travel used most often for home and work or school trips. Most walking trips were made to the bus stops. People residing closer to their places of work or educational institutions also might have walked to work.

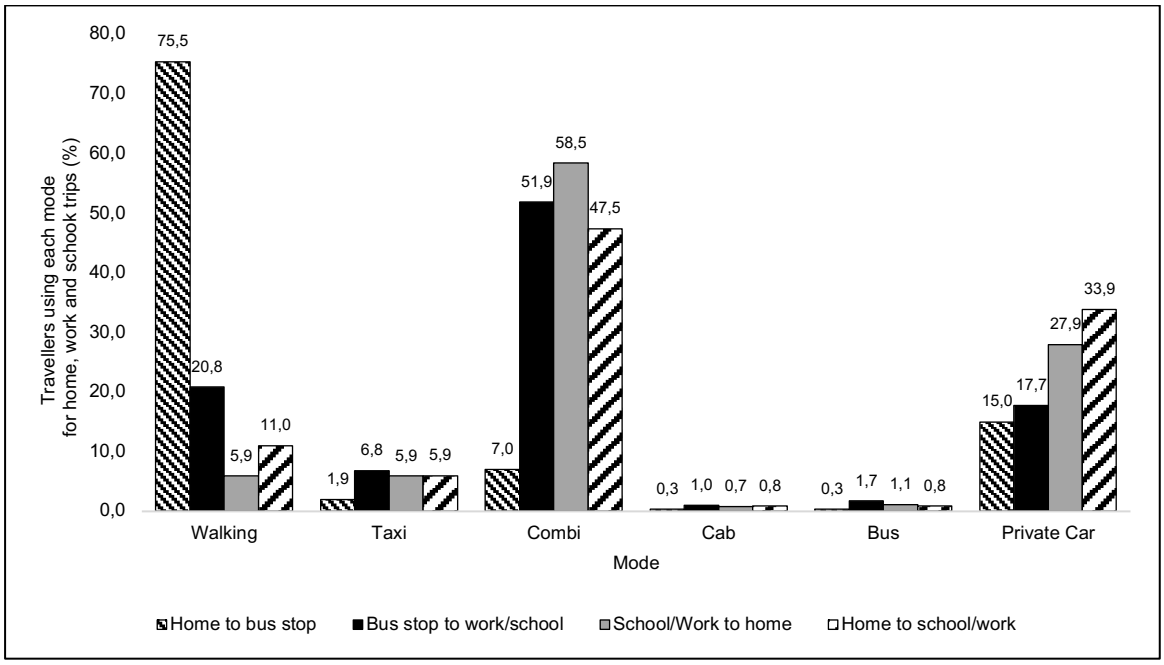

Figure 4.32: Percentage of participants using modes of travel between home, school and work and Gaborone

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Figure 4.32 shows the modes used by the participants in Gaborone to travel from home to the bus stop, to and from home to school or work, and from the bus stop to school or work. A total of 75.5% of trips from home to the bus stop were made by walking, while 1.9% of the trips from home to the bus stop were made by taxi and 7% were made by combi. A further 15% of the participants used private vehicles from home to the bus stop. In addition, 0.3% indicated that they used cabs and buses, respectively. The high number of participants who used private vehicles from home to the bus stop could have been because a non-driving member of the household travelled with a driver from home to the bus stop and waited for public transportation.

Combi trips were made by 51.9% of the participants to travel from the bus stop to work or school, while 20.8% walked and 17.7% used private cars. Furthermore, 6.8% and 1.7% of the trips from the bus stop to school or work were made by taxi and bus, respectively, while only 1% of the trips from the bus stop to school or work were made by cab.

For trips from home to school or work, and from school or work going home, 58.8% of the participants travelled by combi from school or work going home, compared with 47.5% who used combis on the trip from home going to school or work. Furthermore, 27.9% used private vehicles going home from school or work, but 33.9% used the same mode going from home to school or work. A further 5.9% of the participants walked from school or work going home, while 11% walked from home going to school or work. In addition, 5.9% of participants travelled by taxi for the trip from home to school or work and from school or work to home, respectively. Only 0.7% and 0.8% of participants used cabs from school or work going home and from home to school or work, respectively. Also, 1.1% of participants used buses to travel from school or work going home, compared with 0.8% who used the bus from home going to school or work.

These results indicated that combis were the most used method of transportation for trips between home and school or work, followed by the use of private vehicles and walking. Buses did not operate within the city as a local mode of public transportation, but operated between Gaborone and the villages or towns near the city. People using

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buses might have been those living along the routes used by buses between Gaborone and villages such as Ramotswa, Thamaga and Gabane, among others.

4.5.5 Summary of accessibility by distance and time

In summary, the distance travelled, and the time spent travelling have a direct influence on participants' perceived level of accessibility. The results indicated that there was a positive person-based accessibility based on the amount of time and distance covering the transportation network to access locations in the cities. The shorter the distance travelled and the less the time spent travelling made an area or public transportation more accessible. Walking distances to the bus stop, the distance travelled between home and school or work, as well as the duration of the trip between these places were evaluated in the study. The first trip from home to the bus stop was made by walking a distance of a kilometre or less. Accessible public transportation systems meant access to infrastructure and vehicles within short distances and short periods of time. Most areas within both cities were described as being accessible within a period of an hour and distances of 25 km. However, the mode of travel plays an important role in ascertaining accessibility based on time. Public transportation journeys involving multiple trips take more time than single public transportation tip journeys and journeys by private vehicles. Other factors, such as congestion, time of day in which the trips are undertaken also influence accessibility. It is therefore important to note that proximity of a place does not automatically translate into accessibility, as various factors contribute to the ease of reach.

4.6 Perceptions of Congestion Based on Time of Travel

In this section, the times of day at which the participants undertook their trips on a typical day were explored. Participants were asked to select the times at which they travelled, the duration of time they spent travelling, and their perceptions of the levels of congestion they experienced during these trip times. To measure the reliability of the scale towards measuring the general congestion, Cronbach's Alpha was used. A Cronbach's Alpha of 0,349 was obtained for congestion in Bloemfontein, which is unreliable. A Cronbach's Alpha of 0.611 was obtained for Gaborone, which is acceptable when N = 3, as it is greater than 0.5.

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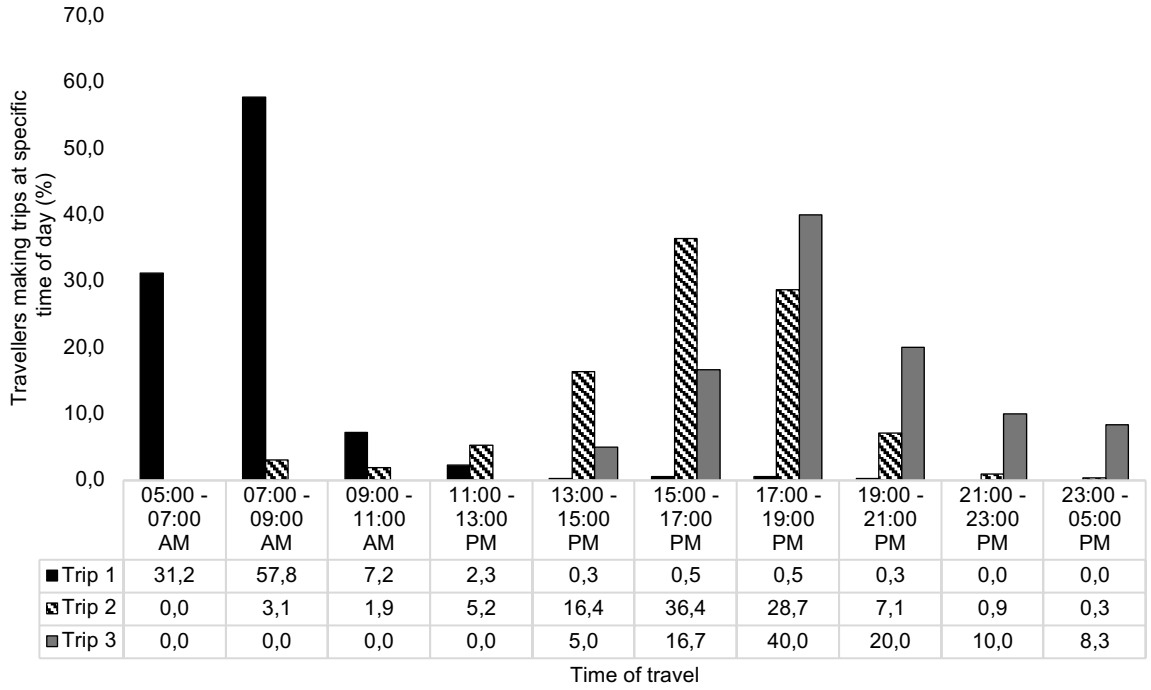
4.6.1 Trip times

The times at which the participants made the first three trips of the day are shown in Figures 4.33 and 4.34.



	05:00 - 07:00 AM	07:00 - 09:00 AM	09:00 - 11:00 AM	11:00 - 13:00 PM	13:00 - 15:00 PM	15:00 - 17:00 PM	17:00 - 19:00 PM	19:00 - 21:00 PM	21:00 - 23:00 PM	23:00 - 05:00 PM
Trip 1	31,2	57,8	7,2	2,3	0,3	0,5	0,5	0,3	0,0	0,0
Trip 2	0,0	3,1	1,9	5,2	16,4	36,4	28,7	7,1	0,9	0,3
Trip 3	0,0	0,0	0,0	0,0	5,0	16,7	40,0	20,0	10,0	8,3

Figure 4.33: Percentage of participants making trips at given times in Bloemfontein

Figure 4.33 shows the times at which the participants in Bloemfontein undertook their regular trips. Participants were asked to select three times at which they travelled in a day. For the first trip of the day, 31.2% of the participants travelled between 05:00 and 07:00, while 57.8% travelled between 07:00 and 09:00. A further 7.2% of the participants made their first trips of the day between 09:00 and 11:00, while 2.3% travelled between 11:00 and 13:00. On the other hand, 0.3% of participants made their first trips of the day between 13:00 and 15:00, and 19:00 and 21:00, respectively. Also, 0.5% of participants made their first trips between 15:00 and 17:00, and 17:00 and 19:00, respectively.

The second trips of the day were reported to start after 07:00, with 3.1% of participants travelling between 07:00 and 09:00, followed by 1.9% between 09:00 and 11:00, and 5.2% between 11:00 and 13:00. The number of people taking their second trips

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increased significantly between 13:00 and 19:00. Furthermore, 16.4% of the participants took their second trips between 13:00 and 15:00, 36.4% between 15:00 and 17:00, and 28.7% between 17:00 and 19:00. Thereafter, the number of people making their second trips dropped significantly, with 7.1% of the participants travelling between 19:00 and 21:00, 0.9% between 21:00 and 23:00, and 0.3% between 23:00 and 05:00.

None of the participants took their third trips of the day between 05:00 and 13:00. However, 5% of the participants who made three trips on a typical day, travelled between 13:00 and 15:00, followed by 16.7% between 15:00 and 17:00, and noteworthy more (40%) between 17:00 and 19:00. A further 20% of the participants made their third trips between 19:00 and 21:00, 10% between 21:00 and 23:00, and 8.3% of the participants made their third trip between 23:00 and 05:00.

Morning peak times in Bloemfontein were reported to be between 05:00 and 09:00. The first peak occurred between 05:00 and 07:00. The highest peak travel time for the day was between 07:00 and 09:00. Morning peak times were the times when the participants started their travels for work or school. For the remainder of the day, peak times occurred between 15:00 and 17:00, and 17:00 and 19:00. The afternoon and evening peak times were when the participants travelled back home from their day-time activities. Peak times are the times characterised by large numbers of people travelling, which signifies more vehicles on the road and increased chances of congestion.

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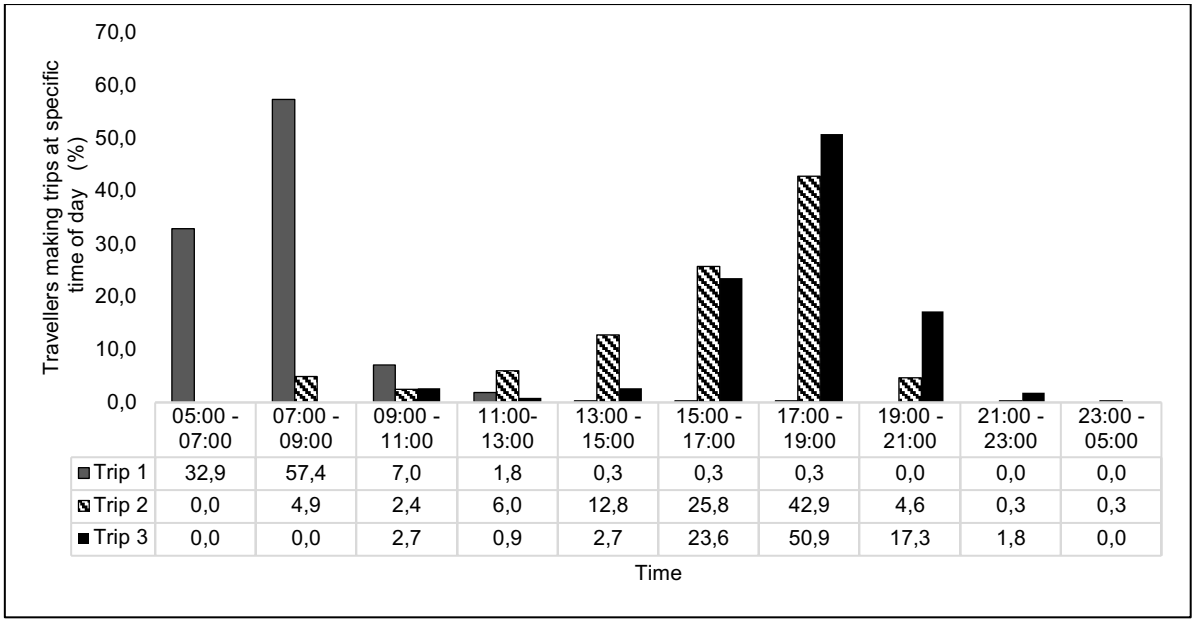

	05:00 - 07:00	07:00 - 09:00	09:00 - 11:00	11:00- 13:00	13:00 - 15:00	15:00 - 17:00	17:00 - 19:00	19:00 - 21:00	21:00 - 23:00	23:00 - 05:00
Trip 1	32,9	57,4	7,0	1,8	0,3	0,3	0,3	0,0	0,0	0,0
Trip 2	0,0	4,9	2,4	6,0	12,8	25,8	42,9	4,6	0,3	0,3
Trip 3	0,0	0,0	2,7	0,9	2,7	23,6	50,9	17,3	1,8	0,0

Figure 4.34: Percentage of participants making trips at given times in Gaborone

Figure 4.34 shows the times at which the participants in Gaborone made their trips on a typical day. Specifically, 32.9% of the first trips of the day were made between 05:00 and 07:00, and a majority of 57.4% at times between 07:00 and 09:00. Furthermore, 7.0% of the participants travelled at times between 09:00 and 11:00 and 1.8% between 11:00 and 13:00. Only 0.3% of participants made their first trips of the day between 13:00 and 15:00, 15:00 and 17:00, and 17:00 and 19:00, respectively. None of the participants took their first trips between 19:00 and 05:00.

The second trip of the day started after 07:00, showing 4.9% of the participants travelling between 07:00 and 09:00, 2.4% between 09:00 and 11:00, and 6% between 11:00 and 13:00. An increase in the number of participants travelling for the second time started between 13:00 and 15:00 with 12.8% of participants, followed by 25.8% travelling between 15:00 and 17:00, and a majority of 42.9% between 17:00 and 19:00. The frequency of trips then decreased to 4.6% between 19:00 and 21:00, and 0.3% between 21:00 and 23:00, and 23:00 and 05:00, respectively.

The third trips of the day started after 09:00 as none of the participants indicated that they travelled between 05:00 and 09:00. However, 2.7% of the participants took their third trip of the day between 09:00 and 11:00, and 0.9% between 11:00 and 13:00. A further 2.7% of the participants made their third trips between 13:00 and 15:00. The

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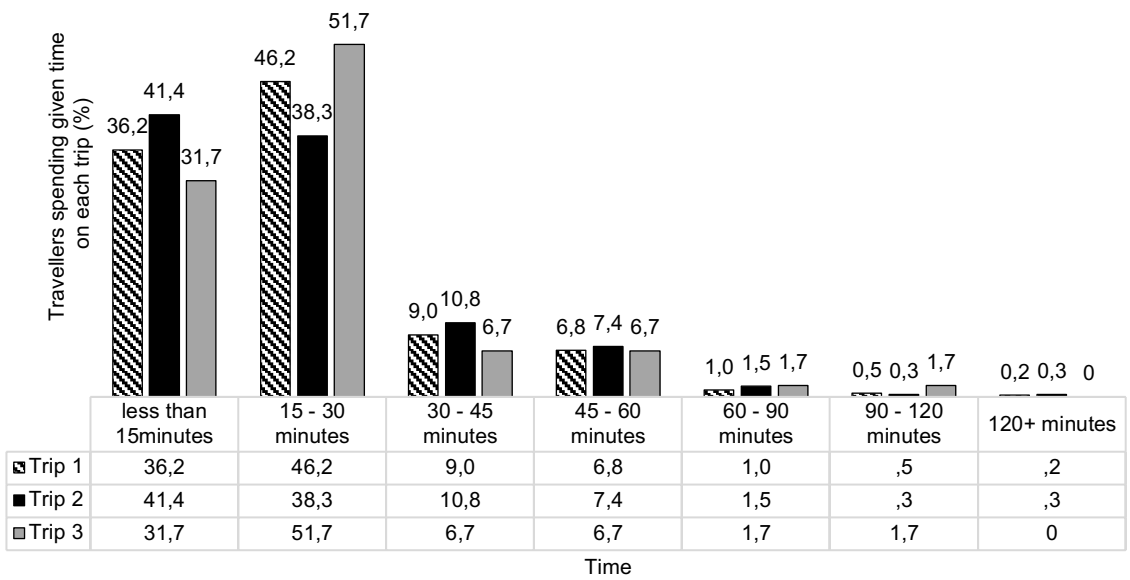
frequency of trips increased between 15:00 and 21:00, with 23.6% of trips occurring between 15:00 and 17:00, increasing to 50.9% between 17:00 and 19:00, and decreasing to 17.3% between 19:00 and 21:00. The frequency of trips then decreased to 1.8% between 21:00 and 23:00. None of the participants travelled between 23:00 and 05:00.

The morning peak travel times in Gaborone occurred first between 05:00 and 07:00 thereafter, between 07:00 and 09:00. The second and third peaks occurred between 17:00 and 19:00. There were similarities in morning travel times in both cities, with their peaks occurring between 05:00 and 09:00. However, evening peaks had fewer similarities; for example, Bloemfontein recorded afternoon peaks between 15:00 and 17:00, whereas in Gaborone, peak hours occurred between 17:00 and 19:00.

Further responses were recorded to understand the travel experiences and state of the road during the times that the participants spent travelling on their respective trips.

4.6.2 Trip duration

The durations of the first three trips of the day are shown in Figure 4.35 and Figure 4.36.



	less than 15minutes	15 - 30 minutes	30 - 45 minutes	45 - 60 minutes	60 - 90 minutes	90 - 120 minutes	120+ minutes
Trip 1	36,2	46,2	9,0	6,8	1,0	,5	,2
Trip 2	41,4	38,3	10,8	7,4	1,5	,3	,3
Trip 3	31,7	51,7	6,7	6,7	1,7	1,7	0

Figure 4.35: Percentage of durations of trips made by participants in Bloemfontein

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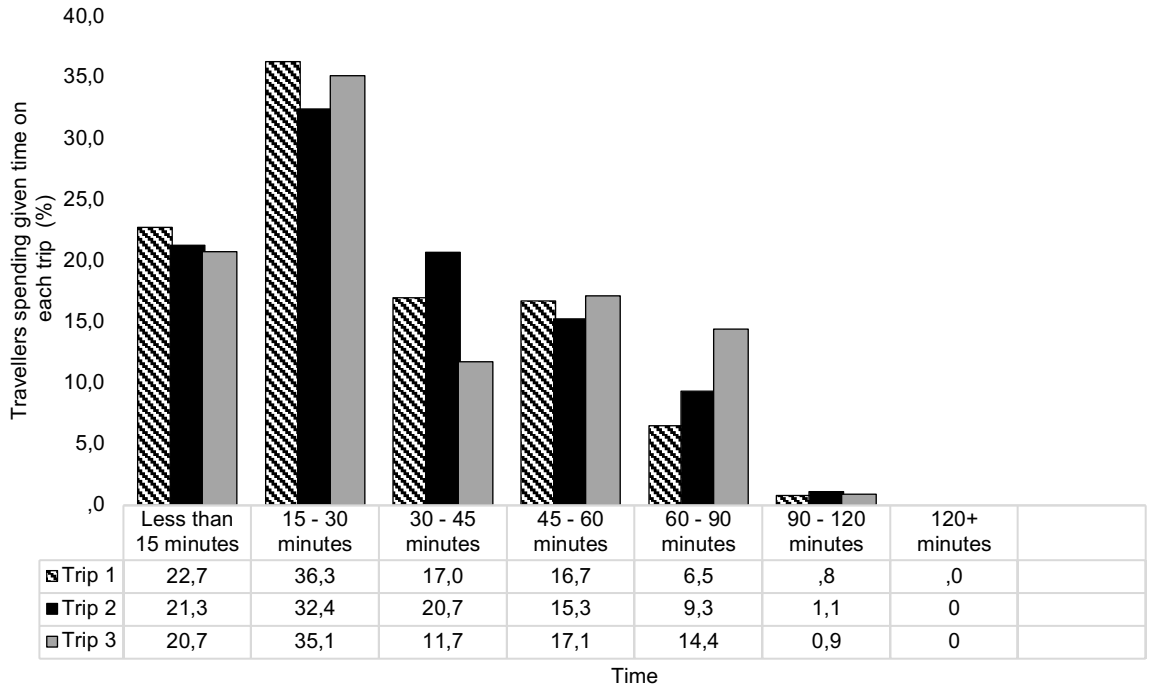
Figure 4.35 shows the times spent travelling on the first, second and third trips of a regular day by participants in Bloemfontein. Most of the participants (46.2%) spent 15 to 30 minutes on their first trips, followed by 36.2% who spent less than 15 minutes, and 9% who spent 30 to 45 minutes on the trip. Only 1% spent 60 to 90 minutes, 0.5% spent 90 to 120 minutes and 0.2% spent more than 120 minutes on their first trips of the day.

Most of the participants (41.4%) making their second trips of the day spent less than 15 minutes on the trip, followed by 38.3% who spent 15 to 30 minutes on the trip. A further 10.8% of the trips took 30 to 45 minutes and 7.4% took 45 to 60 minutes. In addition, 1.5% of the participants took between 60 and 90 minutes, and 0.3% of trips took 90 to 120 minutes and more than 120 minutes, respectively.

On the third trip, 51.7% of the participants took 15 to 30 minutes, followed by 31.7% who took less than 15 minutes. A further 6.7% of the participants took 30 to 45 minutes and 45 to 60 minutes, respectively, and 1.7% of the trips took 60 to 90 minutes and 90 to 120 minutes, respectively.



	Less than 15 minutes	15 - 30 minutes	30 - 45 minutes	45 - 60 minutes	60 - 90 minutes	90 - 120 minutes	120+ minutes
Trip 1	22,7	36,3	17,0	16,7	6,5	,8	,0
Trip 2	21,3	32,4	20,7	15,3	9,3	1,1	0
Trip 3	20,7	35,1	11,7	17,1	14,4	0,9	0

Figure 4.36: Percentage of durations of trips made by participants in Gaborone

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Figure 4.36 shows the travelling times for the first three trips of a regular day in Gaborone. A total of 36.3% of the first trips made by participants took 15 to 30 minutes, followed by 22.7% whose first trips took less than 15 minutes. A further 17% of the first trips took 30 to 45 minutes, and 16.7% took 45 to 60 minutes, while 6.5% of the trips made by participants took 60 to 90 minutes and, 0.8% of trips took between 90 and 120 minutes.

Most of the second trips of the day (32.4%) took 15 to 30 minutes, followed by 21.3% that took less than 15 minutes and 20.7% that took 30 to 45 minutes. Furthermore, 15.3% of the trips made by the participants took 45 to 60 minutes, while 9.3% took 60 to 90 minutes. Also, 1.1% of the second trips made by the participants took between 90 and 120 minutes.

On the third trip of the day, 35.1% of the participants took 15 to 30 minutes, 20.7% took less than 15 minutes, and 17.1% took 45 to 60 minutes. A further 14.4% of the trips took 60 to 90 minutes, and 11.7% took 30 to 45 minutes. Also, 0.9% of the third trips took 90 to 120 minutes. None of the participants spent more than 120 minutes travelling for all three trips.

The participants in Gaborone spent more time travelling compared with the participants in Bloemfontein. Various factors could explain these results, for instance, the road infrastructure, and the fact that the traffic management systems in Bloemfontein are more functional in accommodating vehicular traffic than in Gaborone. Bloemfontein also has a larger road network compared with Gaborone.

4.6.3 Perceptions of traffic congestion

The perceptions of the participants of the level of congestion during their times of travel were assessed and the results are presented in Figure 4.37 and Figure 4.38.

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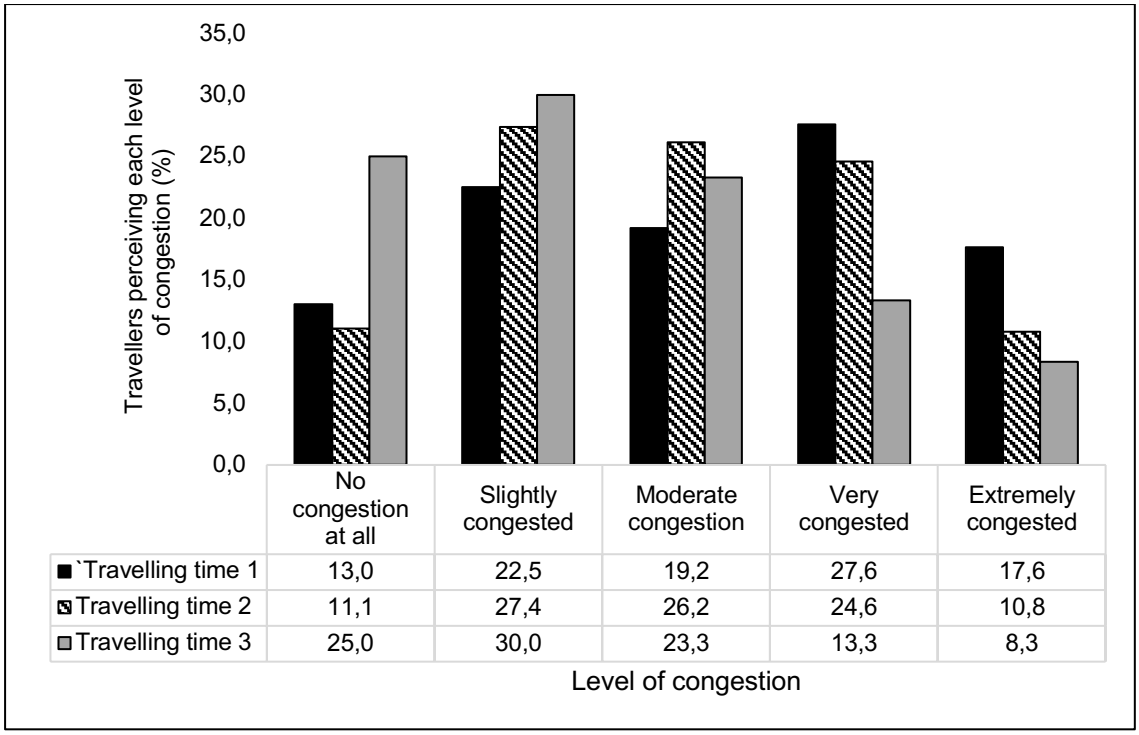

Figure 4.37: Percentage of perceptions of levels of congestion by participants in Bloemfontein

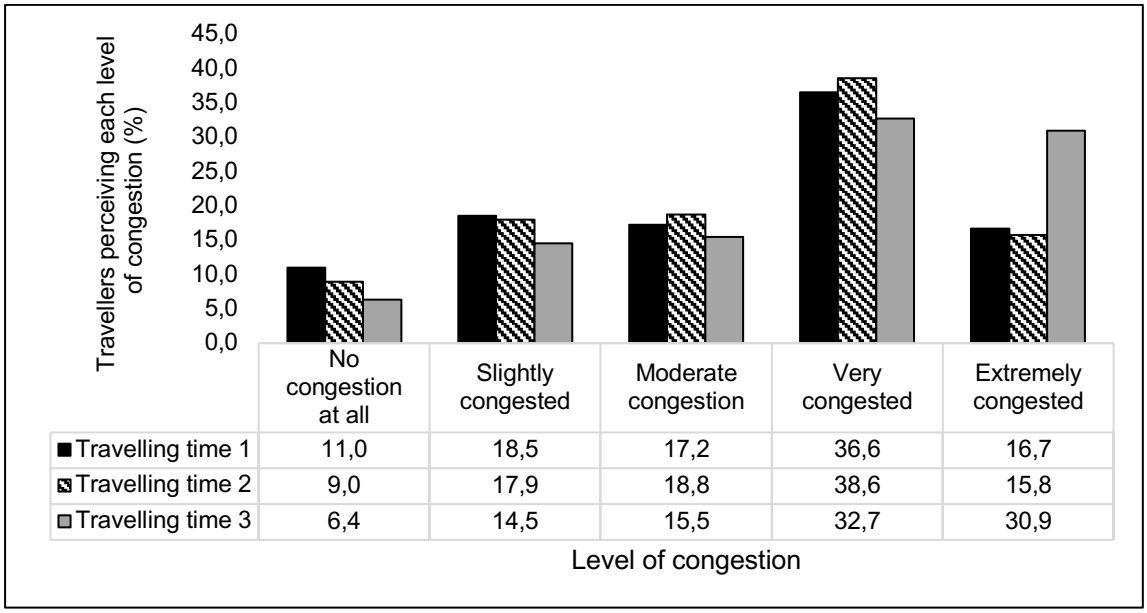

Figure 4.38: Percentage of perceptions of levels of congestion by participants in Gaborone

The participants' perceptions of the levels of congestion are shown in Figure 4.37 (Bloemfontein) and Figure 4.38 (Gaborone). In Bloemfontein, 13% of the participants perceived that there was no congestion at all during their first trip, 22.5% perceived the roads to be slightly congested, while 19.2% indicated the level as being moderately

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congested. However, a noteworthy level of the participants (27.6%) perceived the roads to be very congested and, 17.6% perceived the levels of congestion to be extreme. The results obtained in Gaborone indicated that 11% of the participants did not experience congestion on the first trip, 18.5% experienced slight congestion, and 17.2% experienced moderate congestion. However, far more participants (36.6%) experienced very congested roads, while 16.7% experienced extremely congested roads.

For the second trips of the day, 11.1% of the participants in Bloemfontein indicated that they did not experience any congestion, while 27.4% experienced slight congestion, and 26.2% and 24.6% experienced moderate to very congested levels, respectively. Also, 10.8% experienced extreme congestion levels. In Gaborone, 9% experienced slight congestion during their second trips, while 17.9% and 18.8% experienced slight and moderate congestion, respectively. Far more participants (38.6%) experienced very congested roads and, 15.8% experienced extreme congestion levels.

In Bloemfontein, 25% of the participants did not experience any congestion during their second trips, while 30% experienced slight congestion; 23.3% and 13.3% experienced moderate to very congested roads, respectively, and 8.3% experienced extreme congestion. In Gaborone, 6.4% experienced no congestion during their second trips; 14.5% and 15.5% experienced slight and moderate congestion, respectively, while 32.7% experienced very congested roads and 30.9% experienced extreme congestion levels.

According to the participants, congestion levels in Gaborone were very high to extremely high. High congestion levels in Gaborone could be the result of the high use of private vehicles and the small road network, in which traffic management systems are seldom functional. Traffic accumulates significantly at traffic circles, which are highly evident in the City of Gaborone and cause build-ups of vehicles.

4.6.4 Relationship between perceived congestion and trip duration

The correlation between trip duration and perceived congestion was investigated further. Tables 4.8 and 4.9 show the correlation coefficients between perceived

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congestion level and the duration of each trip. Correlation graphs were prepared and have been presented in Appendix Section 6.

The null hypothesis in both instances was that a perfect linear relationship existed between perceived congestion level and trip duration, which implied that an increase in the perceived level of congestion would lead directly to an increase in the time taken to complete a trip. The alternative hypothesis was that trip duration did not have a perfect linear relationship with the perceived congestion level.

$$H_0: \text{Level of perceived congestion has a perfect linear relationship with trip duration.}$$

$$H_1: \text{The relationship between level of perceived congestion and trip duration is not perfectly linear.}$$

The results of a Pearson's correlation analysis are shown below.

Table 4.8: Correlation between perceived congestion and trip duration in Bloemfontein

Correlation parameters	Trip of day		
	Trip 1	**Trip 2**	**Trip 3**
Pearson's correlation (r)	-0.145	0.201	0.350
Sig (2-tailed) (p)	0.009	0.000	0.006
N	324	324	60
R2	6.059E-4	0.040	0.122
Equation	$y = 3.1 + 1.81E - 3x$	y = 2.66 + 0.01x	Y = 1.93 + 0.02x

Table 4.8 shows that both negative and positive correlations were found in the analysis of the relationship between perceived congestion and the duration of trips in Bloemfontein. The low, negative correlation coefficient of -0.145 for Trip 1 indicated a weak negative relationship between trip duration and perceived congestion levels for the first trip of the day. The negative correlation might have been influenced by factors such as short travel distances where congestion was still encountered, but the time of delay did not increase the total trip duration significantly. The relationship between the variables indicated that perceived congestion did not increase with an increase in trip duration. Even though the participants might have experienced congestion, trip duration was instead influenced by distance. Even though the participants might have

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experienced congestion, the trips might have taken less time to complete, depending on how far they had to travel. The coefficient of 0.201 for Trip 2 indicated a positive low degree of correlation, while the coefficient of 0.350 for Trip 3 indicated a moderately strong correlation. All correlations indicated non-perfect relationships between perceived congestion and trip duration, which, together with the low significance levels of 0.009, 0.000 and 0.006, justified the rejection of the null hypothesis.

Table 4.9: Correlation of perceived congestion and trip duration in Gaborone

Correlation parameters	Trip of day		
	Trip 1	**Trip 2**	**Trip 3**
Pearson's correlation	0.372	0.442	0.453
Sig (2-tailed)(p)	0.000	0.000	0.000
N	383	367	111
R2	0.138	0.195	0.205
Equation	y = 2.54+0.02x	y = 2.49+0.02x	Y = 2.81+0.02x

Table 4.9 shows moderately strong and significant relationships between trip duration and perceived congestion on all trips in Gaborone. The degrees of correlation (r) for Trips 1, 2 and 3 were 0.372, 0.442 and 0.453, respectively. Furthermore, the Pearson's correlation test showed significance values (p) of 0.000 for each trip. The positive correlations indicated a moderately positive relationship between trip duration and perceived congestion. Although moderate, the participants who perceived higher levels of congestion were likely to have spent more time on their trips, while those who perceived low levels of congestion were likely to have taken shorter times to complete their trips. However, the significance values for all correlations were 0.000; thus, the moderately positive relationships established were not perfectly linear. Therefore, the null hypothesis was rejected.

4.6.5 Frequency of trip delays

Participants were asked further to indicate the frequency of delays they experienced because of traffic congestion. The results obtained in both cities are shown in Figure 4.39 below, and further, Figure 4.40 presents the time spent or lost on delays experienced by the participants.

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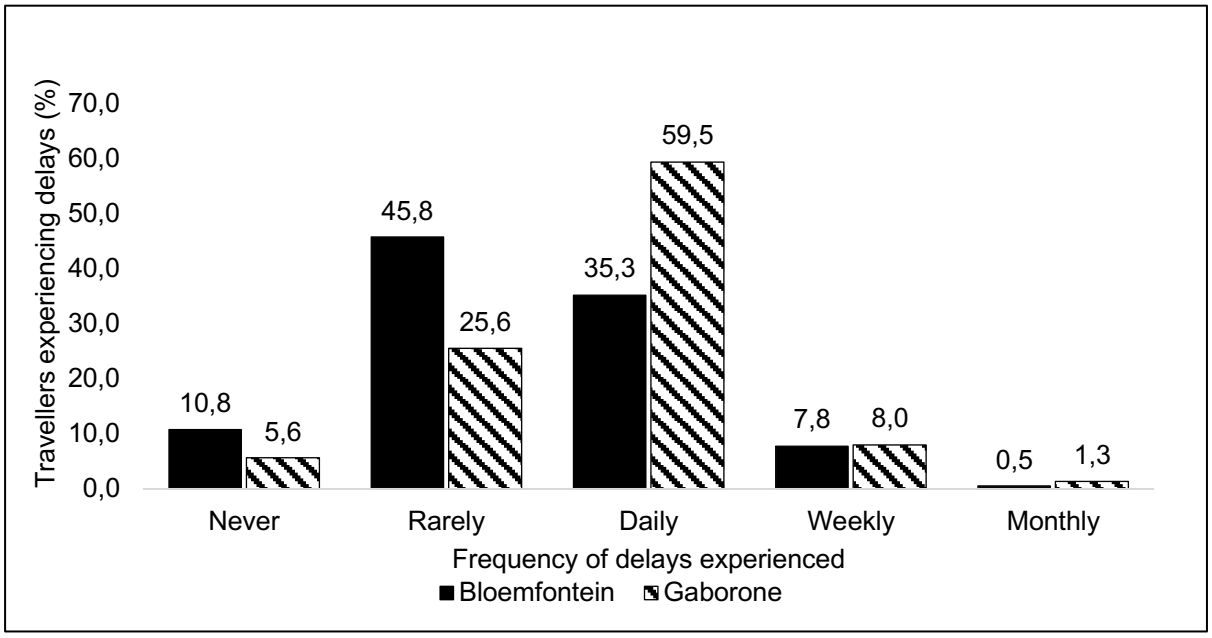
Figure 4.39: Percentage frequency of trip delays experienced by participants

Figure 4.39 shows that in Bloemfontein, 45.8% of the participants rarely experienced trip delays, 35.3% experienced trip delays daily, 10.8% never experienced delays and 7.8% experienced delays only once a week. Also, 0.5% experienced delays only once a month. In Gaborone, 59.5% of the participants experienced trip delays daily and 25.6% rarely experienced delays. A further 8% experienced delays once a week, while 5.6% never experienced delays. Also, 1.3% of participants only experienced trip delays on a monthly basis.

Experiencing delays was common in both areas, but in Gaborone, the participants experienced more delays on a daily basis compared with Bloemfontein. These results showed that traffic congestion and delays were less common in Bloemfontein compared with Gaborone. The broader road network in Bloemfontein and less private vehicle ownership resulted in fewer delays and lower traffic congestion. Significant percentages of participants in both cities indicated that they had never experienced



trip delays, which could have been a result of shorter travelling distances, shorter trip durations and travelling at off-peak hours when there was less traffic on the roads. This could also be related to the participants' perceptions that there was no congestion at all during some of the trips.

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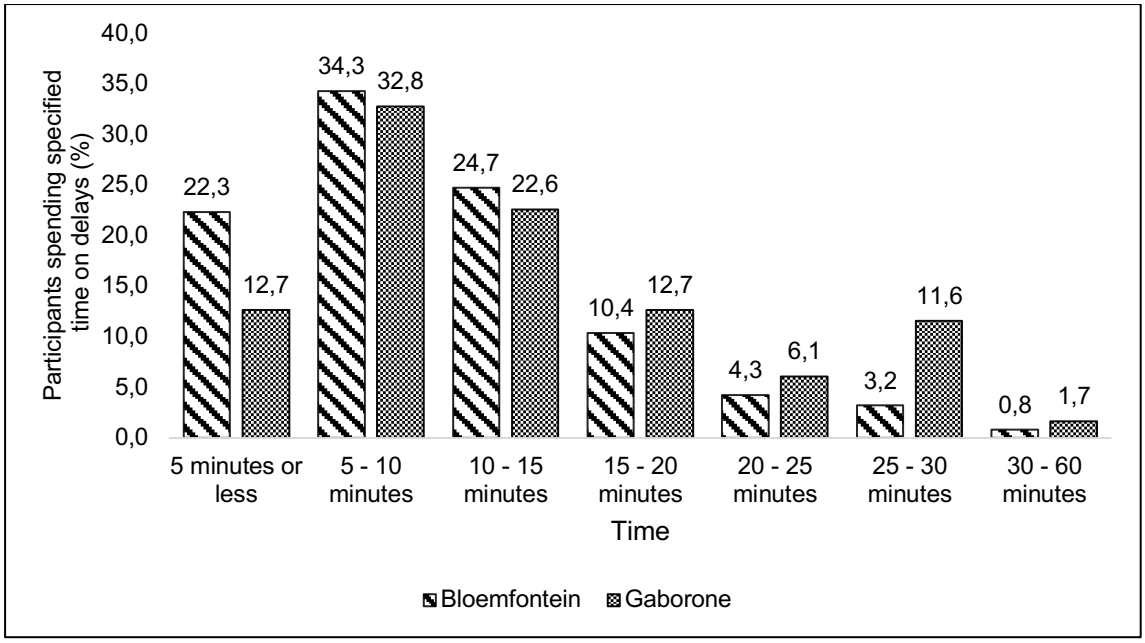

Figure 4.40: Percentage of travel time spent on delays by participants

Figure 4.40 shows parts of the trip times that were spent on delays. A total of 22.3% of the participants in Bloemfontein spent less than 5 minutes on delays, while a majority of 34.3% reported spending 5 to 10 minutes on delays. A further 24.7% said that their delays lasted 10 to 15 minutes, 10.4% lasted 15 to 20 minutes, 4.3% were delayed for 20 to 25 minutes, and 3.2% reported spending 25 to 30 minutes on delays. Also, 0.8% spent 30 to 60 minutes on delays.

In Gaborone, 12.7% of the participants experienced delays of 5 minutes or less, while 32.8% of the delays lasted 5 to 10 minutes, 22.6% were delayed by 10 to 15 minutes, while 12.7% of the delays lasted 15 to 20 minutes. Furthermore, 6.1% of the participants spent 20 to 25 minutes on delays, 11.6% spent 25 to 30 minutes, and 1.7% spent 30 to 60 minutes. Therefore, less time was spent on delays in Bloemfontein than in Gaborone. More time spent on delays meant an increased travel time, while less time spent on delays meant a shorter travel time. These results showed that there were more delays for longer periods in Gaborone, which meant that the participants in Gaborone experienced higher levels of congestion.

Factors affecting trips that are associated with time, such as delays, waiting time and congestion, are some of the main contributors towards negative perceptions of

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passenger transportation systems. They also contribute to the decision-making process towards these participants' choice of travel mode. Further influences towards mode choice are explored in the following section.

4.7 Choice of Travel Mode Influencers

In this section, factors that influenced individuals' choice of travel mode are explored. The participants were asked to indicate, from a set of given options, the factors that were likely to influence their chosen mode of travel, using a specific mode.

The most common methods of public transportation in both cities differed in terms of operational aspects and mode. In Bloemfontein, there are buses and taxis, while in Gaborone, there are combis and taxis. There are no bus services operating in the City of Gaborone, only in nearby villages and towns, which can be used by people staying in Gaborone if they use stops along these bus routes. In Bloemfontein, buses are the second most common mode of public transportation, operating in most of the city's suburbs.

Cronbach's Alpha was used to test for reliability of the variables.

Cronbach's Alpha: α

$$\alpha = N.\,vv{+}N - 1.c$$

Where:

$$N = Number\ of\ items$$
$$\underline{v} = average\ variance$$
$$\underline{c} = Average\ inter - item\ covariance$$

The test was employed to test the reliability of mode choice factors towards determining, which particular mode of travel to use. In all cases, N = 13 and the results indicated varying levels of reliability. The data obtained in Bloemfontein produced Cronbach's Alpha values of 0.640 reliability of factors towards the decision to travel by bus, 0.754 towards the decision to travel by taxi, 0.310 towards the decision to use private vehicles, and 0,627 towards the decision to walk. In Gaborone, Cronbach's Alpha values of 0.832 for determining the decision to use a combi, 0.825 for the decision to use a taxi, 0.459 for use of a private vehicle and 0.635 contribution towards

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the decision to walk were obtained. Reliability factors for private vehicle use in both areas are low, an undesirable 0.310 in Bloemfontein and a moderate 0.459 in Gaborone.

Taxis in Bloemfontein, as in the rest of South Africa, are minibuses, often 16 to 24 seaters. These same vehicles are referred to as combis in Gaborone. A taxi in Gaborone refers to a 5-seater sedan car, registered to offer public transportation services.

For these reasons, the influencing factors were analysed separately and the first section was focused on public transportation in Bloemfontein.

4.7.1 Factors influencing choices of public transportation mode in Bloemfontein

The decision to choose either a bus or taxi (minibus) as a mode of travel in Bloemfontein was influenced by various factors. The participants were asked to indicate the level of importance of factors that influenced their choice of travel mode. These results are presented in Table 4.10.

Factors influencing choice to travel by bus

Affordability, convenience, safety, flexibility, accessibility, travelling time and comfort were essential to the participants' choice to travel by bus. The participants would travel by bus because of affordable fares. Convenience and flexibility were influenced by travel time and reliability, so that participants would arrive at their destinations on time. Flexibility enables participants to select their own bus routes and travel at times suitable for them, instead of being constrained by bus schedules.

Safe bus services would include security in buses and at bus stations and stops. The participants were more likely to travel by bus if they felt safe and secure.

Traveller Information Services, as well as a provision of internet access were very important and absolutely essential for many participants to make the decision to use the bus services. These ICT-related factors have the potential to attract passengers to use the bus system.

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Infrastructure, including facilities such as roads, bus stops and waiting areas are absolutely essential when deciding to use bus services. The significance of the relevant infrastructure can also influence the resulting perception of security, comfort and ease of use. Lack of security at bus ranks and bus stops will negatively affect whether people choose to travel by bus or not.

Fuel efficiency and freedom of choosing personal entertainment during trips were the least important factors to the participants when using the bus. Commuters did not seem to be interested in the fuel efficiency of buses, as their only focus is arriving safely at their destinations. The responsibility of fuel efficient vehicles lies with the bus operators and does not affect the travellers' choice.

Factors influencing choice to travel by taxi

Attributes that appealed to the participants in choosing to travel by taxi were similar to those influencing the likelihood of their choosing buses. Affordability, convenience, safety, flexibility, accessibility, travelling time, as well as comfort were all essential factors influencing their choice to travel by taxi. Infrastructure used by the taxi system was also important.

Traveller Information Services and the provision of internet and Wi-Fi were also very important factors in influencing the participants' choice to travel by taxi.
Fuel efficiency, privacy and freedom to choose own entertainment were the least important attributes.

The importance of the highlighted attributes indicated why travellers were likely to use a mode of transportation if the most important factors were offered. That is, if taxi services were to provide cheap, demand-responsive services with state-of-the-art TIS and operated on time, even more people would be likely to use their services. Travellers were not concerned about the amount of fuel used by taxis, the (lacking) privacy in taxis, or their freedom to choose any form of entertainment in taxis.

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Table 4.10: Factors influencing decision to travel b fontein

Level of Importance	Factors Influencing decisions to travel by bus												
	Affordability	Convenience	Safety	Flexibility	Accessibility	Travelling Time	Traveller Information Services	Comfort	Internet/ Wi-Fi	Fuel Efficiency	Privacy	Infrastructure	Freedom of personal entertainment choice
Not Important	1,9	2,5	0,5	2,4	2,4	1,9	4,1	4,1	7,7	39,3	13,6	1,9	23,6
Slightly important	1,9	4,6	3,3	7,1	4,3	6,2	7,9	6,0	11,0	30,3	30,4	5,9	24,2
Of average importance	7,3	9,8	10,1	16,8	8,4	16,2	15,8	12,8	11,8	12,6	22,0	9,5	13,3
Very Important	33,3	36,5	37,2	37,5	34,4	33,7	36,1	34,9	27,4	10,7	20,4	31,6	21,2
Absolutely essential	55,6	46,6	48,9	36,1	50,4	42,0	36,1	42,2	42,2	7,1	13,6	51,1	17,7
	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

Level of Importance	Factors influencing decisions to travel by taxis												
	Affordability	Convenience	Safety	Flexibility	Accessibility	Travelling Time	Traveller Information Services	Comfort	Internet/ Wi-Fi	Fuel Efficiency	Privacy	Infrastructure	Freedom of personal entertainment choice
Not Important	1,0	1,0	2,8	2,9	4,7	5,7	15,4	8,1	16,3	28,4	16,8	6,5	17,2
Slightly important	5,4	8,8	5,5	10,7	8,3	11,3	12,5	21,6	13,5	35,7	23,9	16,5	27,2
Of average importance	6,2	14,8	12,7	12,3	9,9	13,1	14,9	14,3	10,4	10,2	17,6	12,0	17,4
Very Important	40,1	39,1	44,0	42,4	41,1	35,8	27,9	30,7	23,3	13,5	19,7	24,9	21,1
Absolutely essential	47,3	36,3	35,0	31,7	35,9	34,0	29,2	25,3	36,5	12,2	21,8	40,1	17,2
	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

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4.7.2 Factors influencing choices of public transportation mode in Gaborone

The factors that influenced the decisions of the participants in Gaborone to use either combis (minibuses) or taxis (5-seaters) are presented in Table 4.11 below.

Factors influencing choice to travel by combi

Affordability, convenience, safety, flexibility, accessibility and travel time were essential attributes in influencing the participants to choose to travel by combi. TIS, on-board internet, fuel efficiency, privacy and freedom to choose personal entertainment while travelling were not important, while infrastructure and comfort were deemed to be very important.

Factors influencing choice to travel by taxis

The most important factors that influenced the participants in Gaborone to choose to travel by taxi were affordability, convenience, safety, flexibility, accessibility, travel time and comfort. Infrastructure was also very important in choosing taxis.

Internet, fuel efficiency and the freedom to choose personal entertainment were the least important attributes. Privacy was of average importance when choosing taxis.

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Table 4.11: Factors influencing decision to travel b orone

Level of Importance	Factors Influencing decision to travel by combi												
	Affordability	Convenience	Safety	Flexibility	Accessibility	Travel time	Traveller Information Services	Comfort	On-board internet	Fuel efficiency	Privacy	Infrastructure	Personal Entertainment choice
Not Important	6,0	7,4	6,2	10,2	5,0	9,7	42,3	12,0	61,1	42,0	34,7	14,2	38,3
Slightly important	4,1	10,9	10,8	15,7	5,0	10,5	13,3	15,4	16,0	10,0	15,1	7,3	15,3
Of average importance	8,2	12,5	13,5	21,6	16,4	17,5	16,9	15,8	8,6	10,8	17,5	21,5	21,7
Very Important	29,9	30,1	22,0	20,4	31,3	28,4	13,7	35,5	8,6	26,0	25,9	34,6	17,4
Absolutely essential	51,9	39,1	47,5	32,2	42,4	33,9	13,7	21,2	5,7	11,2	6,8	22,4	7,2

Level of Importance	Factors Influencing decision to travel by taxi												
	Affordability	Convenience	Safety	Flexibility	Accessibility	Travel time	Traveller Information Services	Comfort	On-board internet	Fuel efficiency	Privacy	Infrastructure	Personal Entertainment choice
Not Important	7,0	4,4	6,3	7,4	5,6	5,6	27,9	8,1	49,5	30,8	24,8	16,0	34,4
Slightly important	7,0	11,5	7,2	9,3	11,2	11,1	17,3	9,0	19,2	10,6	16,5	7,0	12,5
Of average importance	17,4	11,5	18,0	24,1	18,7	16,7	20,2	15,3	9,1	22,1	30,3	19,0	28,1
Very Important	37,4	39,8	32,4	37,0	34,6	38,9	18,3	43,2	11,1	25,0	20,2	30,0	17,7
Absolutely essential	31,3	32,7	36,0	22,2	29,9	27,8	16,3	24,3	11,1	11,5	8,3	28,0	7,3

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Factors influencing choice to use private vehicles

The importance of attributes that influenced decisions of the participants in either of the two cities to travel using private vehicles are presented in Table 4.12. Fuel efficiency was a more important factor than other attributes that influenced the choice of the participants to use private vehicles for travel in Gaborone and Bloemfontein. A large percentage of participants (72.8%) in Bloemfontein indicated that fuel efficiency was absolutely essential for their choice to use private vehicles. Convenience, accessibility, comfort and affordability were indicated also as being essential factors for consideration by 63.4%, 61.8%, 61% and 60.5%, respectively. The results obtained in Gaborone indicated that convenience, safety, flexibility, accessibility and privacy were essential factors for 63.4%, 58.6%, 58.5%, 55% and 54%, respectively. TIS, access to the internet or the infrastructure were the least important factors influencing the use of private vehicles.

Private vehicle users and possible future users of public transportation seemed to be highly influenced by affordability, convenience, safety, flexibility, accessibility, travelling time and comfort. Internet and ICT-related attributes were not consideeered to be important when deciding to use private vehicles.

The results could also mean that people buying private vehicle would be less likely to be influenced by the availability of the internet in a public transport vehicle, and would still buy private cars, even if the infrastructure in the city was not in a good condition to accommodate private vehicles. Participants stated that they were are more likely to use private vehicles for their convenience, safety, accessibility and flexibility. The participants in Bloemfontein would not be attracted by the privacy experienced when driving private vehicles, while those in Gaborone would definitely choose private vehicles because of their privacy.

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Table 4.12: Factors influencing decision to use pri

Level of Importance	Bloemfontein												
	Affordability	Convenience	Safety	Flexibility	Accessibility	Travelling Time	Traveller Information Services	Comfort	Internet/ Wi-Fi	Fuel Efficiency	Privacy	Infrastructure	Freedom of personal entertainment choice
Not Important	2,6	,9	1,4	2,3	,6	2,0	14,7	1,4	19,5	1,1	8,2	2,6	20,0
Slightly important	3,4	1,7	2,6	3,7	4,2	2,9	19,7	4,0	25,3	2,0	17,3	8,0	19,1
Of average importance	3,1	5,4	4,6	7,1	4,2	6,6	18,5	4,0	14,7	2,0	22,4	6,3	13,7
Very Important	30,4	28,7	31,6	30,7	29,2	34,4	26,0	29,6	22,4	22,1	26,7	37,5	21,7
Absolutely essential	60,5	63,4	59,8	56,3	61,8	54,2	21,1	61,0	18,1	72,8	25,3	45,6	25,4
	Gaborone												
Level of Importance	Affordability	Convenience	Safety	Flexibility	Accessibility	Travel time	Traveller Information Services	Comfort	Internet / Wi-Fi	Fuel efficiency	Privacy	Infrastructure	Freedom of personal Entertainment choice
Not Important	8,5	3,3	4,8	4,0	2,2	7,7	25,0	5,9	47,6	9,6	5,3	16,5	8,6
Slightly important	6,8	2,2	3,8	5,1	3,9	4,4	5,1	2,2	18,7	7,3	5,9	4,9	3,4
Of average importance	12,5	4,9	5,9	10,2	8,9	5,5	17,6	6,5	10,2	8,5	3,7	18,9	14,9
Very Important	28,4	26,2	26,9	22,2	30,0	32,4	21,0	33,0	8,4	34,5	31,0	35,4	29,1
Absolutely essential	43,8	63,4	58,6	58,5	55,0	50,0	31,3	52,4	15,1	40,1	54,0	24,4	44,0

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Factors influencing the decision to walk

The same attributes were presented to the participants to determine the factors that influenced the decision to walk. The results are shown in Table 4.13.

From the results obtained in both cities, it was evident that walking was used mostly for affordability reasons. Walkers were not influenced by the roads' infrastructure. The participants walked mostly because it was free, without any costs involved, and they were likely to continue walking for this reason. Travelling time, TIS, comfort, internet, privacy and fuel efficiency did not play a role when participants decided to walk. Convenience, flexibility and accessibility were of moderate importance to walking. Internet and Wi-Fi when walking would be the responsibility of the person walking and could be a welcome distraction when used on a smartphone.

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Table 4.13: Factors influencing the decision to wal

Level of Importance	Bloemfontein												
	Affordability	Convenience	Safety	Flexibility	Accessibility	Travelling Time	Traveller Information Services	Comfort	Internet/ Wi-Fi___33	Fuel Efficiency	Privacy	Infrastructure	Freedom of personal entertainment choice
Not Important	12,3	12,2	32,0	11,9	11,7	32,1	36,9	35,4	48,8	69,3	38,4	12,5	22,5
Slightly important	3,3	23,3	28,9	24,1	20,1	28,5	35,0	33,1	29,4	19,0	33,4	13,4	23,6
Of average importance	3,3	16,7	8,0	12,7	15,6	10,5	11,1	11,3	7,5	3,4	11,1	15,6	18,9
Very Important	23,7	25,0	17,1	31,9	33,4	17,2	11,4	12,7	9,7	4,2	10,9	34,3	20,0
Absolutely essential	57,5	22,8	14,0	19,4	19,2	11,6	5,6	7,5	4,7	4,2	6,1	24,2	15,0
Level of Importance	**Gaborone**												
	Affordability	Convenience	Safety	Flexibility	Accessibility	Travel time	Traveller Information Services	Comfort	On-board internet	Fuel efficiency	Privacy	Infrastructure	Freedom of personal entertainment choice
Not Important	39,1	26,2	25,0	32,7	31,3	37,0	64,1	48,4	81,2	76,7	58,1	54,1	42,2
Slightly important	4,5	9,7	7,7	5,1	10,1	6,0	5,4	17,9	7,1	4,4	7,5	10,6	6,7
Of average importance	8,2	15,5	9,6	20,4	14,1	17,0	10,9	12,6	4,7	6,7	15,1	9,4	12,2
Very Important	4,5	11,7	21,2	12,2	14,1	13,0	7,6	7,4	3,5	5,6	5,4	10,6	10,0
Absolutely essential	43,6	36,9	36,5	29,6	30,3	27,0	12,0	13,7	3,5	6,7	14,0	15,3	28,9

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4.8 The Cost of Travel

The focus of this section is on the monetary costs of both private and public transportation, fuel and fare costs. First, the costs of travel by private vehicles are shown in Figure 4.41 (Bloemfontein) and Figure 4.42 (Gaborone) and, second, the cost of public transportation in Bloemfontein (Figure 4.43) and in Gaborone (Figure 4.44).

4.8.1 Cost of travel using private vehicles

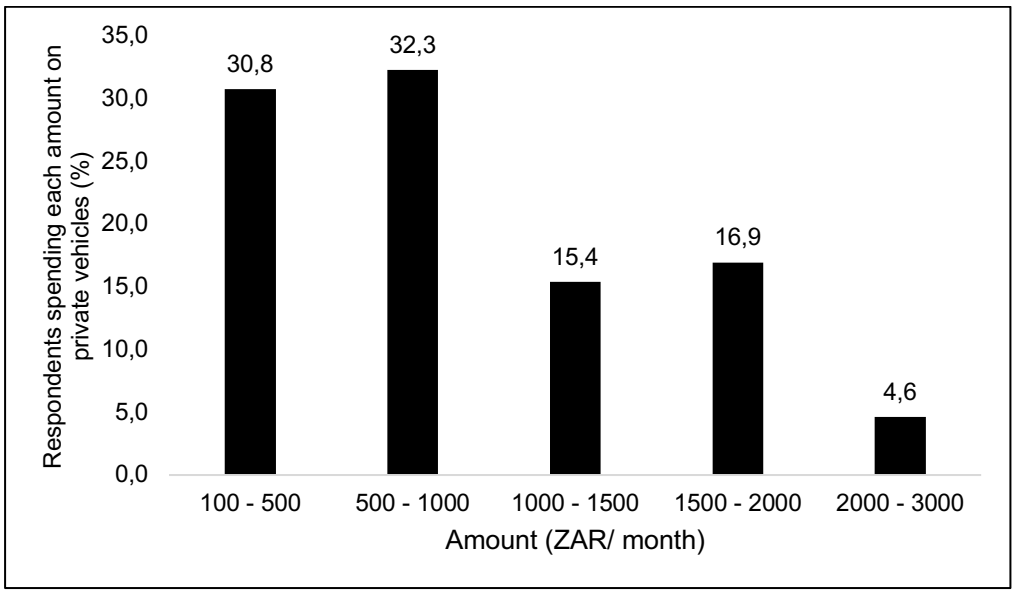

Figure 4.41: Monthly expenditure on private vehicles in Bloemfontein

Figure 4.41 shows the monthly costs of fuel for private vehicles used in Bloemfontein. A total of 32.3% of the participants spent amounts between R500.00 and R1 000.00 per month, 30.8% spent between R100.00 and R500.00, and 16.9% spent between R1 500.00 and R2 000.00 on fuel on a monthly basis. Furthermore, 15.4% spent amounts between R1 000.00 and R1 500.00, and 4.6% spent between R2 000.00 and R3 000.00 per month on fuel.

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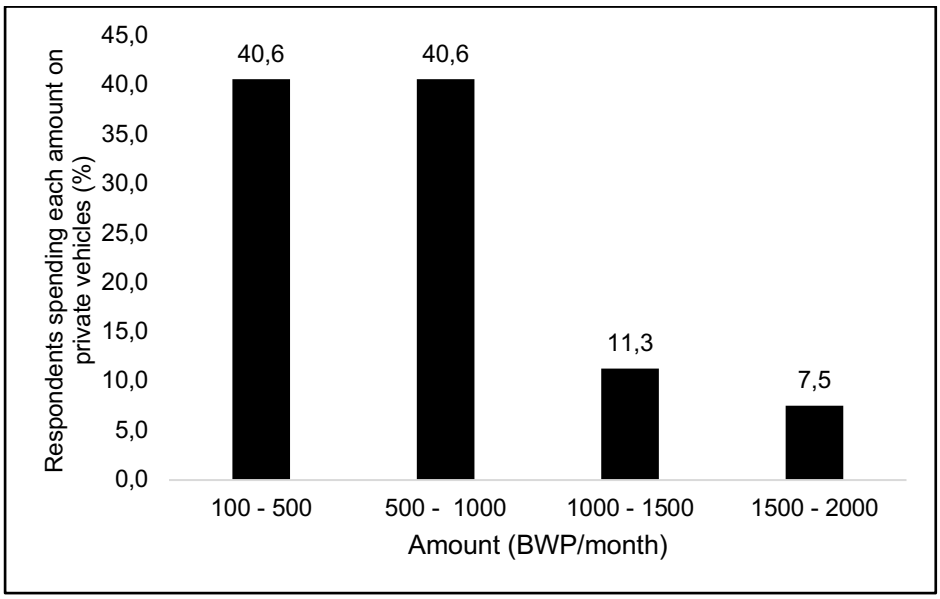

Figure 4.42: Monthly expenditure on private vehicles

Figure 4.42 shows the monthly costs of fuel used in private vehicles in Gaborone. In total, 40.6% of the participants spent P100.00 to P500.00 and P500.00 to P1 000.00, respectively, on private car transportation, while 11.3% spent between P1 000.00 and P1 500.00, and 7.5% spent between P1 500.00 and P2 000.00 per month on fuel.

Participants who drove short distances might have been spending less on fuel, even though they travelled regularly. Spending more on fuel would be the result of regular travel and longer trips. Fuel is cheaper in Botswana compared with South Africa, so private vehicle users in Bloemfontein spend more on fuel than in Gaborone.

4.8.2 Cost of travel using public transportation

Figure 4.43 below shows the monthly costs of using bus and taxi services in Bloemfontein. A majority of 70.7% of taxi users spent between R100.00 and R500.00 on taxi usage, while only 29.9% of bus users spent the same amount. More bus users (35.8%) spent between R750.00 and R1 000.00 on bus fare per month, compared with 2.7% of taxi users spending the same amount.

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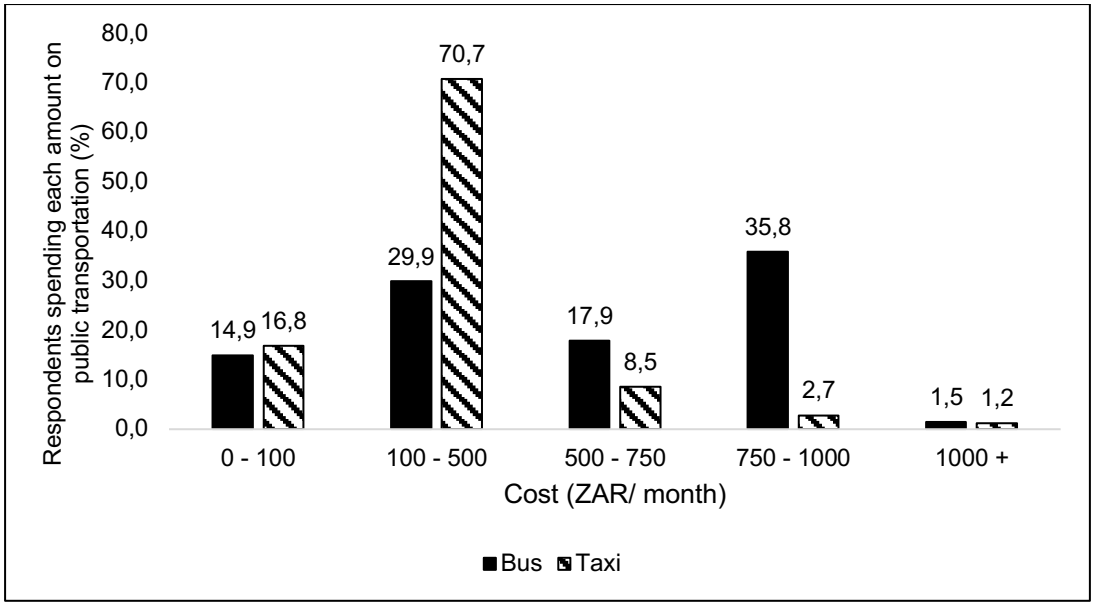

Figure 4.43: Cost of using public transportation in Bloemfontein

Furthermore, 14.9% and 16.8% of the participants spent less than R100.00 on bus and taxi fare, respectively, while 17.9% and 8.5% spent between R500.00 and R750.00 on buses and taxis, respectively, and 1.5% and 1.2% spent more than R1 000.00 on bus and taxi fare, respectively.

Spending less money on public transportation could have been influenced by participants travelling a few times a month or making single trips per day on a regular basis. The participants who made multiple trips using public transportation on a daily basis, spent more. These results showed also that taxi users spent less on transportation than bus users.

Figure 4.44 showed the monthly costs of using combis and taxi services in Gaborone. A total of 58.5% of taxi users spent less than P100.00 per month, compared with 19.1% of bus users. A larger portion (41.8%) of combi users spent between P100.00 and P250.00 compared with 28% of taxi users. Furthermore, 37.2% of combi users spent between P250.00 and P500.00 on fares, compared with 10.2% who spent the same amount on taxi fares. Also, 1.8% and 0.8% spent between P500.00 and P750.00 on combis and taxis, respectively, and 0.4% and 2.5% spent between P750.00 and P1 000.00 on combi and taxi fares, respectively.

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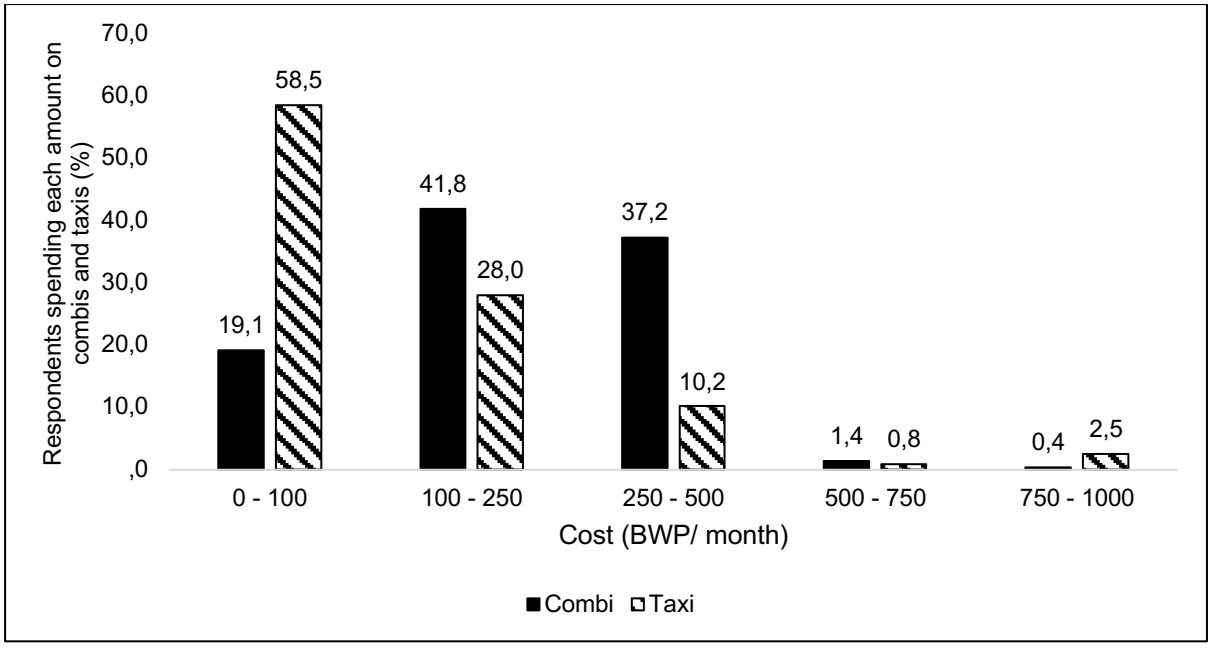

Figure 4.44: Cost of using public transportation in Gaborone

A single trip by taxi costs P5.00, while a combi trip costs P4.00. The results showed that more money was spent on combis than taxis, which could be because of the popularity of combis. Taxis were used less frequently compared with combis, which explains the lower monthly expenditure on taxis and higher expenditure on combis.

4.9 Public Transportation Challenges

The focus of this section is on public transportation problems as experienced by the participants and the resolutions to these problems. First, the problems encountered in Bloemfontein are shown in Figure 4.45 and those encountered in Gaborone are shown in Figure 4.46.

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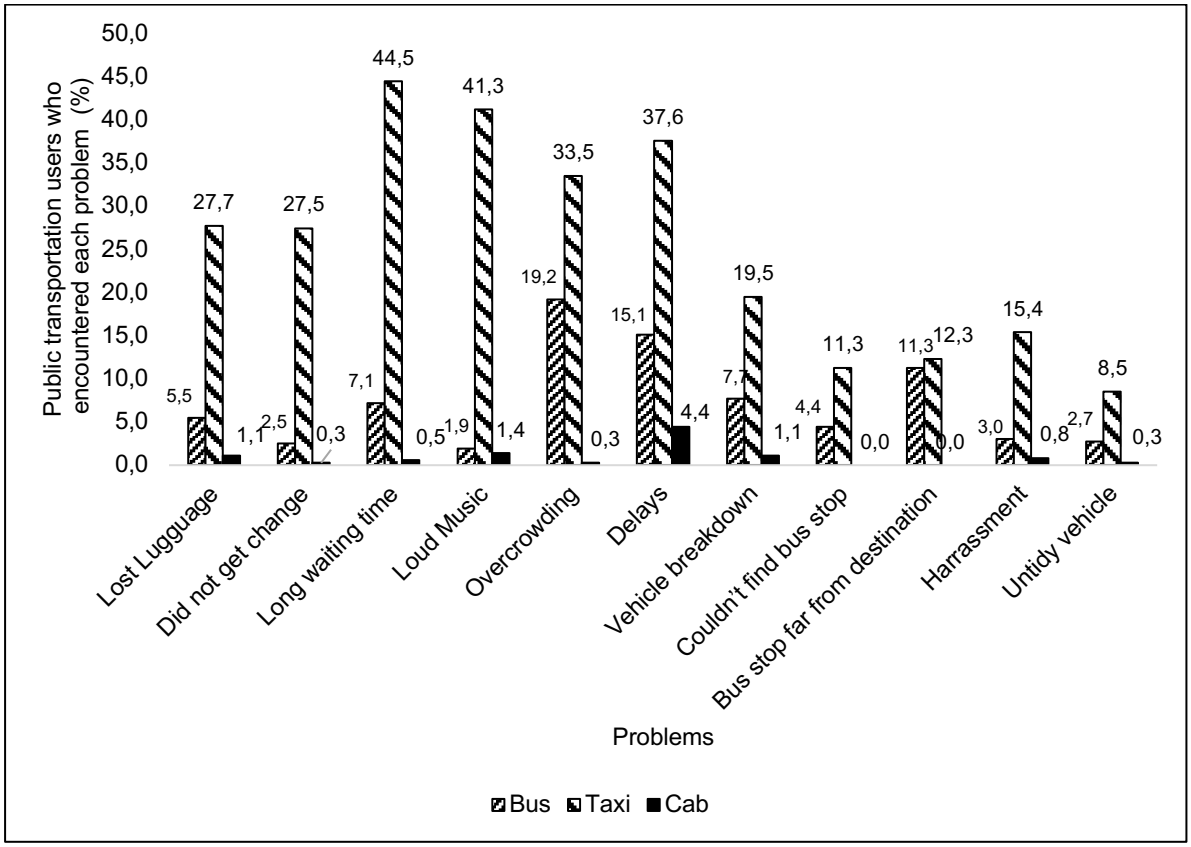

Figure 4.45: Public transportation problems experienced in Bloemfontein

Figure 4.45 shows the problems encountered by the participants in Bloemfontein when using the three main public transportation modes. The most common problem encountered by 19.2% of the participants in buses was overcrowding, followed by 15.1% who experienced delays, and 11.3% who reported that bus stops were too far away from their departure or the destination points. A further 7.7% of participants experienced vehicle breakdowns when using the bus, while 7.1% waited long times for buses. In addition, 5.5% of participants lost luggage, while 3% experienced harassment on buses, 2.7% encountered untidy vehicles, 2.5% were not given change on bus fare they were paying, and 1.9% experienced loud music in buses.

However, the participants experienced more problems with taxis compared with buses and cabs. A total of 44.5% reported having had to wait for a long time for taxis to arrive, while 41.3% encountered loud music being played in taxis. A further 37.6% experienced delays and 33.5% experienced overcrowding. Furthermore, 27.5% did not receive their change and 27.7% lost luggage in taxis, while 19.5% experienced

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vehicle breakdowns and 15.4% experienced harassment. Also, 12.3% of participants reported that taxi stops were too far away from their departure or destination points, while 11.3% could not find taxi stops, and 8.5% reported untidy/dirty taxis.

Cabs were the least used of the three modes of public transportation, with 4.4% of the participants having experienced delays, while 1.4% encountered loud music in cabs. A further 1.1% had lost luggage and experienced vehicle breakdowns, respectively. In addition, 0.8% had been harassed, 0.5% waited for extended periods, and 0.3% had experienced overcrowded cabs, did not receive change, or encountered untidy/dirty cabs, respectively. None of the participants complained about having missed a cab stop or having had to walk long distances from the cab stops to their final destinations as cabs are demand-responsive and flexible.

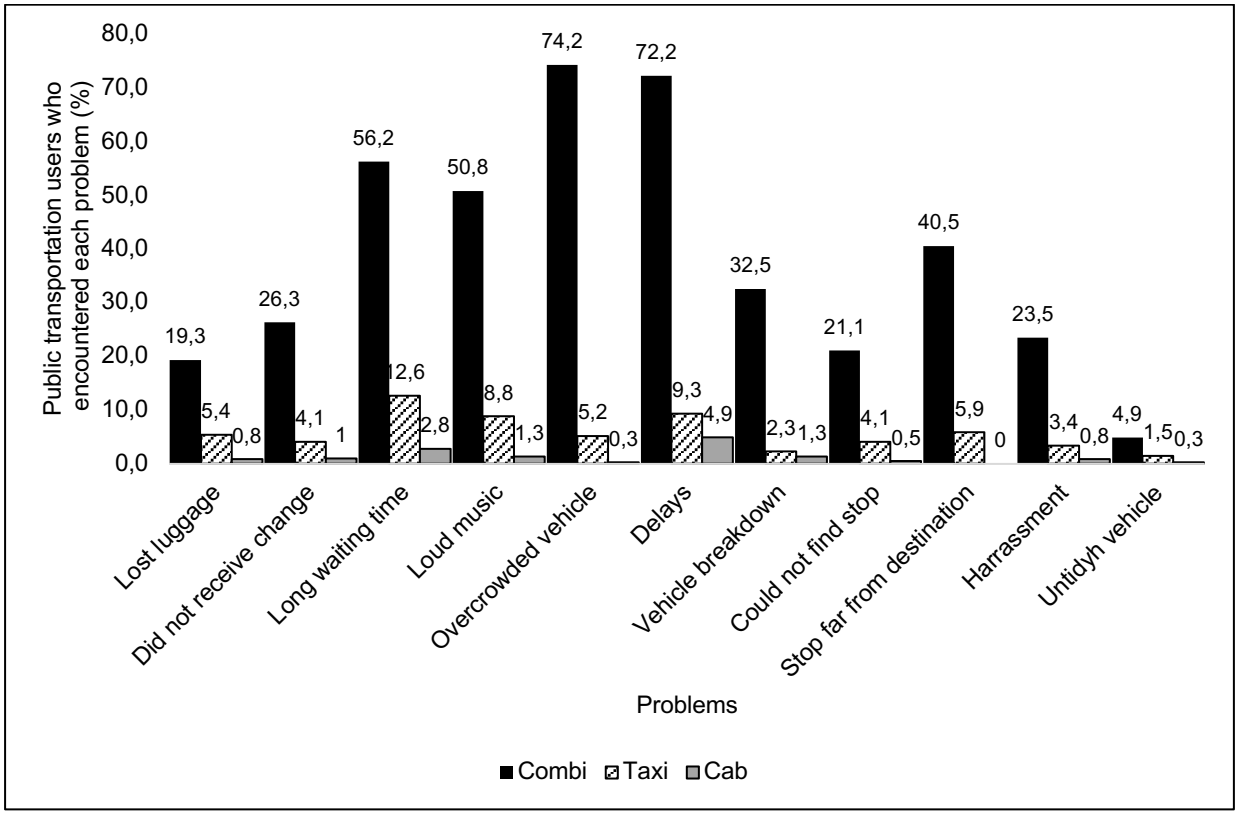

Figure 4.46: Public transportation problems experienced in Gaborone

Figure 4.46 shows problems encountered by public transportation users in Gaborone. A total of 74.2% of participants experienced overcrowding and 72.2% experienced delays in combis. Furthermore, 56.2% experienced long waiting times and 50.8% reported loud music, while 40.5% said that bus stops were far from their departure or final destination points, and 32.5% encountered vehicle breakdowns in combis. In addition, 23.5% of the participants experienced harassment in combis, 21.1% could

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not find where the combis stopped, and 19.3% lost luggage, while 4.9% of combi users had to use untidy/dirty vehicles.

Overall, 12.6% of taxi users waited a long time for taxis to arrive, while 9.3% experienced delays and 8.8% experienced loud music. An additional 5.9% encountered having to walk long distances from taxi stops to their destination, 5.4% lost luggage and 5.2% encountered overcrowding in taxis. Furthermore, 4.1% did not receive change and could not find taxi stops, respectively, while 3.4% were harassed and 1.5% of participants had to use untidy/dirty taxis.

Regarding the complaints raised against cabs, 4.9% of cab users encountered delays, while 2.8% experienced long waiting times, and 1.3% encountered loud music and vehicle break downs, respectively. A further 1% did not receive their change, while 0.8% experienced harassment and lost luggage, respectively. Only 0.5% reported not being able to find cab stops, while 0.3% experienced overcrowding and untidy vehicles, respectively. None of the participants' stops were far from their destinations.

Most of the problems were encountered in combis compared to taxis and cabs. The popularity of combis over other modes exposed them to greater scrutiny from users and complaints when their expectations were not fully satisfied. Cabs were the least used mode, therefore, fewer people were likely to face any challenges with cabs.

4.9.1 Resolutions to current public transportation challenges

The participants were asked further to indicate how the problems they encountered were resolved. A total of 293 responses (55.1%) indicated that the problems encountered in Bloemfontein were not resolved and 1.7% did not take action to resolve the problem. In Gaborone, 54.9% of the 352 indicated that the problems they encountered on public transportation had not been resolved, while 1.4% did not take any action to log complaints. Table 4.14 shows the generalised responses to public transportation problems.

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Table 4.14: Action taken to resolve problems encountered on public transportation

Resolution	Gaborone	Bloemfontein
Not Resolved	54,9	55,1
No Action Taken	1,4	1,7
Resolved to some degree	43,7	43,2

The participants whose problems were resolved provided answers that are presented in Appendix 5. These answers were obtained from 43.2% of the participants in Bloemfontein and 43.7% in Gaborone and were classified into the themes analysed below.

Lost luggage

Most of the participants did not recover the luggage they lost, even after tracking the specific vehicle in which they had made their trip. Some commuters indicated that they sourced the contact details of the taxi driver, only to find that their luggage had been stolen by another passenger, never to be recovered. In one instance, the passenger was able to track the lost luggage by going to the taxi rank and looking for the taxi used and found that the driver had kept the luggage. Another passenger indicated that the taxi driver had promised to replace the lost luggage, but never did so. Bus users indicated that they had called the bus service provider and were able to trace the missing luggage.

Not receiving change

Instances of passengers not receiving the balance in change after paying for a trip were common in Bloemfontein. Cash payments were made by passing money to other passengers to pass to the driver, and if the passenger had paid an amount that required change, returned the balance by passing the money to other passengers until it reached the payee. In Gaborone, payments were made directly to the driver or conductor, therefore, there were fewer such incidents.

Long waiting time

Passengers waited until another taxi arrived or walked in the mornings because taxis were usually full in the morning. Some participants extended their travel time in order to accommodate the possible long waiting times. Long waiting times usually resulted

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from taxis being at full capacity during peak hours, and taxis and combis taking more time to reach full capacity during off-peak hours. In some instances, taxis or combis only left their ranks once they were full, so passengers had to wait longer. Passengers waiting at bus stops along taxi or combi routes might have experienced this problem when the vehicles using the route were full already and no passengers disembarked.

Loud music

Loud music is one of the most prevalent nuisances in public transportation, specifically in minibus taxis and combis. When passengers asked taxi drivers to reduce the volume, some obliged, while some were rude and disrespectful to the passengers and paid no heed to the passengers' requests to lower the volume of the music. In one instance, the driver switched off the music and apologised to passengers. In some instances, the passengers tried to ignore the music for the duration of their trips. Some drivers controlled the music systems in their vehicles for their own entertainment, with no consideration for the passengers. This often conflicted with the passengers' interests.

Vehicle breakdowns

Passengers who had experienced a cab breakdown during a trip indicated that the cab company had made another vehicle available to replace the one that broke down to take passengers to their destinations. Taxi users indicated that taxis were also made available to replace those that had broken down, either by waiting for another taxi, which had been called specifically for this reason, or taxis that were already operating on the route stopped for passengers to board. In some cases, mechanics were called to attend to the vehicle breakdown on site, while passengers waited before continuing their journey with the same vehicle. Vehicle breakdowns were inconveniences as they added more travel time to the trip.

Overcrowded vehicles

Bus users indicated that they still experienced overcrowding in buses, especially during peak hours. Overcrowding was common in combis during peak hours in Gaborone. Passengers often asked other passengers to share seats because of the unavailability of combis in the mornings and evenings. However, most drivers did not permit the practice, as it is punishable by law.

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Delays

Bus users said that sometimes, they received prior notice of delays, while other participants indicated that the delays could not be solved, as they were a result of congestion. Some participants indicated that they adjusted their schedules by starting their trips earlier in order to avoid delays.

Solving problems associated with public transportation is often complex, because the system is not recognised as a formal business. Although the transportation departments set the laws for standard practice, individual drivers and operators do not usually adhere to these standards. Only one participant indicated that the public transportation system had improved, while one other indicated that the problems involved the taxi association and the Traffic Department. Lack of constant monitoring of the public transportation system by authorities allowed for problems to go unnoticed and unresolved. Some participants indicated that as a result of these experiences, they no longer used public transportation. Former public transportation users bought their own vehicles to avoid the problems they had encountered with public transport.

4.10 The Public's Perceptions of Public Transportation

The participants' views on public transportation were obtained from both public and private transportation users. The results produced similar themes of perceptions in the two selected cities. The open-ended, multiple-response questionnaire received a total of 269 responses in Bloemfontein and 431 responses in Gaborone, which were grouped under themes, as shown in Table 4.15.

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Table 4.15: Perceptions of public transportation

Perception	Bloemfontein	Gaborone
Affordability	3,7	10,9
Safety and security	7,1	4,2
Psychological	1,1	2,1
Structural and operational	4,5	5,1
Customer service	8,9	12,1
Driver behaviour	23,4	8,4
Infrastructure	7,8	10,9
State of vehicles	6,3	3,5
Convenience and reliability	7,1	25,1
Bad	9,3	3,5
System needs improvement	4,5	4,9
Good	4,8	4,4
Comfort	5,9	2,1
A necessity	5,6	3,0

4.10.1 Convenience and reliability

Perceptions raised by 7.1% of the participants in Bloemfontein indicated that the system was “unreliable”, “inconvenient” and involved many delays. In Gaborone, 25.1% also responded by citing factors related to the lack of convenience and reliability of the system, which included “delays most of the times”, “long waiting time” and “it is slow”. Only one participant in Gaborone indicated that the public transportation system was “reliable”.

4.10.2 Affordability

The need for travel and the affordability of public transportation were the main reasons why majority of the participants used the system. Only 3.7% of the participants in Bloemfontein and 10.9% in Gaborone raised perceptions concerning a lack of affordability. Most indicated that the systems were affordable. Public transportation services were viewed as an essential service, especially for people with no access to private vehicles. Public transportation was also considered to be their only option. Participants also indicated that public transportation was essential to reduce traffic congestion.

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4.10.3 Necessity

While the participants acknowledged that public transportation was necessary, especially for people without other means of transportation, their many negative experiences reflected that they were not attracted to public transportation, but used it as the only available option. In Bloemfontein, 5.6% of the participants and 3% of participants in Gaborone referred to the use of public transportation as being essential.

4.10.4 Safety and security

A total of 7.1% of the participants in Bloemfontein raised safety concerns about the public transportation system, while 4.2% in Gaborone raised similar concerns. Lack of safety was an important concern in public transportation. Participants indicated that public transportation facilities were disorderly and there was a lack of security. Many public transportation drivers were not concerned about the safety of the passengers or of other road users, as they did not obey road signs and speed limits.

4.10.5 Social and psychological factors

Only 1.1% of the participants in Bloemfontein and 2.1% in Gaborone expressed perceptions relating to their feelings and social interaction on public transportation. The participants described the system as “depressing”, while others indicated that public transportation promoted social interaction among its users, who found it useful for socialising and meeting new people.

4.10.6 Customer service

In Bloemfontein, 8.9% of the participants indicated that they were not pleased with the public transportation’s customer services. In Gaborone, 12.1% also cited concerns about customer service. The comments were mostly negative and included remarks, such as “bad service”, “poor customer service”, “operators are rude”, and “poor communication”. Factors such as inconvenience and inefficiency, as well as bad customer service were mentioned as indicators of poor service rendered by the public transportation system. The participants also indicated that the services did not meet their needs as paying customers and that the system was not user-friendly as it did not provide 24-hour services. One passenger also felt that passengers were forced to carry the exact amount of money needed for taxi fare instead of using larger currency than needed, as it was difficult to receive change from the taxi drivers. Suggestions were made to implement electronic payment machines for taxis in order to reduce the

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lack of change problem. Participants indicated that cab services were the best compared with other modes of transport, but they were more expensive.

4.10.7 Driver behaviour

In Bloemfontein, 23.4% of the participants and 8.4% in Gaborone expressed perceptions related to driver behaviour, which were all negative. Most of the participants indicated recklessness, disrespectful manners and being rude as unpleasant behaviours displayed by the drivers. Drivers also fought among themselves, putting the lives of passengers at risk. Drivers also dropped off passengers in unsafe areas where there were no bus stops. Drunk taxi drivers were also a problem. The participants indicated that taxi drivers made uninvited sexual advances to passengers, making them feel uncomfortable or even threatened. Some passengers even suggested the installation of cameras in taxis to monitor drivers and passengers.

4.10.8 Infrastructure

Users indicated that the public transportation infrastructure was lacking in some cases, and the limited number of bus stops and bus shelters did not serve the needs of the public. A total of 7.9% of the participants in Bloemfontein and 10.9% in Gaborone expressed perceptions on the public transportation system, which were related to public transportation infrastructure. The participants noted a “lack of bus stops”, “limited space at taxi ranks” and “poor infrastructure” as problems.

4.10.9 State of vehicles

In Bloemfontein, 6.3% of the participants and 3.5% in Gaborone indicated that the physical state of taxis and combis was not suitable for their daily operation. Responses included “combis are too old”, “taxis are not roadworthy”, “old buses” and “torn chair covers in combis”. Conclusively, vehicles were old and not roadworthy, which was a safety concern. The attractiveness of vehicles also influenced passengers’ decisions to use public transportation.

4.10.10 Comfort

In Bloemfontein, 5.9% of the participants and 2.1% in Gaborone expressed perceptions relating to comfort offered by public transportation vehicles. The

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perceptions were mostly negative, indicating that the vehicles were “uncomfortable”, while one participant indicated that the vehicles needed better ventilation.

4.10.11 Positive and negative perceptions of public transportation

The participants generalised their perceptions as being either “good” or “bad”. These responses indicated either their satisfaction or displeasure with the status of public transportation. In Bloemfontein, 9.3% of the participants and 3.5% in Gaborone indicated that the public transportation systems were bad, while 4.8% in Bloemfontein and 4.4% in Gaborone said the public transportation systems were good. The negative response, such as “bad”, referred to poor service and defective conditions experienced by public transportation commuters, while the positive response of “good” indicated that the participants found the services to be acceptable and enjoyable.

4.10.12 System needs improvement

In Bloemfontein, 4.5% of the participants indicated that the public transportation system needed improvement, while in Gaborone, 4.5% of the participants shared the same sentiments. Examples of responses included “could be better”, “there is room for improvement” and “the system needs to be upgraded”. These responses indicated that people were not fully satisfied with the public transportation system in either of the two cities, and there was a need to improve the system.

Many of the perceptions held about the public transportation by users and non-users were negative. Positive perceptions were influenced mostly by financial reasons for captive public transportation users. Some indicated that even though the public transportation system was not pleasant or comfortable, they were used to the conditions, as they had been using the system for extended periods of time. Users referred to the public transportation system as being outdated, with a need for transformation.

4.11 Private Vehicle Usage

Private vehicle users were asked to provide reasons why they preferred using their own vehicles rather than public transportation. There were similarities in the reasons for using private vehicles over public transportation in both study areas. Most of the

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participants used private vehicles for convenience and reliability, such as flexibility during shopping trips and family outings, as well as for emergency trips. Private vehicle users found it convenient for taking children to school and attending meetings with clients. The participants also indicated that they used private vehicles for comfort, peace and quiet. Public transportation was not accessible in some areas, leaving participants with the only option of using private transportation. Dislike of the public transportation system was also one of the reasons why people chose their personal vehicles in preference to the system.

4.11.1 Use of private vehicles for sightseeing activities

Private vehicle users were asked whether they drove their vehicles for sightseeing trips. The results are shown in Figure 4.47 below. Convenience was necessary for activities such as sightseeing.

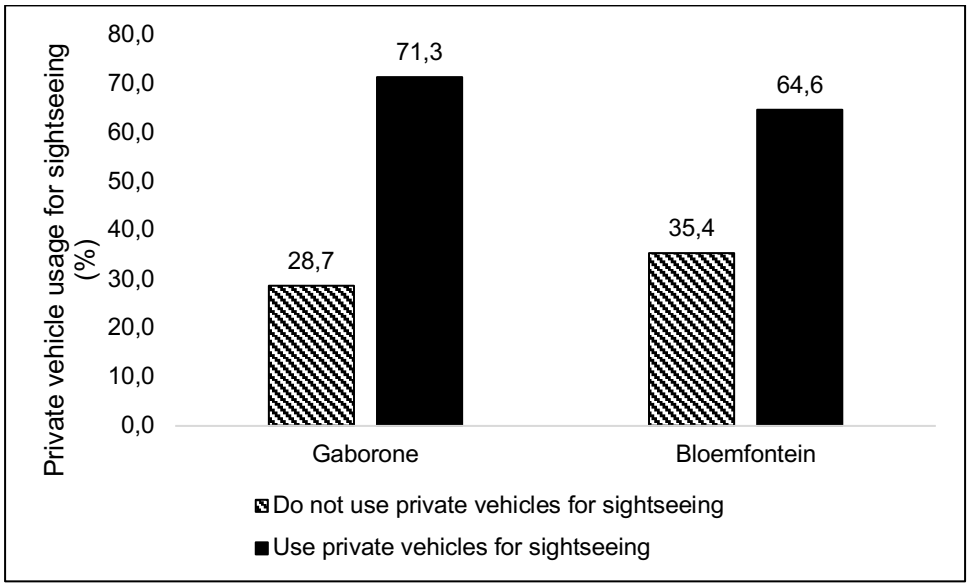

Figure 4.47: Use of private vehicles for sightseeing

As shown in Figure 4.47, 64.6% of the participants in Bloemfontein and 71.3% in Gaborone used their private vehicles for sightseeing. Sightseeing is influenced by car ownership or access to a car. The higher level of private vehicle ownership in Gaborone explained the higher percentage of people driving for sightseeing in Gaborone compared with Bloemfontein. However, the increased number of vehicles on the road has a negative impact on the environment.

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Furthermore, private vehicle users were asked about their awareness of the impact of an increased number of vehicles on the environment. Most of the participants indicated that they knew that air pollution was one of the major effects of an increased number of vehicles on the roads, contributing to global warming, carbon emissions and poisonous fumes. Some of the consequences of the increasing number of vehicles of which private car drivers were aware included climate change, increased car accidents, and congestion and traffic jams at peak hours. The participants were asked whether being aware of any of these negative factors would influence them to shift from private to public transportation. The results are shown in Figure 4.48 below.

4.11.2 Factors influencing private to public transportation modal shift

Figure 4.48 shows factors that would influence private vehicle users in Bloemfontein and Gaborone to shift to the use of public transportation.

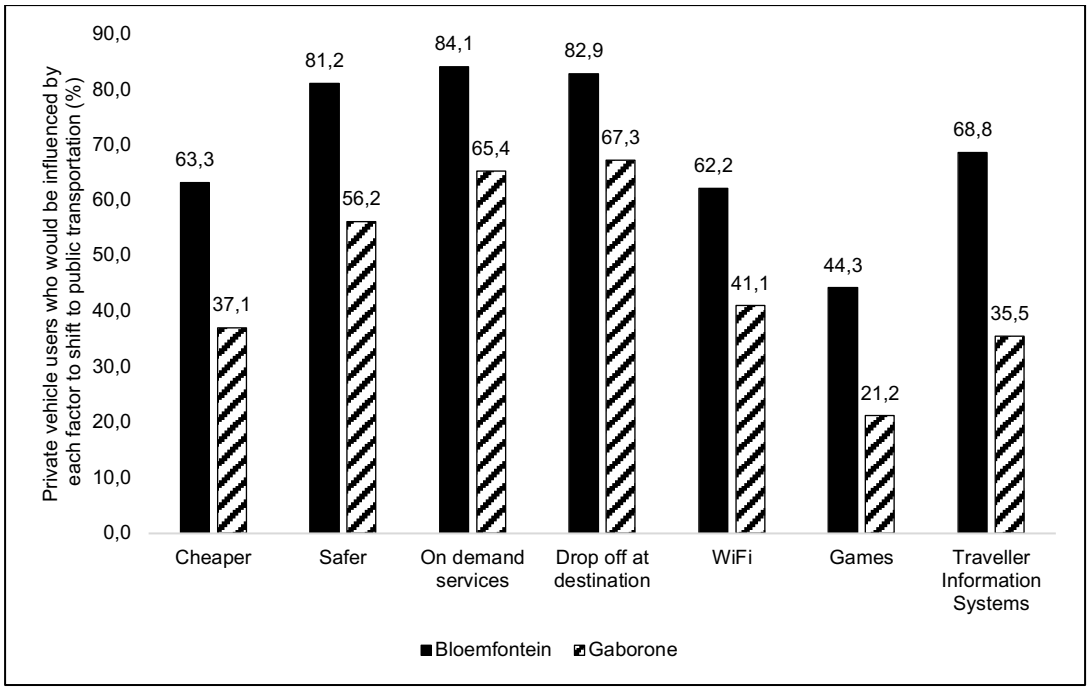

Figure 4.48: Factors that might influence modal shift to public transportation

A total of 63.3 % of the participants in Bloemfontein would change modes if public transportation were cheaper compared with 37.1% in Gaborone. Safer public transportation would attract 81.2% in Bloemfontein and 56.2% in Gaborone. Furthermore, 84.1% in Bloemfontein and 65.4% in Gaborone would be attracted by public transportation offering on-demand services, while 82.9% in Bloemfontein and

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67.3% in Gaborone would shift if public transportation vehicles dropped them off at their exact destinations. A further 68.8% and 62.2%, respectively, of participants in Bloemfontein claimed that they would change modes if the public transportation system were to offer TIS and Wi-Fi, whereas 41.1% and 35.5%, respectively, in Gaborone claimed that they would be influenced by the availability of Wi-Fi and TIS. Also, 44.3% in Bloemfontein and 21.2% in Gaborone would be attracted by the availability of video games in public transportation vehicles.

Convenience, safety and affordability were the most important factors that had the potential of influencing a modal shift. ICT-related factors were the least influential in modal shift. Therefore, ICT-related components introduced in public transportation would not attract a significant population of the current private vehicle users in Gaborone. Concern over affordability of public transportation was more apparent in Bloemfontein. However, private vehicle users were more concerned with the convenience and safety of public transportation.

4.12 Information Communication Technology in Public Transportation Systems

In this section, the use of ICT in passenger transportation systems, for both private and public transportation is presented.

4.12.1 ICT access and use in public transportation

ICT awareness and availability of ICT in public transportation, participants' ICT knowledge, access to the internet and the use of ICT for public transportation are explored in this sub-section, as shown in Figure 4.49. Tables 4.16 and 4.17 show the knowledge of ICT, and internet access by participants of different age groups, monthly income, and occupations.

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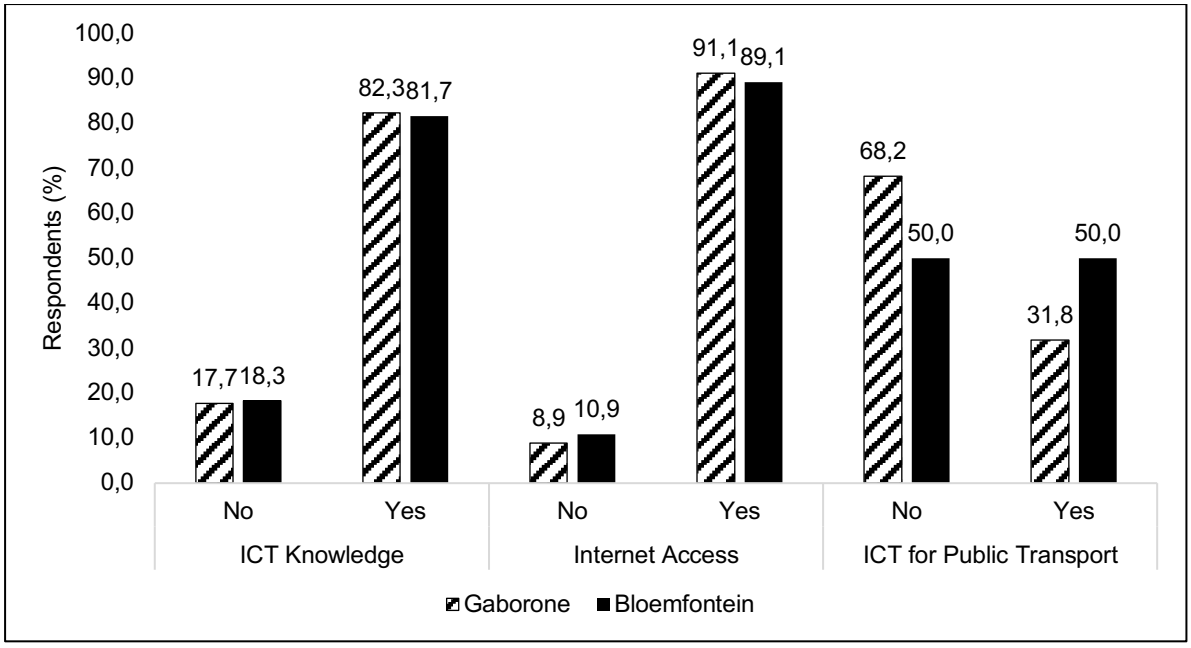

Figure 4.49: Awareness and use of ICT in public transportation

Table 4.16: ICT knowledge and Internet access by socioeconomic groups (Bloemfontein)

		ICT Knowledge		Internet access	
		No	Yes	No	Yes
Demographic characteristics		N = 74	N = 330	N = 44	N = 360
Age of participants (years)	18-25	14,2%	85,8%	7,1%	92,9%
	25-35	17,9%	82,1%	9,9%	90,1%
	36-45	22,1%	77,9%	11,8%	88,2%
	46-55	24,1%	75,9%	24,1%	75,9%
	55+	75,0%	25,0%	75,0%	25,0%
Participants' monthly income in ZAR	R0 -R 2500	15,3%	84,7%	11,3%	88,7%
	R2500 - R5000	18,1%	81,9%	11,4%	88,6%
	R5000 - R10 000	21,2%	78,8%	11,5%	88,5%
	R10 000 - R30 000	21,3%	78,7%	10,1%	89,9%
	R30 000 - R50 000	28,6%	71,4%	0,0%	100,0%
	R50 000+	0,0%	100,0%	0,0%	100,0%
Occupation	Student	14,4%	85,6%	7,6%	92,4%
	Part-time employee	18,5%	81,5%	13,0%	87,0%
	Self-employed	25,0%	75,0%	10,7%	89,3%
	Full-time employee	19,5%	80,5%	11,0%	89,0%
	Unemployed	21,4%	78,6%	17,9%	82,1%
	Student and part-time employee	18,2%	81,8%	13,6%	86,4%

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Table 4.17: ICT knowledge and Internet access by socioeconomic groups (Gaborone)

		ICT Knowledge		Internet access	
		No	Yes	No	Yes
GABORONE		N = 68	N = 316	N = 34	N = 340
Age of participants (Years)	18-25	17,2%	82,8%	8,6%	91,4%
	25-35	14,5%	85,5%	5,5%	94,5%
	36-45	20,0%	80,0%	8,3%	91,7%
	46-55	43,8%	56,3%	43,8%	56,3%
	55+	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in BWP	P0 -P2500	19,7%	80,3%	12,1%	87,9%
	P2500 - P5000	19,4%	80,6%	3,2%	96,8%
	P5000 - P10 000	14,3%	85,7%	2,4%	97,6%
	P10 000 - P30 000	7,4%	92,6%	0,0%	100,0%
	P30 000 - P50 000	0,0%	100,0%	0,0%	100,0%
	P50 000+	0,0%	0,0%	0,0%	0,0%
Occupation	Student	16,7%	83,3%	6,3%	93,7%
	Part-time employee	17,9%	82,1%	3,6%	96,4%
	Self-employed	30,4%	69,6%	21,7%	78,3%
	Full-time employee	14,6%	85,4%	5,7%	94,3%
	Unemployed	17,4%	82,6%	21,7%	78,3%
	Student and part-time employee	33,3%	66,7%	33,3%	66,7%

ICT knowledge

In Gaborone, 82.3% of the participants indicated that they had basic ICT knowledge compared with 81.7% in Bloemfontein, while 17.7% in Gaborone and 18.3% in Bloemfontein did not have the minimal level of ICT knowledge required to use basic technology.

Internet access

In Gaborone, 91.1% of the participants and 89.1% in Bloemfontein had access to the internet, and only 8.9% and 10.9%, respectively, did not have any such access.

The high internet access rate has the potential to influence the incorporation of ICT into transportation systems by using technologies such as TIS and mobile applications.

ICT for public transportation

The use of ICT for reasons related to public transportation was very low, as shown in Figure 4.46. The results indicated that 68.2% of the participants in Gaborone did not

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use ICT for any purposes related to public transportation and travel, compared with 31.8% of the participants who indicated that they did use ICT for reasons related to public transportation. In Bloemfontein, 50% of participants used ICT for reasons related to public transportation and the other 50% did not. The results indicated that there was a limited presence of ICT platforms for public transportation, such as the bus tag system, which enabled bus users to tag a previously loaded ticket on a machine within the bus upon entry, as a form of proof of the validity of the ticket.

4.12.2 Online presence of public transportation service providers

The participants were asked further whether the public transportation services they used had any form of online or web presence. The participants were asked to answer "Yes" or "No" and the results are shown in Figure 4.50 below.

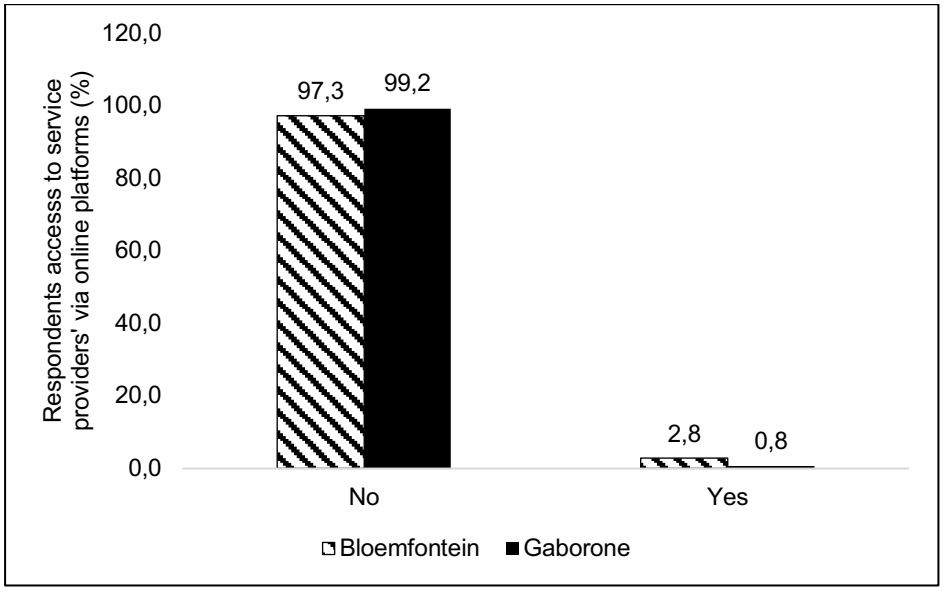

Figure 4.50: Online presence of public transportation service providers

Figure 4.50 shows the access the participants had to public transportation service providers through internet-based platforms. A majority of 97.2% of the participants in Bloemfontein indicated that public transportation service providers did not have an online or web presence, or they were not aware of such presence, while 2.8% stated that they had a web presence. In Gaborone, 0.8% indicated that their service providers were discoverable online, while 98.2% indicated that public transportation service providers in the city did not have any online presence that they were aware of.

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The results depicted a significant lack of online platforms offered by public transportation service providers in both cities. The participants in Bloemfontein, whose public transportation service providers had an online presence, indicated that their bus service provider had a website, and this was also accessible through email. Others indicated that their service providers were available on WhatsApp and Facebook. In Gaborone, of the 0.8% (3) of the participants, two indicated that WhatsApp was the online platform used by their public transportation service provider, while one indicated that the service provider used Facebook.

The participants were asked further how they communicated with their public transportation service providers that were not accessible online. The responses were as follows.

Communication in public transportation systems

Owing to the lack of ICT for communication with service providers, participants provided the following as methods they used for communication. In Gaborone, 46.7% of the participants did not communicate with their service providers at all, while 30.6% of the participants only had contact with their service providers in person, and 4.1% communicated in person by speaking out loudly to get the driver's attention. A further 17.4% used phone calls, especially when calling cabs. Only 1.2% communicated via WhatsApp.

In Bloemfontein, 0.3% of the participants visited the bus company's offices, while 0.3% went to the taxi association offices. A further 63% of the participants did not communicate with their service providers, while 11.4% spoke with the operators and drivers during their trips. Furthermore, 24.6% used phone calls, while 0.6% used emails, and 0.3% indicated that they only communicated by staging protests against the public transportation system.

ICT components for travel purposes

The ICT components, devices, applications and systems used for travel-related reasons were explored further in the study. The participants were provided with options of components and were asked to indicate whether they used them or not. Figure 4.51 shows the ICT components and their use for travel in Bloemfontein, while Figure 4.52 shows the results from Gaborone. A majority of 82.9% of the participants

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used smartphones for travel, while 13.7% used computer tablets, 17.9% used computers, and 8.6% used conventional, non-smart mobile phones. Furthermore, 70.3% of the participants used phone calls and SMS for travel-related reasons, 25.6% used social networks, while 33.9% browsed the web for reasons related to travel. Tables 4.18 to 4.20 show the use of devices, applications and systems by participants of different age groups, monthly income groups, and occupations in Bloemfontein.

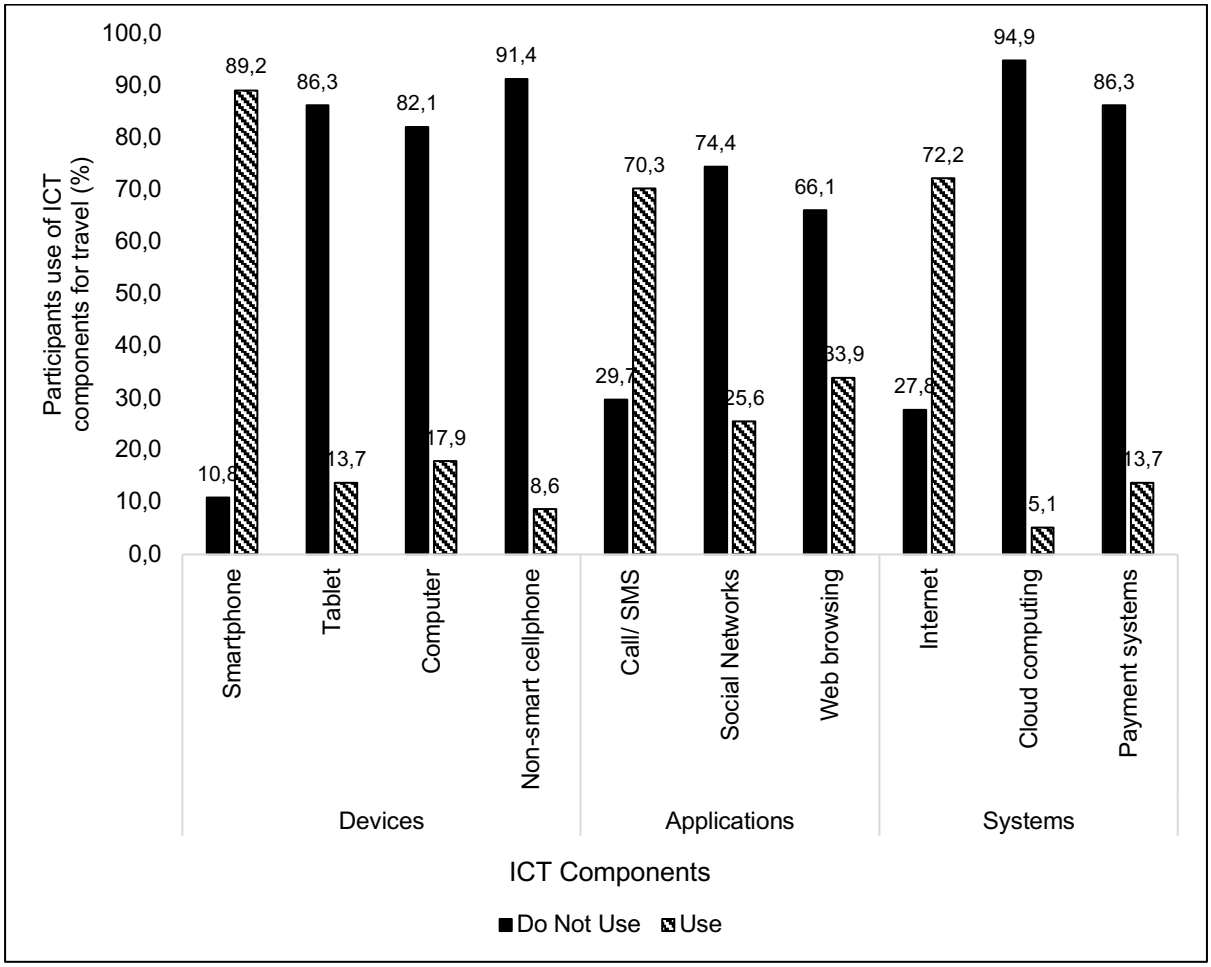

Figure 4.51: ICT components used for travel in Bloemfontein

Smartphones were the most commonly used device for making calls, using social media and browsing on the internet for travel purposes. In addition, 72.2% used the internet for travel-related reasons, while only 5.1% used cloud computing systems and 13.7% used payment systems.

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Table 4.18: ICT device usage for travel by demogra[illegible]fontein

Demographic characteristics		ICT use for public transportation-related reasons		Use smartphone for travel purposes		Use tablet for travel purpose		Use computer for travel purpose		Use phone for travel purposes	
		No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
		N = 202	N = 202	N = 34	N = 280	N=271	N=43	N = 256	N = 56	N = 286	N = 27
Age of Participants (years)	18-25	41,8%	58,2%	6,7%	93,3%	89,5%	10,5%	81,0%	19,0%	95,2%	4,8%
	26-35	53,7%	46,3%	10,6%	89,4%	80,3%	19,7%	83,3%	16,7%	89,4%	10,6%
	36-45	54,4%	45,6%	16,4%	83,6%	90,9%	9,1%	84,9%	15,1%	88,9%	11,1%
	46-55	58,6%	41,4%	15,8%	84,2%	94,7%	5,3%	73,7%	26,3%	89,5%	10,5%
	55+	50,0%	50,0%	33,3%	66,7%	100,0%	0,0%	66,7%	33,3%	100,0%	0,0%
Participants' monthly income in ZAR	R0 -R 2500	50,0%	50,0%	12,5%	87,5%	84,8%	15,2%	87,3%	12,7%	90,1%	9,9%
	R2500 - R5000	46,7%	53,3%	9,1%	90,9%	90,9%	9,1%	76,1%	23,9%	95,5%	4,5%
	R5000 - R10 000	51,9%	48,1%	9,1%	90,9%	86,4%	13,6%	86,4%	13,6%	90,9%	9,1%
	R10 000 - R30 000	51,7%	48,3%	12,5%	87,5%	85,9%	14,1%	81,3%	18,8%	87,5%	12,5%
	R30 000 - R50 000	57,1%	42,9%	0,0%	100,0%	60,0%	40,0%	40,0%	60,0%	100,0%	0,0%
	R50 000+	100,0%	0,0%	0,0%	100,0%	0,0%	100,0%	100,0%	0,0%	100,0%	0,0%
Occupation	Student	40,7%	59,3%	8,6%	91,4%	87,1%	12,9%	81,7%	18,3%	93,5%	6,5%
	Part-time employee	57,4%	42,6%	13,3%	86,7%	86,7%	13,3%	73,3%	26,7%	93,3%	6,7%
	Self-employed	75,0%	25,0%	22,2%	77,8%	83,3%	16,7%	77,8%	22,2%	77,8%	22,2%
	Full-time employee	50,0%	50,0%	8,5%	91,5%	84,6%	15,4%	83,8%	16,2%	92,3%	7,7%
	Unemployed	60,7%	39,3%	9,5%	90,5%	90,5%	9,5%	95,0%	5,0%	80,0%	20,0%
	Student and part-time employee	36,4%	63,6%	20,0%	80,0%	90,0%	10,0%	84,2%	15,8%	95,0%	5,0%

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Table 4.19: ICT applications usage for travel by de Bloemfontein

Demographic characteristics		ICT use for public transportation-related reasons		Use of call/SMS for travel purposes		Use of Social Networks for travel purposes		Use of Web-browsing for travel purposes	
		No	Yes	No	Yes	No	Yes	No	Yes
		N = 202	N = 202	N = 93	N = 220	N = 233	N = 80	N = 207	N = 106
Age of Participants (Years)	18-25	41,8%	58,2%	31,4%	68,6%	69,5%	30,5%	65,7%	34,3%
	26-35	53,7%	46,3%	26,5%	73,5%	72,7%	27,3%	64,4%	35,6%
	36-45	54,4%	45,6%	35,2%	64,8%	87,0%	13,0%	64,8%	35,2%
	46-55	58,6%	41,4%	26,3%	73,7%	84,2%	15,8%	84,2%	15,8%
	55+	50,0%	50,0%	33,3%	66,7%	33,3%	66,7%	66,7%	33,3%
Participants' monthly income in ZAR	R0 -R 2500	50,0%	50,0%	30,6%	69,4%	69,4%	30,6%	72,1%	27,9%
	R2500 - R5000	46,7%	53,3%	31,8%	68,2%	73,9%	26,1%	56,8%	43,2%
	R5000 - R10 000	51,9%	48,1%	34,1%	65,9%	77,3%	22,7%	65,9%	34,1%
	R10 000 - R30 000	51,7%	48,3%	21,9%	78,1%	81,3%	18,8%	65,6%	34,4%
	R30 000 - R50 000	57,1%	42,9%	40,0%	60,0%	80,0%	20,0%	100,0%	0,0%
	R50 000+	100,0%	0,0%	0,0%	100,0%	100,0%	0,0%	100,0%	0,0%
Occupation	Student	40,7%	59,3%	34,4%	65,6%	65,6%	34,4%	71,0%	29,0%
	Part-time employee	57,4%	42,6%	24,4%	75,6%	77,8%	22,2%	55,6%	44,4%
	Self-employed	75,0%	25,0%	33,3%	66,7%	66,7%	33,3%	61,1%	38,9%
	Full-time employee	50,0%	50,0%	24,8%	75,2%	80,3%	19,7%	70,1%	29,9%
	Unemployed	60,7%	39,3%	30,0%	70,0%	75,0%	25,0%	50,0%	50,0%
	Student and part-time employee	36,4%	63,6%	45,0%	55,0%	80,0%	20,0%	65,0%	35,0%

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Table 4.20: ICT systems usage by demographic gr

Demographic characteristics		ICT use for public transportation-related reasons		Use of internet for travel purposes		Use of Cloud computing / Storage for travel purposes		Use of Payments for travel purposes	
		No	Yes	No	Yes	No	Yes	No	Yes
		N = 202	N = 202	N = 87	N =226	N = 297	N = 16	N = 270	N = 43
Age of Participants (Years)	18-25	41,8%	58,2%	27,6%	72,4%	92,4%	7,6%	86,7%	13,3%
	26-35	53,7%	46,3%	24,2%	75,8%	97,0%	3,0%	85,6%	14,4%
	36-45	54,4%	45,6%	27,8%	72,2%	92,6%	7,4%	87,0%	13,0%
	46-55	58,6%	41,4%	47,4%	52,6%	100,0%	0,0%	84,2%	15,8%
	55+	50,0%	50,0%	66,7%	33,3%	100,0%	0,0%	100,0%	0,0%
Participants' monthly income in ZAR	R0 -R 2500	50,0%	50,0%	27,0%	73,0%	94,6%	5,4%	87,4%	12,6%
	R2500 - R5000	46,7%	53,3%	22,7%	77,3%	94,3%	5,7%	88,6%	11,4%
	R5000 - R10 000	51,9%	48,1%	31,8%	68,2%	97,7%	2,3%	88,6%	11,4%
	R10 000 - R30 000	51,7%	48,3%	29,7%	70,3%	93,8%	6,3%	78,1%	21,9%
	R30 000 - R50 000	57,1%	42,9%	60,0%	40,0%	100,0%	0,0%	100,0%	0,0%
	R50 000+	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%
Occupation	Student	40,7%	59,3%	29,0%	71,0%	91,4%	8,6%	84,9%	15,1%
	Part-time employee	57,4%	42,6%	24,4%	75,6%	95,6%	4,4%	86,7%	13,3%
	Self-employed	75,0%	25,0%	50,0%	50,0%	100,0%	0,0%	77,8%	22,2%
	Full-time employee	50,0%	50,0%	25,6%	74,4%	94,9%	5,1%	84,6%	15,4%
	Unemployed	60,7%	39,3%	30,0%	70,0%	100,0%	0,0%	100,0%	0,0%
	Student and part-time employee	36,4%	63,6%	20,0%	80,0%	100,0%	0,0%	95,0%	5,0%

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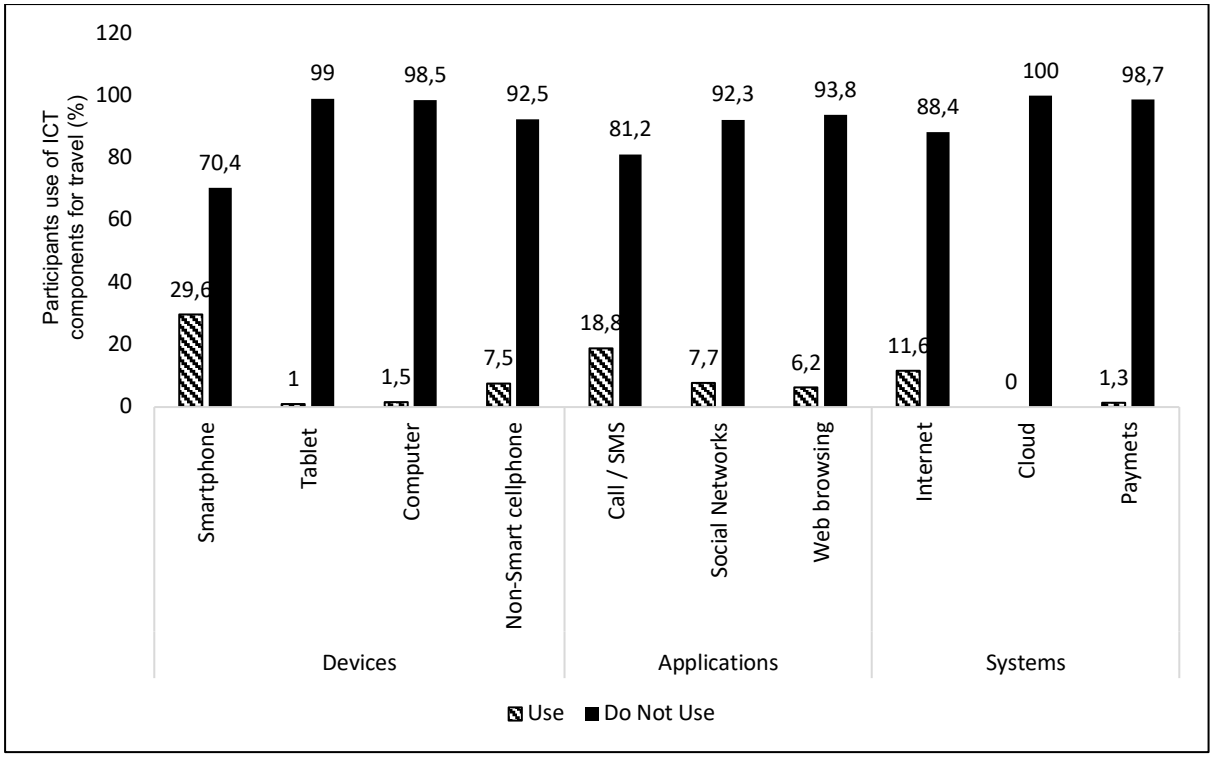

Figure 4.52: ICT components used for travel in Gaborone

Overall, 29.6% of the participants used their smartphones for travel purposes, and 7.5% used conventional, non-smart phones. A further 1.5% used computers, and 1% used computer tablets. A further 18.8% used calls and SMS technology, 7.7% used social networks and 6.2% browsed the web for travel-related reasons. In addition, 11.6% used the internet, and 1.3% used technology-based payment systems. None of the participants used cloud computing systems for travel-related reasons. Tables 4.21 to 4.23 show the use of devices, application and systems by participants from Gaborone by age, income and occupation.

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Table 4.21: ICT device usage by demographic grou

Demographic characteristics		ICT use for public transportation-related reasons		Use smartphone for travel purposes		Use tablet for travel purpose		Use computer for travel purpose		Use phone for travel purposes	
		No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
		N = 262	N = 122	N = 273	N = 115	N = 384	N = 4	N = 382	N = 6	N = 359	N = 29
Age of Participants (Years)	18-25	65,6%	34,4%	64,1%	35,9%	98,8%	1,2%	97,0%	3,0%	91,6%	8,4%
	26-35	66,9%	33,1%	69,7%	30,3%	98,6%	1,4%	100,0%	0,0%	91,7%	8,3%
	36-45	78,3%	21,7%	81,7%	18,3%	100,0%	0,0%	98,3%	1,7%	98,3%	1,7%
	46-55	68,8%	31,3%	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%	87,5%	12,5%
	55+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in BWP	P0 -P2500	66,5%	33,5%	67,4%	32,6%	98,9%	1,1%	97,1%	2,9%	89,7%	10,3%
	P2500 - P5000	71,0%	29,0%	65,6%	34,4%	96,9%	3,1%	100,0%	0,0%	96,9%	3,1%
	P5000 - P10 000	73,8%	26,2%	71,4%	28,6%	97,6%	2,4%	100,0%	0,0%	95,2%	4,8%
	P10 000 - P30 000	55,6%	44,4%	70,4%	29,6%	100,0%	0,0%	100,0%	0,0%	96,3%	3,7%
	P30 000 - P50 000	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%
	P50 000+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	61,1%	38,9%	64,8%	35,2%	98,4%	1,6%	96,1%	3,9%	90,6%	9,4%
	Part-time employee	78,6%	21,4%	75,9%	24,1%	100,0%	0,0%	100,0%	0,0%	96,6%	3,4%
	Self-employed	65,2%	34,8%	73,9%	26,1%	97,8%	2,2%	97,8%	2,2%	89,1%	10,9%
	Full-time employee	70,3%	29,7%	73,0%	27,0%	99,4%	,6%	100,0%	0,0%	93,7%	6,3%
	Unemployed	87,0%	13,0%	69,6%	30,4%	100,0%	0,0%	100,0%	0,0%	95,7%	4,3%
	Student and part-time employee	66,7%	33,3%	66,7%	33,3%	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%

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Table 4.22: ICT applications usage by demographi

Demographic characteristics		ICT use for public transportation-related reasons		Use of call/SMS for travel purposes		Use of Social Networks for travel purposes		Use of Web-browsing for travel purposes	
		No	Yes	No	Yes	No	Yes	No	Yes
		N = 262	N= 122	N = 315	N = 73	N = 358	N = 30	N = 364	N = 24
Age of Participants (Years)	18-25	65,6%	34,4%	74,9%	25,1%	90,4%	9,6%	92,8%	7,2%
	26-35	66,9%	33,1%	82,8%	17,2%	91,7%	8,3%	93,8%	6,2%
	36-45	78,3%	21,7%	93,3%	6,7%	96,7%	3,3%	95,0%	5,0%
	46-55	68,8%	31,3%	87,5%	12,5%	100,0%	0,0%	100,0%	0,0%
	55+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in BWP	P0 -P2500	66,5%	33,5%	77,1%	22,9%	89,7%	10,3%	94,3%	5,7%
	P2500 - P5000	71,0%	29,0%	87,5%	12,5%	87,5%	12,5%	90,6%	9,4%
	P5000 - P10 000	73,8%	26,2%	90,5%	9,5%	95,2%	4,8%	97,6%	2,4%
	P10 000 - P30 000	55,6%	44,4%	96,3%	3,7%	96,3%	3,7%	85,2%	14,8%
	P30 000 - P50 000	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%
	P50 000+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	61,1%	38,9%	73,4%	26,6%	90,6%	9,4%	93,8%	6,3%
	Part-time employee	78,6%	21,4%	82,8%	17,2%	86,2%	13,8%	96,6%	3,4%
	Self-employed	65,2%	34,8%	84,8%	15,2%	97,8%	2,2%	97,8%	2,2%
	Full-time employee	70,3%	29,7%	84,9%	15,1%	93,1%	6,9%	92,5%	7,5%
	Unemployed	87,0%	13,0%	87,0%	13,0%	91,3%	8,7%	91,3%	8,7%
	Student and part-time employee	66,7%	33,3%	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%

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Table 4.23: ICT systems usage by demographic gr

Demographic characteristics		ICT use for public transportation-related reasons		Use of internet for travel purposes		Use of Cloud computing / Storage for travel purposes		Use of Payments for travel purposes	
		No	Yes	No	Yes	No	Yes	No	Yes
		N = 262	N = 122	N = 343	N = 45	N = 388	N = 0	N = 383	N = 5
Age of Participants (Years)	18-25	65,6%	34,4%	86,8%	13,2%	100,0%	0,0%	98,8%	1,2%
	26-35	66,9%	33,1%	86,9%	13,1%	100,0%	0,0%	99,3%	0,7%
	36-45	78,3%	21,7%	93,3%	6,7%	100,0%	0,0%	96,7%	3,3%
	46-55	68,8%	31,3%	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%
	55+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in BWP	P0 -P2500	66,5%	33,5%	86,3%	13,7%	100,0%	0,0%	99,4%	0,6%
	P2500 - P5000	71,0%	29,0%	90,6%	9,4%	100,0%	0,0%	96,9%	3,1%
	P5000 - P10 000	73,8%	26,2%	90,5%	9,5%	100,0%	0,0%	100,0%	0,0%
	P10 000 - P30 000	55,6%	44,4%	85,2%	14,8%	100,0%	0,0%	96,3%	3,7%
	P30 000 - P50 000	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%
	P50 000+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	61,1%	38,9%	84,4%	15,6%	100,0%	0,0%	99,2%	0,8%
	Part-time employee	78,6%	21,4%	89,7%	10,3%	100,0%	0,0%	100,0%	0,0%
	Self-employed	65,2%	34,8%	91,3%	8,7%	100,0%	0,0%	95,7%	4,3%
	Full-time employee	70,3%	29,7%	89,9%	10,1%	100,0%	0,0%	98,7%	1,3%
	Unemployed	87,0%	13,0%	91,3%	8,7%	100,0%	0,0%	100,0%	0,0%
	Student and part-time employee	66,7%	33,3%	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%

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The use of ICT components for travel by different demographic groups implies that there was a keen interest towards the technologies used.

4.12.3 Factors influencing ICT use for public transportation

Binary probit models were developed to determine the factors influencing the use of ICT for public transportation in both study areas. These factors are potential contributors to ICT-enabled public transportation. In this case, the event that IC technologies were used for public transportation-related reasons was used as the dependant variable. Various independent variables, which were determined by their normality as well as significance values ($p < 0.05$) were applied to each city's model.

4.12.4 ICT use for public transportation in Bloemfontein

Variables used to determine ICT use for public transportation in Bloemfontein were tested for normality using skewness and kurtosis tests. The normality test results are shown in Table 4.24

Table 4.24: Normality tests for ICT use for public transportation - Bloemfontein

	ICT use for public transportation-related reasons	Internet access	Time spent in the internet for transportation-related reasons	Data used for transportation purposes per month (Mb)
Std. Deviation	0,501	0,312	0,987	0,533
Skewness	0,000	-2,520	1,572	1,688
Std. Error of Skewness	0,121	0,121	0,126	0,130
Kurtosis	-2,010	4,373	1,922	3,898
Std. Error of Kurtosis	0,242	0,242	0,251	0,260

The data was acceptable for further analysis. The hypothesis that people with internet access and their use of internet, in other words mobile data, and the time they spent on the internet influenced whether or not they used ICT for transportation.

The binary probit analysis results and model are discussed below.

From a total number of 258 observations (N = 258), 46.9% (N = 121) of the participants did not use ICT for public transport and therefore responded 'No', while 53.1% (N =

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137) used ICT for public transportation, responding 'Yes'. The model was used to predict whether or not ICT use for public transportation-related reasons is influenced by internet access, time spent on the internet for transportation-related reasons and the amount of data used for transport related purposes.

$$x_1 = Internet\ access$$
$$x_2 = Time\ spent\ on\ the\ internet\ for\ transportation\ related\ reasons$$
$$x_3 = Data\ used\ on\ transportation\ per\ month$$

The omnibus test produced results that indicated that the model was significant: Likelihood ratio chi-square (103.815), DF (3), significance (0.000). The following model parameters were produced.

Table 4.25: Regression coefficients for ICT use for public transportation model - Bloemfontein

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-1,977	0,4483	-2,856	-1,098	19,444	1	0,000
Internet access	1,522	0,4468	0,646	2,398	11,604	1	0,001
Time on internet for transport	0,630	0,1102	0,414	0,846	32,690	1	0,000
Data for transport	0,743	0,1900	0,370	1,115	15,286	1	0,000

Table 4.25 shows the coefficient and significance statistics of the variables used in the Bloemfontein model. The analysis produced a significant model. Internet access, time spent on the internet and the amount of data used for transportation-related reasons were positive and significant variables towards the model ($p < 0.05$). The Wald chi-square statistics also indicated that the variables contributed significantly to the model.

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There was a positive regression slope for internet access, time spent on the internet for transportation and data usage for transport.

This meant that:

a) People with internet access were more likely to use ICT for public transportation-related reasons than those without internet access;
b) People spending more time on the internet were likely to use that time for transportation-related purposes;
c) People who used more data for transportation were likely to be those who used ICT for public transportation-related reasons.

4.12.5 ICT use for public transportation in Gaborone

The Binary Probit Model developed for Gaborone estimated the probability of ICT use for public transportation-related reasons. The model was based on the hypothesis that ICT use for public transportation in the city was influenced by internet access, smartphone use and use of calls and SMS. Normality tests conducted on the data produced the results shown in Table 4.26, which were acceptable for further analysis of the data.

Table 4.26: Normality tests for ICT use for public transportation - Gaborone

	Internet access	Use of smartphone for travel purposes	Use of Call/SMS for travel purposes	ICT use for public transportation-related reasons
Std. Deviation	0,284	0,457	0,391	0,466
Skewness	-2,908	0,895	1,602	0,786
Std. Error of Skewness	0,125	0,124	0,124	0,125
Kurtosis	6,491	-1,205	0,570	-1,389
Std. Error of Kurtosis	0,248	0,247	0,247	0,248

$$x_1 = Internet\ access$$
$$x_2 = Use\ of\ smartphone\ for\ travel\ purposes$$
$$x_3 = Use\ of\ call\ or\ SMS\ for\ travel\ purposes$$

The model employed “Yes” and “No” as the responses to whether participants used ICT for public transportation. The “Yes” response was treated as the response, while

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"No" was used as the reference category. A total of 68.2% (N = 262) did not use ICT for public transportation, while 31.8% (N = 122) used ICT for public transportation-related reasons.

The overall model was significant as per the omnibus test, which produced the following statistics: Likelihood ratio chi-square (34.551), DF (3) and P (0.000).

Table 4.27: Regression coefficients for ICT use for public transportation model - Gaborone

			95% Wald Confidence Interval		Hypothesis Test		
Parameter	B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-1,345	0,2913	-1,916	-,774	21,319	1	0,000
Internet access	0,672	0,2986	0,086	1,257	5,057	1	0,025
Smartphone	0,446	0,1703	0,112	0,779	6,849	1	0,009
Call/ SMS	0,467	0,1957	0,084	0,851	5,699	1	0,017

Table 4.27 displays the coefficients of the model. These results indicate that ICT use for public transportation was significantly influenced by factors relating to basic ICT access, smartphone access, internet access and the use of phone calls and SMS. These independent variables were all positive predictors of the model. All the independent variables were significant, with p-values of less than 0.05.

Internet access, smartphone usage and call/SMS usage positively influenced ICT usage for public transportation-related reasons. The model could be interpreted by the following:

a) ICT usage for public transportation in Gaborone was used by those with internet access.
b) Smartphone users were likely to use ICT for public transportation-related reason.
c) Call and SMS were the ICT technologies mostly used for public transportation.

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The models for both cities showed that ICT use for public transportation could be explained by factors associated with ICT access. These factors can be used to determine areas of improvement of access to ICT in an effort to support ICT-enabled public transportation in both areas. The purposes of the ICT component used have been described below.

4.12.6 Purposes of ICT components in travel

Smartphones were used for calling cabs, calling relatives to arrange pick-ups at bus stops, and for WhatsApp texting with service providers and general communication with cab drivers. Other uses of smartphones were to request directions, check vehicle departure times, make bookings online, and access the internet for social media purposes. Smart phones were also used for traffic updates and entertainment during trips.

Computers and tablets were used for GPS navigation, and for internet browsing to make online bookings. Non-smart phones were used to call cabs and taxis. Calls and SMS were used to book cabs and for communication with service providers. Social networks were used mainly for entertainment during the trip, and to share locations with friends. Web-browsing was used mostly for navigation, checking weather updates, buying bus tickets, downloading maps, doing research about destinations, and making bookings online.

The internet was used for browsing, as it hosts access to entertainment, maps and websites, as well as social network applications. Only one participant in Bloemfontein used cloud computing for backing up pictures from leisure trips. None of the participants in Gaborone used cloud computing.

Payment systems were used to make online payments for bookings, and for electronic payment systems to pay for cab services using bank cards. In Gaborone, 33.3% of the participants, who used payment systems for travel, used technology-based payment systems for airline bookings, card payments for long-distance buses, and paying for fuel.

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4.13 The Internet and Travel

4.13.1 Time spent on the internet

The time spent on the internet, and the part of that time used for travel purposes, were also evaluated. The results showing the relationship between total time spent on the internet daily and time spent on the internet for travel reasons are presented in Figure 4.53 and Figure 4.54 below.

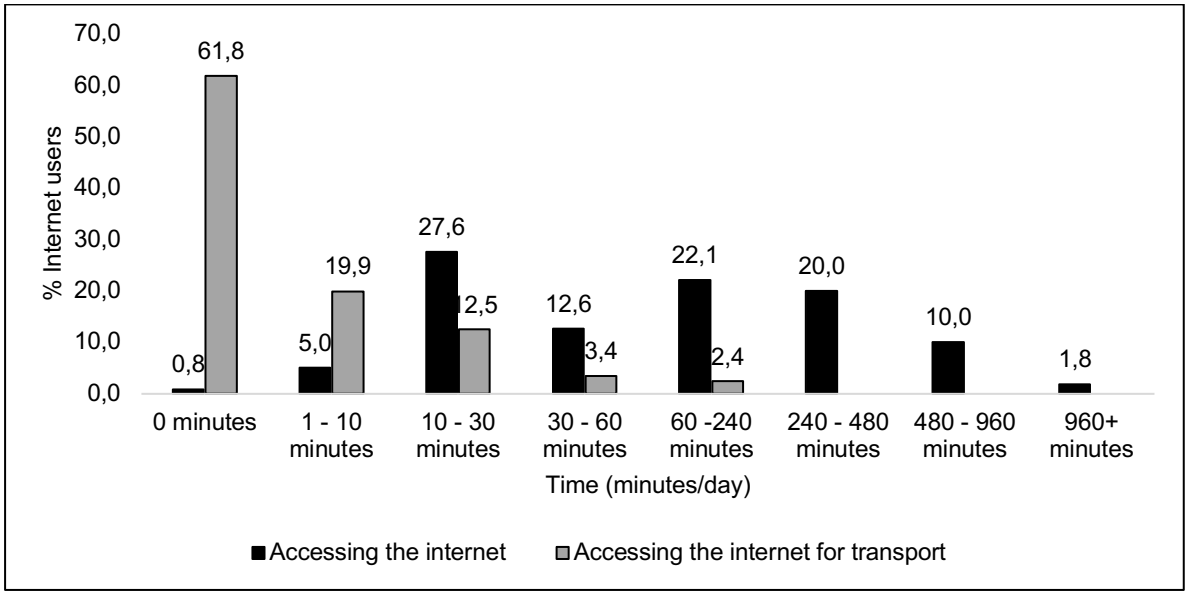

Figure 4.53: Time spent on the internet for travel purposes in Bloemfontein

Figure 4.53 shows the time the participants spent on the internet per day and the part of that time spent on the internet for reasons related to transportation and travel. Overall, 0.8% of the participants did not spend any time on the internet, while 5% spent 1 to 10 minutes on the internet daily. A further 27.6% spent 10 to 30 minutes on the internet, 12.6.% spent 30 to 60 minutes, and 22.1% spent 60 to 240 minutes daily on the internet. Furthermore, 20% spent 240 to 480 minutes, 10% spent 480 to 960 minutes, and 1.8% spent over 960 minutes on the internet on a daily basis. However, 61.8% of the participants did not spend any of their time on the internet for reasons related to travel and transportation, while 19.9% spent less than 10 minutes on the internet for travel purposes, 12.5% spent 10 to 30 minutes, 3.4% spent 30 to 60 minutes, and 2.4% spent 60 to 240 minutes per day on the internet for purposes related to transportation and travel.

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As shown in Figure 4.53, less time was spent on the internet for travel reasons, compared with the overall time spent on the internet. A deeper analysis of these results, based upon demographic groups as shown in tables 4.28 and 4.29, paints a picture regarding the characteristics of people using the internet and the time they spent on the internet. People over 46 years of age spent less time on the internet compared to those between the ages of 25 and 45 years old, while the 18 to 25 years age group spent most of the time on the internet.

However, the demographic groups did not have a significant impact on the amount of time spent on the internet for travel and transportation-related reasons. This is attributed to the limited ICT usage for travel.

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Table 4.28: Time spent on the internet by demogra[illegible]ntein)

		Time spent accessing internet daily							
		0 minutes	1 - 10 minutes	10 - 30 minutes	30 - 60 minutes	60 -240 minutes	240 - 480 minutes	480 - 960 minutes	960+ minutes
		N = 3	N = 19	N = 105	N = 48	N = 84	N = 76	N = 38	N = 7
Age of Participants (Years)	18-25	0,0%	6,3%	19,5%	13,3%	21,9%	23,4%	11,7%	3,9%
	26-35	0,0%	5,0%	37,5%	10,6%	20,6%	17,5%	8,1%	0,6%
	36-45	0,0%	3,2%	24,2%	14,5%	22,6%	22,6%	11,3%	1,6%
	46-55	11,1%	3,7%	18,5%	14,8%	29,6%	11,1%	11,1%	0,0%
	55+	0,0%	0,0%	0,0%	33,3%	33,3%	33,3%	0,0%	0,0%
Participants' monthly income in ZAR	R0 -R 2500	0,0%	4,4%	30,4%	12,6%	22,2%	18,5%	8,9%	3,0%
	R2500 - R5000	0,0%	7,9%	32,7%	13,9%	14,9%	18,8%	10,9%	1,0%
	R5000 - R10 000	0,0%	1,9%	28,8%	5,8%	26,9%	32,7%	1,9%	1,9%
	R10 000 - R30 000	3,6%	4,8%	16,7%	15,5%	27,4%	15,5%	15,5%	1,2%
	R30 000 - R50 000	0,0%	0,0%	28,6%	0,0%	28,6%	28,6%	14,3%	0,0%
	R50 000+	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	0,0%	5,6%	22,2%	12,0%	21,3%	18,5%	15,7%	4,6%
	Part-time employee	0,0%	2,0%	41,2%	7,8%	17,6%	27,5%	3,9%	0,0%
	Self-employed	0,0%	7,7%	15,4%	7,7%	26,9%	34,6%	7,7%	0,0%
	Full-time employee	2,0%	6,7%	34,2%	12,8%	23,5%	12,1%	8,1%	0,7%
	Unemployed	0,0%	0,0%	4,2%	25,0%	25,0%	29,2%	12,5%	4,2%
	Student and part-time employee	0,0%	0,0%	18,2%	18,2%	18,2%	36,4%	9,1%	0,0%

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Table 4.29: Time spent of the internet for travel by [illegible]n Bloemfontein

Demographic characteristics		Time spent in the internet for transportation-related reasons							
		0 minutes	1 - 10 minutes	10 - 30 minutes	30 - 60 minutes	60 -240 minutes	240 - 480 minutes	480 - 960 minutes	960+ minutes
		N = 233	N = 75	N = 47	N = 13	N = 9	N= 0	N = 0	N = 0
Age of Participants (Years)	18-25	53,4%	25,2%	13,0%	4,6%	3,8%	0,0%	0,0%	0,0%
	26-35	67,9%	16,0%	13,5%	1,9%	0,6%	0,0%	0,0%	0,0%
	36-45	67,2%	16,4%	8,2%	4,9%	3,3%	0,0%	0,0%	0,0%
	46-55	55,6%	22,2%	14,8%	3,7%	3,7%	0,0%	0,0%	0,0%
	55+	50,0%	50,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in ZAR	R0 -R 2500	62,6%	19,4%	12,9%	1,4%	3,6%	0,0%	0,0%	0,0%
	R2500 - R5000	53,1%	25,0%	12,5%	6,3%	3,1%	0,0%	0,0%	0,0%
	R5000 - R10 000	72,0%	12,0%	14,0%	2,0%	0,0%	0,0%	0,0%	0,0%
	R10 000 - R30 000	62,4%	20,0%	11,8%	4,7%	1,2%	0,0%	0,0%	0,0%
	R30 000 - R50 000	85,7%	14,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	R50 000+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	55,0%	22,5%	13,5%	4,5%	4,5%	0,0%	0,0%	0,0%
	Part-time employee	70,0%	12,0%	12,0%	4,0%	2,0%	0,0%	0,0%	0,0%
	Self-employed	76,9%	15,4%	3,8%	3,8%	0,0%	0,0%	0,0%	0,0%
	Full-time employee	65,5%	20,7%	11,0%	2,1%	0,7%	0,0%	0,0%	0,0%
	Unemployed	60,9%	13,0%	13,0%	4,3%	8,7%	0,0%	0,0%	0,0%
	Student and part-time employee	36,4%	31,8%	27,3%	4,5%	0,0%	0,0%	0,0%	0,0%

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Figure 4.54 shows the contrast in time spent on the internet per day and time spent on the internet for travel purposes by participants in Gaborone. Tables 4.30 and 4.31 show an in-depth view into the results by age group, income group and occupation.

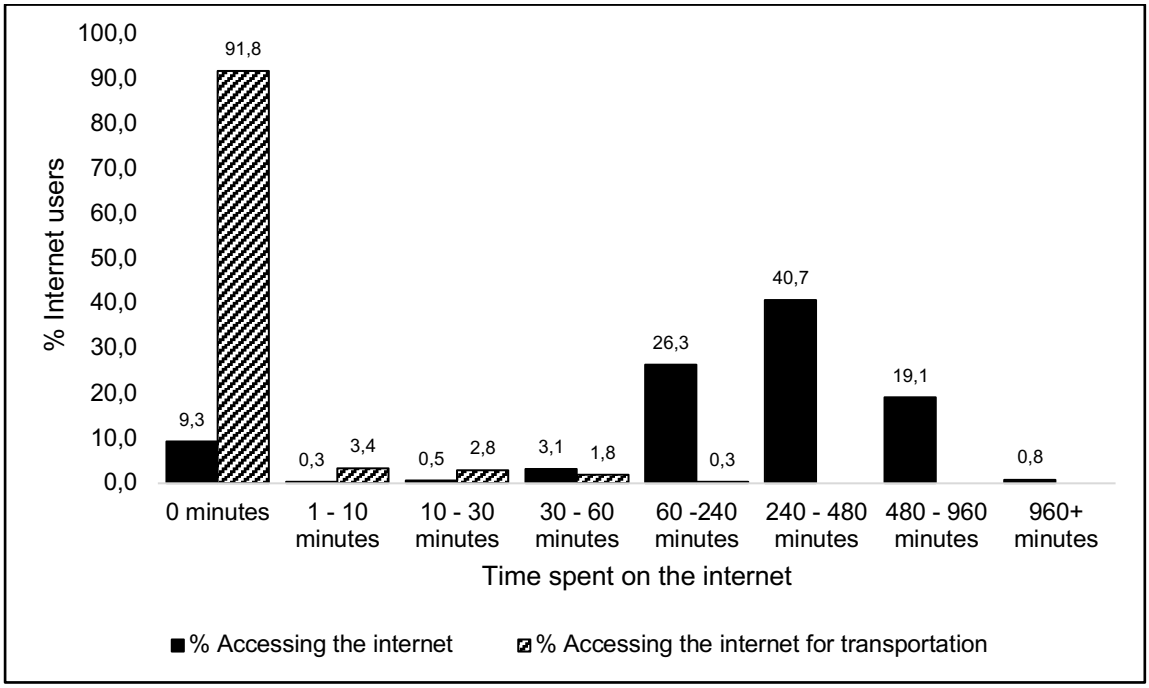

Figure 4.54: Time spent on the internet for travel purposes in Gaborone

A total of 9.3% of the participants did not spend any time on the internet, 0.3% spent less than 10 minutes and 0,5 % spent 10 to 30 minutes on the internet. A further 3.1% spent 30 to 60 minutes and 26.3% spent 60 to 240 minutes surfing the net. A total of of 40.7% of the participants spent 240 to 480 minutes per day on the internet, and 19.1% spent between 480 and 960 minutes there, while only 0.8% spent more than 960 minutes on the internet daily.

Analysis of the time spent on the internet for reasons related to transportation showed that 91.8% of the participants did not spend any of their time on the internet for travel and transportation purposes, 3.4% spent less than 10 minutes there and 2.8% spent 10 to 30 minutes, 1.8% spent 30 to 60 minutes, and 0.3% spent 60 to 120 minutes on the internet for travel information.

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Table 4.30: Time spent on the internet by demogra[illegible]ne

Demographic characteristics		Time spent accessing internet daily							
		0 minutes	1 - 10 minutes	10 - 30 minutes	30 - 60 minutes	60 -240 minutes	240 - 480 minutes	480 - 960 minutes	960+ minutes
		N = 36	N = 1	N = 2	N =12	N = 102	N = 158	N = 74	N = 3
Age of Participants (Years)	18-25	6,0%	0,0%	0,0%	4,2%	25,1%	37,1%	26,3%	1,2%
	26-35	9,7%	0,7%	0,7%	2,1%	24,8%	46,2%	15,2%	0,7%
	36-45	13,3%	0,0%	0,0%	3,3%	31,7%	38,3%	13,3%	0,0%
	46-55	25,0%	0,0%	6,3%	0,0%	31,3%	37,5%	0,0%	0,0%
	55+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in BWP	P0 -P2500	13,1%	,6%	1,1%	3,4%	17,7%	41,1%	21,7%	1,1%
	P2500 - P5000	12,5%	0,0%	0,0%	0,0%	28,1%	43,8%	15,6%	0,0%
	P5000 - P10 000	4,8%	0,0%	0,0%	7,1%	35,7%	45,2%	7,1%	0,0%
	P10 000 - P30 000	3,7%	0,0%	0,0%	0,0%	29,6%	44,4%	18,5%	3,7%
	P30 000 - P50 000	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%
	P50 000+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	4,7%	0,0%	0,8%	3,1%	24,2%	40,6%	25,0%	1,6%
	Part-time employee	3,4%	3,4%	0,0%	0,0%	37,9%	37,9%	17,2%	0,0%
	Self-employed	23,9%	0,0%	2,2%	0,0%	26,1%	32,6%	15,2%	0,0%
	Full-time employee	9,4%	0,0%	0,0%	3,8%	25,8%	44,7%	15,7%	0,6%
	Unemployed	8,7%	0,0%	0,0%	8,7%	30,4%	30,4%	21,7%	0,0%
	Student and part-time employee	33,3%	0,0%	0,0%	0,0%	0,0%	66,7%	0,0%	0,0%

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Table 4.31: Time spent of the internet for transportation purposes by demographic groups - Gaborone

Demographic characteristics		Time spent in the internet for transportation-related reasons							
		0 minutes	1 - 10 minutes	10 - 30 minutes	30 - 60 minutes	60 -240 minutes	240 - 480 minutes	480 - 960 minutes	960+ minutes
		N = 256	N = 13	N = 11	N = 7	N = 0	N = 1	N = 0	N = 0
Age of Participants (Years)	18-25	89,8%	5,4%	2,4%	1,8%	0,0%	0,6%	0,0%	0,0%
	26-35	92,4%	1,4%	3,4%	2,8%	0,0%	0,0%	0,0%	0,0%
	36-45	93,3%	3,3%	3,3%	0,0%	0,0%	0,0%	0,0%	0,0%
	46-55	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	55+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in BWP	P0 -P2500	92,0%	4,0%	2,3%	1,1%	0,0%	0,6%	0,0%	0,0%
	P2500 - P5000	93,8%	3,1%	0,0%	3,1%	0,0%	0,0%	0,0%	0,0%
	P5000 - P10 000	90,5%	2,4%	4,8%	2,4%	0,0%	0,0%	0,0%	0,0%
	P10 000 - P30 000	77,8%	3,7%	14,8%	3,7%	0,0%	0,0%	0,0%	0,0%
	P30 000 - P50 000	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	P50 000+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	89,1%	5,5%	2,3%	2,3%	0,0%	0,8%	0,0%	0,0%
	Part-time employee	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Self-employed	91,3%	2,2%	4,3%	2,2%	0,0%	0,0%	0,0%	0,0%
	Full-time employee	92,5%	2,5%	3,1%	1,9%	0,0%	0,0%	0,0%	0,0%
	Unemployed	91,3%	4,3%	4,3%	0,0%	0,0%	0,0%	0,0%	0,0%
	Student and part-time employee	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

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The results indicated that the use of the internet for travel purposes was uncommon in both study areas, and the limited use might have been by people travelling by cabs and travelling out of the cities.

4.13.2 Costs of ICT for transportation reasons

The cost of access to ICT in terms of airtime and data for travel and transportation reasons in both cities was investigated further. Monthly data costs for participants in Bloemfontein are shown in Figure 4.55 and for those in Gaborone are shown in Figure 4.56.

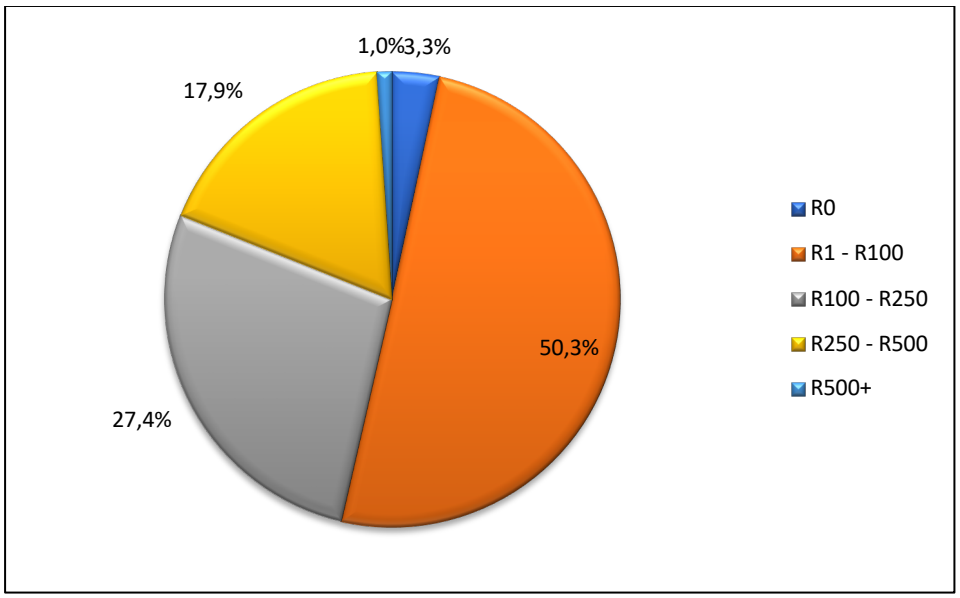

Figure 4.55: Monthly data costs - Bloemfontein

A 50.3% majority spent between R1.00 and R100.00 on data on a monthly basis, while 27.4% spent between R100.00 and R250.00, and 17.9% spent between R250.00 and R500.00. A further 1%% spent over R500.00 on data per month, while 3.3% of the participants did not spend any money on data. The cost of data by age group, income and occupation is shown in Table 4.32.

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Table 4.32: Money spent on data by demographic c

Demographic characteristics		Money spent on data per month				
		R0	R1 - R100	R100 - R250	R250 - R500	R500+
		N = 13	N = 196	N = 107	N = 70	N = 4
Age of Participants (Years)	18-25	1,5%	49,6%	25,2%	23,7%	0,0%
	26-35	2,5%	56,5%	24,8%	14,3%	1,9%
	36-45	6,2%	43,1%	35,4%	13,8%	1,5%
	46-55	11,1%	33,3%	33,3%	22,2%	0,0%
	55+	0,0%	50,0%	50,0%	0,0%	0,0%
Participants' monthly income in ZAR	R0 -R 2500	2,8%	59,6%	20,6%	17,0%	0,0%
	R2500 - R5000	1,0%	50,0%	30,4%	17,6%	1,0%
	R5000 - R10 000	5,8%	46,2%	34,6%	13,5%	0,0%
	R10 000 - R30 000	5,7%	39,1%	31,0%	21,8%	2,3%
	R30 000 - R50 000	0,0%	42,9%	28,6%	14,3%	14,3%
	R50 000+	0,0%	0,0%	0,0%	100,0%	0,0%
Occupation	Student	2,6%	46,1%	27,8%	22,6%	,9%
	Part-time employee	1,9%	56,6%	28,3%	13,2%	0,0%
	Self-employed	3,8%	50,0%	19,2%	23,1%	3,8%
	Full-time employee	5,3%	47,7%	31,1%	14,6%	1,3%
	Unemployed	0,0%	60,9%	21,7%	17,4%	0,0%
	Student and part-time employee	0,0%	63,6%	13,6%	22,7%	0,0%

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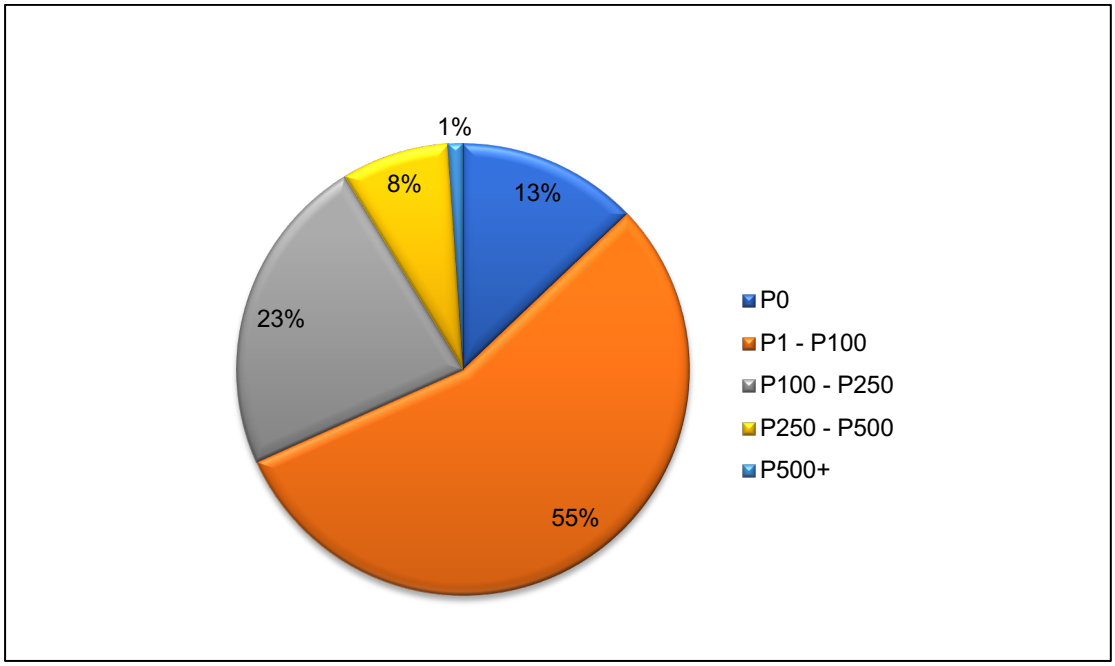

BWP = Botswana Pula (P)

Figure 4.56: Monthly data costs in Gaborone (BWP)

Overall, 55.4% spent between P1.00 and P100.00, and 22.9% spent between P100.00 and P250.00 on data per month. Furthermore, 7.7% spent P250.00 to P500.00. In addition, 1% of participants spent over P500.00 on data, and 12.9% did not spend any money on data. The results are further elaborated by age group, income and occupation as shown in Table 4.33.

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Table 4.33: Money spent on data by demographic c

Demographic characteristics		Money spent on data per month				
		P0	P1 - P100	P100 - P250	P250 - P500	P500+
		N = 50	N = 215	N = 89	N = 30	N = 4
Age of Participants (years)	18-25	12,0%	64,7%	16,8%	5,4%	1,2%
	26-35	11,0%	56,6%	24,1%	7,6%	0,7%
	36-45	15,0%	35,0%	31,7%	16,7%	1,7%
	46-55	31,3%	25,0%	43,8%	0,0%	0,0%
	55+	0,0%	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in BWP	P0 -P2500	18,9%	62,9%	14,3%	2,9%	1,1%
	P2500 - P5000	15,6%	56,3%	21,9%	3,1%	3,1%
	P5000 - P10 000	4,8%	54,8%	33,3%	7,1%	0,0%
	P10 000 - P30 000	3,7%	33,3%	37,0%	25,9%	0,0%
	P30 000 - P50 000	0,0%	100,0%	0,0%	0,0%	0,0%
	P50 000+	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	9,4%	67,2%	18,8%	3,9%	0,8%
	Part-time employee	10,3%	72,4%	17,2%	0,0%	0,0%
	Self-employed	26,1%	39,1%	26,1%	8,7%	0,0%
	Full-time employee	11,9%	47,8%	27,7%	10,7%	1,9%
	Unemployed	17,4%	52,2%	13,0%	17,4%	0,0%
	Student and part-time employee	0,0%	66,7%	33,3%	0,0%	0,0%

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64.7% of those aged between 18 and 25 spent less than P100 on mobile data, while 25.9% of those earning a monthly income of between P10 000 and P30 000 spent P100 – P250 on mobile data per month. Most of those who did not spend any amount of money on mobile data were 26.1% of self-employed people, 18.9% of those earning below P2500 and 31.3% of people aged between 46 to 55 years. In Gaborone, all mobile network service providers offer monthly data packages to access social networking platforms at for instance, P60.00 per month for 200 Mb/day. For this reason, most of the participants spent less than P100.00 per month on data. People spending more than P100.00 might have been those subscribing to data packages including access to email and web-browsing applications.

4.13.3 Use of mobile data for travel

The amount of mobile data used by participants monthly, their general data usage, and use of data for transportation reasons are shown in Figure 4.57 for Bloemfontein and Figure 4.58 for Gaborone.

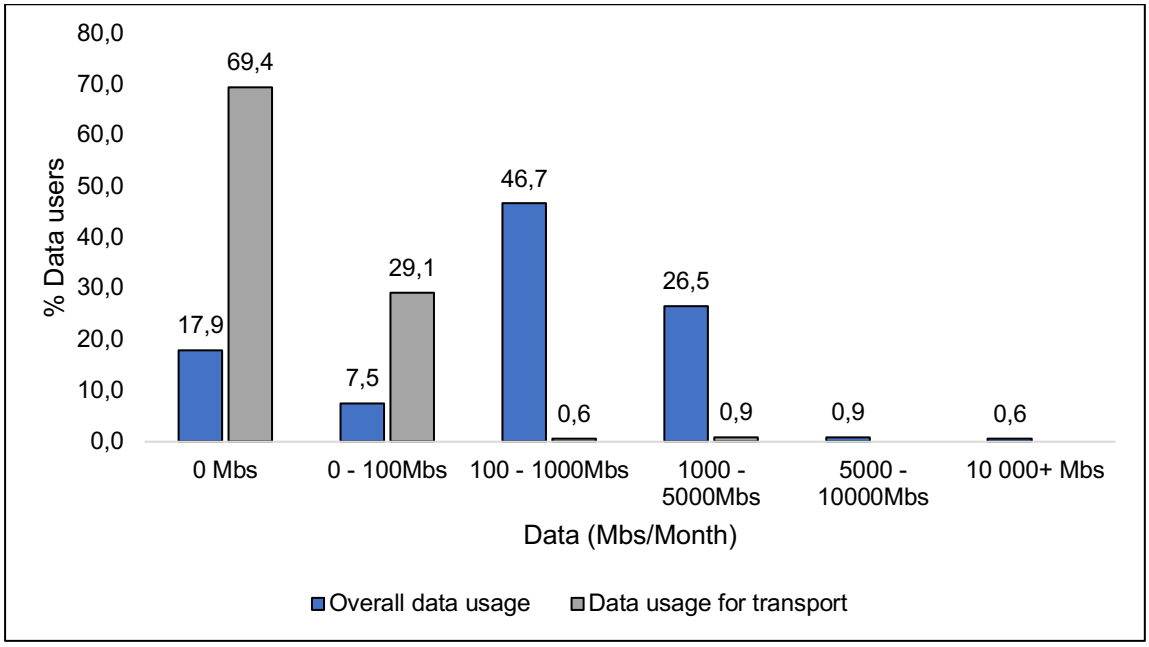

Figure 4.57: Monthly mobile data usage - Bloemfontein

Figure 4.57 shows the amount of data used by participants in Bloemfontein on a monthly basis and the amount of that data used for transportation-related purposes. A total of 46.7% of the participants used 100-1000 Mb of data per month, while 26.5%

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used 1000 to 5000Mbs. Furthermore, 7.5% used 0 to 100 Mb monthly, while 17.9% did not use any mobile data per month.

In addition, 69.4% of the participants did not use any data for purposes related to transportation and travel, while 29.1% used less than 100 Mb, 1.1% used 100-500 Mb, and 0.3% used 1- 5 GB for transportation-related reasons.

Table 4.34 shows data usage in Bloemfontein by demographic groups, while Table 4.35 shows data usage for transportation purposes by age, income and occupation.

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Table 4.34: Monthly mobile data usage by demogr[illegible]ontein

Demographic characteristics		Data spent per month (Mb)					
		0 Mbs	0 - 100Mbs	100 - 1000Mbs	1000 - 5000Mbs	5000 - 10000Mbs	10 000+ Mbs
		N = 62	N = 26	N = 162	N = 92	N = 3	N = 2
Age of Participants (Years)	18-25	15,9%	7,9%	44,4%	31,0%	,8%	0,0%
	26-35	14,0%	6,6%	58,1%	20,6%	0,0%	,7%
	36-45	21,7%	6,7%	41,7%	28,3%	1,7%	0,0%
	46-55	36,4%	13,6%	9,1%	36,4%	0,0%	4,5%
	55+	66,7%	0,0%	0,0%	0,0%	33,3%	0,0%
Participants' monthly income in ZAR	R0 -R 2500	17,8%	10,1%	50,4%	20,9%	,8%	0,0%
	R2500 - R5000	12,4%	5,6%	51,7%	28,1%	1,1%	1,1%
	R5000 - R10 000	23,8%	9,5%	33,3%	33,3%	0,0%	0,0%
	R10 000 - R30 000	21,5%	5,1%	43,0%	29,1%	0,0%	1,3%
	R30 000 - R50 000	14,3%	0,0%	42,9%	28,6%	14,3%	0,0%
	R50 000+	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%
Occupation	Student	15,7%	5,6%	47,2%	30,6%	,9%	0,0%
	Part-time employee	12,2%	12,2%	51,0%	22,4%	2,0%	0,0%
	Self-employed	4,0%	20,0%	40,0%	32,0%	4,0%	0,0%
	Full-time employee	19,8%	4,0%	47,6%	27,0%	0,0%	1,6%
	Unemployed	40,0%	10,0%	45,0%	5,0%	0,0%	0,0%
	Student and part-time employee	26,3%	10,5%	36,8%	26,3%	0,0%	0,0%

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Table 4.35: Monthly mobile data usage for transpo emographic group - Bloemfontein

Demographic characteristics		Data used for transportation purposes per month (Mb)					
		0 Mbs	0 - 100Mbs	100 - 1000Mbs	1000 - 5000Mbs	5000 - 10000Mbs	10 000+ Mbs
		N = 243	N = 102	N = 2	N = 3	N = 0	N = 0
Age of Participants (Years)	18-25	65,5%	31,9%	1,7%	,9%	0,0%	0,0%
	26-35	73,3%	26,0%	0,0%	,7%	0,0%	0,0%
	36-45	69,5%	28,8%	0,0%	1,7%	0,0%	0,0%
	46-55	63,6%	36,4%	0,0%	0,0%	0,0%	0,0%
	55+	66,7%	33,3%	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in ZAR	R0 -R 2500	72,2%	27,0%	0,0%	,8%	0,0%	0,0%
	R2500 - R5000	68,1%	29,8%	2,1%	0,0%	0,0%	0,0%
	R5000 - R10 000	64,4%	35,6%	0,0%	0,0%	0,0%	0,0%
	R10 000 - R30 000	67,5%	29,9%	0,0%	2,6%	0,0%	0,0%
	R30 000 - R50 000	85,7%	14,3%	0,0%	0,0%	0,0%	0,0%
	R50 000+	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	67,3%	30,7%	2,0%	0,0%	0,0%	0,0%
	Part-time employee	73,5%	26,5%	0,0%	0,0%	0,0%	0,0%
	Self-employed	95,7%	4,3%	0,0%	0,0%	0,0%	0,0%
	Full-time employee	64,4%	34,1%	0,0%	1,5%	0,0%	0,0%
	Unemployed	87,0%	13,0%	0,0%	0,0%	0,0%	0,0%
	Student and part-time employee	52,6%	42,1%	0,0%	5,3%	0,0%	0,0%

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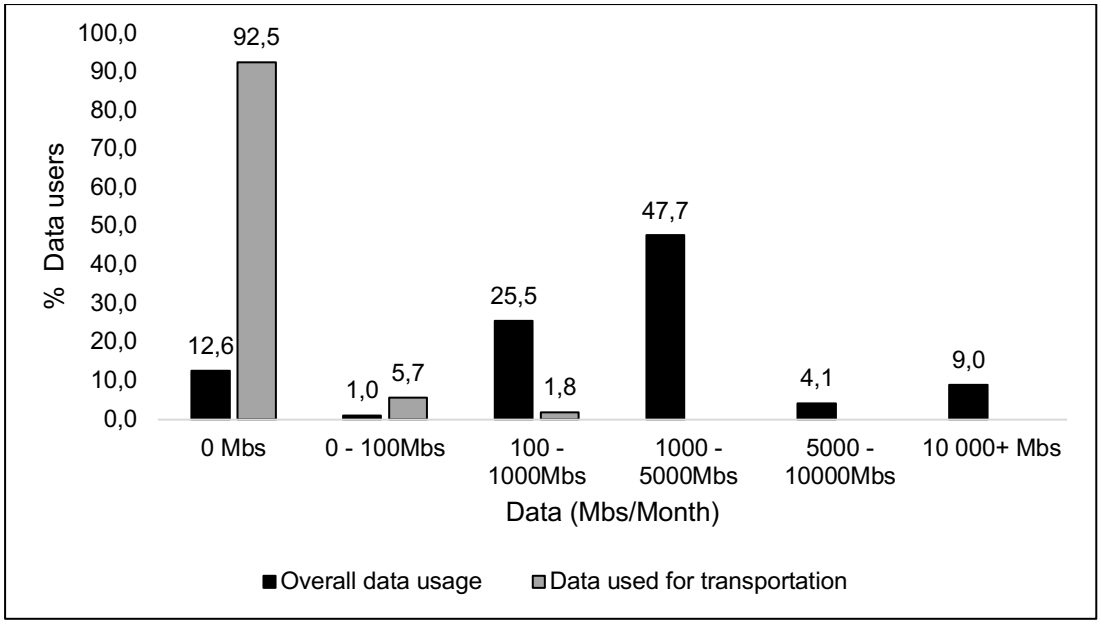

Figure 4.58: Monthly mobile data usage - Gaborone

Figure 4.58 shows the amount of data used per month and the amount of that data used for travel and transportation purposes in Gaborone. A total of 47.7% of the participants used data of between 1000Mbs and 5000Mbs per month, , while 25.5 % used between 100 Mb and 100 Mbs. Furthermore, 4.1% used 5000 Mbs and 10 000Mbs, while 9% used data of more than 10 000Mbs. Only 1% used a total of less than 100Mbs, while 12.6% did not use any data. The amount of this data used for transportation and travel reasons is also shown, indicating that an overwhelming 92.5% of participants did not use the data for any reasons associated with travel. Only 5.7% of the participants who actually used the data for travel, used less than 100Mbs, while 1.8% used data of more than 100Mbs but less than 1000Mbs for transportation purposes. Overall data usage and data usage for transportation-related purposes by demographic groups in Gaborone is shown in Tables 4.36 and 4.37, respectively.

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Table 4.36: Monthly mobile data usage by demogr[illegible]one

Demographic characteristics		Data spent per month (Mb)					
		0 Mbs	0 - 100Mbs	100 - 1000Mbs	1000 - 5000Mbs	5000 - 10000Mbs	10 000+ Mbs
		N = 59	N= 4	N = 99	N =185	N = 16	N = 35
Age of Participants (Years)	18-25	11,4%	1,2%	26,9%	46,7%	4,2%	9,6%
	26-35	11,0%	0,7%	24,1%	47,6%	5,5%	11,0%
	36-45	15,0%	1,7%	25,0%	53,3%	1,7%	3,3%
	46-55	31,3%	0,0%	25,0%	37,5%	0,0%	6,3%
	55+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in BWP	P0 -P2500	18,3%	0,6%	24,0%	45,1%	5,1%	6,9%
	P2500 - P5000	15,6%	6,3%	25,0%	31,3%	3,1%	18,8%
	P5000 - P10 000	4,8%	0,0%	23,8%	59,5%	2,4%	9,5%
	P10 000 - P30 000	3,7%	0,0%	22,2%	59,3%	3,7%	11,1%
	P30 000 - P50 000	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%
	P50 000+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	10,2%	1,6%	26,6%	52,3%	5,5%	3,9%
	Part-time employee	10,3%	0,0%	37,9%	41,4%	6,9%	3,4%
	Self-employed	23,9%	0,0%	23,9%	43,5%	4,3%	4,3%
	Full-time employee	12,6%	0,6%	23,9%	46,5%	2,5%	13,8%
	Unemployed	8,7%	4,3%	17,4%	47,8%	4,3%	17,4%
	Student and part-time employee	0,0%	0,0%	33,3%	33,3%	0,0%	33,3%

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Table 4.37: Monthly mobile data usage for transpo emographic groups -Gaborone

Demographic characteristics		Data used for transportation purposes per month (Mb)					
		0 Mbs	0 - 100Mbs	100 - 1000Mbs	1000 - 5000Mbs	5000 - 10000Mbs	10 000+ Mbs
		N = 359	N = 22	N = 7	N = 0	N = 0	N = 0
Age of Participants (Years)	18-25	93,4%	5,4%	1,2%	0,0%	0,0%	0,0%
	26-35	89,7%	7,6%	2,8%	0,0%	0,0%	0,0%
	36-45	95,0%	3,3%	1,7%	0,0%	0,0%	0,0%
	46-55	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	55+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in BWP	P0 -P2500	93,7%	5,7%	0,6%	0,0%	0,0%	0,0%
	P2500 - P5000	96,9%	3,1%	0,0%	0,0%	0,0%	0,0%
	P5000 - P10 000	92,9%	4,8%	2,4%	0,0%	0,0%	0,0%
	P10 000 - P30 000	77,8%	7,4%	14,8%	0,0%	0,0%	0,0%
	P30 000 - P50 000	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	P50 000+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	92,2%	7,0%	0,8%	0,0%	0,0%	0,0%
	Part-time employee	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Self-employed	93,5%	4,3%	2,2%	0,0%	0,0%	0,0%
	Full-time employee	89,9%	6,9%	3,1%	0,0%	0,0%	0,0%
	Unemployed	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Student and part-time employee	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%

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Data used for transportation-related purposes was extremely low in both study areas, indicating a lack of ICT use for transportation purposes.

4.13.4 Use of airtime for travel-related reasons

Figure 4.59 shows the amount of airtime used monthly for transportation-related purposes by the participants in Bloemfontein.

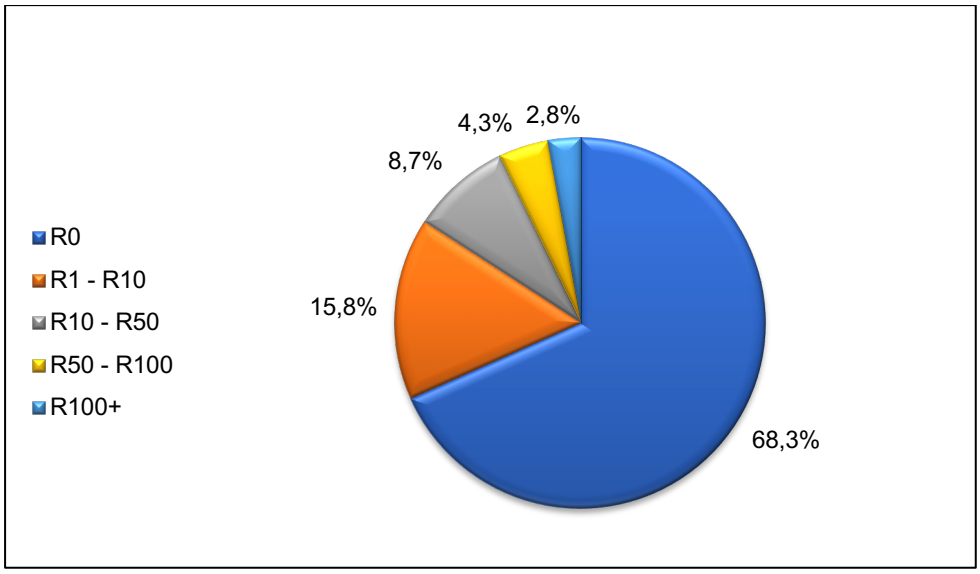

Figure 4.59: Value of airtime used for transportation in Bloemfontein (ZAR)

Overall, 68.3 % of the participants did not use any airtime for transportation, while 15.8% used between R1.00 and R10.00, 8.7% used airtime worth between R10.00 and R50.00, while 4.3% and 2.8% spent between R50 and R100 or more than R100, respectively.

Noteworthy airtime usage of 13% and 15.2 % was noted in the 45 to 55, and the 18 to 25 years age groups, who spent airtime worth between R10 and R50. The figure referred to 13.5% of students and 20%, respectively, of those who were students and working part-time who also spent between R10 and R50 on airtime. Table 4.38 shows airtime usage by age, income and occupation.

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Table 4.38: Airtime usage for transportation purpo roup - Bloemfontein

Demographic characteristics		Airtime used for transportation-related reasons per month				
		R0	R1 - R10	R10 - R50	R50 - R100	R100+
		N = 220	N = 51	N = 28	N = 14	N = 9
Age of Participants (years)	18-25	58,9%	17,9%	15,2%	4,5%	3,6%
	26-35	71,9%	15,6%	5,5%	5,5%	1,6%
	36-45	78,6%	14,3%	1,8%	3,6%	1,8%
	46-55	65,2%	13,0%	13,0%	0,0%	8,7%
	55+	100,0%	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in ZAR	R0 -R 2500	65,8%	17,5%	9,2%	3,3%	4,2%
	R2500 - R5000	68,2%	14,1%	9,4%	5,9%	2,4%
	R5000 - R10 000	66,7%	17,9%	7,7%	7,7%	0,0%
	R10 000 - R30 000	71,4%	14,3%	8,6%	2,9%	2,9%
	R30 000 - R50 000	85,7%	14,3%	0,0%	0,0%	0,0%
	R50 000+	100,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	57,3%	21,9%	13,5%	2,1%	5,2%
	Part-time employee	77,3%	9,1%	4,5%	6,8%	2,3%
	Self-employed	86,4%	4,5%	4,5%	4,5%	0,0%
	Full-time employee	70,9%	17,9%	5,1%	4,3%	1,7%
	Unemployed	73,9%	8,7%	8,7%	8,7%	0,0%
	Student and part-time employee	60,0%	10,0%	20,0%	5,0%	5,0%

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Figure 4.60 shows the amount of airtime used per month for transportation by participants in Gaborone.

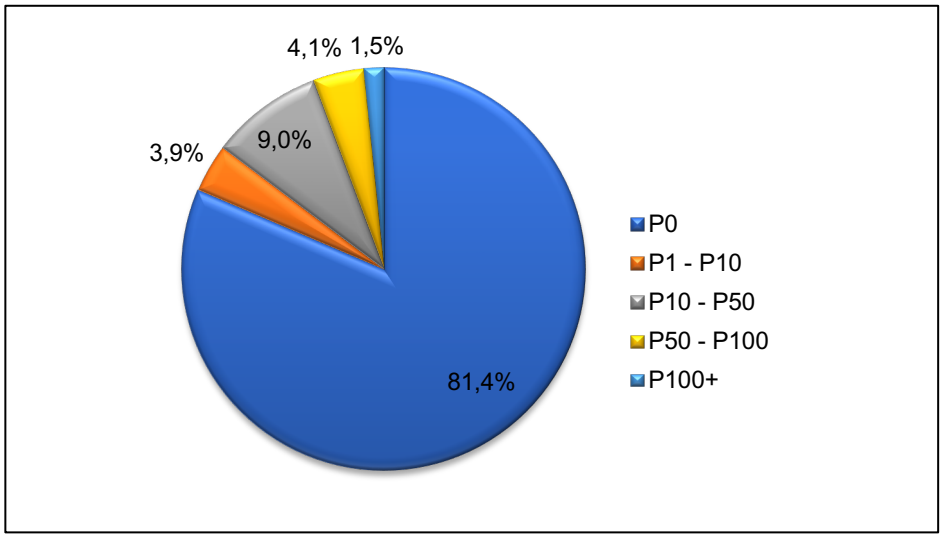

Figure 4.60: Value of airtime used for transportation in Gaborone

In total, 81. 4 % did not use airtime for transportation-related purposes, and only 9% used airtime worth between P10 and P50 per month for transportation purposes, while 4.1% and 1.5%, respectively, spent airtime worth between P50 and P100 and over P100 on airtime. Usage of airtime among different demographic groups is presented in Table 4.39 below.

A total of only 14.8% of those whose monthly income was between P10 000 and P30 000 spent between P50 and P100 on airtime for transportation purposes. Most of the people who used airtime valued between P10 and P50 were students (14.8%), people aged between 18 and 25 years (15.6%) and those earning less than P2500 per month (13.1%). Airtime was used mostly for calls and SMS, which usually cost less than R10.00 in Bloemfontein and P50.00 in Gaborone. The low incidence in both cities among the different demographic groups of larger amounts of airtime can be attributed to calls to cab companies for services.

Most participants (85.3%) used less than P10.00 worth of airtime for transportation-related purposes per month, and 9% used between P10.00 and P50.00, while 4.1% used between P50.00 and P100.00. Only 1.5% used more than P100.00 worth of airtime for transportation-related purposes per month.

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Table 4.39: Airtime usage for transportation purpo roup - Gaborone

Demographic characteristics		Airtime used for transportation-related reasons per month				
		P0	P1 - P10	P10 - P50	P50 - P100	P100+
		N =316	N = 15	N = 35	N = 16	N = 6
Age of Participants	18-25	74,9%	4,8%	15,6%	3,6%	1,2%
	26-35	84,8%	4,8%	5,5%	2,8%	2,1%
	36-45	86,7%	0,0%	1,7%	10,0%	1,7%
	46-55	100,0%	0,0%	0,0%	0,0%	0,0%
	55+	0,0%	0,0%	0,0%	0,0%	0,0%
Participants' monthly income in BWP	P0 -P2500	77,1%	5,1%	13,1%	3,4%	1,1%
	P2500 - P5000	90,6%	0,0%	6,3%	3,1%	0,0%
	P5000 - P10 000	83,3%	2,4%	4,8%	4,8%	4,8%
	P10 000 - P30 000	85,2%	0,0%	0,0%	14,8%	0,0%
	P30 000 - P50 000	100,0%	0,0%	0,0%	0,0%	0,0%
	P50 000+	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	76,6%	3,9%	14,8%	3,1%	1,6%
	Part-time employee	93,1%	0,0%	3,4%	0,0%	3,4%
	Self-epployed	82,6%	2,2%	8,7%	4,3%	2,2%
	Full-time employee	81,8%	5,0%	5,7%	6,3%	1,3%
	Unemployed	87,0%	4,3%	8,7%	0,0%	0,0%
	Student and part-time employee	100,0%	0,0%	0,0%	0,0%	0,0%

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4.13.5 Methods of payment for public transportation services

Figure 4.61 shows the methods of payment used by the participants for public transportation services in both cities.

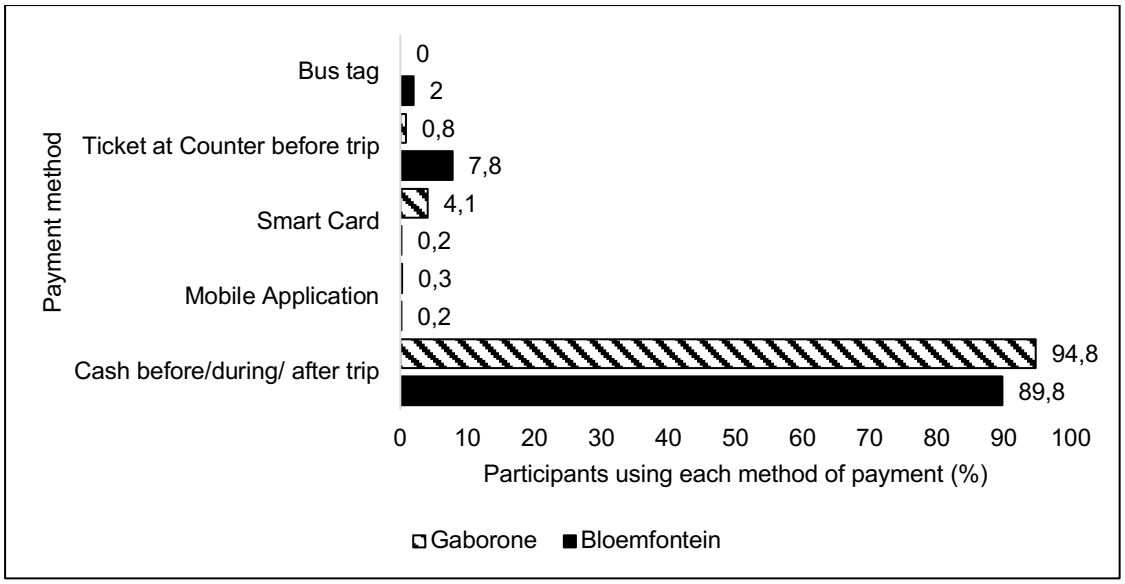

Figure 4.61: Methods of payment for public transportation services

Most participants used cash payments, 94.8% in Gaborone and 89.8% in Bloemfontein. In Bloemfontein, 7.8% of the participants bought tickets at counters before their trips, while only 0.8% in Gaborone used tickets bought at counters before their trips. Furthermore, 4.1% of participants in Gaborone used smart cards, compared with 0.2% in Bloemfontein, while 0.3% in Gaborone used mobile applications, and 2% of participants used bus tags to pay for their trips.

Cash was the most common method of payment for public transportation services. For this reason, customers were susceptible to problems, such as not receiving any change back after paying cash, or they were paid short, and safety concerns for both passengers and drivers, as they could be targets of criminals for pickpocketing and robberies. Less use of ICT platforms for payments indicated that a) there was an absence of suitable ICT in public transportation systems, or b) participants' lack of access or interest in using such ICT for transportation purposes.

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4.13.6 Influence of ICT on travel

Figure 4.62 shows ICT's influence on travel in Bloemfontein and Gaborone. The majority of participants' travel was not in any way influenced by ICT.

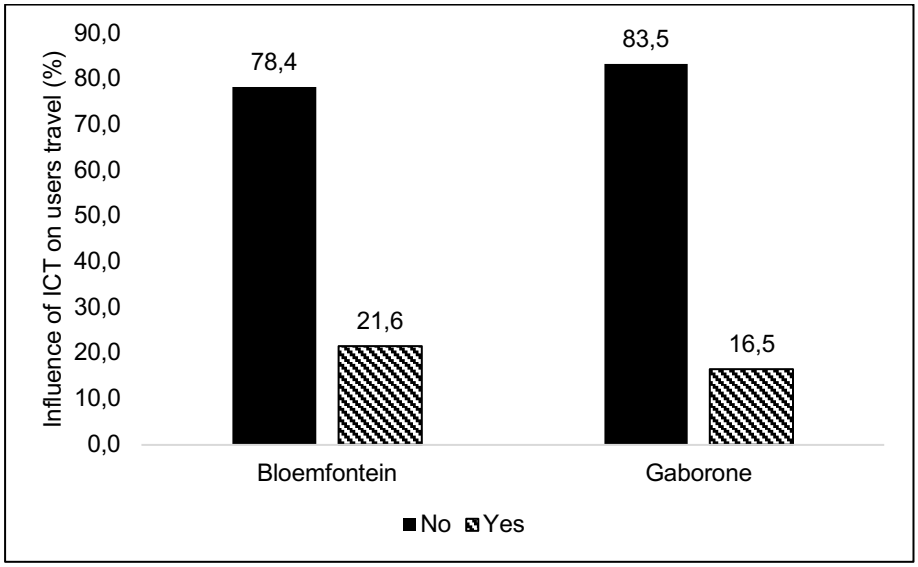

Figure 4.62: Influence of ICT on travel

In Gaborone, 83.5% of the participants, and 78.4% in Bloemfontein, were not influenced by ICT. Only 21.6% of the participants in Gaborone were influenced by ICT, and 16.5% of the participants in Bloemfontein were influenced by ICT. ICT did not have a significant impact on the way the participants in Bloemfontein and Gaborone currently travelled.

Participants whose travel was influenced by ICT were asked to elaborate further. In Bloemfontein, the influence of ICT was limited to calling cabs and for entertainment during trips, mapping applications for monitoring trips, and directions and technology for a limited percentage of participants. Searching for information about travel and traffic updates were less common ways in which ICT influenced travel.

The participants in Gaborone also noted factors such as calling cabs, entertainment and social networking while travelling as the main roles that ICT played in their travel. Availability of television and internet in vehicles made trips enjoyable to the few passengers who experienced them.

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4.14 ICT for Sustainability

4.14.1 Importance of ICT for sustainability

The participants were asked whether they thought ICT was important for the sustainability of transportation. The results are presented in Figure 4.63 below, which shows whether the participants in both cities perceived the importance of ICT in achieving sustainability.

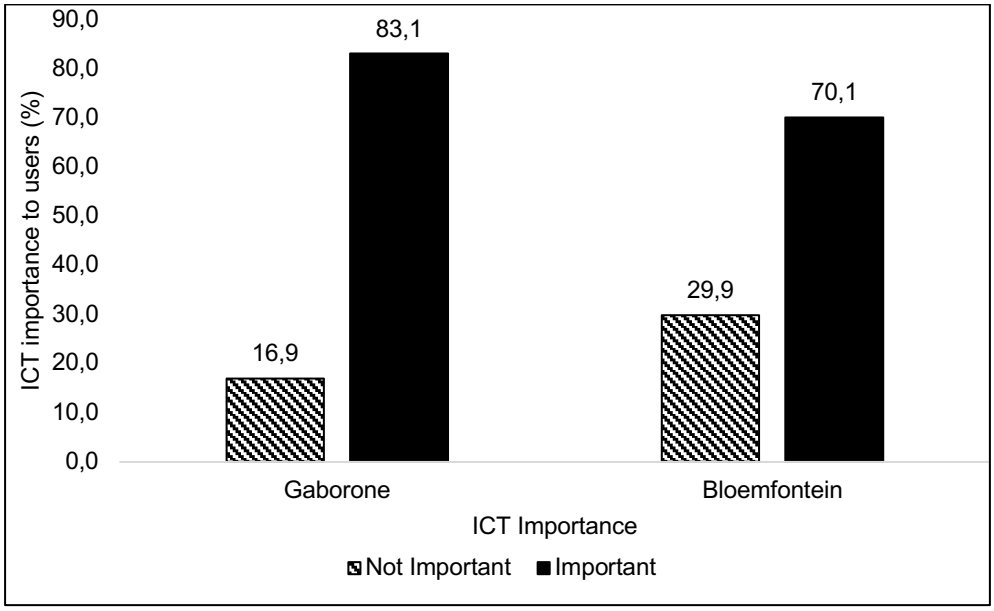

Figure 4.63: The importance of ICT for sustainability

Figure 4.63 shows that, overall, 83.1% of the participants in Gaborone indicated that ICT was important for sustainability, compared with 70.1% in Bloemfontein. In both cities, lower percentages of participants indicated that ICT was not important in achieving sustainability in transportation. In Bloemfontein, 29.9% of the participants indicated that it was not important, compared with 16.9% in Gaborone.

The following reasons, provided by the participants, indicated why they thought ICT was important for the sustainability of transportation.

In Bloemfontein, the participants noted that the use of ICT to improve sustainability would have to include accessible and convenient transportation; ICT in transportation would save energy and time, and help people make informed decisions; ICT would make communication easier between service providers and passengers; ICT would

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also reduce the need to carry cash, which would make public transportation safer; ICT would also help travellers with route selection and save them time; ICT would forge a virtual relationship between public transportation service providers and users. On the other hand, the reasons given by the participants who indicated ICT was not important included that ICT would be distracting to drivers; one participant indicated that such technologies would eventually become irrelevant in the future; and some suggested that ICT was “not important”, “useless”, “okay the way it is”, and would not affect transportation.

In Gaborone, the participants mentioned the important role of accessibility and convenience as positive effects ICT would have on transportation’s sustainability; communication between transportation systems and users would lead to more sustainable transportation; ICT would improve transportation efficiency; ICT would save time as it enabled online payments and assisted with trip planning; ICT could also reduce traffic congestion by offering travellers a choice of routes prior to trips. The participants who perceived ICT as not being important for sustainability indicated that transportation would still be needed in future, even without ICT, so ICT was not important for sustainability; one participant indicated that choice of travel was not influenced by ICT, but rather by the destination, and that combis were already readily accessible, so there was no need for ICT.

4.15 The Importance of ICT at Different Stages of a Trip

The aim of this section was to identify people’s perceptions of ICT at various stages of a trip. Cronbach’s Alpha was used to determine the interrelatedness of aspects contributing to the need for ICT at the different stages of a trip. These results are presented in Table 4.40, indicating values of between 0.7 and 1.0, which shows that all the factors were reliable and sufficient towards predicting the need for ICT, based on the high internal consistency.

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Cronbach's Alpha: α

$$\alpha = N.\,vv{+}N - 1.c$$

Where:

$$N = Number\ of\ items$$
$$\underline{v} = average\ variance$$
$$\underline{c} = Average\ inter - item\ covariance$$

Table 4.40: Cronbach's Alpha coefficients

	Bloemfontein			Gaborone		
Stage of trip	Before	During	After	Before	During	After
α	0.7	0.9	0.9	0.9	0.9	0.9

The participants were asked at which stage of making a trip ICT would be useful and these results are shown in Figures 4.64 and 4.65.

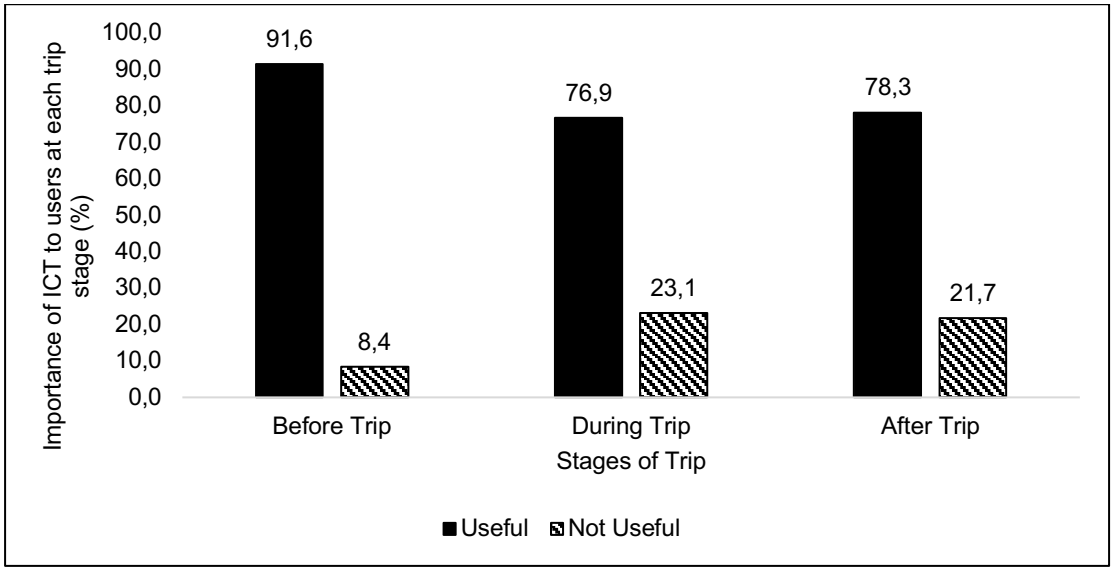

Figure 4.64: Importance of ICT at different stages of making a trip - Bloemfontein

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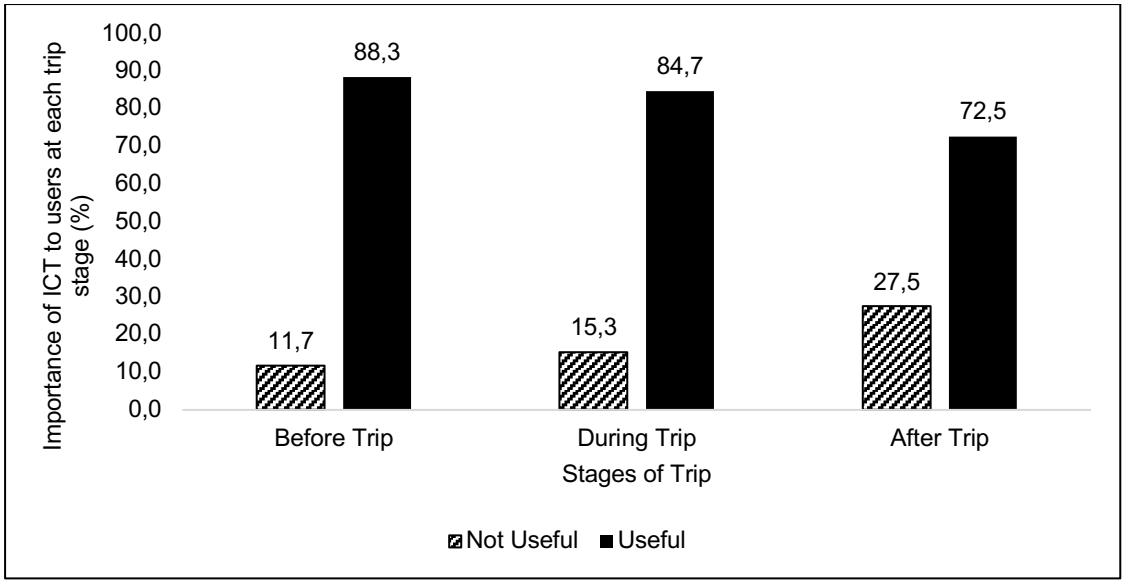

Figure 4.65: Importance of ICT at different stages of making a trip - Gaborone

Figure 4.64 shows the participants' perceptions of the usefulness of ICT at different stages of a trip in Bloemfontein and Figure 4.65 shows the results obtained in Gaborone. Based on the majority of responses from both study areas, theoretically, ICT would be important at all stages of a trip. Specifically, 91.6% and 88.3% from Bloemfontein and Gaborone, respectively, would find ICT useful before a trip, while 8.4% and 11.7% would not find ICT as useful before a trip.

According to 76.9% and 84.7% of participants in Bloemfontein and Gaborone, respectively, ICT would be useful during a trip, while 23.1% and 15.3% of participants, respectively, indicated that ICT would not be useful to them during the trip. ICT would be useful after a trip to 78.3% of the participants in Bloemfontein and 72.5% in Gaborone, but would not be useful to 21.7% and 27.5%, respectively.

The results were mainly positive, and ICT would be accepted in both study areas, which indicated willingness to use ICT for travel reasons. To identify the purposes for which participants anticipated using ICT, they were asked further to rate the importance of given ICT-based activities for various purposes at different stages of a trip. Tables 4.41, 4.42 and 4.43 show the importance of ICT uses at different stages of trip-making.

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4.15.1 The importance of ICT before trips

In this sub-section, ICT-enabled activities and services that participants deemed important and would use before beginning their trips were identified. Table 4.41 below shows the level of importance as deemed by the participants in both Bloemfontein and Gaborone.

Table 4.41: Importance of ICT before making a trip

Uses of ICT before a trip						
Bloemfontein						
Level of Importance	**Trip planning**	**Inquiries**	**Route mapping**	**Information before trip**	**Modes comparison**	**Traffic information**
Not important	9,2	10,2	12,6	12,4	16,2	14,3
Slightly important	7,8	8,0	6,3	9,5	13,1	9,4
Fairly important	7,1	9,0	11,7	12,6	10,2	9,7
Important	20,4	32,4	31,6	25,5	25,4	28,1
Very important	55,4	40,4	37,9	40,0	35,1	38,5
Gaborone						
Level of Importance	**Trip planning**	**Inquiries**	**Route mapping**	**Information before trip**	**Modes comparison**	**Traffic information**
Not important	16,4	13,2	16,4	15,3	17,1	17,4
Slightly important	4,7	5,7	3,6	7,3	8,6	6,0
Fairly important	7,3	11,4	9,4	14,8	11,9	17,7
Important	34,5	30,4	36,1	30,4	30,6	29,1
Very important	37,1	39,2	34,5	32,2	31,7	29,9

Most of the participants in both cities considered trip planning, inquiries, route mapping, and sourcing information, comparing available modes of transportation, and sourcing traffic information before a trip to be important or very important. The percentages of responses in Bloemfontein ranging from 20.4% to 31.6% indicated that all activities were believed to be reasonably important, while 37.9% to 55.4% indicated that the activities were very important. The responses obtained in Gaborone showed percentages ranging from 29.1% to 36.1% indicating that ICT was important for all activities, while 29.9% to 39.2% indicated that ICT was very important before trips. A noteworthy number of participants considered that using ICT was not important before making trips. Lower percentages of participants classified the activities as not important to fairly important.

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Overall, the participants indicated that ICT would be very important before a trip for planning, inquiries, route mapping, comparing available modes of transportation and for traffic information. However, trip planning would be the most important use for ICT before trips, while mode comparisons would be the least important to the participants in Bloemfontein. To the participants in Gaborone, ICT would be important before trips mostly for inquiries, followed by trip planning and route mapping. Although very important, browsing for information about the destination, comparisons of modes and traffic information would be the least important uses of ICT before trips.

4.15.2 The importance of ICT use during trips

Table 4.42 below shows the level of importance of ICT-enabled activities during trips. The activities evaluated were trip planning, travel monitoring, and entertainment during the trip, traffic updates, working during the trip, and monitoring the duration of the journey.

Table 4.42: Importance of ICT during a trip

Uses of ICT during a trip						
Bloemfontein						
Level of Importance	**Trip planning**	**Travel monitoring**	**Entertainment**	**Real-time traffic updates**	**Work**	**Duration monitoring**
Not important	28,2	24,5	20,9	19,9	23,1	27,0
Slightly important	13,6	10,4	12,1	10,7	11,9	11,9
Fairly important	10,9	12,1	16,7	16,0	12,9	11,7
Important	21,6	26,5	21,8	24,0	23,3	22,4
Very important	25,7	26,5	28,4	29,4	28,9	27,0
Gaborone						
Level of Importance	**Trip planning**	**Travel monitoring**	**Entertainment**	**Real-time traffic updates**	**Work**	**Duration monitoring**
Not important	26,8	20,5	18,2	21,3	27,3	22,6
Slightly important	6,2	7,0	9,1	8,8	13,0	8,6
Fairly important	13,2	14,8	22,1	20,3	18,2	15,1
Important	28,8	29,9	28,3	28,3	22,6	31,7
Very important	24,9	27,8	22,3	21,3	19,0	22,1

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The results indicated that even though most of the participants deemed these activities to be mostly important or very important, a significant number of participants deemed them to be not important. Most of the participants in Bloemfontein indicated that ICT would be very important for entertainment, traffic updates and work. In Gaborone, 27.8% of the participants indicated that ICT would be very important for monitoring travel.

Travel monitoring and trip planning were the most important uses of ICT during trips in Gaborone. Working during the trip was the least important use of ICT during the trip. Travellers were less likely to use ICT during a trip than they would before the journey. ICT would be most important for travel monitoring, followed by real-time traffic updates and working during a trip. However, the results showed significant percentages of participants who did not find real-time traffic updates to be important during a trip.

4.15.3 The importance of ICT after trips

Table 4.43 shows the level of importance of ICT-enabled activities and services after trips.

Table 4.43: Importance of ICT after trips

Uses of ICT after a trip					
Bloemfontein					
Level of Importance	**Payment**	**Trip evaluation**	**Service evaluation**	**Logging queries**	**Customer Satisfaction Evaluation**
Not important	22,4	27,1	28,4	24,9	32,0
Slightly important	10,7	12,4	11,2	16,3	11,7
Fairly important	8,3	10,7	13,9	11,0	10,5
Important	18,0	26,6	20,8	21,7	17,1
Very important	40,5	23,2	25,7	26,1	28,8
Gaborone					
Level of Importance	**Payment**	**Trip evaluation**	**Service evaluation**	**Logging queries**	**Customer Satisfaction Evaluation**
Not important	24,4	30,6	30,4	28,8	31,2
Slightly important	3,6	9,9	6,2	7,5	5,7
Fairly important	9,9	13,2	18,2	10,6	19,0
Important	26,2	32,2	29,9	33,5	28,6
Very important	35,8	14,0	15,3	19,5	15,6

The table above shows that the participants would use payment platforms, trip evaluation and customer evaluation platforms to log queries and evaluate

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transportation services after a trip. There was a noticeable variance in the degrees of importance of all the uses provided. The most common use for ICT after a trip would be to make payments, which was deemed to be very important by 40.5% of the participants in Bloemfontein and 35.5% of the participants in Gaborone. Percentages of the participants in Bloemfontein ranging from 17.1% to 28.8% indicated that all the other activities would be important or very important. In Gaborone, 26.2% to 33.5% of the participants indicated that similar activities would be important. Lower percentages, ranging from 14% to 19.5% indicated that the activities were very important. However, significant percentages of participants in both cities indicated that all activities were not important, with percentages ranging from 22.4% to 32% in Bloemfontein and 24.4% to 31.2% in Gaborone. Lower percentages of participants indicated that the activities were slightly or fairly important. The significance in disparities showed gaps in how an activity deemed to be very important by some participants, but could be of less importance to others.

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CHAPTER 5: RESULTS, ANALYSIS AND DISCUSSION OF TRAVEL PATTERNS

5.1 Introduction

This chapter contains the results from a survey that was focused on the geographic locations of the origins and destinations of trips made by public transportation users. The data was gathered through questionnaire surveys carried out in both study areas to determine the characteristics of trips made by regular users of public transportation. The focus of this chapter is on the composition of trips made by individual travellers. The critical variables were the public transportation users' reasons for travel, from where they were travelling, the time they spent on the trips, and where the trips terminated. Based on the origins and destinations of the participants' trips, major public transportation nodes in the areas, as well as time and financial costs of trips were identified in this section. Use of ICT during public transportation trips, and satisfaction with the transportation systems are also presented.

5.2 Demographic Background

The demographic information about the participants in the study are presented in Figure 5.1, which shows gender distribution of 51.6% female compared with 48.4% male participants in Bloemfontein, and 59.3% female compared with 40.7% male participants in Gaborone.

The age range of participants in Bloemfontein showed that 26% of the participants were aged between 18 and 25 years, 37.8% between 26 and 35 years, 22.7% between 36 and 45 years, 9.4% between 46 and 55 years and 3.6% and 0.5% were aged between 55 and 65 years and over 65 years, respectively. In Gaborone, 41.0% of the participants were between the ages of 18 and 25, 48.4% were aged between 26 and 35, while 10.6% were aged between 36 and 45 years.

Bloemfontein participants comprised 23.4% students, 5.5% part-time employees, 3.9% self-employed, 58.1% full-time employees, 1% pensioners and 8.1% unemployed participants. The participants from Gaborone comprised 28.3% students,

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8.4% part-time employees, 41.4% full-time employees, 8.2% self-employed, 12.5% unemployed and 1.2% pensioners.

Gender did not have a significant influence on travel by public transportation. Age and employment status could have influenced the frequency at which the participants travelled, as well as how long they had been using the public transportation system. Age and employment status also influenced the current use, desire and ability to use technological devices.

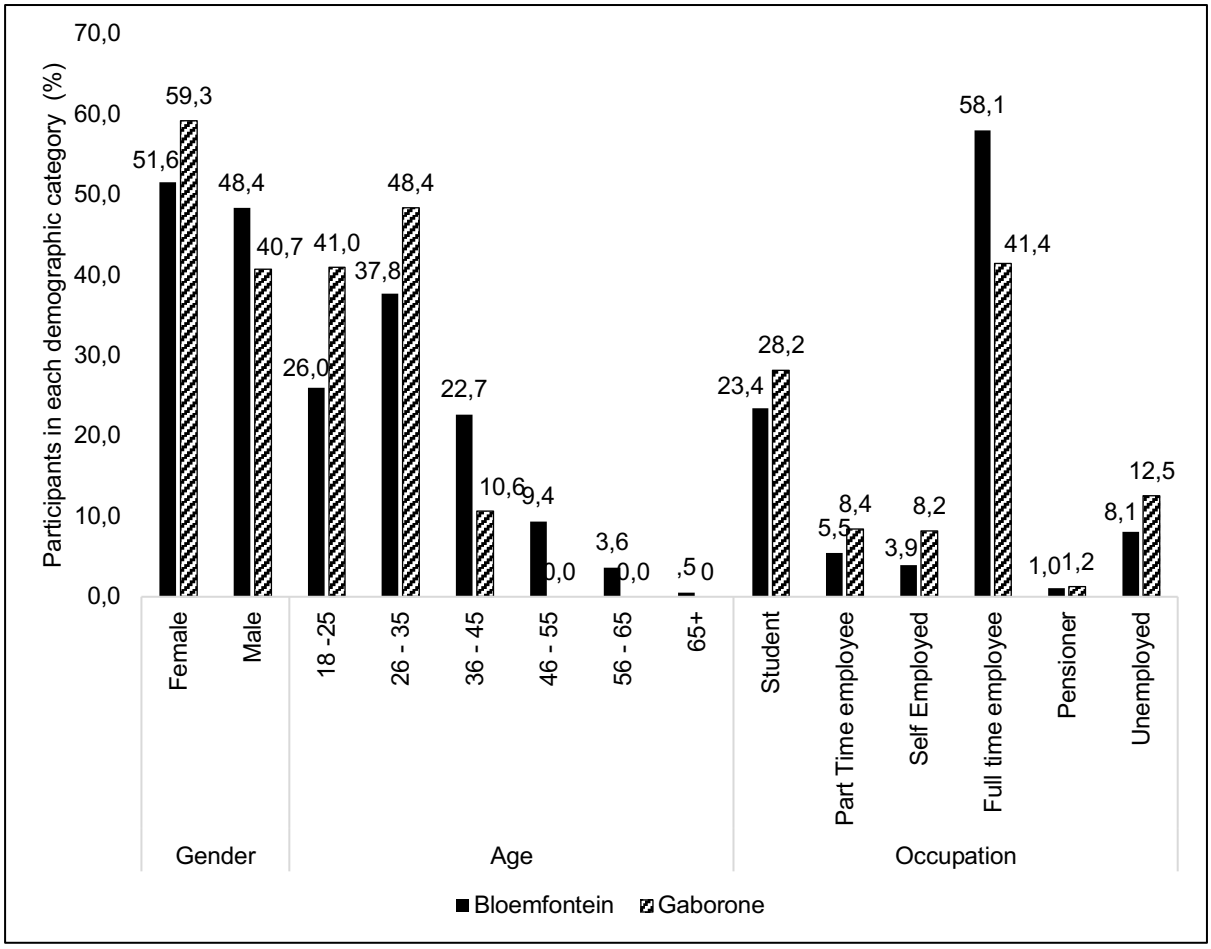

Figure 5.1: Background and demographic data of public transportation users

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5.3 Characteristics of Trips

5.3.1 Trip frequency

The participants were asked to provide details of their most frequent trips made using public transportation, the purpose of the trips and the frequency with which they made the trips. In Bloemfontein, 68% of the trips were weekday trips, undertaken between Monday and Friday, 16.7% were daily trips made every day of the week, 3.4% of the trips were made only on Saturdays and Sundays, 10.7% of the trips were made only 2-3 times a week, while 1.3% were first-time trips undertaken in the area by public transportation. In Gaborone, 56.1 % of the participants made trips 5 days per week using public transportation, 17.6% of the trips were made every day, 10.4 % of the trips were undertaken once on Saturdays or Sundays only, and 15.9% of the trips were made 2-3 days per week.

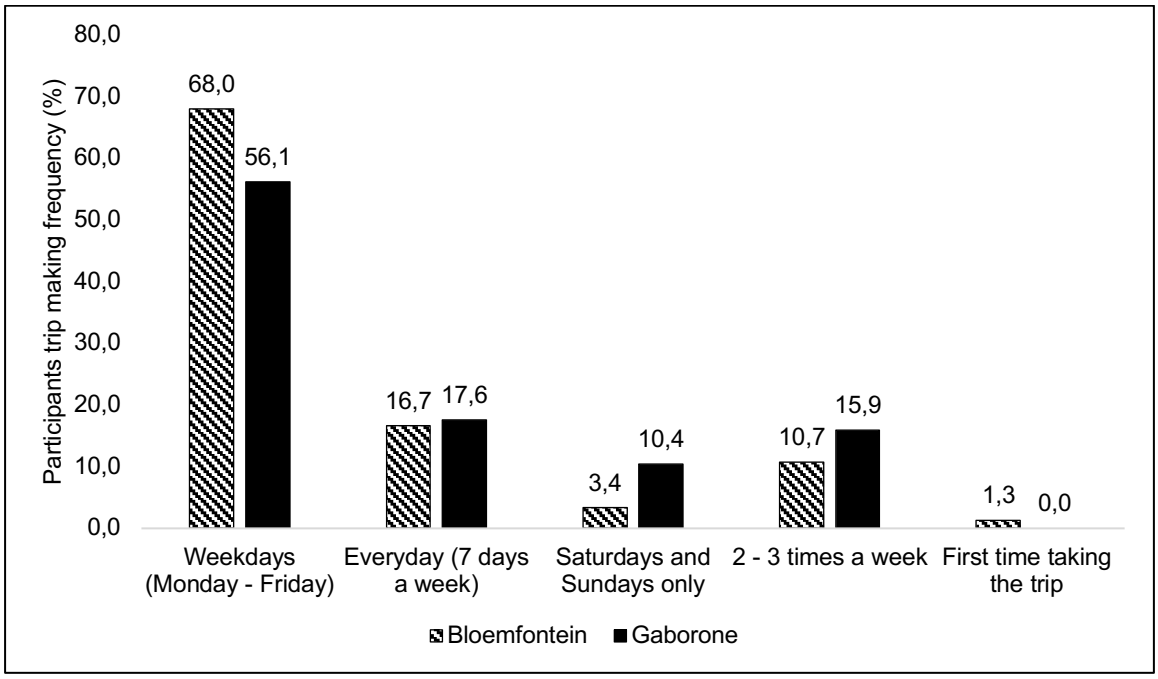

Figure 5.2: Trip frequency

Figure 5.2 shows the frequency with which the participants made trips by public transportation. In both study areas, most of the trips were made on weekdays. These results corresponded with the purposes of the trips, as most of them were trips for work and educational purposes. Tables 5.1 and 5.2 show the distribution of trips among people of different age groups and occupations. Weekdays trips were the most

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common among ages between 18 and 65 years old in Bloemfontein, and 64.4% of students, 76.7% of full-time employees and 57.1% of part-time employees travelled by public transportation each weekday. Everyday trips (undertaken 7 days a week) were also worth noting, where 20% of the 26 to 35-year-old population and 18.4% of those aged between 36 and 45 years travelled daily. Similar trends were revealed by the survey in Gaborone. Weekday trips were common among all age groups and all occupations. Daily trips were also noteworthy among full-time employees, part-time employees and those who were self- employed.

Table 5.1: Frequency of public transportation trips by demographic groups - Bloemfontein

Demographic group (N = 384)		Frequency at which trip is undertaken				
		Weekdays (Monday - Friday)	Every day (7 days a week)	Saturdays and Sundays only	2 - 3 times a week	First time taking the trip
		N = 261	N = 64	N = 13	N = 41	N = 5
Age (Years)	18 -25	56,0%	14,0%	9,0%	18,0%	3,0%
	26 - 35	66,9%	20,0%	2,8%	9,7%	0,7%
	36 - 45	77,0%	18,4%	0,0%	4,6%	0,0%
	46 - 55	77,8%	13,9%	0,0%	5,6%	2,8%
	56 - 65	92,9%	0,0%	0,0%	7,1%	0,0%
	65+	0,0%	0,0%	0,0%	100,0%	0,0%
Participant's Occupation	Student	64,4%	8,9%	7,8%	15,6%	3,3%
	Part-time employee	57,1%	23,8%	9,5%	9,5%	0,0%
	Self-employed	53,3%	33,3%	0,0%	13,3%	0,0%
	Full-time employee	76,7%	19,7%	0,0%	3,6%	0,0%
	Pensioner	50,0%	0,0%	0,0%	50,0%	0,0%
	Unemployed	32,3%	6,5%	12,9%	41,9%	6,5%

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Table 5.2: Frequency of public transportation trips by demographic groups - Gaborone

Demographic group (N = 415)		Frequency at which trip is undertaken				
		Weekdays (Monday - Friday)	Every day (7 days a week)	Saturdays or Saturdays only	2 - 3 Days a week	First time taking the trip
		N = 233	N = 73	N = 43	N = 66	N = 0
Age (years)	18 - 25	58,8%	10,0%	8,8%	22,4%	0,0%
	26 - 35	53,7%	21,9%	13,4%	10,9%	0,0%
	36 - 45	56,8%	27,3%	2,3%	13,6%	0,0%
	46 - 55	0,0%	0,0%	0,0%	0,0%	0,0%
	56 - 65	0,0%	0,0%	0,0%	0,0%	0,0%
	65+	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	61,5%	6,0%	8,5%	23,9%	0,0%
	Part-time employee	60,0%	20,0%	14,3%	5,7%	0,0%
	Self-employed	44,1%	29,4%	17,6%	8,8%	0,0%
	Full-time employee	65,7%	27,3%	4,1%	2,9%	0,0%
	Pensioner	80,0%	0,0%	0,0%	20,0%	0,0%
	Unemployed	15,4%	3,8%	28,8%	51,9%	0,0%

A workweek in Southern African countries often lasts from Monday to Friday. However, some companies operate on weekends, especially in the retail and hospitality industries, creating the need for employees' travel on weekends. Trip frequency dictates the need for transportation. High volumes of people travelling during weekdays means more public transportation is needed then. However, people still undertake trips apart from their regular trips on other days. Therefore, trip frequencies are critical to planning, scheduling and operating an efficient and reliable public transportation system.

5.3.2 Trip purpose

The purposes for which the trips were undertaken are shown in Figure 5.3. Overall, 68.5% of the most frequent trips in Bloemfontein were work trips, 10.7% of the trips were shopping trips, while 15.1% were educational trips. Furthermore, 0.8% of the trips were both for recreation and to access public services, 2.9% of the trips were for attending to family obligations, 0.5% of the trips were for religious and leisure activities, while only 0.3% of the trips were undertaken for sporting activities. In Gaborone, 56.4% of the trips were work trips, 23.6% were educational trips, 6% were shopping trips, 1% of the trips were for public services, 0.2% were for recreational activities,

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2.9% for sporting activities, 2.9% for family obligations, 3.9% were leisure trips, 2.4 were for religious activities, while 0.5% of the trips were for job hunting purposes.

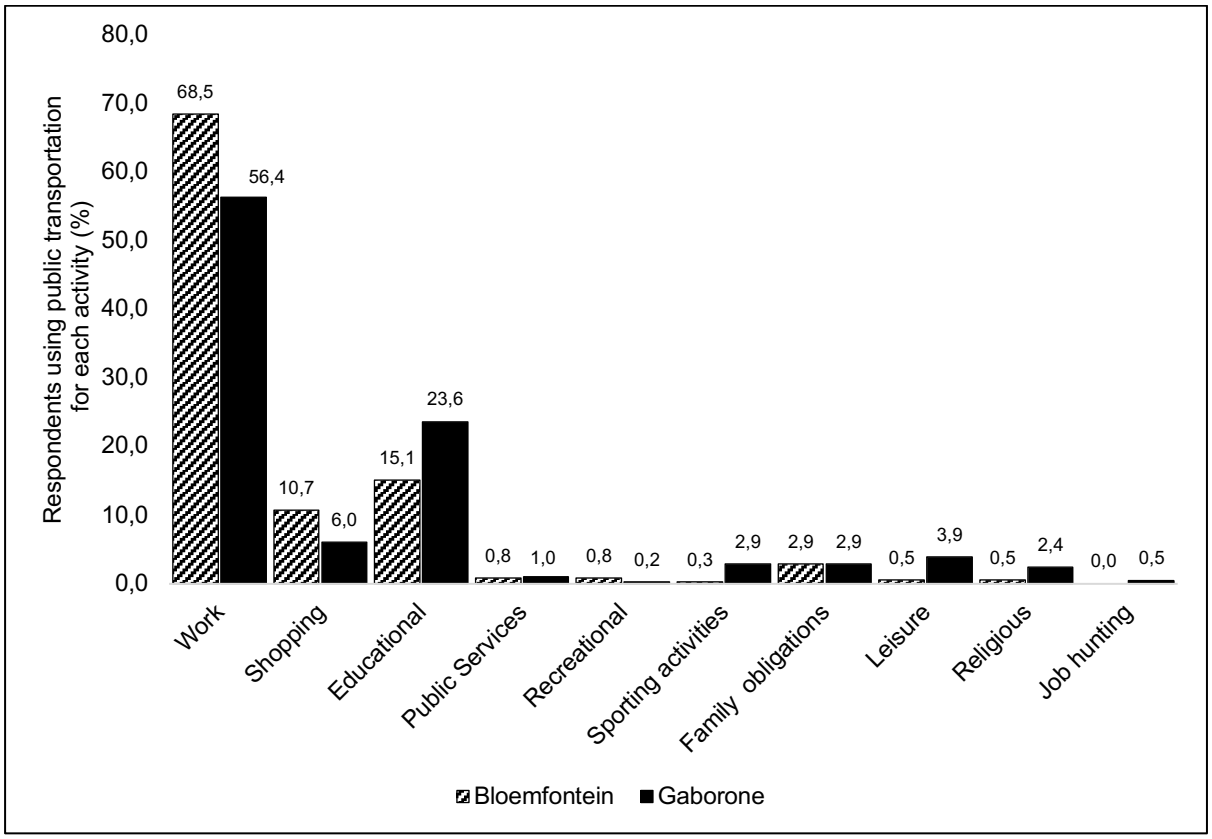

Figure 5.3: Purpose of regular trips made using public transportation

Work, education and shopping trips were the main reasons why the participants travelled, corroborating the high percentage of weekday trips.

Recreational and leisure activities were often performed on weekends or a few days per week. Other activities, for social and recreational reasons, did not give much reason for travel. Leisure activities, including sporting activities and recreational activities, did not occur as often. Although most companies and educational institutions use a five-day work or academic week, the hospitality and retail industries, as well as security companies work every day of the week, where participants' most frequent trips occurred every day of the week, specifically, 16.7% in Bloemfontein and 17.6% in Gaborone.

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Travel to access public services and for job hunting was minimal, given the low number of unemployed and the elderly population who used public transportation included in the sample, and most religious entities meet on a weekly basis, so these activities did not generate most of the trips. Family obligations, such as visiting children's schools and visiting family members, generated significantly frequent trips.

Tables 5.3 and 5.4 show trip purposes as distributed among age groups and occupations of the participants. The data supports results shown in Figure 5.3, highlighting work trips as the most common undertaken by public transportation; 97.8% of full-time employees in Bloemfontein and 93.6% in Gaborone were undertaking a work trip. Trips for the purpose of reaching educational venues were common among the 18 to 25 age bracket in both cities, but 58.9% of students in Bloemfontein undertook trips for educational purposes compared to 76.9% of students in Gaborone. More part-time employees, 14.3% in Bloemfontein compared to 5.7% in Gaborone undertook trips for educational purposes.

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Table 5.3: Purpose of most frequent trip by demog fontein

Demographic group (N = 384)		Purpose of most frequent trips										
		Work	Shopping	Educational	Public Services	Recreatio n	Sports	Banking	Family obligations	Leisure	Religious	Home
		N = 263	N = 41	N = 58	N = 3	N = 3	N = 1	N = 0	N = 11	N = 2	N = 2	N = 0
Age (years)	18 -25	35,0%	14,0%	45,0%	0,0%	0,0%	0,0%	0,0%	4,0%	1,0%	1,0%	0,0%
	26 - 35	69,7%	15,2%	8,3%	0,0%	2,1%	0,7%	0,0%	3,4%	0,7%	0,0%	0,0%
	36 - 45	94,3%	3,4%	0,0%	0,0%	0,0%	0,0%	0,0%	1,1%	0,0%	1,1%	0,0%
	46 - 55	88,9%	2,8%	2,8%	2,8%	0,0%	0,0%	0,0%	2,8%	0,0%	0,0%	0,0%
	56 - 65	92,9%	0,0%	0,0%	7,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	65+	0,0%	50,0%	0,0%	50,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Occupatio n	Student	15,6%	17,8%	58,9%	0,0%	0,0%	1,1%	0,0%	4,4%	2,2%	0,0%	0,0%
	Part-time employee	76,2%	4,8%	14,3%	0,0%	0,0%	0,0%	0,0%	4,8%	0,0%	0,0%	0,0%
	Self-employed	86,7%	6,7%	6,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Full-time employee	97,8%	1,8%	0,0%	0,0%	0,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Pensioner	0,0%	50,0%	0,0%	50,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Unemployed	6,5%	54,8%	3,2%	3,2%	6,5%	0,0%	0,0%	19,4%	0,0%	6,5%	0,0%

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Table 5.4: Purpose of most frequent trips by demo[illegible]rone

Demographic group (N = 415)		Trip purpose											
		Work	Shopping	Educational	Public services	Recreational	Sporting activities	Banking	Family obligations	Leisure	Religious	Home	Job hunting
		N = 234	N = 25	N = 98	N = 4	N = 1	N = 12	N = 0	N = 12	N = 16	N = 10	N = 1	N = 2
Age (years)	18 - 25	32,4%	6,5%	45,9%	0,6%	0,0%	4,1%	0,0%	2,9%	5,3%	2,4%	0,0%	0,0%
	26 - 35	69,2%	6,0%	10,0%	1,5%	0,5%	2,5%	0,0%	3,5%	3,0%	3,0%	0,5%	0,5%
	36 - 45	90,9%	4,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	2,3%	0,0%	0,0%	2,3%
	46 - 55	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	56 - 65	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	65+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	9,4%	2,6%	76,9%	0,0%	0,9%	6,0%	0,0%	0,9%	2,6%	0,9%	0,0%	0,0%
	Part-time employee	82,9%	5,7%	5,7%	0,0%	0,0%	2,9%	0,0%	0,0%	2,9%	0,0%	0,0%	0,0%
	Self-employed	76,5%	2,9%	2,9%	2,9%	0,0%	2,9%	0,0%	8,8%	2,9%	0,0%	0,0%	0,0%
	Full-time employee	93,6%	2,3%	1,2%	0,0%	0,0%	0,6%	0,0%	0,6%	1,2%	0,6%	0,0%	0,0%
	Pensioner	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Unemployed	3,8%	28,8%	5,8%	5,8%	0,0%	3,8%	0,0%	13,5%	17,3%	15,4%	1,9%	3,8%

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5.3.3 Activities during travel

Table 5.5 shows the activities performed by the participants in Bloemfontein during their trips using public transportation. A total of 64.7% used , while 30.3% used either Facebook or Twitter. Table 5.7 shows that WhatsApp was popular among most age groups: 57% of those in the 18 to 25 age group; 58.6% in the 26 to 35 age bracket, and 62.1% of participants in the 36 to 45 age bracket. Most of those who use Twitter and Facebook during their trips are those aged between 18 and 35, while 86.7% of self-employed participants used WhatsApp during travel. A further 6.6% of the participants read during the trip, while 6.9% attended to their emails. Playing games and listening to music were not very common activities during their trips, as only 6.3% and 4.1%, respectively, of users selected these activities. Furthermore, 25.6% of the participants made or received phone calls during the trips, and 22.8% of the participants indicated that they did not carry out any activities during their most regular trips.

Table 5.5: Activities performed during trips on public transportation – Bloemfontein

		Responses		Percent of cases
		N	Percent	
Activities	Reading	21	3.9%	6.6%
	Emails	22	4.1%	6.9%
	Facebook / Twitter	97	18.1%	30.3%
	WhatsApp	207	38.7%	64.7%
	Phone call	82	15.3%	25.6%
	Playing games	20	3.7%	6.3%
	Listening to music	13	2.4%	4.1%
	No activities	73	13.6%	22.8%
	Total	**535**	**100.0%**	**167.2%**

Table 5.6 shows the activities performed by public transportation users during their trips in Gaborone. The majority (85.7%) of the participants indicated that they used WhatsApp while travelling, 74.4% used Facebook and Twitter, 36.4% made phone calls, 12.3% attended to their emails, 10.1% listened to music, 9.7% played games, 5.5% read during the trip, while 9.4% did not perform any activities during trips. Table 5.8 reveals activities performed by people of different age groups and occupations. WhatsApp was common among participants aged between 18 and 45 with an

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overwhelming use by 71.2% among the 18 to 25 age bracket, 61.7%, and 41.2%, respectively, among the 26 to 35 and 36 to 45 age groups indicated the decreasing popularity of WhatsApp as participants were older. Use of Facebook and Twitter was common among all age groups and different occupations of participants.

Table 5.6: Activities performed during trips on public transportation - Gaborone

		Responses		Percent of cases
		N	Percent	
Activities	Reading	17	2.3%	5.5%
	Email	38	5.1%	12.3%
	Facebook / Twitter	229	30.5%	74.4%
	WhatsApp	264	35.2%	85.7%
	Phone call	112	14.9%	36.4%
	Games	30	4.0%	9.7%
	Music	31	4.1%	10.1%
	No activities	29	3.9%	9.4%
	Total	**750**	**100.0%**	**243.5%**

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Table 5.7: Activities performed by demographic groups during public transportation trips - Bloemfontein

		Reading during trip		Attending to emails during trip		Facebook / Twitter during trip		WhatsApp during trips		Phone call during trips		Playing games during trip		Listening to music while travelling	
		No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Demographic group (N = 384)		N = 363	N = 21	N = 362	N = 22	N = 287	N = 97	N = 177	N = 202	N = 302	N = 82	N = 364	N = 20	N = 371	N = 31
Age (years)	18 -25	92,0%	8,0%	95,0%	5,0%	64,0%	36,0%	43,0%	57,0%	81,0%	19,0%	92,0%	8,0%	95,0%	5,0%
	26 - 35	95,2%	4,8%	91,7%	8,3%	69,0%	31,0%	41,4%	58,6%	79,3%	20,7%	94,5%	5,5%	97,9%	2,1%
	36 - 45	96,6%	3,4%	94,3%	5,7%	82,8%	17,2%	37,9%	62,1%	77,0%	23,0%	96,6%	3,4%	94,3%	5,7%
	46 - 55	94,4%	5,6%	100,0%	0,0%	97,2%	2,8%	72,2%	27,8%	75,0%	25,0%	97,2%	2,8%	100,0%	0,0%
	56 - 65	92,9%	7,1%	100,0%	0,0%	100,0%	0,0%	92,9%	7,1%	85,7%	14,3%	100,0%	0,0%	100,0%	0,0%
	65+	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%	0,0%	100,0%	100,0%	0,0%	100,0%	0,0%
Occupation	Student	93,3%	6,7%	96,7%	3,3%	72,2%	27,8%	52,2%	47,8%	77,8%	22,2%	93,3%	6,7%	94,4%	5,6%
	Part-time employee	95,2%	4,8%	95,2%	4,8%	81,0%	19,0%	52,4%	47,6%	90,5%	9,5%	95,2%	4,8%	100,0%	0,0%
	Self-employed	93,3%	6,7%	93,3%	6,7%	46,7%	53,3%	13,3%	86,7%	86,7%	13,3%	93,3%	6,7%	100,0%	0,0%
	Full-time employee	95,1%	4,9%	93,3%	6,7%	74,9%	25,1%	43,9%	56,1%	80,3%	19,7%	94,6%	5,4%	96,9%	3,1%
	Pensioner	100,0%	0,0%	100,0%	0,0%	100,0%	0,0%	75,0%	25,0%	25,0%	75,0%	100,0%	0,0%	100,0%	0,0%
	Unemployed	93,5%	6,5%	93,5%	6,5%	87,1%	12,9%	51,6%	48,4%	64,5%	35,5%	100,0%	0,0%	96,8%	3,2%

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Table 5.8: Activities performed by demographic gr nsportation trips - Gaborone

Demographic group (N = 415)		Reading		Email		Facebook/ Twitter		WhatsApp		Phone call		Games		Music	
		No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
		N = 398	N = 17	N = 377	N = 38	N = 186	N = 229	N = 151	N = 264	N = 303	N = 112	N = 385	N = 30	N = 384	N = 31
Age (years)	18 - 25	95,3%	4,7%	95,3%	4,7%	32,4%	67,6%	28,8%	71,2%	72,9%	27,1%	88,8%	11,2%	89,4%	10,6%
	26 - 35	95,5%	4,5%	86,1%	13,9%	49,8%	50,2%	38,3%	61,7%	72,6%	27,4%	95,0%	5,0%	94,0%	6,0%
	36 - 45	100,0%	0,0%	95,5%	4,5%	70,5%	29,5%	56,8%	43,2%	75,0%	25,0%	97,7%	2,3%	97,7%	2,3%
	46 - 55	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	56 - 65	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	65+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	94,9%	5,1%	91,5%	8,5%	29,1%	70,9%	26,5%	73,5%	72,6%	27,4%	86,3%	13,7%	88,9%	11,1%
	Part-time employee	91,4%	8,6%	88,6%	11,4%	57,1%	42,9%	40,0%	60,0%	80,0%	20,0%	91,4%	8,6%	94,3%	5,7%
	Self-employed	94,1%	5,9%	79,4%	20,6%	50,0%	50,0%	38,2%	61,8%	70,6%	29,4%	94,1%	5,9%	94,1%	5,9%
	Full-time employee	96,5%	3,5%	92,4%	7,6%	51,7%	48,3%	40,1%	59,9%	70,3%	29,7%	96,5%	3,5%	93,0%	7,0%
	Pensioner	100,0%	0,0%	80,0%	20,0%	40,0%	60,0%	40,0%	60,0%	60,0%	40,0%	80,0%	20,0%	80,0%	20,0%
	Unemployed	100,0%	0,0%	94,2%	5,8%	46,2%	53,8%	42,3%	57,7%	80,8%	19,2%	96,2%	3,8%	98,1%	1,9%

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As shown in tables 5.5 to 5.8, social networking activities were the most prevalent during trips on public transportation. Access during the trips to smartphones and other mobile devices, such as tablets for entertainment or social communication, was common among the participants. There was a lack of availability of Wi-Fi in public transportation vehicles, so users connected to these platforms using mobile data, which is costly compared with Wi-Fi. Phone calls, although not as popular as social networks, were also made during trips. However, these were momentary social activities compared with social networks that users often logged onto for longer periods of time. Reading during travel was not common, although it can be performed online through smartphones. Most smartphones support various formats of documents, which users can download and read offline or stored in their phones from other devices. Music and video games were used for entertainment during travel, but were less common than the use of social media.

News and current affairs were also available instantly online through smartphones. Attending to emails, which are accessible through smartphones, was not as common as the use of social networks and entertainment. Email was used for professional communication more than for social communication. The data showed that most of the activities performed during trips were for entertainment and social activities. A noteworthy number of participants did not perform any activities during the trips. The results are presented graphically in Figure 5.4 below.

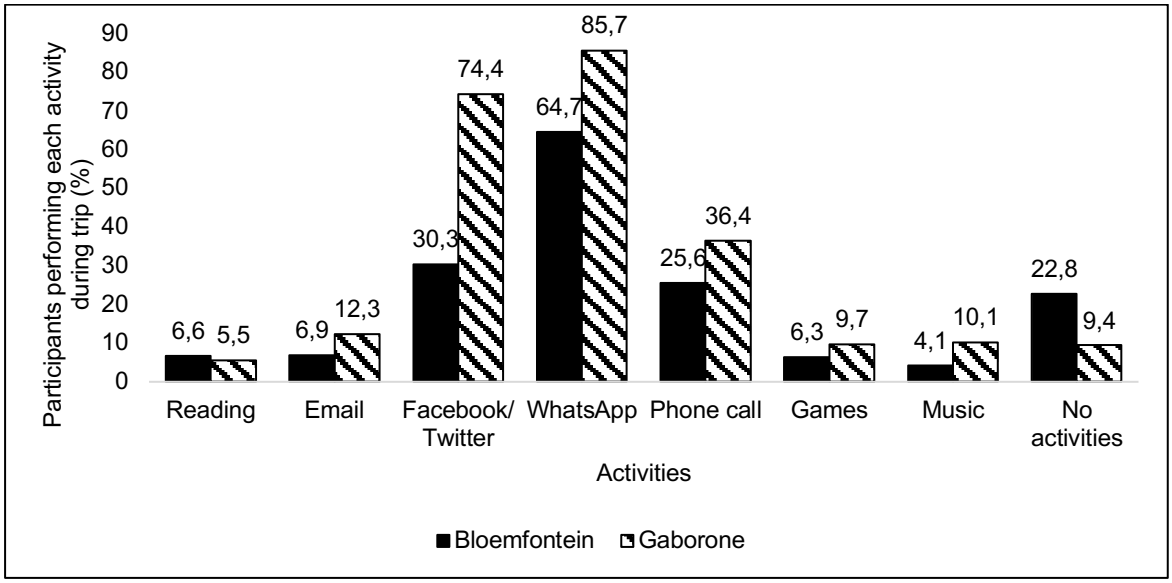

Figure 5.4: Comparison of activities performed during trips on public transportation

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Figure 5.4 shows activities performed by users of public transportation in Bloemfontein and Gaborone during their trips. Use of ICT during the trips was common but not related to travel. In both cases, 37.5% and 31.8% of the participants, respectively, did not use any devices during the trip, and most of them did not use ICT for travel purposes. These results are evidence that users of public transportation in both cities used social networks on their smartphones during their commutes. The 22.8% of people in Bloemfontein who did not perform any activities while travelling could be explained by the age of the participants. People who used public transportation in Bloemfontein were older than those in Gaborone. Incorporation of public transportation information and dispensation into social networks could be beneficial to meeting users' needs and to maintaining sustainable public transportation. Information on travel time and delays by public transportation service providers and authorities could assist in avoiding passengers experiencing long waiting times and delays.

5.3.4 Use of devices while travelling

The participants were asked whether they used any ICT devices in performing any of the activities indicated above. The results are shown in Figure 5.5. The use of devices was prevalent in both cities, with 62.5% in Bloemfontein and 68.2% in Gaborone indicating that they used ICT devices, while 37.5% in Bloemfontein and 31.8% in Gaborone did not use any ICT devices.

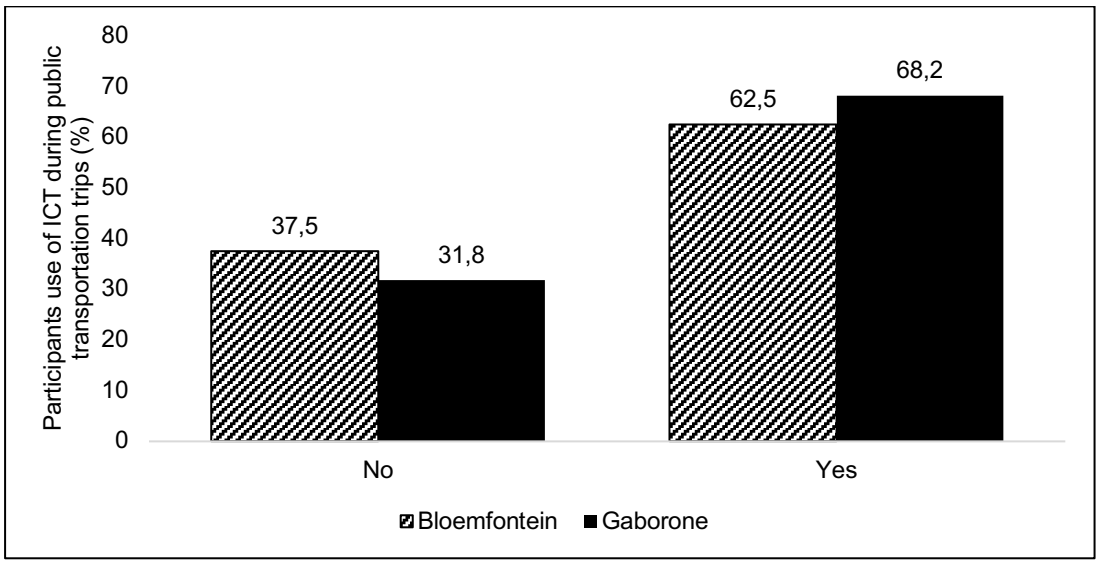

Figure 5.5: Use of ICT on trips

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Much higher percentages of participants used some form of ICT during their trips than those who did not use ICT during the trips. Smartphones were most used ICT devices. Conventional mobile phones were also used, although these were not as common.

Portability of devices had an influence on the types of devices passengers were able to carry around, explaining the popularity of both smart and conventional mobile phones. Although very rarely used, tablets were more common than computers and laptops, also attributable to their ease of being carried around. However, the results indicated that most of the participants did not use technology for travel purposes.

Table 5.9: ICT device usage by demographic groups during public transportation trip - Bloemfontein

		Use of technological devices during trip		ICT device/system/applications used				
		No	Yes	Smartphone	Cell phone	Tablet	Computer/ laptop	No device used
Demographic group (N = 384)		N = 144	N = 240	N = 220	N = 72	N = 25	N = 8	N = 59
Age (Years)	18 -25	37,0%	63,0%	58,0%	26,0%	11,0%	1,0%	4,0%
	26 - 35	36,6%	63,4%	62,8%	17,2%	6,9%	4,1%	9,0%
	36 - 45	27,6%	72,4%	66,7%	13,8%	1,1%	1,1%	17,2%
	46 - 55	55,6%	44,4%	30,6%	13,9%	8,3%	0,0%	47,2%
	56 - 65	71,4%	28,6%	14,3%	14,3%	0,0%	0,0%	71,4%
	65+	0,0%	100,0%	0,0%	100,0%	0,0%	0,0%	0,0%
Occupation	Student	46,7%	53,3%	47,8%	33,3%	11,1%	2,2%	5,6%
	Part-time employee	42,9%	57,1%	57,1%	23,8%	4,8%	0,0%	14,3%
	Self-employed	20,0%	80,0%	80,0%	0,0%	6,7%	0,0%	13,3%
	Full-time employee	29,6%	70,4%	65,5%	11,2%	3,1%	0,0%	20,2%
	Pensioner	25,0%	75,0%	0,0%	75,0%	0,0%	0,0%	25,0%
	Unemployed	74,2%	25,8%	22,6%	29,0%	19,4%	19,4%	9,7%

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Table 5.10: ICT device usage by demographic groups during public transportation trip – Gaborone

Demographic group (N = 415)		Use of device while travelling		Type of device					
		No	Yes	Smartphone	Cell phone	Tablet	Computer / Laptop	GPS	No devices used
		N = 132	N = 283	N = 300	N = 34	N = 6	N = 2	N = 0	N = 73
Age	18 - 25	24,7 %	75,3%	78,2%	2,9%	1,8%	1,2%	0,0%	15,9%
	26 - 35	32,8 %	67,2%	71,1%	9,0%	1,5%	0,0%	0,0%	18,4%
	36 - 45	54,5 %	45,5%	54,5%	25,0%	0,0%	0,0%	0,0%	20,5%
	46 - 55	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	56 - 65	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	65+	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Occupation	Student	18,8 %	81,2%	81,2%	2,6%	2,6%	,9%	0,0%	12,8%
	Part-time employee	42,9 %	57,1%	62,9%	8,6%	0,0%	0,0%	0,0%	28,6%
	Self-employed	35,3 %	64,7%	67,6%	14,7%	2,9%	0,0%	0,0%	14,7%
	Full-time employee	34,9 %	65,1%	72,1%	8,7%	1,2%	0,0%	0,0%	18,0%
	Pensioner	40,0 %	60,0%	60,0%	20,0%	0,0%	0,0%	0,0%	20,0%
	Unemployed	40,4 %	59,6%	63,5%	13,5%	0,0%	1,9%	0,0%	21,2%

5.3.5 Types of devices used during travel

The participants who used ICT during their travel were asked to indicate the types of devices they used, and the results are presented in Figure 5.6 below. The figure shows that 57.3% of the participants in Bloemfontein used smartphones, compared with 72.3% in Gaborone. A further 18.8% of participants in Bloemfontein used conventional mobile phones, compared with ony 8.2% in Gaborone. A further 6.5% of the participants in Bloemfontein used tablets compared to only 1.4% in Gaborone. Computers and/or laptops were used at much lower rates than other devices, specifically, 2.1% of participants in Bloemfontein used them compared with 0.5% in Gaborone. Some users indicated that they did not use any ICT devices during trips, with 15.4% in Bloemfontein and 17.6% in Gaborone.

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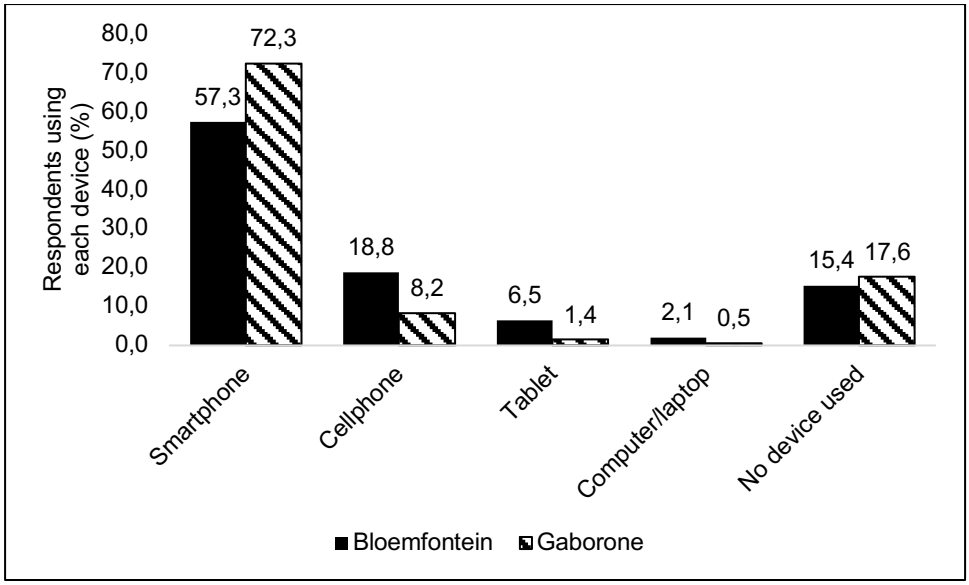

Figure 5.6: ICT devices used during trips on public transportation

Figure 5.6 shows that smartphones were the most used device during trips because of their easy accessibility. Most students and the working participants used smartphones, while conventional mobile phones were used mostly by the older generation, as they are less complicated to operate. Smartphones are used for popular activities during travel, such as social networking and accessing emails, online newspapers and downloadable books. Conventional mobile phones are used mainly for calling, SMS and listening to the radio.

5.4 ICT as a Substitute for Travel

Figure 5.7 shows ICT used for travel purposes and ICT as a substitute for travel. Use of ICT for travel purposes was uncommon in both cities. In Bloemfontein, only 14.6% of the participants used ICT for travel purposes, compared with 85.4% who did not. In Gaborone, only 24.1% of the participants used ICT for travel purposes, while 75.9% did not.

The participants were asked whether they would use ICT as a substitute for travel and the results are shown in Figure 5.7. The responses from both cities were slightly divided over the matter. Specifically, 46.5% of the participants in Bloemfontein would not use ICT as a substitute for travel, compared with 53.6% who would give up travelling to use available ICT options. In Gaborone, 52.0% indicated that they would

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not undertake trips if they had ICT-based alternatives to travel, while 48% indicated that they would still have undertaken the trips, as they were required to travel physically.

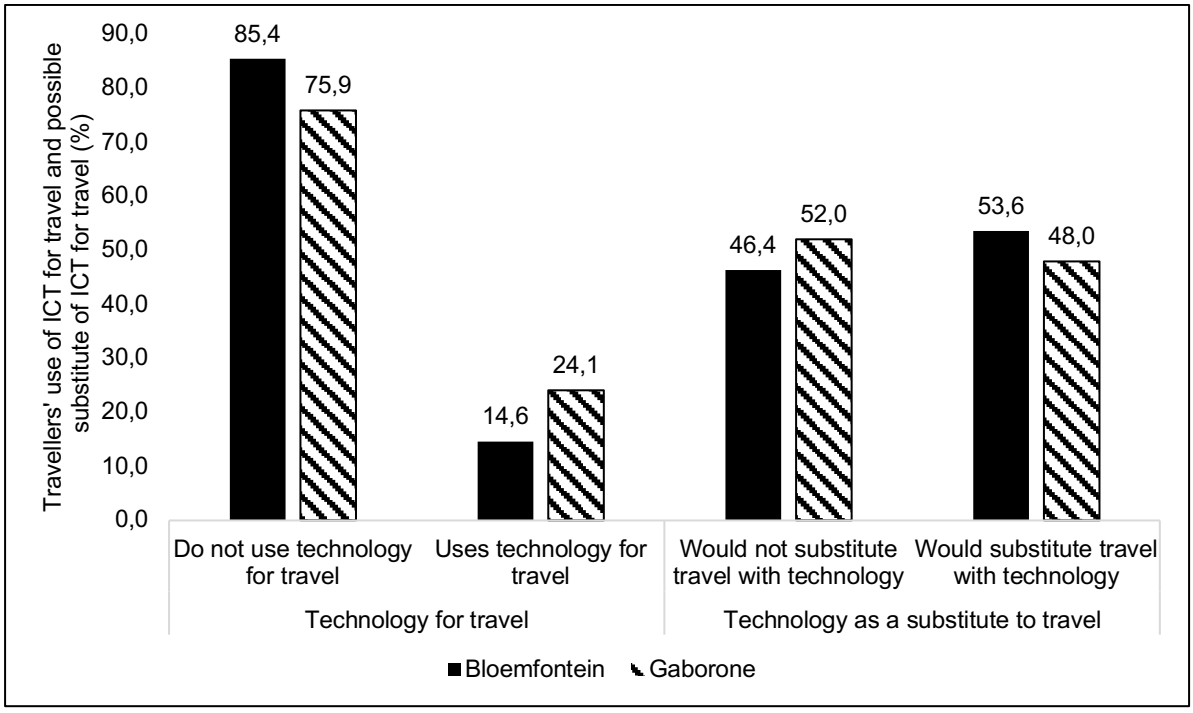

Figure 5.7: Use of ICT for travel versus ICT as a substitute for travel

Since the advancement of technology and introduction of technology into transportation systems, some of the main impacts that technology could have on transportation were technology being used as a substitute for travel or technology increasing people's need and demand for travel. The data showed that noteworthy percentages of the participants claimed that they would consider using technology as a substitute for travel. Also relevant was the high percentage of participants who would still travel physically to perform activities. Ultimately, it was not certain from the results whether ICT would be able to replace the need to travel. Given the option to work remotely by applying ICT, large numbers of trips could still require public transportation together with a noteworthy decline in the number of regular commuters. This indicated that ICT will not replace the need to travel or make public transportation obsolete. Therefore, efforts will have to continue to improve the essential aspects of public transportation, beyond technological enhancements.

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Table 5.11: Current use of ICT for travel compared to prospects of travel substitution by ICT – Bloemfontein

Demographic group (N = 384)		Technology use for travel-related purposes		Would participants' use technology instead of travel	
		No	Yes	No	Yes
		N = 328	N = 56	N = 178	N = 206
Age (years)	18 -25	90,0%	10,0%	54,0%	46,0%
	26 - 35	81,4%	18,6%	51,7%	48,3%
	36 - 45	83,9%	16,1%	32,2%	67,8%
	46 - 55	91,7%	8,3%	47,2%	52,8%
	56 - 65	100,0%	0,0%	28,6%	71,4%
	65+	0,0%	100,0%	0,0%	100,0%
Participant's Occupation	Student	93,3%	6,7%	60,0%	40,0%
	Part-time employee	81,0%	19,0%	47,6%	52,4%
	Self-employed	66,7%	33,3%	40,0%	60,0%
	Full-time employee	83,9%	16,1%	35,0%	65,0%
	Pensioner	50,0%	50,0%	25,0%	75,0%
	Unemployed	90,3%	9,7%	93,5%	6,5%

Table 5.12: Current use of ICT for travel compared to prospects of travel substitution by ICT – Gaborone

Demographic group (N = 415)		ICT for travel		Use of ICT to substitute travel	
		No	Yes	No	Yes
		N = 315	N = 100	N = 216	N = 199
Age (years)	18 - 25	74,1%	25,9%	54,7%	45,3%
	26 - 35	75,1%	24,9%	51,2%	48,8%
	36 - 45	86,4%	13,6%	45,5%	54,5%
	46 - 55	0,0%	0,0%	0,0%	0,0%
	56 - 65	0,0%	0,0%	0,0%	0,0%
	65+	0,0%	0,0%	0,0%	0,0%
Occupation	Student	71,8%	28,2%	53,8%	46,2%
	Part-time employee	77,1%	22,9%	62,9%	37,1%
	Self-employed	79,4%	20,6%	47,1%	52,9%
	Full-time employee	77,9%	22,1%	52,3%	47,7%
	Pensioner	60,0%	40,0%	60,0%	40,0%
	Unemployed	76,9%	23,1%	42,3%	57,7%

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5.4.1 Substituting ICT alternatives for regular travel

The use of ICT alternatives instead of travelling has been one of the impacts that information technology has had on transportation. Binary probit regression was used for this analysis to predict the probabilities of users of public transportation substituting their regular travel through the use of ICT. ICT-based alternatives to travel, such as online studies, working from home and online shopping, have the potential to reduce the need for physical and frequent travel. Independent variables used for both models were mode of travel, trip purpose, activity while travelling, and the use of ICT devices.

Model for substituting ICT for regular travel in Bloemfontein

Normality tests of the variables were performed and the results in Table 5.13 show normal distribution of data.

Table 5.13: Normality Tests for variables used in the substitution of ICT for regular travel - Bloemfontein

	N	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Would participants use technology instead of travel	384	0,499	-,147	0,125	-1,989	0,248
Technology usage for travel-related purposes	384	0,353	2,015	0,125	2,070	0,248
Participant's use of technological devices during trip	384	0,485	-,518	,125	-1,740	0,248

A null hypothesis was tested, stating that usage of technology for travel purposes and use of devices during public transportation trips were independent. Model parameters are shown in Table 5.14. To establish probabilities of public transportation users substituting travel with ICT use in Bloemfontein, significant variables determined by the analysis were technology use for travel purposes and the use of technological devices during trips. Out of N = 384 participants, 53.6% indicated that they would use ICT instead of travelling for some activities, while 46.4% would still keep travelling for activities.

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$$x_1 = Technology\ usage\ for\ travel\ related\ purposes$$
$$x_2 = Use\ of\ technological\ devices\ during\ trip$$

Table 5.14: Regression coefficients for substitution of ICT for regular travel - Bloemfontein

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-,695	,1143	-,919	-,471	36,959	1	,000
Use of technological device during trip	1,133	,1460	,847	1,419	60,200	1	,000
Technology usage for travel-related purpose	,584	,2158	,161	1,007	7,332	1	,007
(Scale)	1[a]						

The Likelihood Ratio chi-square of 86,360; DF = 2 and p-value = 0.000. The event that a person would use ICT instead of travelling to perform activities is determined by the person's use of technological devices during trips and whether the person had been using ICT for travel purposes. All independent variables were significant to the model, with p-values of less than 0.05. Both the use of technological devices during a trip and technology usage for travel-related purposes were positive predictors of the model. The null hypothesis is therefore acceptable.

Model for substituting ICT for regular travel in Gaborone

Skewness and kurtosis normality tests performed on the data showed that the data was normally distributed. These normality test results are shown in Table 5.15.

Table 5.15: Normality Tests for variables used in the substitution of ICT for regular travel - Gaborone

	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Use of ICT to substitute travel	415	0,48	0,500	0,082	0,120	-2,003	0,239
ICT for travel	415	0,24	0,428	1,216	0,120	-,524	0,239
Use of device while travelling	415	0,68	0,466	-,784	0,120	-1,392	0,239

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The following independent variables were suitable for the model.

$$x_1 = ICT\ use\ for\ travel\ purposes$$
$$x_2 = Use\ of\ technological\ devices\ during\ trip$$

The model coefficients are shown in Table 5.16 below, indicating that the two independent variables were significant towards the model. ICT use for travel purposes and the use of technological devices during trips had significance values of < 0.05.

Table 5.16: Regression coefficients for substitution of ICT for regular travel - Gaborone

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	0,104	0,1103	-0,112	0,320	0,891	1	0,345
ICT use for travel purposes	0,368	0,1502	0,074	0,663	6,008	1	0,014
Use of technological devices during trip	-0,359	0,1379	-0,629	-0,089	6,780	1	0,009

Table 5.16 shows the regression coefficients of the ICT substitution for travel in Gaborone. Both independent variables were significant, producing p-values of less than 0.05. The probability that an individual will substitute travel with ICT is based on whether the individuals currently use ICT for travel purposes and whether they have been using ICT device during their trips. Use of ICT for travel was a positive and significant predictor of ICT substitution for travel, while the use of a device was a negative and significant predictor.

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5.5 The Public Transportation Experience

5.5.1 Period of usage of public transportation services

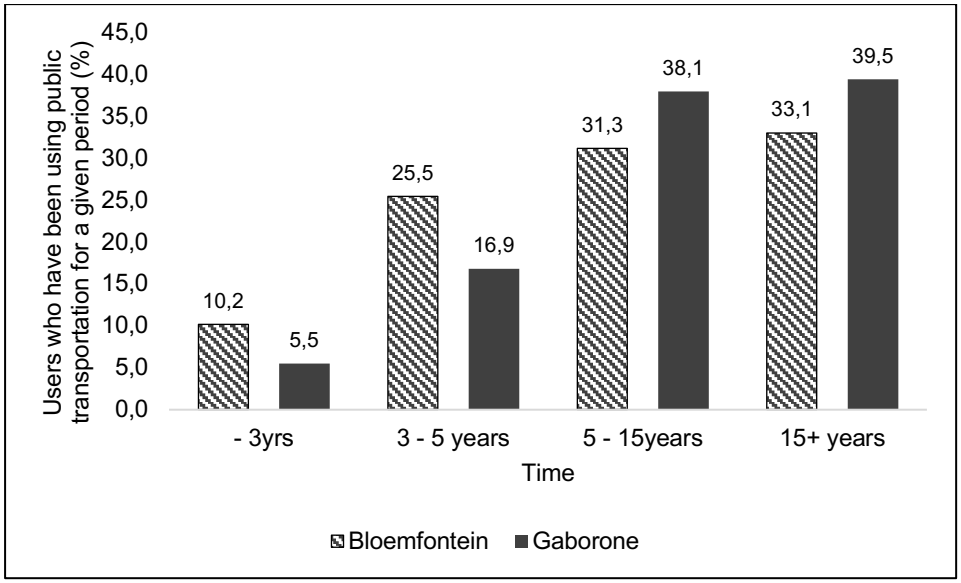

Figure 5.8: Period of usage of public transportation usage by participants

Figure 5.8 shows the periods for which the participants in both areas had been using public transportation. Most of the participants in Bloemfontein had been long-term users of public transportation. Overall, 33.1% of the participants had used public transportation for over 15 years, and 31.3% had been using public transportation for a period between 5 and 15 years. In the shorter term, 25.5% of the participants had been using public transportation for 3 to 5 years, while only 10.2% had been using it during the past 3 years or less.

In Gaborone, 5.5% of the participants had been using the system for 3 years or less, 16.9% had been using it for a period of between 3 and 5 years, 38.1% for a period between 5 and 15 years, while 39.5% had been using it for over 15 years. The results are also presented in Tables 5.17 and 5.18, showing how long people of different age groups and occupations had been using public transportation services.

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Table 5.17: Period of public transportation use by demographic group - Bloemfontein

Demographic group (N = 384)		Period participants have been using public transportation			
		- 3 yrs	3 - 5 years	5 – 10 years	15+ years
		N = 39	N = 98	N = 120	N = 127
Participant's Age	18 -25	27,0%	33,0%	21,0%	19,0%
	26 - 35	5,5%	31,7%	37,2%	25,5%
	36 - 45	2,3%	19,5%	39,1%	39,1%
	46 - 55	0,0%	5,6%	30,6%	63,9%
	56 - 65	7,1%	0,0%	0,0%	92,9%
	65+	50,0%	0,0%	0,0%	50,0%
Participant's Occupation	Student	23,3%	33,3%	27,8%	15,6%
	Part-time employee	9,5%	33,3%	33,3%	23,8%
	Self-employed	6,7%	53,3%	20,0%	20,0%
	Full-time employee	4,9%	18,8%	33,2%	43,0%
	Pensioner	25,0%	0,0%	25,0%	50,0%
	Unemployed	9,7%	35,5%	32,3%	22,6%

Table 5.18: Period of public transportation use by demographic group - Gaborone

Demographic group (N = 415)		Period participants have been using public transportation			
		-3 years	3 – 5 years	5 -15 years	15+ years
		N = 23	N = 70	N = 158	N = 164
Age	18 - 25	8,8%	25,3%	33,5%	32,4%
	26 - 35	2,5%	12,4%	44,3%	40,8%
	36 - 45	6,8%	4,5%	27,3%	61,4%
	46 - 55	0,0%	0,0%	0,0%	0,0%
	56 - 65	0,0%	0,0%	0,0%	0,0%
	65+	0,0%	0,0%	0,0%	0,0%
Occupation	Student	10,3%	27,4%	36,8%	25,6%
	Part-time employee	0,0%	22,9%	34,3%	42,9%
	Self-employed	0,0%	8,8%	41,2%	50,0%
	Full-time employee	4,7%	9,9%	39,5%	45,9%
	Pensioner	20,0%	20,0%	0,0%	60,0%
	Unemployed	3,8%	17,3%	40,4%	38,5%

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5.5.2 Noticeability of change in the public transportation system

Participants were asked to indicate the type of change they had noticed within the public transportation system over the periods of their public transport usage. The results are presented in Figure 5.9. Tables 5.15 and 5.16 show the results according to the different age groups and the participants' occupations.

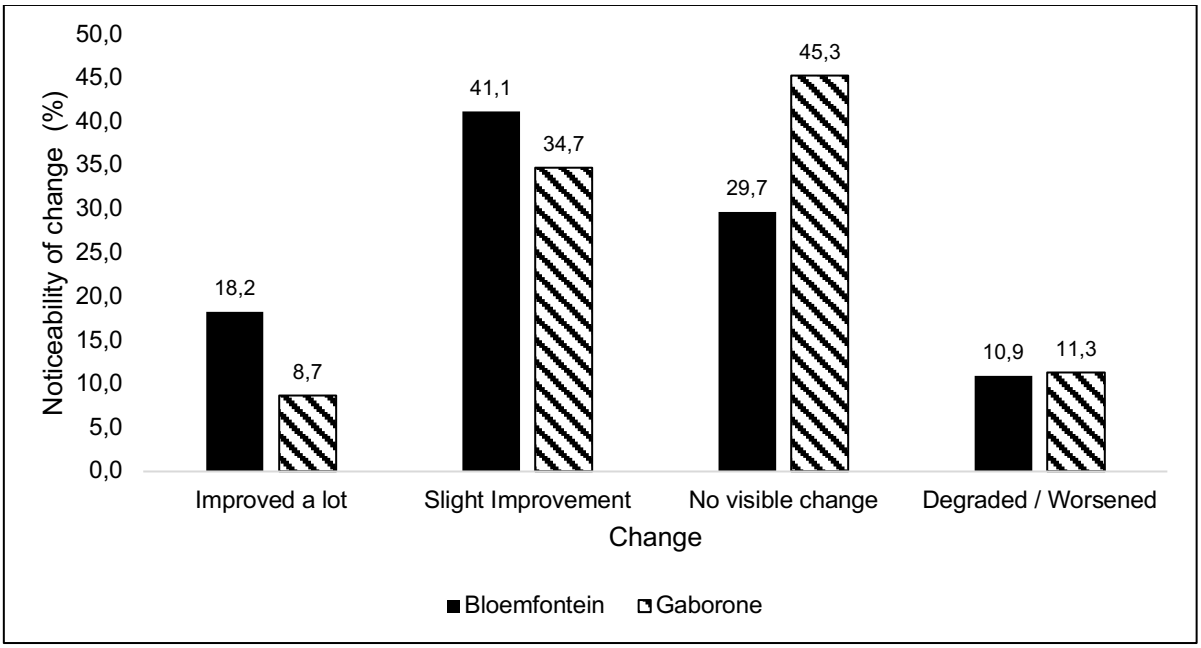

Figure 5.9: Noticeability of change in the public transportation system

Figure 5.9 shows the participants' perspectives of change in the public transportation system over the period of their public transport use. A total of 18.2% had noticed a lot of improvements of the system, 41.1% had noticed a slight improvement, while 29.7% had not noticed any visible change. Furthermore, 10.9% of participants had noticed a deterioration in the Bloemfontein public transportation system over the years. In Gaborone, only 8.7% of participants had noticed a lot of improvements in the public transportation system over the time they had been using the system, while 34.7% indicated that they had noticed a slight improvement. More participants (45.3%) indicated that they had not noticed any visible changes in the system, while 11.3% indicated that the public transportation system in Gaborone had deteriorated. These statistics indicated that both public transportation systems had not improved according to the expectations of users, as more participants noticed only slight improvements or even a deterioration of the system. Tables 5.19 and 5.20 show how people of different ages and occupations perceived the changes in the public transport system.

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Table 5.19: Perception of change of the public transportation system by demographic group - Bloemfontein

Demographic group (N = 384)		Change of public transportation system over the years			
		Improved a lot	Slight Improvement	No visible change	Degraded / Worsened
		N = 70	N = 158	N = 114	N = 42
Age (years)	18 -25	12,0%	35,0%	43,0%	10,0%
	26 - 35	17,2%	47,6%	22,1%	13,1%
	36 - 45	19,5%	41,4%	32,2%	6,9%
	46 - 55	30,6%	33,3%	22,2%	13,9%
	56 - 65	28,6%	42,9%	14,3%	14,3%
	65+	50,0%	0,0%	50,0%	0,0%
Participant's Occupation	Student	14,4%	30,0%	46,7%	8,9%
	Part-time employee	19,0%	47,6%	19,0%	14,3%
	Self-employed	33,3%	53,3%	6,7%	6,7%
	Full-time employee	19,7%	42,2%	25,1%	13,0%
	Pensioner	25,0%	25,0%	50,0%	0,0%
	Unemployed	9,7%	58,1%	29,0%	3,2%

Table 5.20: Perception of change of the public transportation system by demographic group - Gaborone

Demographic group (N = 415)		Change of public transportation system over the years			
		Improved a lot	Slight improvement	No visible change	Degraded
		N = 36	N = 144	N = 188	N = 47
Age (years)	18 - 25	6,5%	34,7%	48,2%	10,6%
	26 - 35	8,0%	35,3%	45,8%	10,9%
	36 - 45	20,5%	31,8%	31,8%	15,9%
	46 - 55	0,0%	0,0%	0,0%	0,0%
	56 - 65	0,0%	0,0%	0,0%	0,0%
	65+	0,0%	0,0%	0,0%	0,0%
Occupation	Student	3,4%	31,6%	54,7%	10,3%
	Part-time employee	8,6%	45,7%	34,3%	11,4%
	Self-employed	17,6%	38,2%	35,3%	8,8%
	Full-time employee	11,0%	35,5%	43,0%	10,5%
	Pensioner	0,0%	40,0%	20,0%	40,0%
	Unemployed	7,7%	28,8%	48,1%	15,4%

Most of the participants who used public transportation in the selected cities had been using the public transportation systems for periods of over 5 years, and an even higher percentage had used the systems for over 15 years. Over such long exposure to the public transport systems, most of the participants had noticed only slight improvements or an overall deterioration of the systems. The public transportation users who had noticed a lot of improvements in the systems could be those who had

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been using public transportation for a long time, and who would have witnessed minor shifts in the systems. These could include increasing numbers of public transportation vehicles, a change in vehicle makes, as well as improved operations. Their perceptions of improvement could have been based on the state the system was in over 15 years ago, the types of vehicles, the physical conditions of the vehicles, as well as the operational structure of the system. Few vehicles would have meant longer waiting periods or a lack of vehicles on some routes. User perceptions of the changes in the systems over the years could also have been affected by the lack of infrastructure to support public transportation.

The data indicated high percentages of stagnancy, especially in Gaborone (45.3%). Table 5.22 shows that stagnancy was noted by 39.6% of people who had been using the system for over 15 years, while 44.3% of those who have been using it for over 5 years but less than 15 years and 55.7% of those who have been using public transport for over 3 years and less than 5 years also noted that there was no change in the system. Finally, 60.9% of those who had been using public transportation for less than 3 years were able to notice any change in this relatively short time of exposure to the system. Table 5.21 shows that 59% of those who had only been using the public transportation in Bloemfontein for less than 3 years did not notice any changes; however, most of those who had been using the system for periods ranging from 3 to 5 years (42.9%), 5 to 10 years (45%) and over 15 years (43.3%) noticed slight improvements of the public transportation system.

Table 5.21: Perceptions on change of public transportation system-based on duration of use - Bloemfontein

		Change of public transportation system over the years			
		Improved a lot	Slight Improvement	No visible change	Degraded / Worsened
		N = 70	N = 158	N = 114	N = 42
Period participants have been using public transportation	- 3 yrs	12,8%	17,9%	59,0%	10,3%
	3 - 5 years	10,2%	42,9%	34,7%	12,2%
	5 – 10 years	19,2%	45,0%	25,0%	10,8%
	15+ years	25,2%	43,3%	21,3%	10,2%

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Table 5.22: Perceptions on change of public transportation system-based on duration of use – Gaborone

		Change of public transportation system over the years			
		Improved a lot	Slight improvement	No visible change	Degraded
		N = 36	N = 144	N = 188	N = 47
Period participants have been using public transportation	-3 years	4,3%	26,1%	60,9%	8,7%
	3 – 5 years	2,9%	30,0%	55,7%	11,4%
	5 -15 years	10,8%	38,6%	44,3%	6,3%
	15+ years	9,8%	34,1%	39,6%	16,5%

5.5.3 Future use of public transportation

The participants were asked whether they would still be using the public transportation system in the next 10 years, if it remained in its current state. The participants from Bloemfontein indicated a 44.7% chance of not using the system in future, while 52.3% would continue using the public transportation system over the next 10 years. In Gaborone, 83.1% claimed that they would not use public transportation in the next 10 years, compared with 16.9% who indicated that they would still use public transportation in future, in its current state. The results are shown in Figure 5.10.

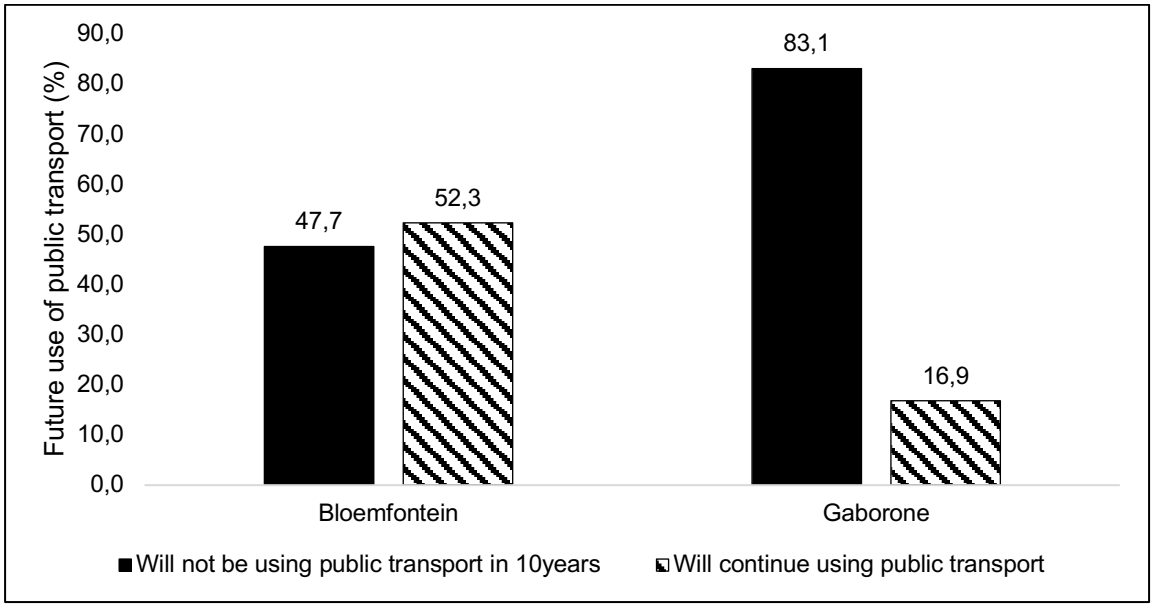

Figure 5.10: Future use of public transportation

More participants (52.3%) in Bloemfontein would still use public transportation in future, while in Gaborone, most (83.1%) did not intend to use public transportation in

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future. Gaborone had already reached a much higher level of private car ownership than Bloemfontein, and it is quite likely that many people in Gaborone were also planning to buy their own cars, once they could afford them.

5.6 Socioeconomic Characteristics of Trips

In the following section, the socioeconomic characteristics of the regular trips made by individual travellers per day were explored. The socioeconomic aspects associated with each trip were the mode of transportation, cost of each trip, and the purposes for which the trips were undertaken.

5.6.1 Public transportation mode

Making a trip by using public transportation involves the use of a selection of available modes of transportation. The results for modes of transportation used for trips per day are presented in Figure 5.11 (Bloemfontein) and Figure 5.12 (Gaborone).

The results showed that the participants in Bloemfontein used minibus taxis for most of their trips by public transportation. The results indicated that 70.3%, 74.5%, 52.6% and 50%, respectively, of the participants mostly used minibus taxis for the first, second, third and fourth trips of the day. The results also indicated that 28.9% used buses for Trip 1, 23.4% for Trip 2, 47.4% for Trip 3 and 50% for the fourth trip. Cabs were used rarely by only 0.8% and 2.1% of the participants for the first and second trips, respectively.

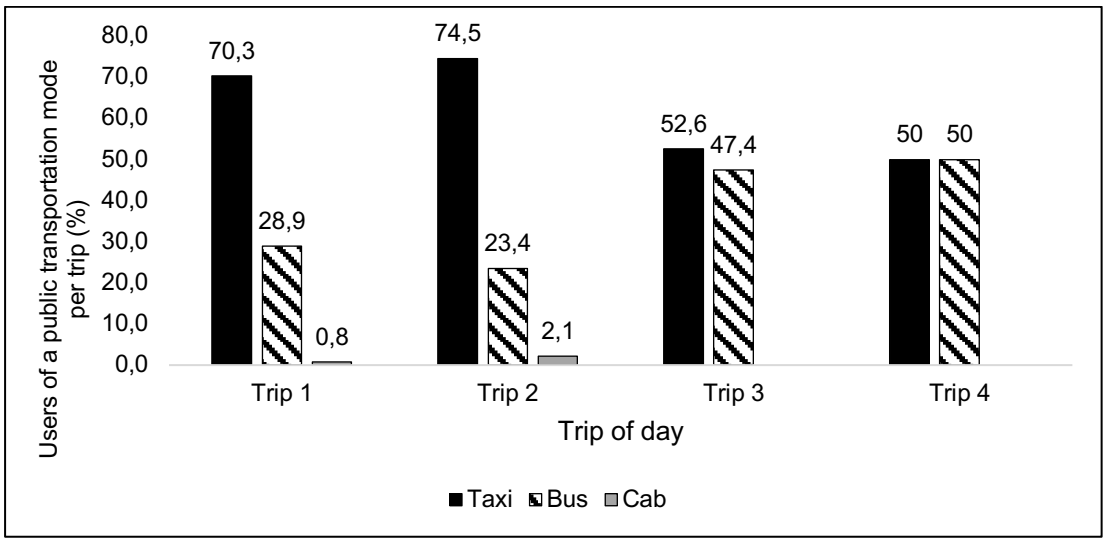

Figure 5.11: Modes of travel for each trip - Bloemfontein

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Table 5.23: Multimodality of public transportation - Bloemfontein

		Mode of Transport for Trip 2			Mode of Transport for Trip 3			Mode of Transport for Trip 4		
		Taxi	Bus	Cab	Taxi	Bus	Cab	Taxi	Bus	Cab
		N = 286	N = 90	N = 8	N = 50	N = 45	N = 0	N = 31	N = 31	N = 0
Mode of Transport for Trip 1	Taxi N = 270	96,3%	2,6%	1,1%	88,2%	11,8%	0,0%	96,7%	3,3%	0,0%
	Bus N = 111	23,4%	74,8%	1,8%	11,4%	88,6%	0,0%	6,3%	93,8%	0,0%
	Cab N = 3	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

Table 5.23 shows that 96.3% of those who used a minibus taxi for their first trip also used the same mode for their second trip. A further 88.2% and 96.7%, respectively, also used minibus taxis for the third and fourth trips. Only 2.6%, 11.8% and 3.3%, respectively, of those who used taxis for their first trip undertook their second, third and fourth trips by bus. Analysing the bus trips, 23.4% of those who travelled by bus for their first trips used minibus taxis for their second trips, 11.4% for their third trip and 6.3% for the fourth trip. These results indicated the limited multimodality and lack of integration between modes as the majority of people used a single mode for all their trips.

In Gaborone, combis were the commonly used mode of public transportation. The results indicated that 76.6%, 73.5%, 48.5% and 44.3%, respectively, of the participants used combis for Trip 1, Trip 2, Trip 3 and Trip 4 per day. The results also indicated that taxis were the second most used mode of public transportation, with 22.9%, 24.8%, 48.5% and 55.7% usage for trips 1 to 4, respectively. Table 5.24 shows the multimodal trip characteristics, where 89.6%, 57.7% and 80.6% of combi users. Similar to Bloemfontein, cabs were the least used mode, with only 0.5% usage for Trip 1, 1.7% for Trip 2, and 3.1% for the third trip, while none of the participants used cabs for the fourth trip.

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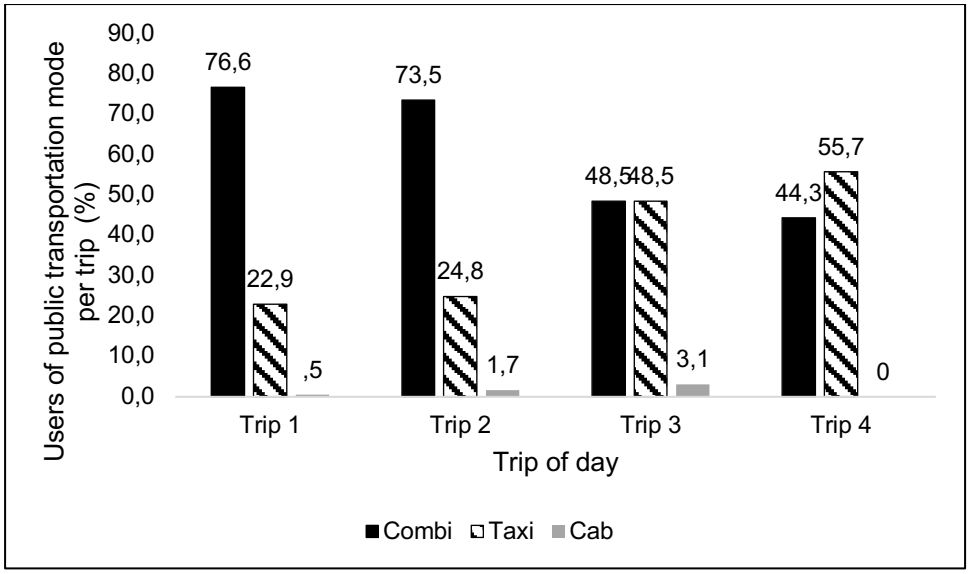

Figure 5.12: Modes of travel for each trip - Gaborone

Table 5.24: Multimodality of public transportation trips - Gaborone

		Mode of transport used for trip 2			Mode of transport used for trip 3			Mode of transport used for trip 4		
		Combi	Taxi	Cab	Combi	Taxi	Cab	Combi	Taxi	Cab
		N = 305	N = 103	N = 7	N = 47	N = 47	N = 3	N = 31	N = 39	N = 0
Mode of transport used for trip 1	Combi (N =318)	89,6%	9,1%	1,3%	57,7%	38,5%	3,8%	80,6%	19,4%	0,0%
	Taxi (N = 95)	21,1%	77,9%	1,1%	37,8%	60,0%	2,2%	5,9%	94,1%	0,0%
	Cab (N = 2)	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

5.6.2 Trip purpose

The purposes for which the individual trips were undertaken were also investigated. Table 5.25 shows the distribution of all trips made by public transportation per day according to the users' purpose in Bloemfontein and Gaborone.

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Table 5.25: Distribution of trips per day according to trip purpose

City	Trip purpose	Percentage of travellers per trip			
		Trip 1	**Trip 2**	**Trip 3**	**Trip 4**
Bloemfontein	Work	66,9	16,4	0,0	0,0
	Shopping	11,5	3,4	0,0	0,0
	Educational	14,3	2,6	0,0	0,0
	Public services	1,3	0,0	0,0	0,0
	Recreation	1,6	0,0	0,0	0,0
	Sports	0,5	0,5	0,0	0,0
	Banking	0,3	0,0	0,0	0,0
	Family obligations	3,1	1,0	0,0	0,0
	Leisure	0,5	0,0	0,0	0,0
	Religious	0,0	0,5	0,0	0,0
	Home	0,0	75,5	100	100
	Total	**100.0**	**100.0**	**100.0**	**100.0**
Gaborone		**Trip 1**	**Trip 2**	**Trip 3**	**Trip 4**
	Work	56,6	12,8	1,0	1,4
	Shopping	6,3	0,5	0,0	0,0
	Educational	23,6	7,2	0,0	0,0
	Public services	1,4	0,2	0,0	0,0
	Recreational	0,7	0,2	0,0	0,0
	Sporting activities	2,7	1,2	0,0	0,0
	Banking	0,2	0,0	0,0	0,0
	Family obligations	2,9	1,2	1,0	0,0
	Leisure	3,6	0,5	1,0	1,4
	Religious	1,9	0,5	1,0	0,0
	Home	0,0	75,7	95,9	97,1
	Total	**100,0**	**100,0**	**100,0**	**100,0**

The results showed that in Bloemfontein, 66.9% of the first trips were undertaken for work, 14.3% were undertaken for educational purposes, 11.5% were shopping trips, and 3.1% were to fulfil family obligations. Only 1.6% of the first trips were for recreational purposes, 1.3% to access public services, 0.5% for sports, 0.3% for banking and 0.5% for leisure activities. There were no religious and home-bound trips made by individuals on the first trips. In Gaborone, 56.6% of the first trips were for work, 23.6% of the trips were for education, and 6.3% were shopping trips. The remaining trips were distributed among activities as follows: 3.6% leisure trips, 2.9% family obligations, 2.7% sporting activities, 1.9% religious, 1.4% to access public services, 0.7% recreational and 0.2% trips for banking reasons.

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The results obtained from the participants in Bloemfontein indicated that the second trips of the day comprised 75.5% home trips, 16.4% work trips, 3.4% shopping trips, 2.6% educational trips, 1% for family obligations, and 0.5% trips each for sporting and religious activities. The second trips of the day in Gaborone comprised 75.7% home trips, 12.8% work trips, and 7.2% educational trips, but only 1.2% sporting activities, 0.5% shopping, leisure and religious activities, and 0.2% to access public services and recreational activities. These results showed that far more participants who used public transportation made only two trips per day, one trip from home to work and one trip from work to home.

In Bloemfontein, 100% of all third and fourth trips were home-bound trips for all the participants. In Gaborone, 95.9% of the third trips were home trips, with only 1.0% each for work, leisure, religious activities and family obligations, respectively. Trip 4 also comprised mainly home-bound trips (97.1%) and 1.4% each for work and leisure trips, respectively.

The distribution of trips per activities and frequency are presented in Tables 5.26 to 5.29. The results showed that the majority of the trips were undertaken for work purposes and occurred every weekday. A total of 65.5% , 60.7% and 87.1%, respectively, of participants from Bloemfontein undertook two, three, and four trips, per day, which were for work reasons. Similarly, in Gaborone, 56%, 77.8% and 50% of those who undertook two, three, and four trips, respectively, undertook these trips for work.

Tables 5.24 and 5.25 substantiate that the majority of the trips by public transportation were weekday trips, where 66%, 50% and 85.5% of those who undertook two, three and four trips per day using public transportation in the city of Bloemfontein travelled on weekdays. In Gaborone, 51.6%, 74.1% and 70% of people undertaking two, three and four trips per day repeated the journey every weekday.

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Table 5.26: Trip distribution for activities - Bloemfo

		Trip purpose										
		Work	Shoppin g	Educational	Public Services	Recreation	Sports	Banking	Family obligations	Leisure	Religious	Home
		N = 263	N = 41	N = 58	N = 3	N = 3	N = 1	N = 0	N = 11	N = 2	N = 2	N = 0
Number of Trips	2	65,3%	12,6%	15,6%	1,0%	1,0%	0,3%	0,0%	2,7%	0,7%	0,7%	0,0%
	3	60,7%	14,3%	14,3%	0,0%	0,0%	0,0%	0,0%	10,7%	0,0%	0,0%	0,0%
	4	87,1%	0,0%	12,9%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

Table 5.27: Trip distribution for activities - Gaborone

		Trip purpose											
		Work	Shopping	Educational	Public services	Recreational	Sporting activities	Banking	Family obligations	Leisure	Religious	Home	Job hunting
		N = 234	N = 25	N = 98	N = 4	N = 1	N = 12	N = 0	N = 12	N = 16	N = 10	N = 1	N = 2
Number of Trips	2	56,0%	7,5%	21,7%	0,9%	0,0%	3,5%	0,0%	2,2%	4,7%	2,8%	0,0%	0,6%
	3	77,8%	0,0%	18,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	3,7%	0,0%
	4	50,0%	1,4%	34,3%	1,4%	1,4%	1,4%	0,0%	7,1%	1,4%	1,4%	0,0%	0,0%

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Table 5.28: Frequency of number of trips - Bloemfontein

		Trip Frequency				
		Weekdays (Monday - Friday)	Every day (7 days a week)	Saturdays and Sundays only	2 - 3 times a week	First-time trip
		N = 261	N = 64	N = 13	N = 41	N = 5
Number of Trips	2	66,0%	17,0%	3,4%	12,2%	1,4%
	3	50,0%	32,1%	10,7%	3,6%	3,6%
	4	85,5%	8,1%	0,0%	6,5%	0,0%

Table 5.29: Frequency of number of trips - Gaborone

		Trip Frequency				
		Weekdays (Monday - Friday)	Every day (7 days a week)	Saturdays or Saturdays only	2 - 3 Days a week	First-time trip
		N = 233	N = 73	N = 43	N = 66	N = 0
Number of Trips per day	2	51,6%	20,1%	10,7%	17,6%	0,0%
	3	74,1%	11,1%	3,7%	11,1%	0,0%
	4	70,0%	8,6%	11,4%	10,0%	0,0%

Urban movements in the two cities were largely characterised by pendulum movement from home to work or for educational purposes, personal movements for shopping, recreational and other voluntary trips were also undertaken regularly by some of the participants. These results showed that a significant percentage of the participants who used public transportation undertook two home-to-work journeys and two work to home trips, mostly because of the lack of direct public transportation connecting all areas of the city.

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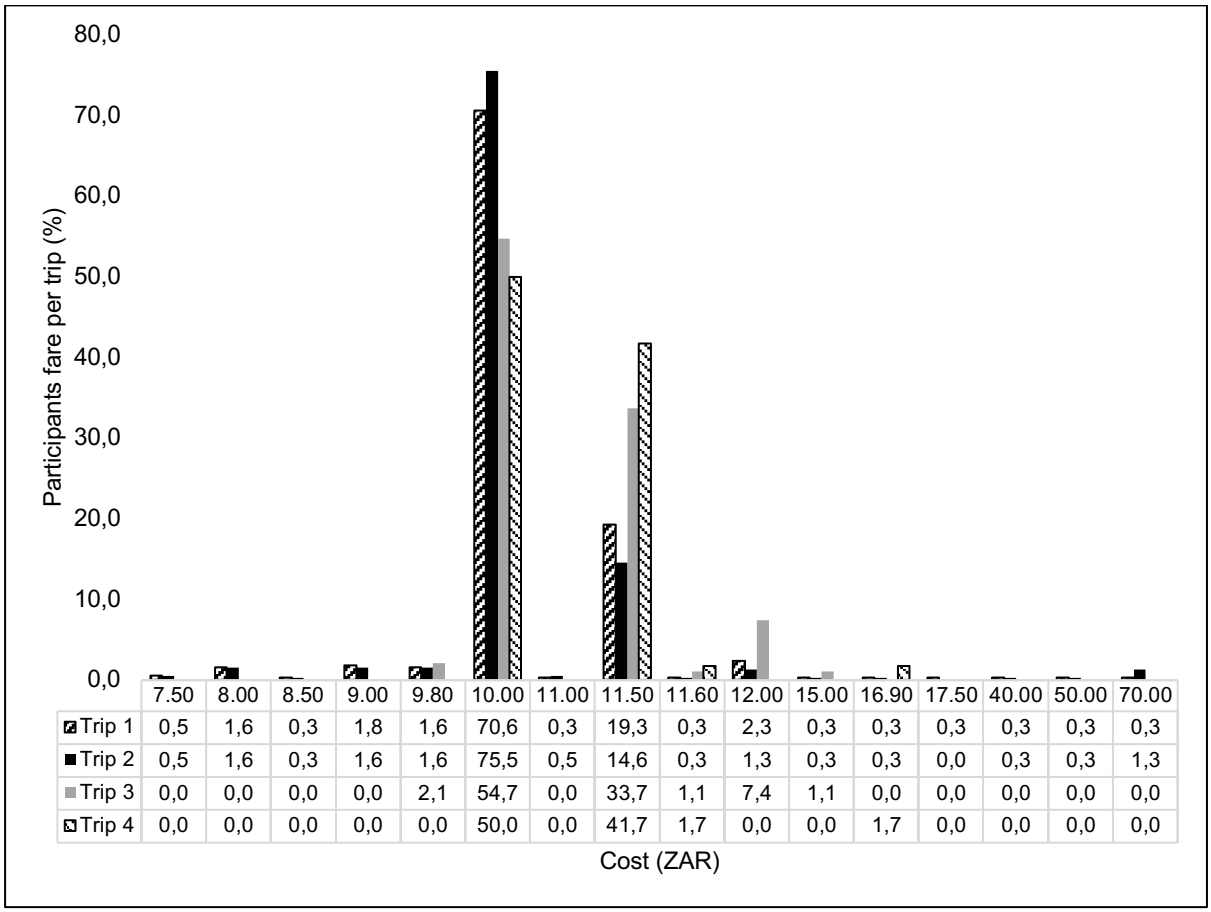
5.6.3 Trip costs



	7.50	8.00	8.50	9.00	9.80	10.00	11.00	11.50	11.60	12.00	15.00	16.90	17.50	40.00	50.00	70.00
Trip 1	0,5	1,6	0,3	1,8	1,6	70,6	0,3	19,3	0,3	2,3	0,3	0,3	0,3	0,3	0,3	0,3
Trip 2	0,5	1,6	0,3	1,6	1,6	75,5	0,5	14,6	0,3	1,3	0,3	0,3	0,0	0,3	0,3	1,3
Trip 3	0,0	0,0	0,0	0,0	2,1	54,7	0,0	33,7	1,1	7,4	1,1	0,0	0,0	0,0	0,0	0,0
Trip 4	0,0	0,0	0,0	0,0	0,0	50,0	0,0	41,7	1,7	0,0	0,0	1,7	0,0	0,0	0,0	0,0

Figure 5.13: Trip costs - Bloemfontein

Figure 5.13 shows the costs of trips in Bloemfontein. The average cost for Trip 1 was R10.00. Most of the participants (70.6%) paid R10.00 per trip for Trip 1; 75.5% for Trip 2; 54.7% for Trip 3; and 50% for Trip 4. Other participants (19.3%) paid R11.50 for Trip 1; 14.6% for Trip 2; 33.7% for Trip 3; and 41.7% for Trip 4.

The standard minibus taxi fare at the time of the survey was R10.00 per trip, while bus fares varied according to zones. However, the average bus fare was R11.50. Taxi fares in Bloemfontein were increased to R12.00 from 1 November 2018 (Bloemfontein Courant, 2018).

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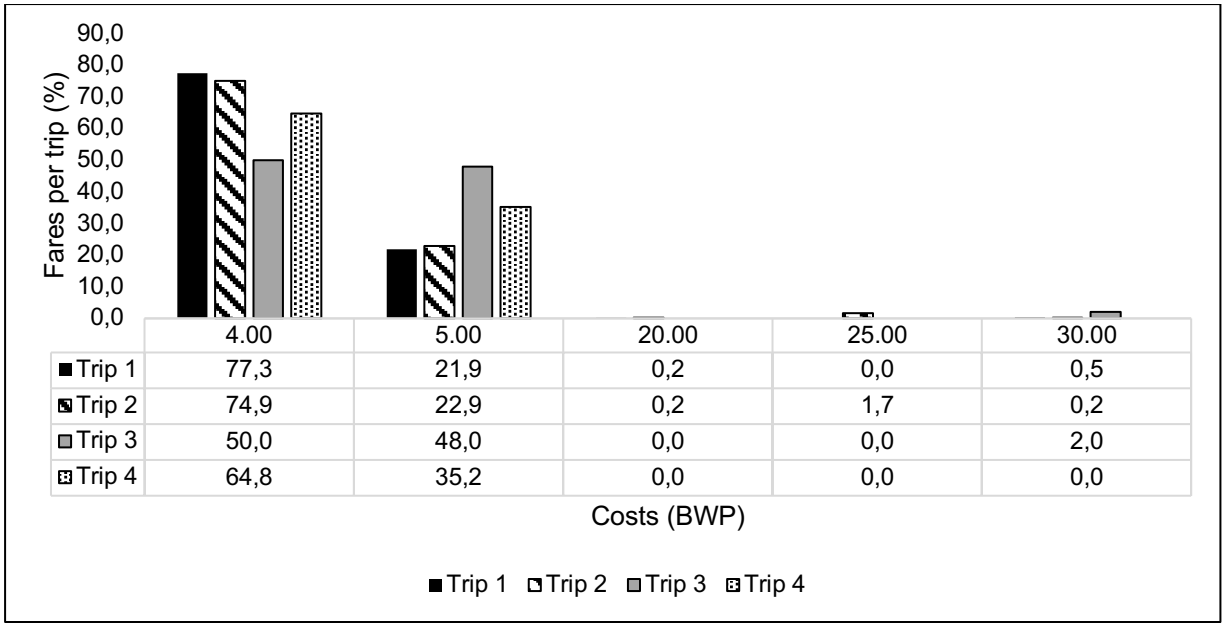

	4.00	5.00	20.00	25.00	30.00
Trip 1	77,3	21,9	0,2	0,0	0,5
Trip 2	74,9	22,9	0,2	1,7	0,2
Trip 3	50,0	48,0	0,0	0,0	2,0
Trip 4	64,8	35,2	0,0	0,0	0,0

Figure 5.14: Trip costs - Gaborone

Figure 5.14 shows the costs of travel by public transportation in Gaborone. Specifically, 77.3%, 74.9%, 50% and 64.8%, respectively, paid P4.00 for Trips 1, 2, 3 or 4. Furthermore, 21.9%, 22.9%, 48% and 35.2% of the participants paid P5.00 for their trips. Only 0.4% of people paid P20.00 for Trips 1 and 2, while 1.7% paid P25.00 for Trip 3 and 2.7% paid P30.00 for Trips 1 to 3. Combis, which were the most common mode of public transportation, cost P4.00 per trip, which validated the results. Taxis cost P5.00 per trip, while special trips by taxi cost P20.00. Cabs cost P25.00 or P30.00, depending on areas and distance.

The results revealed that fares paid for trips using public transportation were pre-set per mode in Gaborone, while in Bloemfontein, bus fares depended on the areas travelled to or from and the distance travelled. Low fees were paid for most of the trips, although this did not automatically lead to participants' perception of affordability of the services. Affordability of transportation services could sustain ridership and, in the long run, keep the demand for public transportation services.

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5.7 Spatio-temporal Characteristics of Trips and Public Transportation Nodes

The characteristics of time and space factors of each trip, using public transportation, are presented in this section. The geographical location of trip origins and destinations were mapped, which were either public transportation stops, or unmarked areas used by public transportation users as boarding or alighting points, as well as established terminals, such as bus and taxi ranks, identified and indicated by the participants. The visual presentation of the geographical data shows public transportation nodes and movement patterns for both researched cities in the study areas. The geographical location of the origins and destinations of each trip made by the participants per day are shown in the sections below. Routes connecting the origins and destinations are also presented.

5.7.1 Mapping of trip origins−destinations in Bloemfontein

Geographic visualisations of the participants' trips in Bloemfontein are presented in this section. Data collected for all four trips was segmented into individual trips. The origin, destination and straight-line OD route for each trip are presented on individual maps. This offers a clear view of the distribution and flow in relation to the urban form of each city. Trip origins and destination maps are presented in Figure 5.15, while the vector route patterns are shown in Figure 5.16.

Further, three-dimensional plots showing the relationship between trip origins and destinations with the times of departure and arrival were used to provide further visualisation. These are followed by an analysis of times of travel and trip durations and presented in Section 5.7.1.1.

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Origins and destinations of Bloemfontein Trips

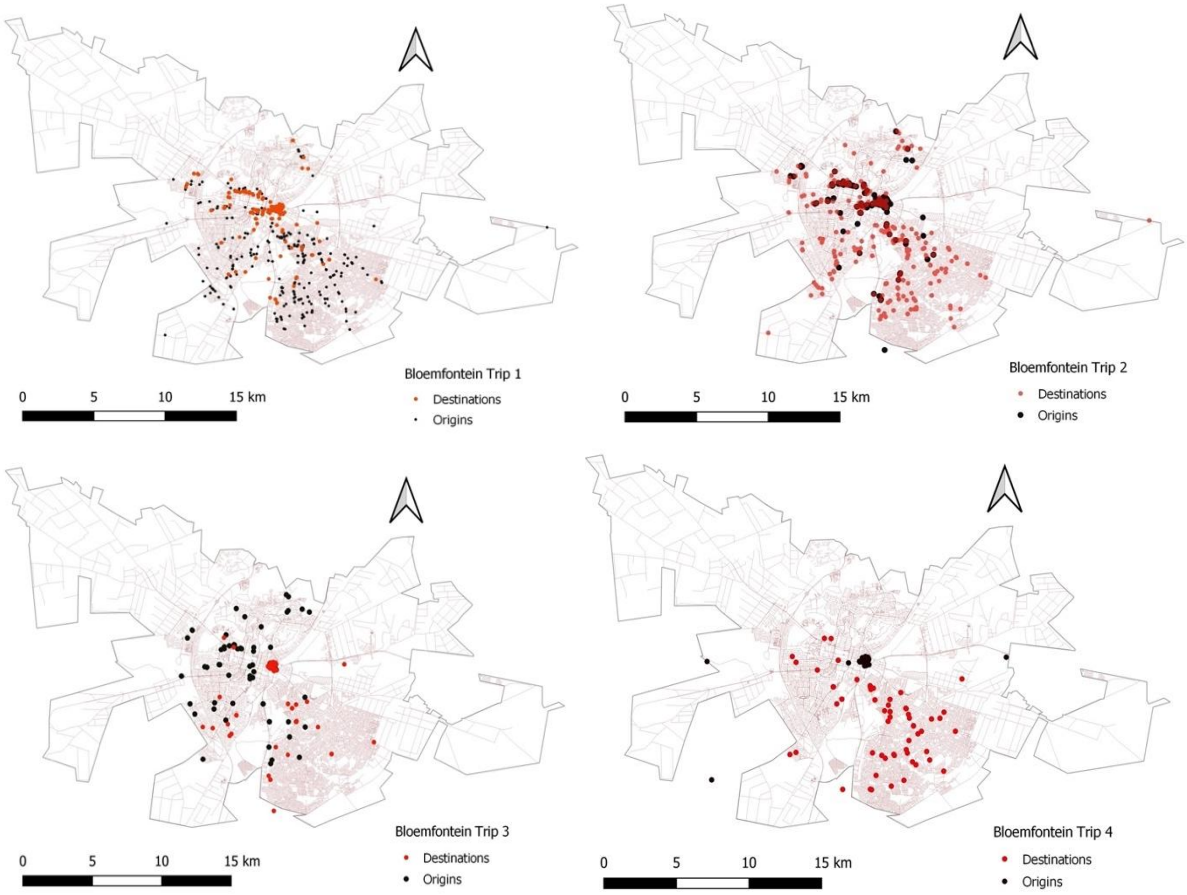

Figure 5.15: Mapping origins and destinations of Bloemfontein trips

Figure 5.15 shows the origins and destinations of trips 1 to 4 made by travellers. The results show that origins of Trip 1 were dispersed to the southern, south-eastern, western and north-western parts of the city. There were low numbers of trips originating from the north-eastern to eastern parts of Bloemfontein. The trips ended in the centre of the city, with most being concentrated in the city centre and north-western parts of the city. From the map, the public transportation nodes show a noticeable concentration of destinations in the downtown area of Bloemfontein where taxi and bus ranks are located. Trip 2 mostly originated in the city centre and spread out to residential areas. However, some of the trips were from the CBD to other central zones and northern parts of Bloemfontein. The results indicate a concentration of destinations towards the north-eastern parts and increased trips originating from the city centre towards the north-western parts of the city, which is an indication of

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multiple-trip journeys. Origins of Trip 3 were scattered around the southern and north-western parts of the inner-city areas. A significant percentage of the origins were concentrated also in the city centre. The trips then dispersed to the south and south-western parts. The noteworthy concentration of destinations in the city centre represented participants whose third trip was part of a two-trip journey from work or school going home. Trip 4 mostly originated in the city centre and spread to the southern parts of the city, while a few dispersed to the central-south-western areas. Trip 4 is usually the final trip of the day for the participants who used public transportation, making two-stage, origin-destination trips.

Figure 5.16 shows vector routes connecting trip origins and destinations. Trip 1 routes (a) show the flow of movement from origins to destinations for Trip 1, which indicate a dispersion of origins and flocking towards the city centre as their destination. Trip 2 (b) shows a concentration of origins and dispersion towards the destinations, while Trip 3 (c) shows a decrease in intensity of routes, showing less travellers moving from the north to the central parts of the city and some from central parts of the city dispersing to the south. Trip 4 (d) shows a distinct decrease in trips beginning in the city centre and ending in the southern parts of the city. An expansion of the travel pattern analysis showing the relationship between trip origins and destinations, and departure and travel times, is provided in the following section.

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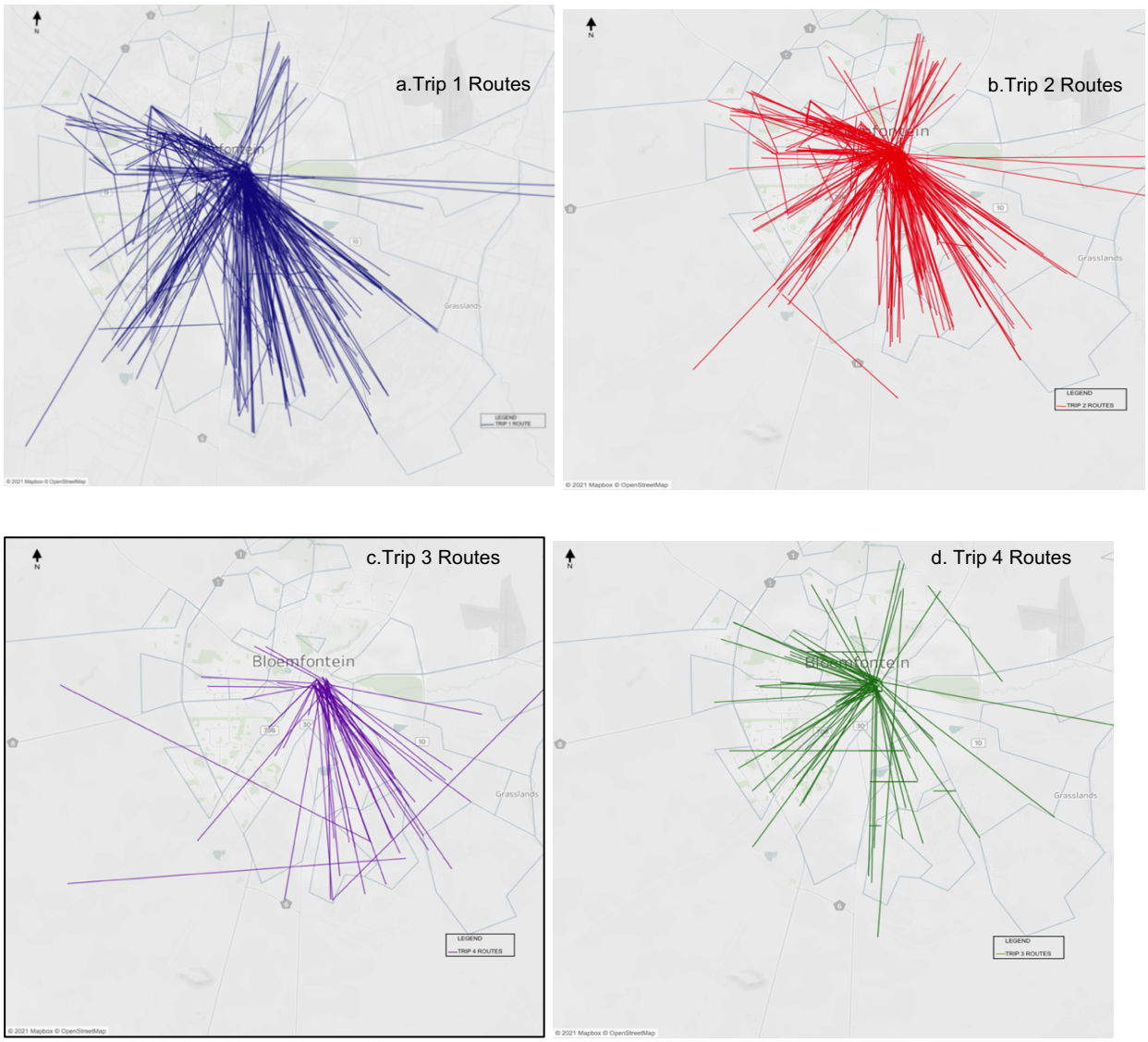

Figure 5.16: Route patterns for Bloemfontein trips

Bloemfontein trips origin-destination spatio-temporal relationships

This section presents the spatio-temporal relationships between origins and destinations in Bloemfontein. The movement of people within geographic context and time is visualised on below.

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Bloemfontein Trip 1

Figures 5.17 and 5.18 show the three-dimensional relationship between origins, destinations and the times participants began and completed their public transportation trips.

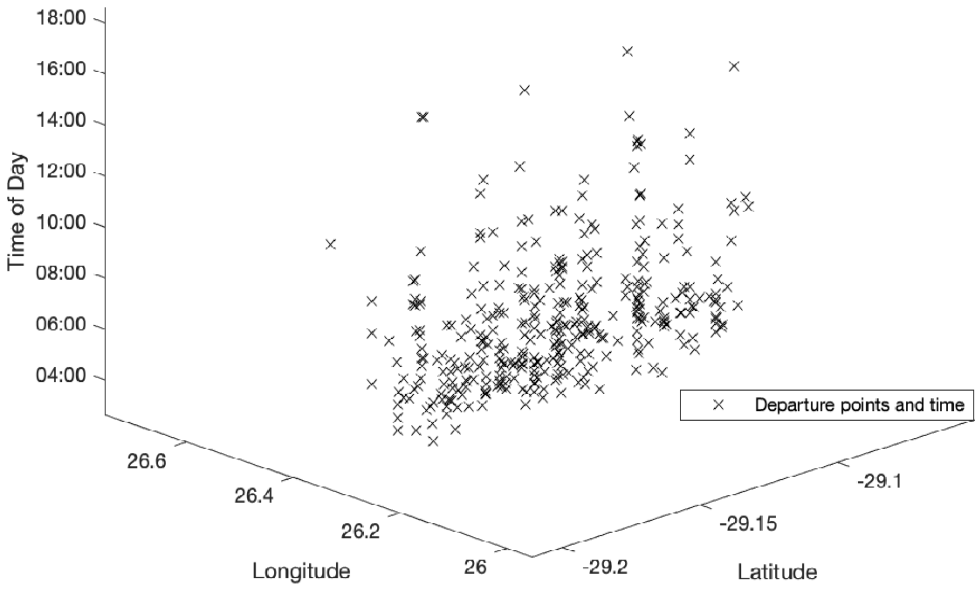

Figure 5.17: Trip 1 origins and departure time plot

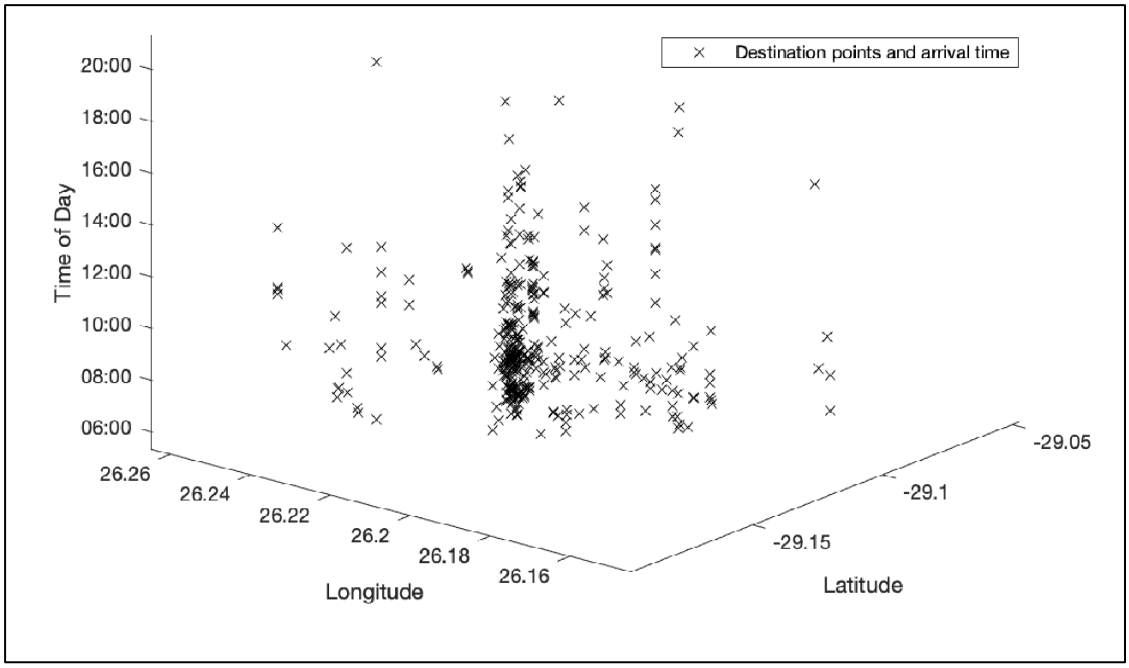

Figure 5.18: Trip 1 destinations and arrival time plot

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Figure 5.17 shows scattered patterns of origins and departure times concentrated in the mornings. Figure 5.18 shows flocking patterns towards central locations. Most of the trips occurred in the mornings between 8 am and 10 am. These are further analysed in Figure 5.19 below.

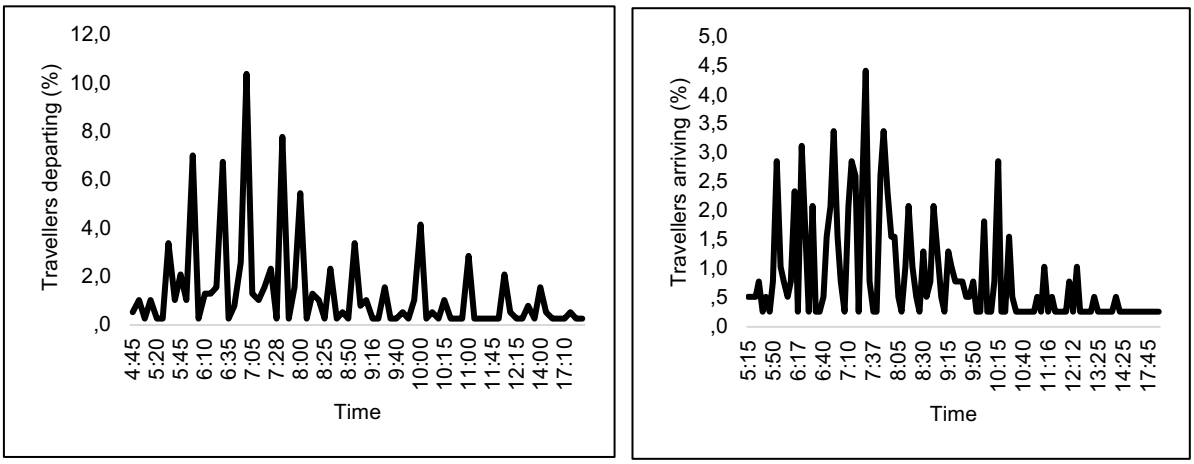

Figure 5.19: a) Departure times from Origin 1 b) Arrival times at Destination 1

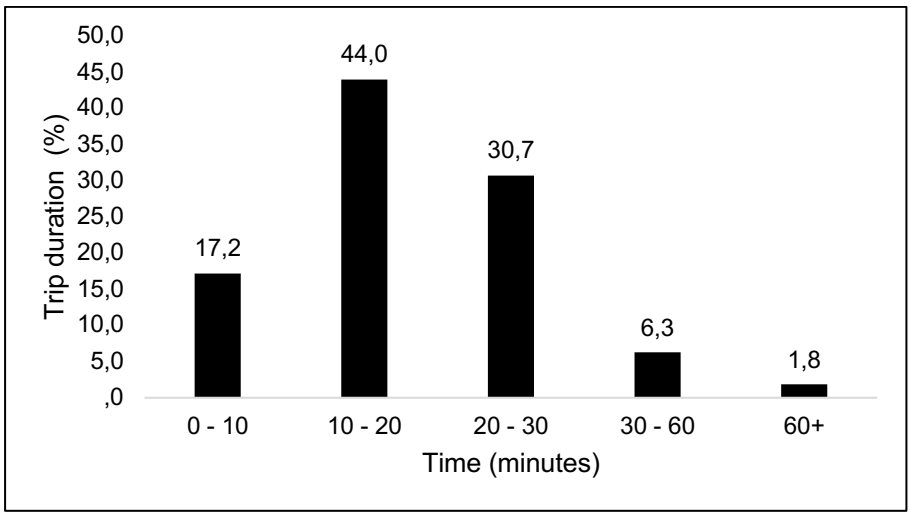

Figure 5.20: Durations of Trip 1

Figure 5.19 shows the times at which the participants left their origins and arrived at their destinations. Evidently, Trip 1 occurred mostly in the mornings, beginning and ending between 06:00 and 10:00. As shown in Figure 5.20, most of these trips (74.7%) took 10 to 30 minutes, while 17.2% of the trips took 10 minutes or less. Only 1.8% of the trips took more than an hour. The first trips of the day contributed to the peak

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morning traffic. On average, the trips occurred before 10:00 for a duration of 10 to 30 minutes.

Bloemfontein Trip 2

Figure 5.21 shows the origins and departure time relationship for the second trip, while Figure 5.22 shows the destinations and arrival times.

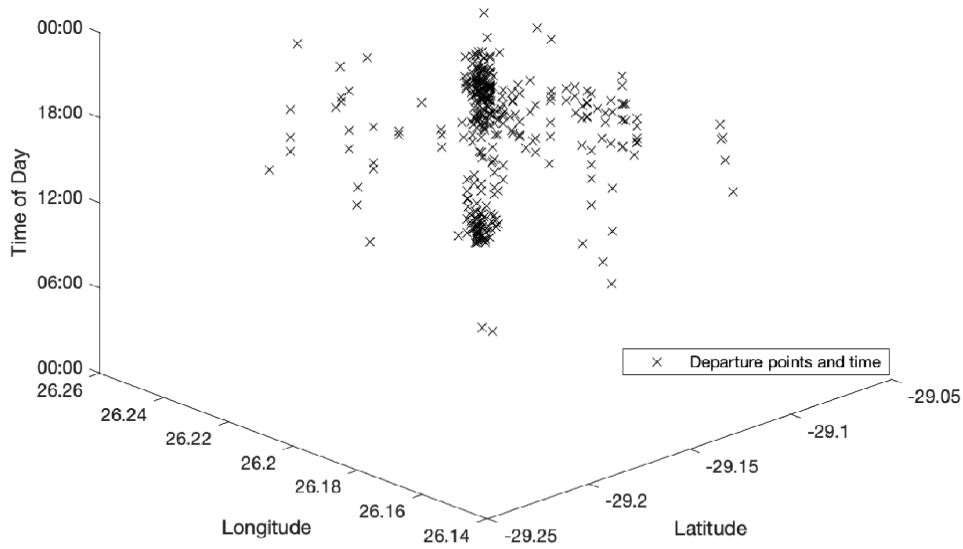

Figure 5.21: Trip 2 origins and departure time

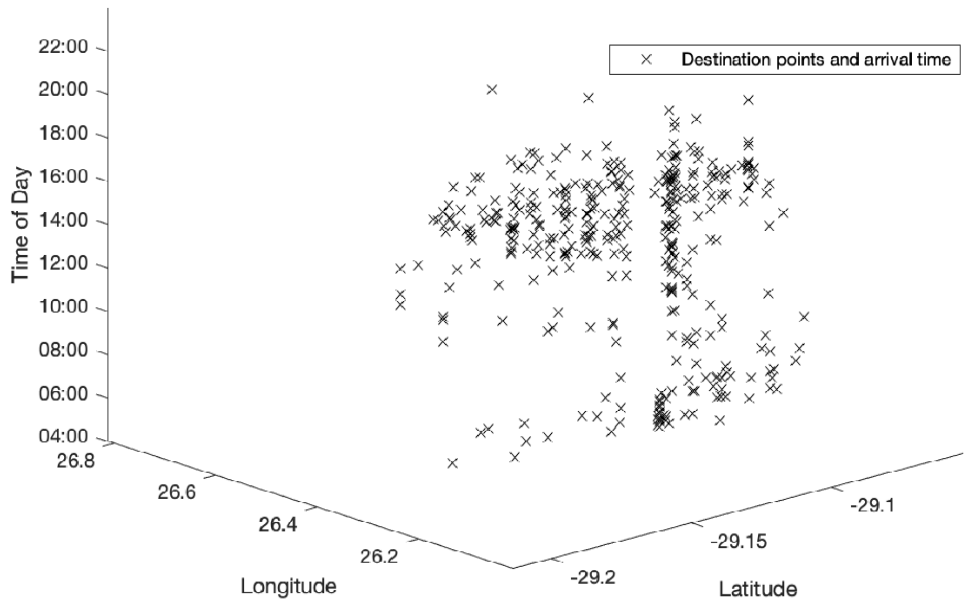

Figure 5.22: Trip 2 destinations and arrival time

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Figure 5.21 shows a high concentration of origins and noteworthy dispersions in the area, while Figure 5.22 shows a dispersed pattern. The trip is characterised by centralised clustered origins and decentralised dispersed destinations. There are also noticeable traces of decentralised clusters of destinations for the second trip, which may have been influenced by multiple-trip single journeys or mixed land zones where some participants reside. Departure and arrival times, as well as trip durations are presented in figures 5.23 and 5.24 below.

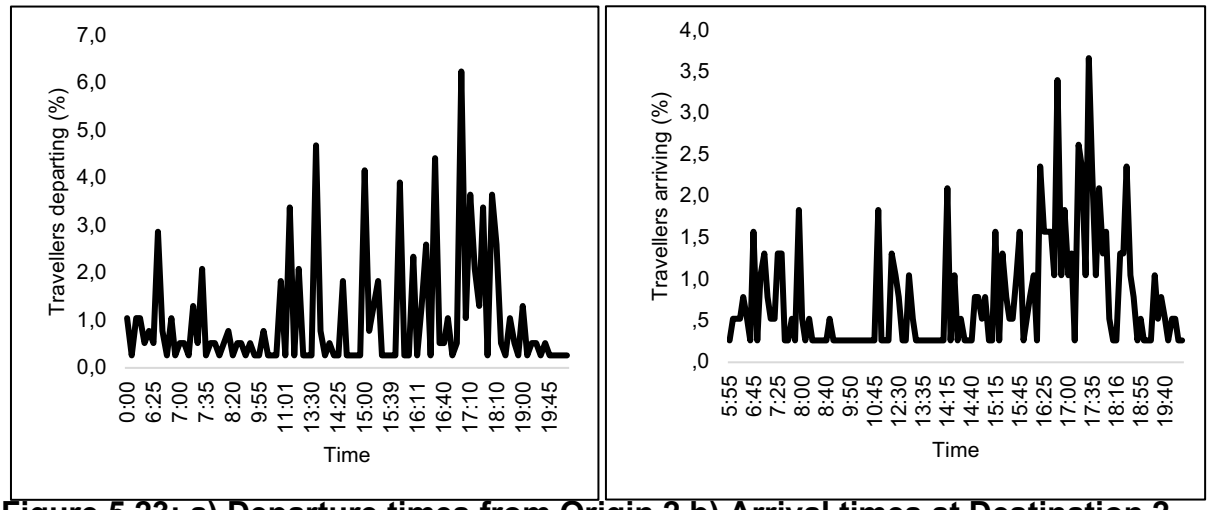

Figure 5.23: a) Departure times from Origin 2 b) Arrival times at Destination 2

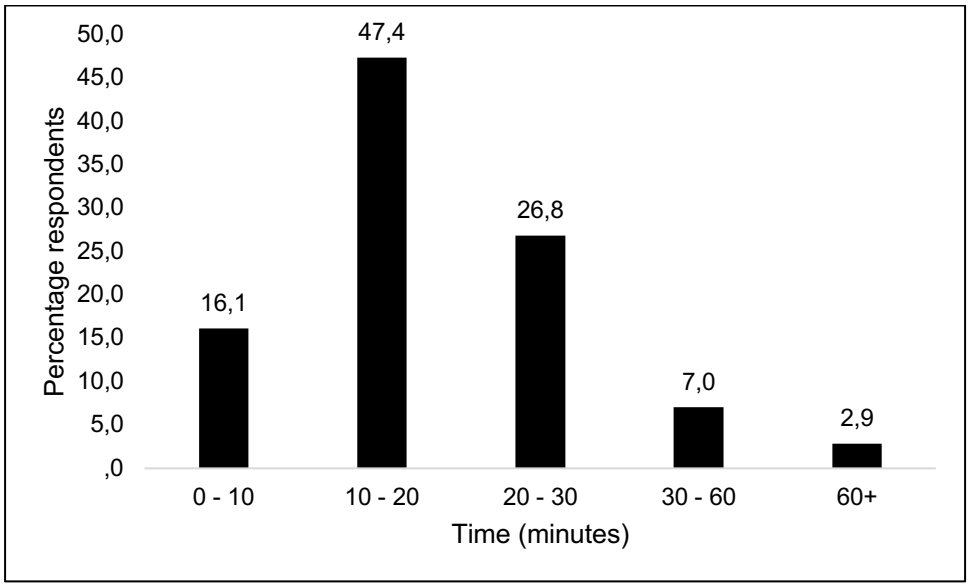

Figure 5.24: Durations of Trip 2

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Figure 5.23 shows (a) departure times and (b) arrival times for Trip 2. Most of the trips started in the afternoons, as they were mostly home-bound trips at the end of a work or school day. However, some of the second trips began in the mornings, as they were continuation trips from home to school or work where the participants had to take more than one trip to reach their destinations. Trip durations are presented in Figure 5.24, showing durations of between 10 and 20 minutes for 47.4% of the participants, and 20 to 30 minutes for 26.8%. Furthermore, 16.1% of the participants' second trips took less than 10 minutes, while 7% took between half an hour to an hour, and only 2.9% of the trips took over an hour.

Bloemfontein Trip 3

The relationship between geographical locations of Trip 3 origins and destinations are shown in Figure 5.25 and Figure 5.26 below.

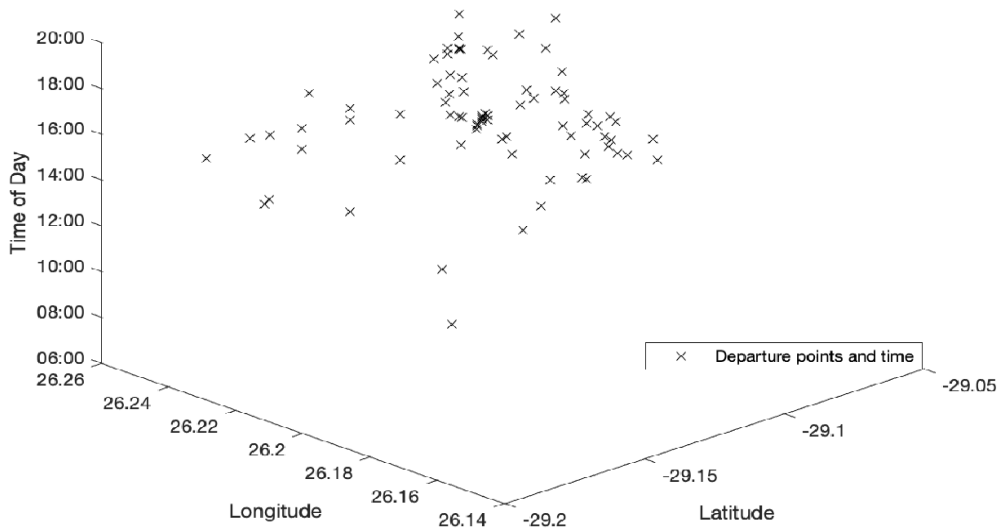

Figure 5.25: Trip 3 Origins and departure times

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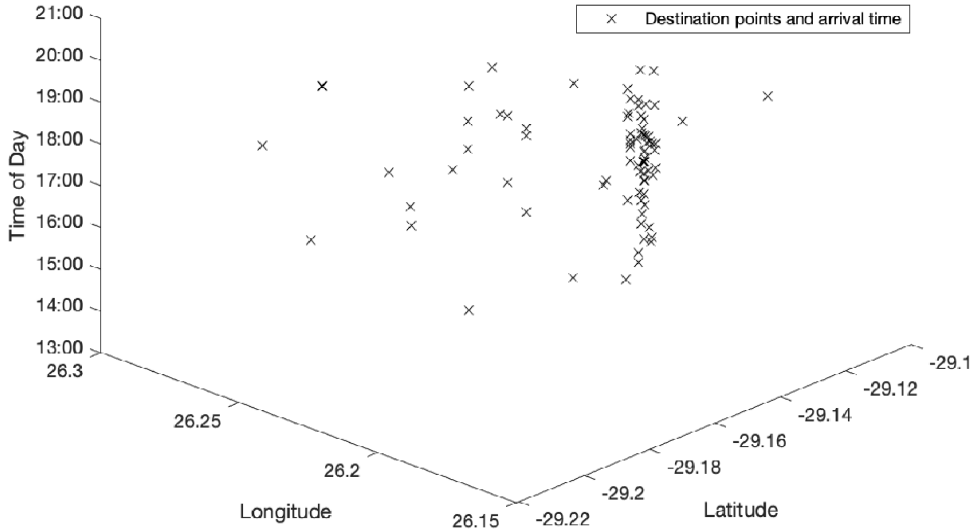

Figure 5.26: Trip 3 Destinations and arrival time

From figures 5.25 and 5.26, it is evident that there was a reduction in the number of people making trips. The destinations were split, with most being clustered and centralised and the remaining origins dispersed across the city. Also noteworthy are the trip-making times, as most trips begin in the afternoons and evenings, which are further shown in Figure 5.27.

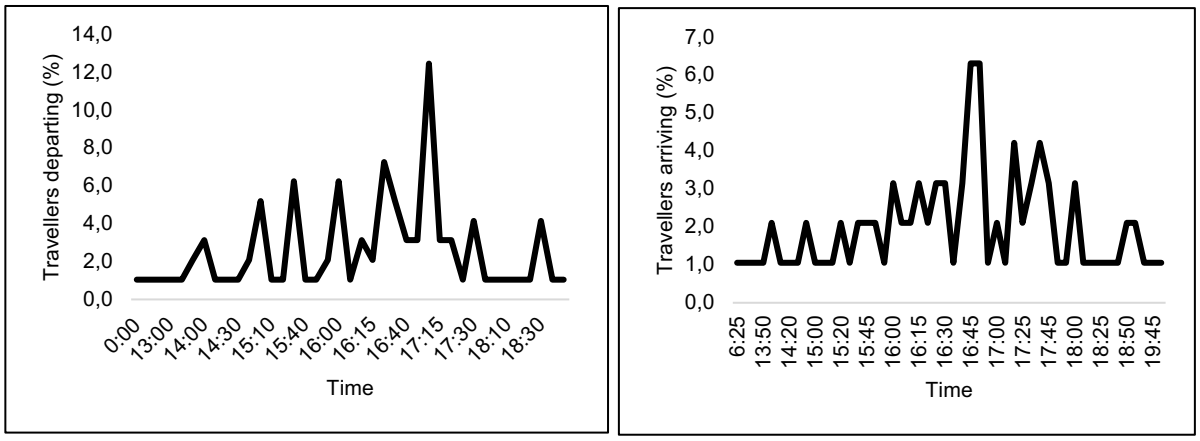

Figure 5.27: a) Departure times from Origin 3 b) Arrival times at Destination 3

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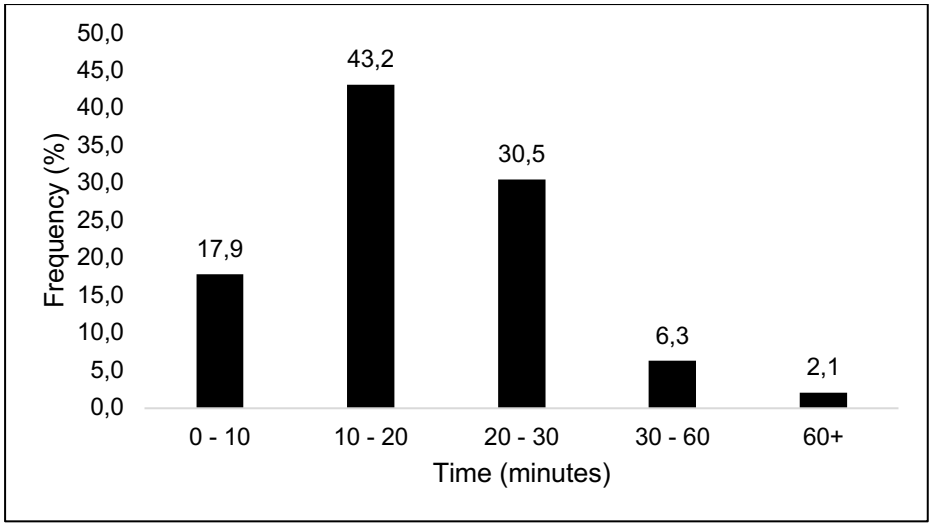

Figure 5.28: Durations of Trip 3

Figure 5.28 shows the departure and arrival times for Trip 3 made by the participants in Bloemfontein. Most of the trips began in the afternoon from 13:00, peaking from 16:00 to 18:00. These were home-bound trips after work, school and other daily activities. Figure 5.29 shows the durations of Trip 3, most of which took less than 30 minutes, while only 6.3% took between 30 and 60 minutes, and 2.1% took over an hour.

Bloemfontein Trip 4

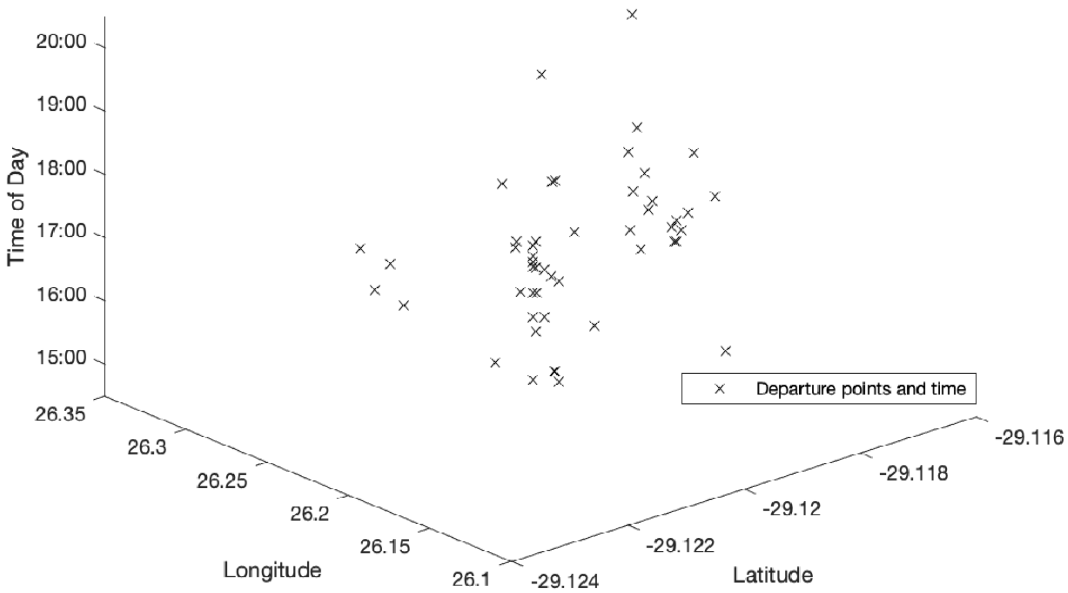

Figure 5.29: Trip 4 Origins and Departure time

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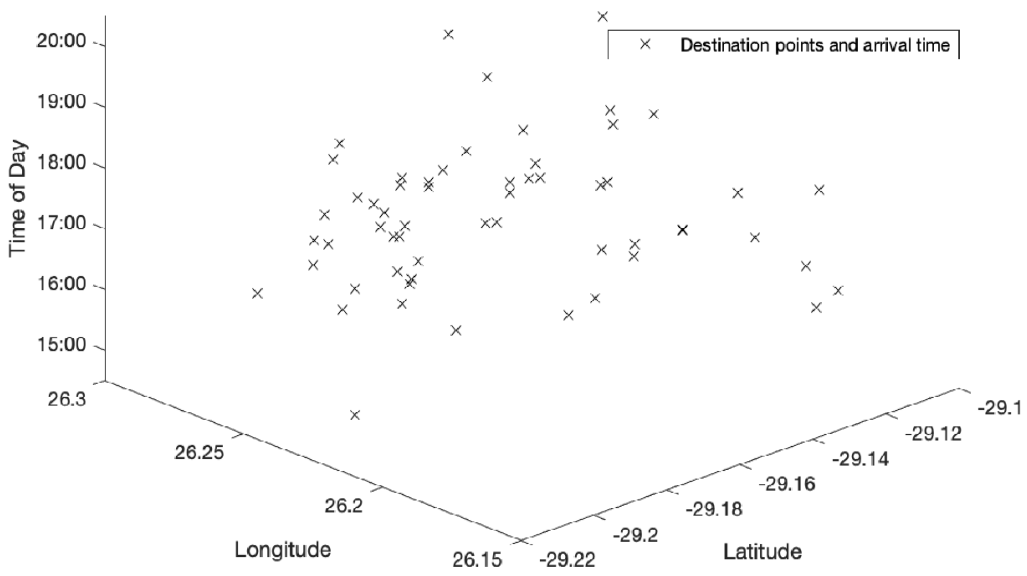

Figure 5.30: Trip 4 Destinations and Arrival time

Figure 5.29 represents departure points and time for the fourth trip, while Figure 5.30 represents arrival times and destinations. It is evident from both figures that the number of travellers decreased compared to the first preceding trips. There was a clear decentralised dispersion of trip destinations, which indicates that these were trips back home as they occurred in the evenings. Trip-making times and trip duration are further presented in figures 5.31 and 5.32 below.

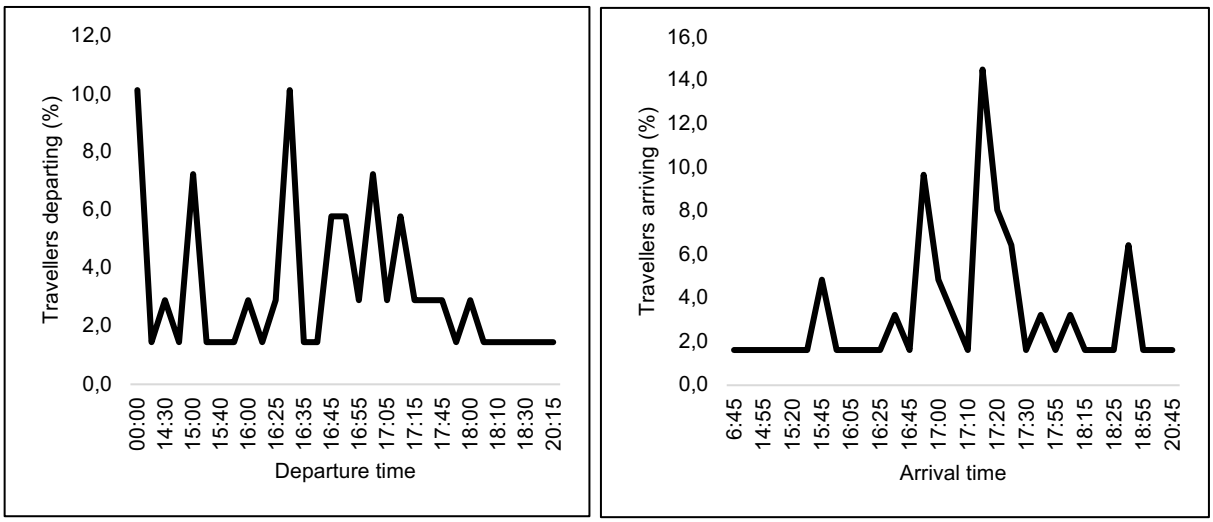

Figure 5.31: a) Departure times from Origin 4 b) Arrival times at Destination 4

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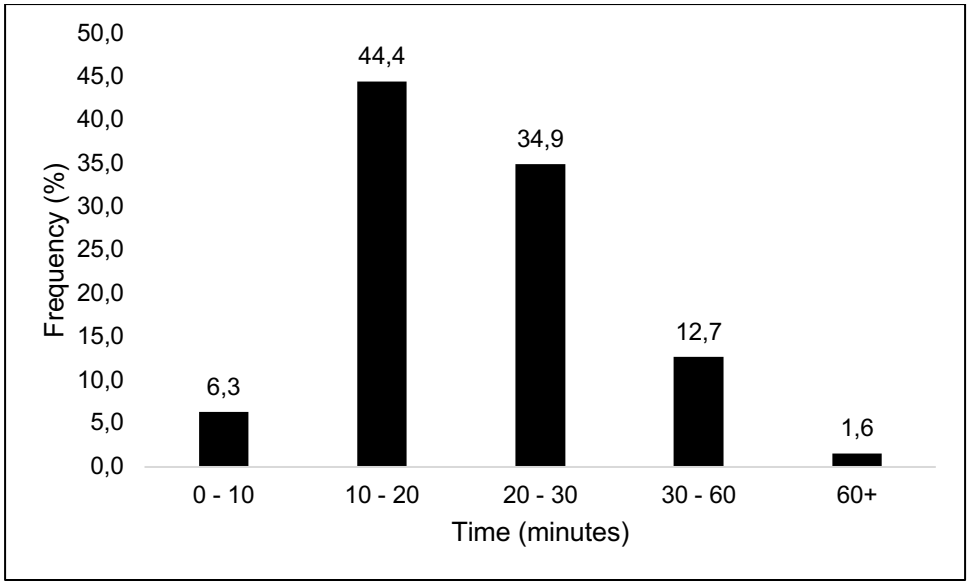

Figure 5.32: Durations of Trip 4

Figure 5.31 shows (a) departure times and (b) arrival times for Trip 4, which usually took place in the late afternoon to evening times. Most of the participants started their trips from 14:30 until 20:15, with peak travel times being between 16:00 and 18:00. The durations of Trip 4 are shown in Figure 5.32. Similar to other trips, most of the participants spent 30 minutes or less on the trip. Only 12.7% and 1.6% spent between 30 minutes to an hour, and over an hour, respectively on the trip.

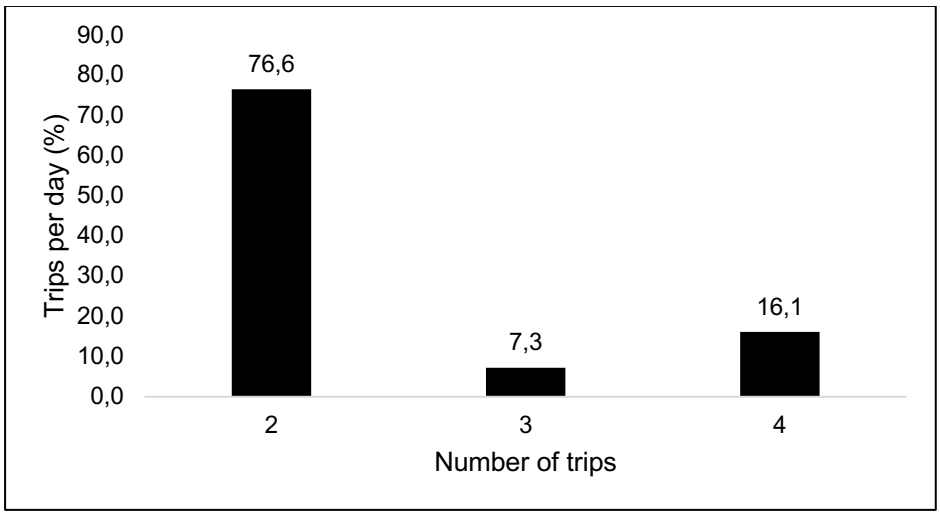

Figure 5.33: Number of trips using public transportation per day – Bloemfontein

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Figure 5.33 shows the total number of trips made by the participants per day in Bloemfontein. Overall, most of the participants (76.6%) used public transportation to make two trips per day, while 7.3% made three trips per day, and 16.1% made four trips using public transportation per day.

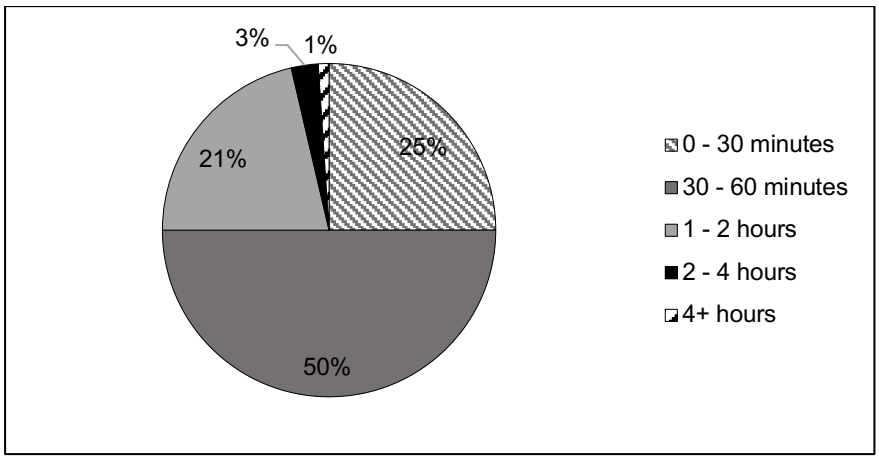

Figure 5.34: Overall time spent travelling

Figure 5.34 shows the overall time spent travelling per day by the participants who used public transportation in Bloemfontein. The results showed that 50% of the participants spent 30 minutes to an hour per day travelling. A further 25% spent less than 30 minutes on trips, while 21% spent an hour to two hours per day travelling. Only 3% and 1%, respectively, spent between two and four hours and over four hours travelling per day.

Summary of trip patterns in Bloemfontein

The origins of Trip 1 were similar in pattern to the destinations of Trip 2, while the destinations of Trip 1 and origins of Trip 2 also displayed the same patterns. The origins of Trip 1 and destinations of Trip 2 were mostly characterised by residential areas in the southern and south-western parts of the city, as well as high-density, mixed land-use areas in the central zones of the city. The southern and south-western parts of Bloemfontein are residential areas for Bloemfontein natives, while the central areas are mostly mixed commercial residential areas accommodating students and the working class who migrated from other parts of the country. The destinations of Trip 1 and origins of Trip 2 were in the central zones of Bloemfontein. In these areas, the busiest public transportation nodes are found, such as minibus taxi ranks and bus stations. Most commercial activities, retail activities and educational institutions are

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located in these areas. These results indicated also that most of the participants made only two trips per day, which referred to the trip from home to school or work and the trip from school or work going home.

Trips 3 and 4 displayed very different patterns. The participants who made more than two trips per day often had to begin their second trip in the CBD area going to outer north-western areas of the city. These were mostly full-time employees working in retail and domestic sectors. A significant percentage of Trip 3 also began in the area of the University of the Free State. The third trips ending in the southern and south-western areas were trips from work to home, while those ending in the CBD areas were likely to be the third of fourth trips to be continued from the CBD. The fourth trips mostly began in the CBD area and ended in the southern residential zones.

Although most trips connected through areas in the city centre, only a few trips did not connect to the city centre, showing limited availability of direct public transportation. The overall pattern of flow indicated also a concentration of public transportation availability in the southern, south-eastern and south-western parts of the city, and less public transportation activity in the north-eastern and north-western parts of the city.

5.7.2 Mapping of trip origins−destinations in Gaborone

Geographical trip data obtained from the participants in Gaborone are presented in this section, together with trip times and durations. Figures 5.38 to 5.59 show the spatial movement between origins and destinations for all four trips as well as the departure times from origins and arrival times at the destinations.

Origins and destinations of Gaborone trips

The origins, destinations and routes of the four trips in Bloemfontein are presented in Figure 5.35, while Figure 5.36 shows the routes from origins to destinations of all the trips.

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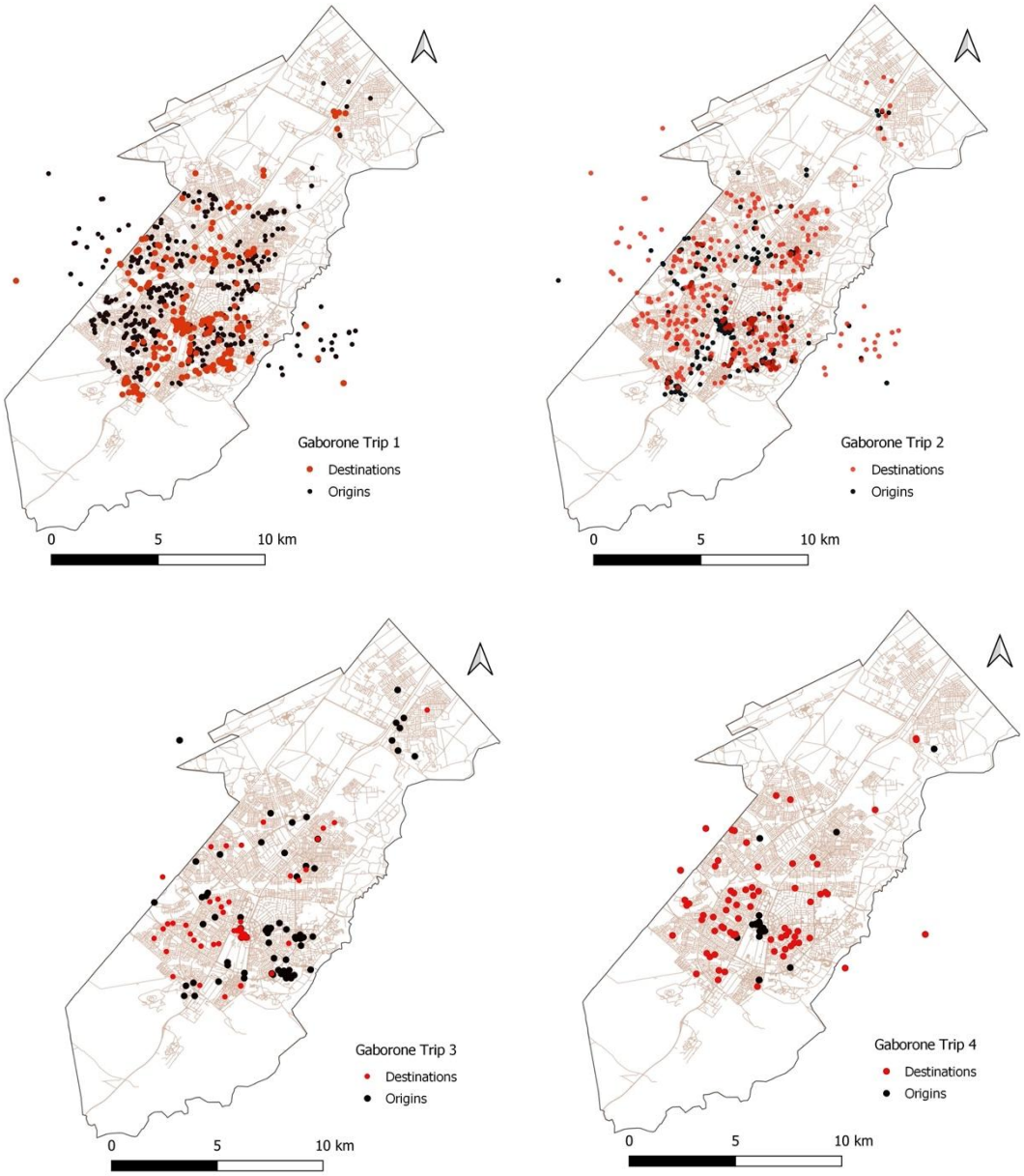

Figure 5.35: Mapping origins and destinations of Gaborone trips

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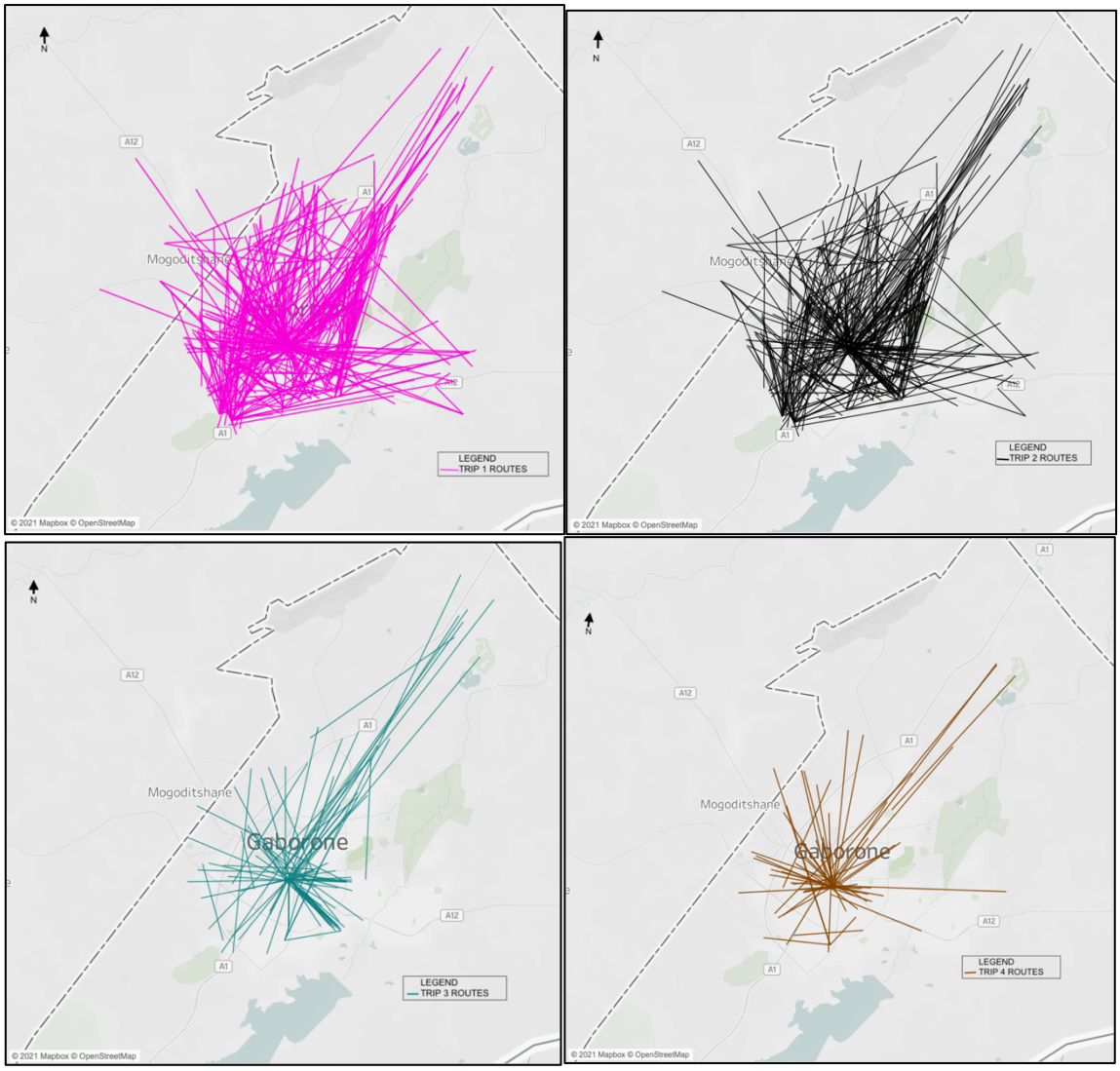

Figure 5.36: Gaborone Trips vector routes

Figure 5.35 shows the origins and destinations of trips 1 to 4 made by the participants in Gaborone. Trip 1 originated from scattered areas around the city and ended similarly in dispersed areas around the city. However, the distinction between the origins and destinations was a concentration of destinations around the city centre and the mall areas. This is also evident from Trip 1 routes in Figure 5.36, which shows that most trips ended in the city centre, at the Main Mall, Gaborone International Commerce Park, Fairgrounds and Broadhurst Centre. Trip 2 originated mostly from the central areas of the city and Broadhurst, and dispersed to residential areas surrounding the city. Trip 3 showed lower numbers of participants travelling, which meant that there was a decrease in people making three trips per day, and the results indicated a

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concentration of origins around the city centre and Broadhurst, and a dispersion of destinations into residential areas surrounding the city centre.

Most of the participants' Trip 4 originated in the central parts of the city and dispersed into the residential areas surrounding the city centre. There was a clear indication of trips beginning and ending in areas outside the boundary of Gaborone, significantly in Tlokweng and Mogoditshane. These can be associated with the lower rental costs in the two areas compared to accommodation costs within the city. Therefore, it is common for people working in the city to reside in these neighbouring villages and commute daily to work and other activities. This has an impact on the city's public transportation system by virtue of the use of infrastructure. Second, passengers in the city who board or off-board public transportation along the routes used by vehicles designated for outside areas are still able to use these vehicles. Areas further away from the city centre, including these villages, are politically independent from the City of Gaborone, but share borders with the city. Political decisions, policy implementation and developments dedicated specifically to the City of Gaborone will not include these areas, as they are under different political spheres and leadership.

Gaborone Trips origin-destination spatio-temporal relationships

This section comprises an analysis of trip-making times, trip durations and visualisation of origins and destinations against the departure and arrival times for Gaborone trips.

Gaborone Trip 1

The first trip taken by participants in Gaborone is detailed below, with figures 5.37 and 5.38 showing the relationship between departure and arrival times with the origin and destination geographical locations.

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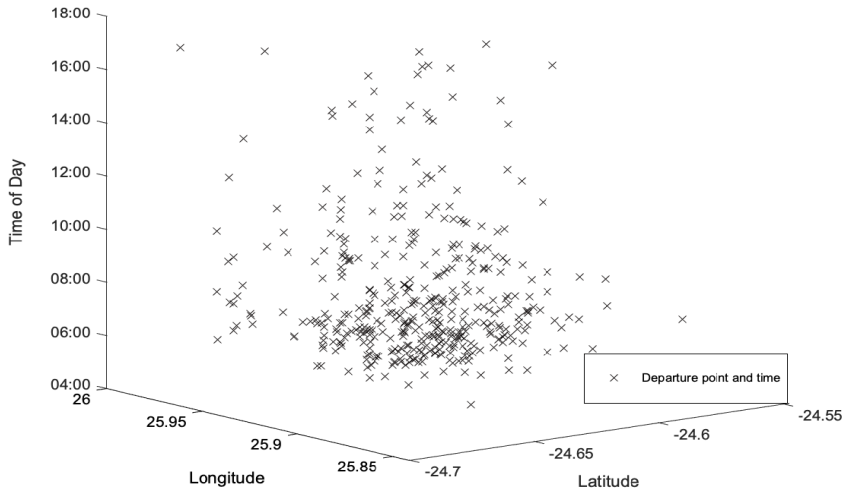

Figure 5.37: Trip 1 Origins and departure time

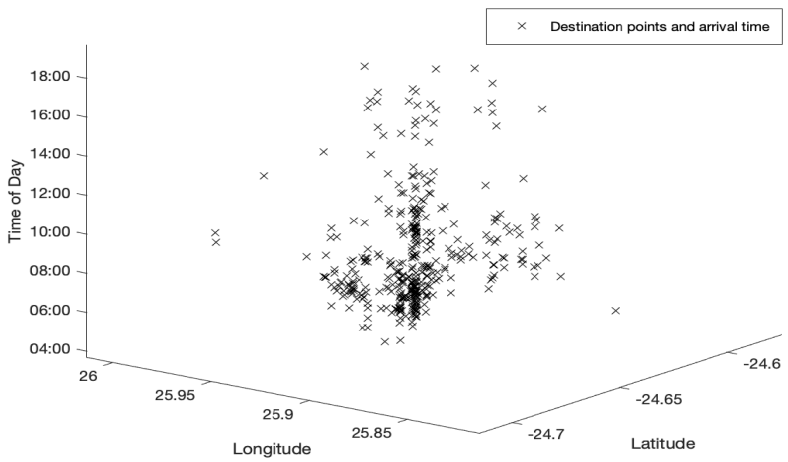

Figure 5.38: Trip 1 destinations and arrival time

Figures 5.37 and 5.38 show the dispersion of origins of the first trip, with a concentration of the trips beginning in the mornings between 06:00 am and 09:00 am. The destinations were also dispersed, but there were distinct clusters of concentration in some locations before 12:00. Figure 5.39 below further puts the trip departure and arrival times in a clearer view, showing the percentages of travellers departing and arriving at their destinations at different times.

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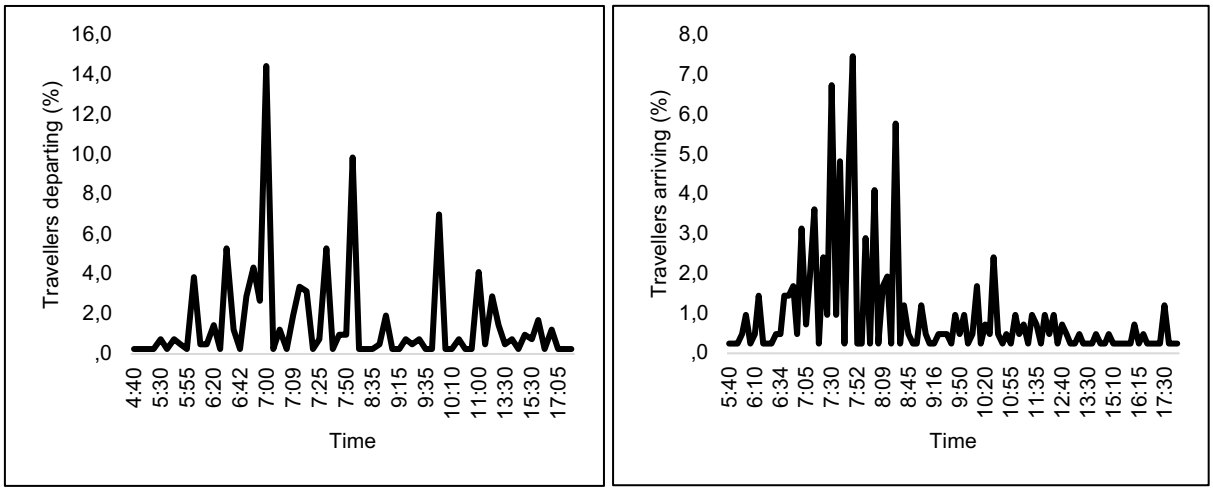

Figure 5.39: a) Departure times from Origin 1 b) Arrival times at Destination 1

Figure 5.39 shows (a) departure times and (b) arrival times for Trip 1. Most trips occurred between 06:00 am and 09:00 am. These trip times correlated with travel to work and school in the mornings. Few of the first trips occurred in the afternoons.

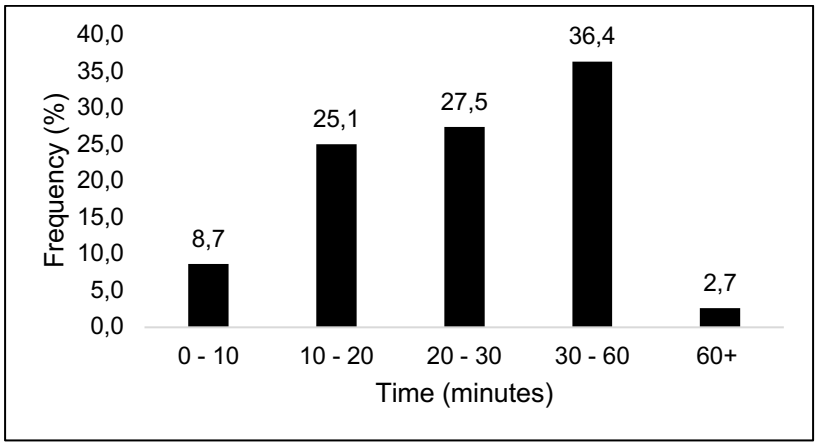

Figure 5.40: Durations of Trip 1 - Gaborone

Figure 5.40 shows the durations of Trip 1 made by the participants in Gaborone. For many participants (36.4%), it took 30 minutes to an hour to complete Trip 1 using public transportation, while 27.5% took between 20 and 30 minutes. A further 25.1% of the participants took between 10 and 20 minutes, while 8.7% of the trips took less than 10 minutes. Only 2.7% took more than an hour for Trip 1.

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Gaborone Trip 2

The relationships between origins and destinations and time for the second trip are illustrated in figures 5.41 and 5.42.

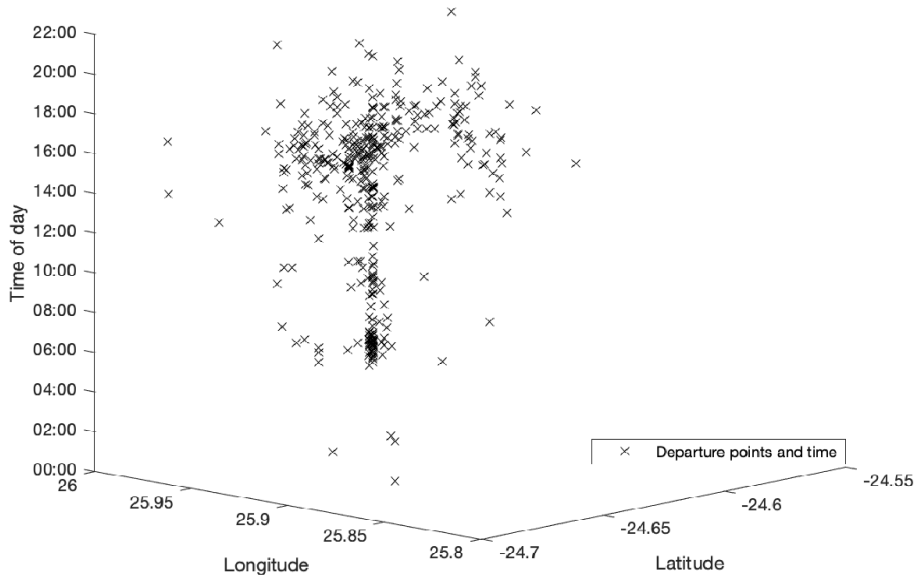

Figure 5.41: Trip 2 origins and departure times

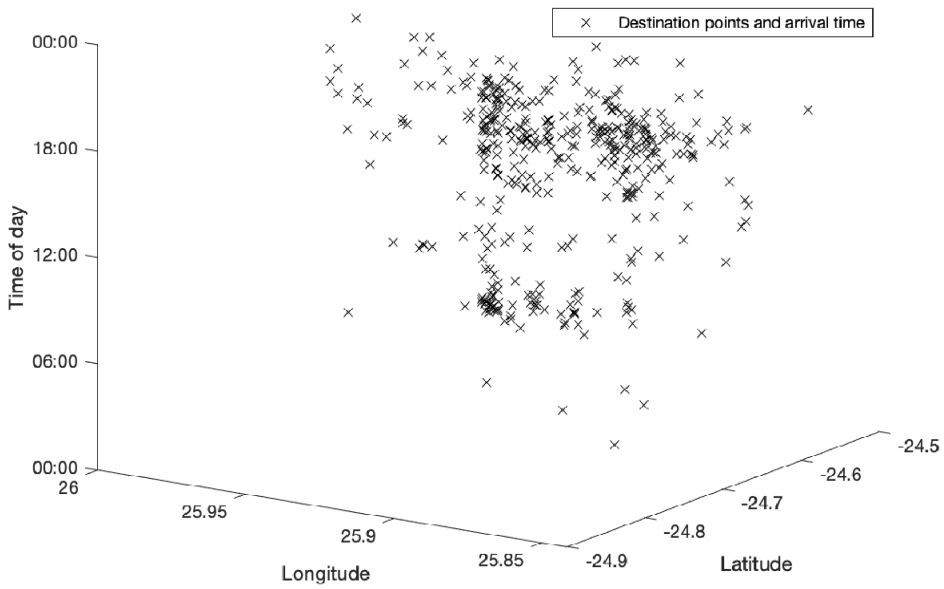

Figure 5.42: Trip 2 destinations and arrival times

Trip origins, as shown in Figure 5.41, displayed a concentration of centralised locations in the earlier hours of the day, while trips beginning in the afternoons and evenings were decentralised and dispersed as shown in Figure 5.42. The destinations

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however, were mostly dispersed. Trip-making times and arrival times are presented in Figure 5.43.

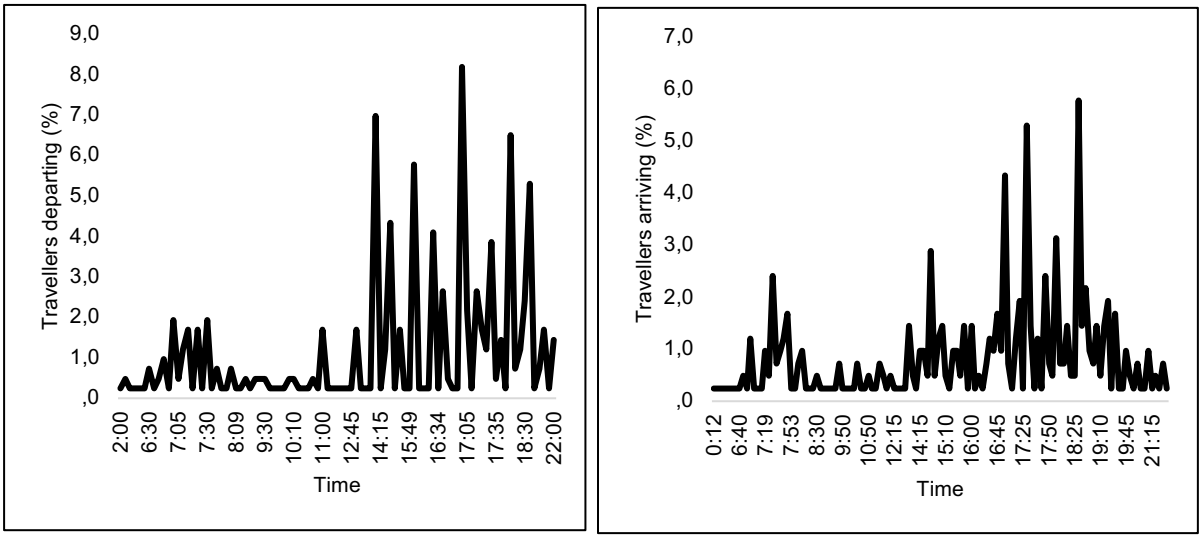

Figure 5.43: a) Departure times from Origin 2 b) Arrival times at Destination 2

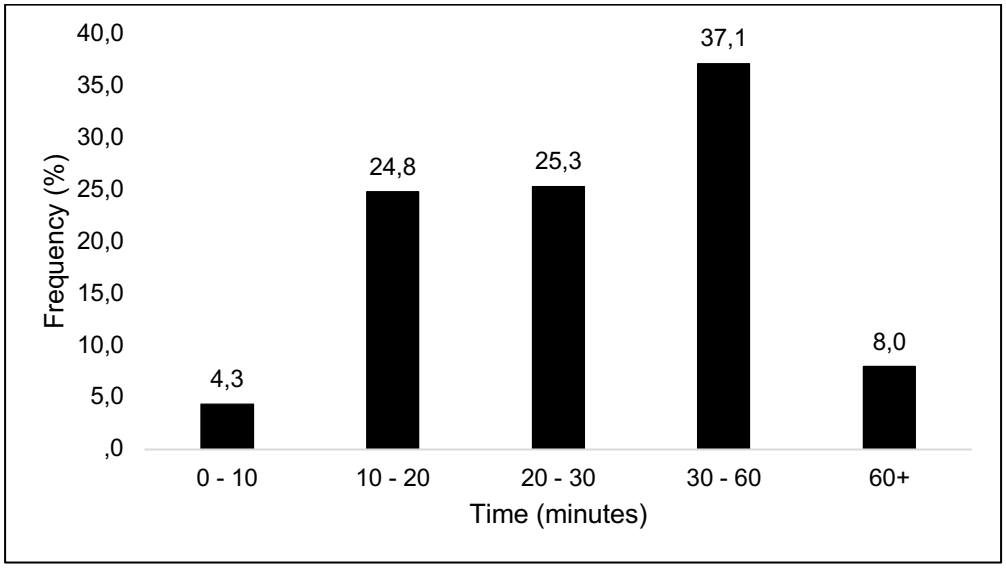

Figure 5.44: Durations of Trip 2 - Gaborone

Trip 2 of the day occurred mostly between 12:45 and 22:00, as shown in Figure 5.43. Both graphs in Figure 5.43 show a peak in trips between 17:00 and 19:00. Figure 5.44 shows that the duration of the trip for most of the participants was less than 60 minutes, 37.1% of the participants travelled for between 30 and 60 minutes, 25.5% travelled for between 20 and 30 minutes and 24.8% travelled for 10 to 20 minutes, while only 8% of the participants using public transportation travelled for more than an hour on their

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second trips of the day. Also, 4.3% of participants indicated that their trips took less than 10 minutes.

Gaborone Trip 3

Trip origins and destination locations' relationships with departure and arrival time are shown in figures 5.45 and 5.46. A decrease in number of trips is noticeable from the first two trips.

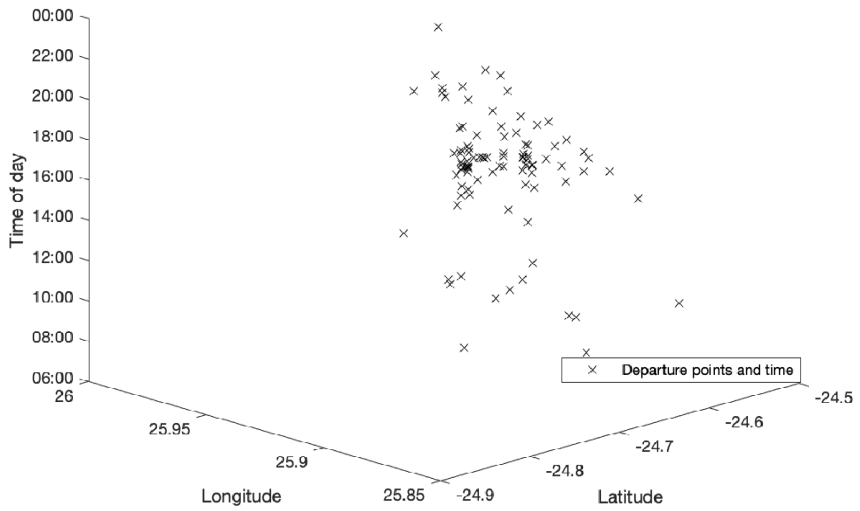

Figure 5.45: Trip 3 origin and departure times

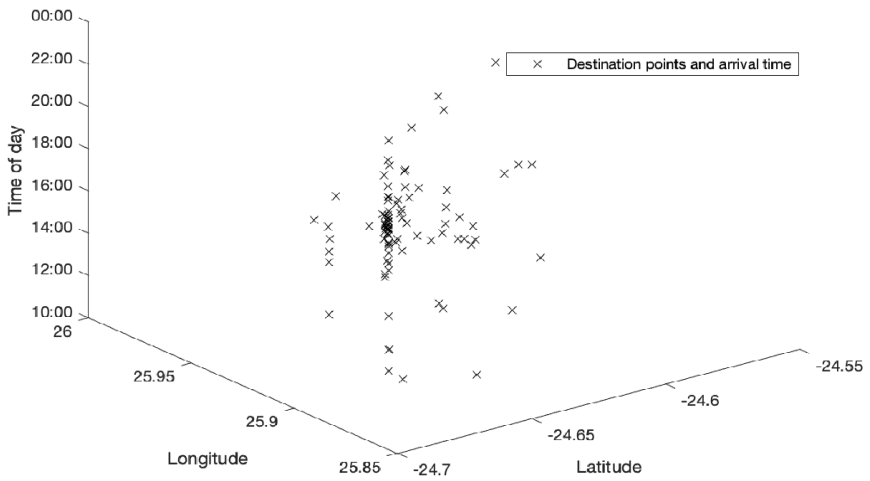

Figure 5.46: Trip 3 destinations and arrival time

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Trip 3 origins as shown in Figure 5.45 were largely dispersed, while the destinations in Figure 5.46 showed a significant distribution of both dispersed locations and flocking patterns occurring in the afternoon and evening. Figure 5.47 presents the times of travel and percentages of travellers departing and arriving at these times, while Figure 5.48 shows the duration of Trip 3.

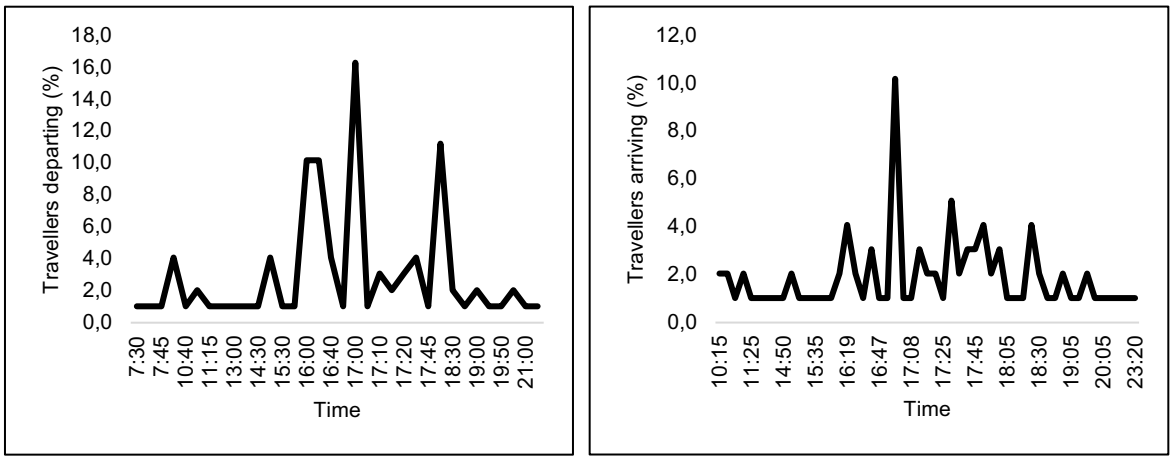

Figure 5.47: a) Departure times from Origin 3 b) Arrival times at Destination 3

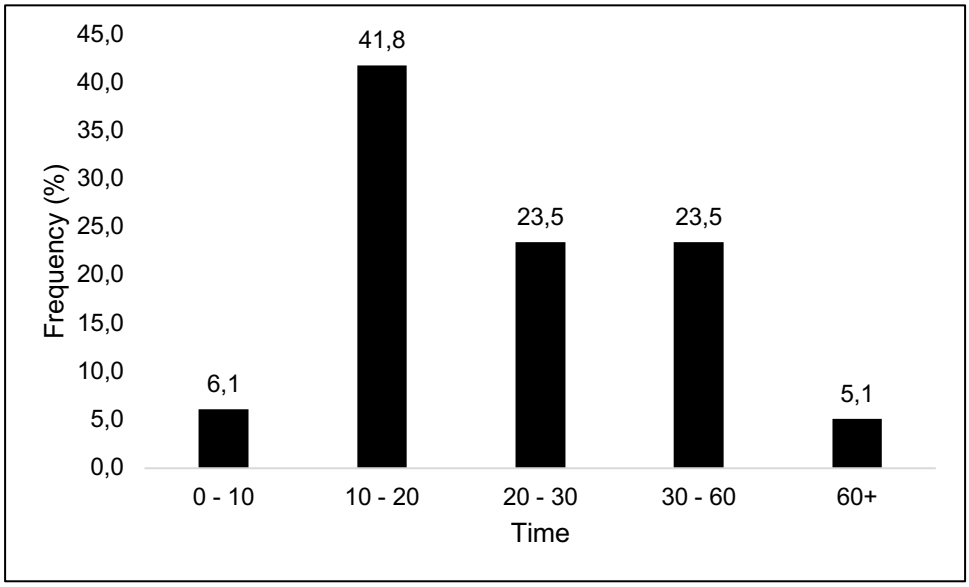

Figure 5.48: Durations of Trip 3 - Gaborone

Figure 5.47 shows (a) that Trip 3 of the day occurred mostly between 15:30 and 18:30. The duration of 41.8% of the trips was between 10 and 20 minutes, 23.5% and a further 23.5% of the participants travelled for 20 to 30 minutes, and 30 to 60 minutes,

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respectively. Fewer participants, 6.1% and 5.1%, respectively, spent less than 10 minutes or more than an hour on the third trip.

Gaborone Trip 4

There are even fewer origins−destinations across the city for Trip 4. The trips are shown in Figure 5.49, which shows the distribution of origins against time, while Figure 5.50 shows the distribution of destinations in relation to arrival time.

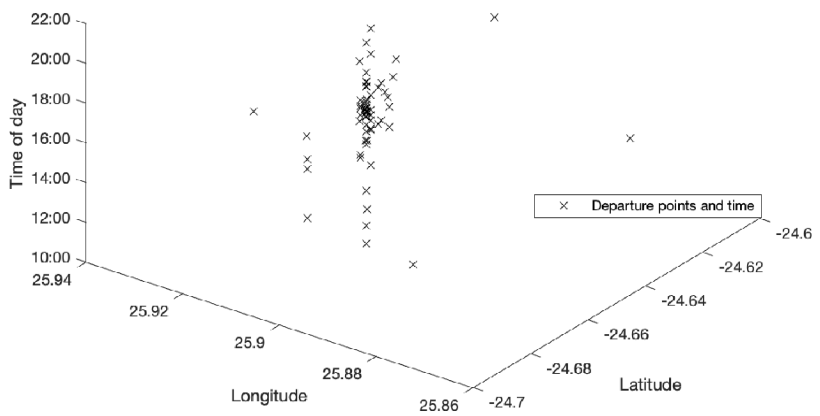

Figure 5.49: Trip 4 origins and departure times

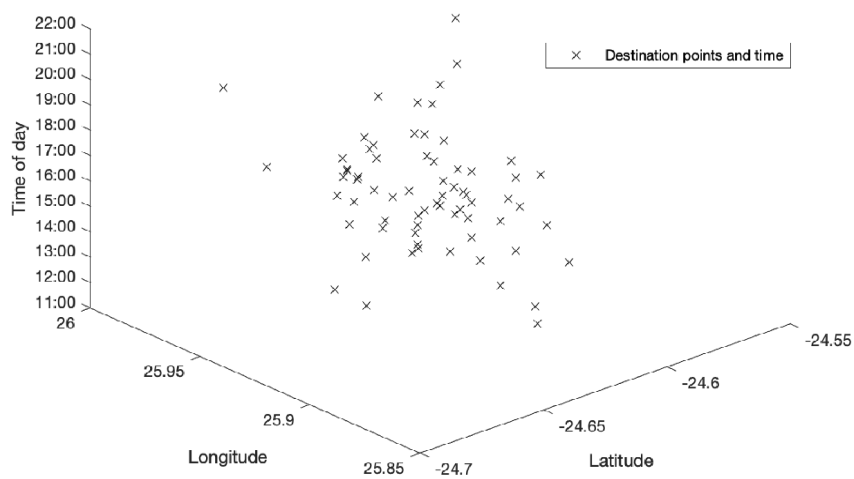

Figure 5.50: Trip 4 destinations and arrival times

Figure 5.49 shows that most of the origins for Trip 4 were centralised. The remainder of the trips were dispersed, while the destinations as shown in Figure 5.50, were

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mostly dispersed and decentralised. Most of the fourth trips occurred in the afternoon and evenings through the nights. Trip departure and arrival times are shown in Figure 5.51, while overall trip duration is shown in Figure 5.52.

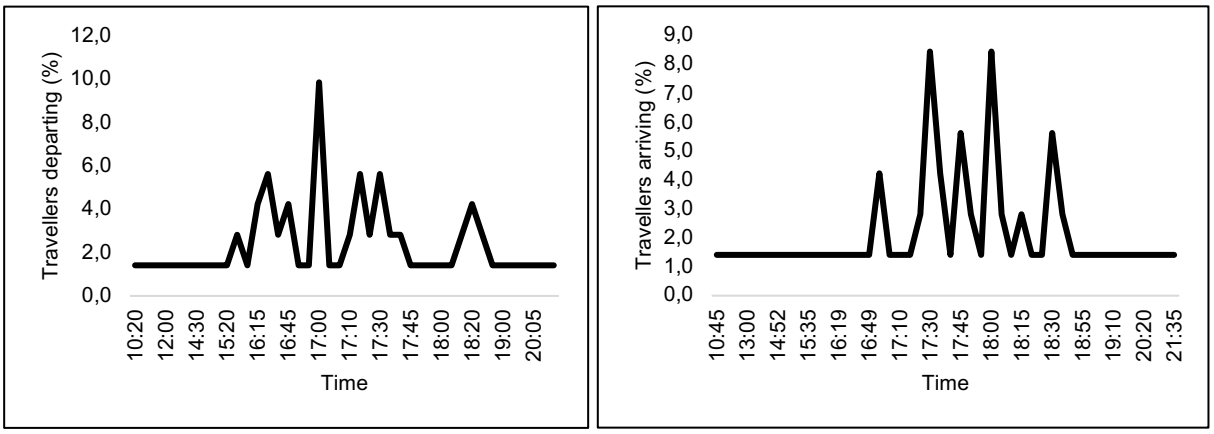

Figure 5.51: a) Departure times from Origin 4 b) Arrival times at Destination 4

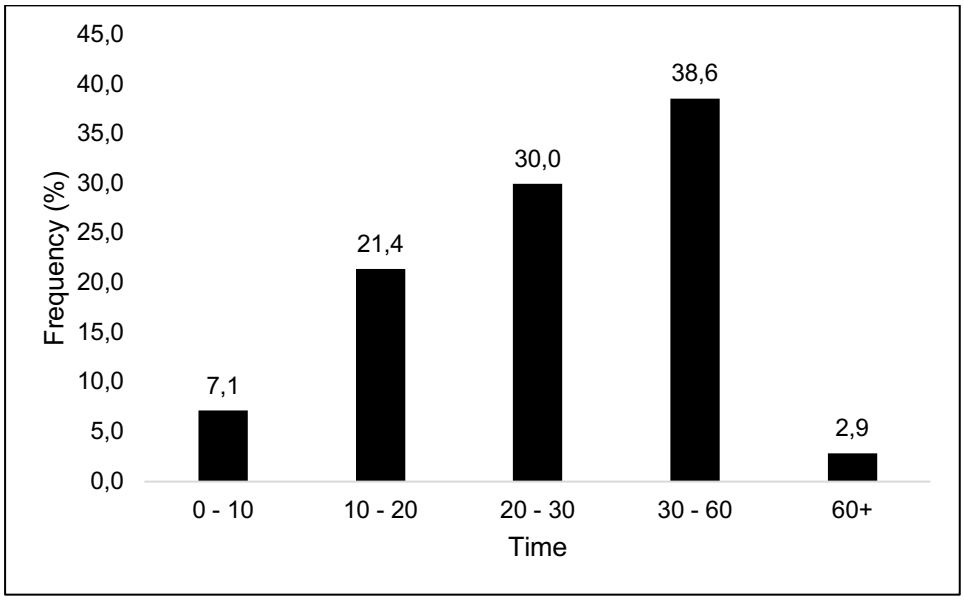

Figure 5.52: Durations of Trip 4 - Gaborone

Trip 4 began mostly after 15:00 and ended before 19:00, as shown in graphs (a) and (b) in Figure 5.51. Trip 4 using public transportation was usually the final trip of the day. Even though most of the trips occurred until 19:00, there were a few trips that occurred until 21:35. Public transportation services in the city, specifically combis and taxis ceased operations after the evening peak. However, special taxis and cab services on request were available 24 hours a day. Figure 5.52 shows the durations

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of Trip 4. Many participants (38.6%) spent between 30 and 60 minutes on the trip, while 30% and 21.4% spent between 20 and 30 minutes, or between 10 and 20 minutes, respectively on such trip. Only 7.1% spent less than 10 minutes, and only 2.9% spent more than an hour on Trip 4.

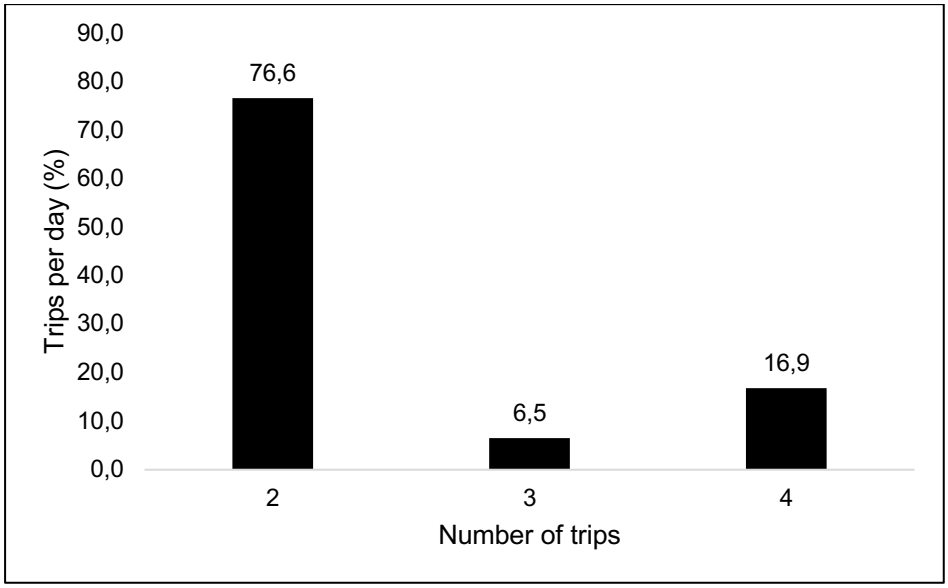

Figure 5.53: Number of trips using public transportation per day – Gaborone

Figure 5.53 shows the number of trips per day made by the participants using public transportation in Gaborone. Most of the participants (76.6%) made two trips per day, while 16.9% made four trips per day. The remaining 6.5% made three trips per day. The average number of trips using public transportation in Gaborone was two trips per day. The lower average number of trips per day indicated the accessibility of urban areas that allowed travellers to reach their destination without having to change their mode of travel too often.

Summary of trip patterns in Gaborone

The patterns established in Gaborone showed centripetal and centrifugal patterns, depending on the time of day – centripetal movements occurred towards the city centre during morning peak hours, and centrifugal patterns to residential areas during the late afternoon peak hours. The urban form of the City of Gaborone is decentralised and clustered, which justifies the formation of public transportation trips. Trip 1 was towards the city centre and some locations that were popular for corporate offices and places of business. A prevalence of two trips per day compared with three and four

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trips per day indicated also that direct public transportation was available, which has increased the accessibility of places by reducing the need to make more trips. Origin-destination maps, route maps as well as the location-time plots all highlighted a concentration of trips beginning or ending in major public transportation nodes in the City of Gaborone. Trip 1 showed a concentration of destinations at the bus rank and the taxi rank (known as the station), both located in the city centre. Most public transportation trips begin and end in the city centre area because of their larger capacity and their location. However, there were other nodes in high-activity areas of the city. Other areas showing a concentration of destinations for Trip 1 were the Broadhurst taxi rank, Game City, University of Botswana, Pula-Spar and Airport Junction areas, which attracted a high frequency of public transportation activity. Similar concentration patterns were observed for Trip 2 origins, Trip 3 origins and destinations, as well as Trip 4 origins. Even though movement to and from the city centre was prevalent, the other nodes assisted in eliminating unnecessary trips to the city centre to complete only one leg of a two-leg journey. Most of the participants who used public transportation made two trips per day, of which the first trip began in the residential areas of the city and ended in the city centre in the mornings. The flow of movement formed a centripetal pattern.

The second trips, in the evenings, began mostly in the city centre and dispersed towards the residential areas (for travellers who made two trips per day) and other transportation nodes for those making a two-legged journey to complete the home-to-work or school trip. Similarities were evident between Trip 1 and Trip 2 origins and destinations. Trip 1 origins were similar to Trip 2 destinations, while Trip 2 origins were similar to Trip 1 destinations. The third and fourth trips were usually two trips of a single journey home from work or school for travellers making four trips per day. Trip 3 began in areas of work or school and ended in the city centre area where Trip 4 began and ended in residential areas around the city.

5.8 Summary

The findings discussed in this chapter showed that ICT-enabled public transportation can be influenced by the current use of ICT, perceptions of substituting ICT-based

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alternatives for travel, as long as employers and educational institutions offer remote work or access, and this will influence the future use of public transportation. Travel is highly influenced by land-use and distribution in both cities, as they dictate the movement and direction of traffic according to trip purposes and activities.

Trips per day are significant in evaluating accessibility of the urban area and the activities it accommodates. Ideally, accessible urban areas should promote sustainable transportation and vice versa. Fewer trips indicate that there is high accessibility within an area. Trip distribution in both cities showed movement from residential areas to central areas of the cities during morning times and trips to residential areas mostly in the evenings. There is less demand for public transportation in mixed land-use areas in Bloemfontein compared with higher demand in mostly residential areas. Mixed land-use areas where residential and commercial areas are combined are not common in Gaborone, resulting in most of the regular trips in the city being inter-zonal trips. The cost of travel between zones is greater than travel within the same zone in relation to the number of trips, time, money and travel distance. An ideal, sustainable public transportation system would involve the lowest possible number of trips per day, at prices that are affordable to users.

The current use of ICT in public transportation is indicative of the lack of, or limited availability of, technologies that assist public transportation operations and, thus, the need to incorporate ICT into public transportation. The common ICT components used by people during public transportation trips are of no significance to trip-making behaviour or trip patterns of taxi and combi users, and are of very limited significance to demand-responsive public transportation such as cabs and metered taxis. The evidence based on the results indicated also that although there is a need for ICT in public transportation, such access tended to be used for entertainment purposes and social media, and not necessarily related to the use of public transportation services. While ICT will not replace the need to travel, it can make travel more enjoyable and efficient.

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CHAPTER 6: GUIDELINES AND FRAMEWORK FOR ICT-ENABLED ROAD PUBLIC TRANSPORTATION SYSTEMS

6.1 Introduction

The thesis is based on a study that aimed at creating a holistic approach and contextualisation of ICT-enabled public transportation systems in two cities in Southern Africa, which are still developing and technologically less advanced. After evaluating the existing state of travel behaviour and road-based public transportation travel patterns in Gaborone and Bloemfontein, and the evaluation of existing literature and theoretical constructs, it is necessary to create guidelines that will be applicable to these cities if they wish to improve their public transport systems. The existing road passenger travel conditions pose threats to the sustainability of transportation, especially in Gaborone, where private car ownership is on the rise, if no measures are taken to intervene. Remedial actions are required to develop new public transportation policies for a more efficient operation and provision of accessible mobility to communities. Leveraging the ICT to facilitate efficiency in public transport requires consideration for the existing socioeconomic, environmental and political landscape, which needs to allow the adoption and integration of ICT solutions befitting the transportation systems in the cities under investigation.

This chapter identifies the contributors towards ICT-enabled road public transportation and provides a development of guidelines and a framework for ICT-enabled public transportation, based on the results of the study, the literature review and theoretical framework.

6.2 Socioeconomic and Infrastructural Contributors Influencing ICT-Enabled Public Transportation

The concept of ICT-enabled public transportation is not a far-fetched idea for Southern African cities. Although the cities in the study area lagged behind the adoption of technology for transportation, other cities have been able to leverage the advancement

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and introduction of ICT for use in public transportation. The socioeconomic status quo and wellbeing of a city's residents influences their exposure to ICT, technologies and devices. This section identifies contributors towards ICT-enabled road public transportation. These are social, economic and infrastructural factors that would contribute towards and become catalysts of attaining ICT-enabled public transportation systems. A simplistic approach for areas where there is limited or non-existence of enabling technologies is needed to cater for the introduction and adoption of new technologies and ultimately the adjustment to a new system. This section discusses and puts forth characteristics of an ICT-enabled public transportation system that would fit the cities of Gaborone and Bloemfontein.

6.2.1 Socioeconomic contributors

Establishing an ICT-enabled public transportation system would be characterised by social empowerment and equity for communities and individuals. The following socioeconomic factors would indicate a positive growth of the cities towards achieving efficient, ICT-enabled public transportation systems.

Reduced vehicle ownership

Households' social status in car-dependent societies is increased by car ownership. Studies have indicated that car ownership among disadvantaged communities is different from that among the average population (Lucas et al., 2016). However, while such drive towards an enhanced social status can be understood, especially among households that did not own much before, the important role of an increasing level of car ownership towards a negative environmental impact, increasing levels of emissions and road congestion and thus, unsustainability are evident in the study. This is especially the case in Gaborone where there are already increasing numbers of cars on the road and travel delays are experienced regularly because of congestion. Reduced private vehicle use per household could maybe lead to car sharing or people using alternative modes of travel, including public transportation options by some of the household members. This could then positively contribute to an improved environmental as well as public transport sustainability by diverting people to the public transportation system, reducing congestion and reducing vehicular traffic on the roads. The effect of the regular, frequent use of private cars, which is associated with convenience, comfort and reliability, could result in low usage of public transportation, especially so, if the public transport systems are considered unsafe, unreliable, not

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easily accessible, or uncomfortable. However, ICT-enabled public transportation systems, with improved, safe and clean vehicles could attract a new customer base from people who currently travel by private car, if the price of fuel, insurance and car maintenance were to become unaffordable. It is unrealistic to envisage the cities of Gaborone and Bloemfontein without any private vehicles driving on all roads. However, long-term transportation planning should include plans to offer travellers the option for affordable, convenient, clean and safe public transportation, especially from the identified residential areas and the city centres/commercial or industrial centres. It will be difficult to achieve a mindset shift in terms of care for the environment or to reduce congestion, while public transport is inconvenient or still has any of the other negative factors associated with it. Minibus taxis and combis address this scenario through their flexibility and convenience, but they have not addressed the safety or cleanliness aspects.

Reduced need for travel

Trip purpose dictates frequency and mode of travel. Some mandatory activities limit travellers' choice of mode and need for travel. Travel for work and school or university, for instance, is more frequent. Technological interests are a positive indication for a prospective adoption of ICT-enabled options as replacements to travel. Given the rigid state of typical work and educational functions, it is difficult to make assertions as to whether trip frequencies they dictate can be decreased. A trip's purpose could either be accelerated or delay the adoption of ICT-enabled public transportation. Trips for regular activities, such as work and school, where ICT cannot substitute the need for physical travel, could become more attractive through ICT-enabled offerings, such as free access to Wi-Fi. While this would not reduce the number of trips made, nor the mode of travel, it could lead to greater loyalty towards the use of such public transport option. From the results, it is obvious that less people would use public transport if ICT were to allow them to work and study from home. This would not result from an ICT-enabled transport system, but a development in commerce and industry, as well as the educational institutions gearing up to remote, online operations, and people would replace travel by ICT alternatives if available. Traffic congestion could only be addressed in the city centres if private cars were no longer allowed in specific zones, and if taxis and buses were to be allocated specific restricted lanes in such areas.

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Increased ICT access

Accelerated developments in technology have led to ownership of devices and accessibility to ICT becoming a social communication enabler with regard to the ease of communication. Therefore, the free access to Wi-Fi in buses and taxis will enhance the service to the users of public transportation information systems. The study observed that smartphones, the internet and basic call and SMS technologies are the most used technologies by participants in Gaborone more so than in Bloemfontein. Free Wi-Fi access will also increase the use of these technologies for travel and during travel and could also incorporate the public transport companies' access vie technology to the travellers for the dissemination of information. Currently, few travellers use ICT for travel information, mostly prior to a trip for updates on departure or arrival times, routes and delays. Far more could be achieved if all trips were to be paid for via smartcards, eliminating the need for cash. The use of such cards would also allow the public transport companies the access to travel data and thus better planning of routes, frequencies and the need for an improved infrastructure.

Increased use of public transportation

The obvious and ultimate end goal of sustainable public transportation systems would be a noteworthy shift from the use of private vehicles to the use of public transportation. It is evident from the study that some participants would shift from private vehicle use to use of public transportation if they were to have the choice of affordable, safe and convenient public transportation alternatives. Some would shift for convenience reasons (for example, demand response to their travel needs and being dropped off at their exact destinations), which can only be achieved at a higher cost to the individuals. The alternatives would be an improved infrastructure (better roads, sensible routes, more bus stops, safer and cleaner vehicles), and a comparison of increasing costs of private car usage compared with affordable costs of public transport usage leading to an increased use of public transportation. An ICT-enabled public transportation system would have to include smartcards for payments, online bookings of trips where possible, and information about costs, routes, congestion and delays to provide travellers with an efficient system how they can plan the optimal use of the public transportation. City planners will also have to consider better road planning, including lanes for buses and taxis, closures of certain parts of the city to private cars and safe Park-and-Ride parking areas to provide travellers with the option

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to use public transport for access to the inner city. Joint ventures could be considered with companies and organisations situated in the city centres to offer their employees free smartcards for use in public transport and thereby increase the use of such public transport.

6.2.2 Infrastructural contributors

ICT infrastructure

Adequate ICT infrastructure is necessary to support ICT-enabled public transportation. This includes connectivity and network coverage that is sufficient to access ICT-enabled buses, taxis/combis and any other public transportation vehicles, as well as travellers' mobile communication tools (smartphones, tablets, and so forth) in all parts of a city for instant information transmission. Seamless network coverage is needed for mobile devices for travellers to receive instant, real-time information.

Monitoring technologies: Devices and technologies for monitoring public transportation facilities for safety and security purposes will be crucial for successful integration. Some reasons for not using public transportation are security reasons, both in-vehicle and at public transportation facilities, including instances of losing luggage and money. The provision of monitoring technologies, such as on-board cameras and cameras at bus stops and taxi ranks, will likely increase the travellers' perception of security and reduce the fear among public transportation users. The study revealed that travel monitoring, real-time traffic updates are among some of the reasons people would use ICT during trips. Technology to support these will be needed for ICT-enabling the public transportation system.

GPS and tracking technologies: Planning is important to trip makers, this is in terms of planning journeys before trips, route mapping and checking for traffic updates. Location and mapping technologies will therefore be a necessary deployment to the public transportation system. Tracking and GPS technologies are necessary installations for real-time location information, either for vehicle location or for estimation of trip end time. The up-to-date provision of such information can enhance the travellers' feeling of convenience and decision-making based on real-time

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information. Equipping the public transportation system with such technologies will be indicative of steps taken towards an improved and up-to-date, sustainable system.

Transportation infrastructure

Artificially intelligent highways and integrated communication methods for roads and public transportation platforms seem to be the ultimate goal of all city planners. However, the success of ICT-enabled public transportation would not rely greatly on advanced highway technologies. The provision of basic ICT infrastructure for internet connectivity and their linkages to the transportation information systems and the existing infrastructure would be adequate tools to improve the current public transportation systems.

Bus stops: These are important facilities to most public transportation users' trips. Given the extended waiting times travellers are often subjected to, it is of outmost importance for this infrastructure to accommodate all users and be equipped with technologies supporting ICT-enabled public transportation. Internet availability is paramount to provide travellers with access to travel information and entertainment while awaiting the next available vehicle.

Bus ranks and terminals: These are the pinnacle of public transportation infrastructure by virtue of being the main public transportation nodes. Improvement of ranks and terminals to accommodate ICT-enabled systems requires a broad adaptation of new technologies, for example, the installation of real-time information relay systems, such as display screens showing the location of vehicles, departure and arrival times will contribute to convenience and reliability of the system.

Vehicles

The state of vehicular infrastructure has to be appealing to all passengers. The current poor and unsafe state of taxis and combis, and even some buses, is a major concern to passengers. Vehicles have to be in a good, roadworthy and clean physical condition. They must also be able to accommodate ICT devices (in-vehicle technologies) such as screens. Vehicles should be able to support ICT without causing discomfort to passengers on-board the vehicle and without interfering negatively with the drivers of such vehicles.

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In-vehicle safety and security: Improved safety and security measures within vehicles will also provide much needed reassurance to public transportation users and potentially attract new users. ICT could potentially be used as a device towards safety and security improvement. Installation of monitoring devices, cameras and tracking devices in buses, taxis and combis (as well as at bus stops and taxi ranks) are some ICT solutions that would reduce these problems.

Installation of ICT devices in vehicle: Many devices are needed to solve problems specific to the requirements of users as indicated in the study. The study's results indicated the types of technologies participants were using and the purposes and trip-making stages when these devices would be needed.

Improved physical conditions of vehicles: Reduction in vehicle breakdowns often encountered by public transportation users will definitely contribute to an improved state of vehicles, factors pertaining to reliability, convenience and comfort would be further improved by provision of vehicles that are roadworthy, in good physical condition and clean.

6.2.3 Summary

Household income is one of the major economic influencers of individual travel differences. Mode of travel is decided by travellers, based on what they can afford. Vehicle ownership also depends on income. Increased household income will also influence access to smartphones, data purchases and usage, as well as multiple trips via public transportation. Unless ICT-enabled public transportation can substitute the need for travel, the monetary cost of travel could increase with ICT-enabled public transportation. ICT-enabled compatible infrastructure in public transportation would be crucial to the integration exercise needed for an upgraded, up-to-date communication system. Besides the infrastructure owned by governments, governing bodies, and transportation operators, individuals would need to own compatible mobile devices and mobile data would be an added cost to travel fares. Costly access to ICT would hinder their access to ICT-enabled public transportation, or limit the accessibility to all ICT components of an ICT-enabled public transportation system. Lower costs for or free access to ICT would promote travellers using ICT-enabled public transportation. Data costs would also affect access to ICT-enabled public transportation. Higher data

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costs would result in limited use of web-based services and platforms. However, with technologies enabling applications such as offline maps and access before trips could benefit users, as they could still have access to these technologies when they no longer have access to the internet.

The economic outcomes of ICT-enabled public transportation should be able to sustain operators, as long as the other factors are also addressed. The implications of equipping public transportation vehicles with ICT systems and devices could be burdensome financially to taxi and combi owners operating on a small-scale basis. Installation, monitoring, and maintenance of devices and internet connectivity would result in added costs to the operational costs of a vehicle. However, these efforts would improve the city's medium-term and long-term transport planning, offering better control over the various modes of public transport, enabling better road and infrastructure planning, efficient use of routes, frequencies of service offerings, number of vehicles needed for those routes, maintenance planning, and leading towards the cities becoming smart cities.

6.3 Guidelines and Framework for ICT-enabled Road Public Transportation Systems in Southern Africa

The following guidelines are developed for consideration towards ICT-enabled road public transportation in the cities of Gaborone and Bloemfontein. The guidelines provide these cities and transportation planners with factors to consider for sustainable, ICT-enabled public transportation services. Policy-makers, and other stakeholders in the system, as well as potential passengers and operators should benefit from the system. Stakeholders can draw suggestions from the analyses in this study to create and implement the necessary steps towards creating ICT-enabled road public transportation systems for their respective cities.

6.3.1 Benefits of efficient public transportation systems

The purpose of public transportation is to serve the public. Achieving efficiency in public transportation will be beneficial to multiple groups of stakeholders. In establishing new systems or improving the existing ones by means of technology, local

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contexts, culture and socio-psychological factors should not be ignored. These factors play an important part in the acceptance and use of new technologies.

Technology acceptance could be hindered by communities upholding societal cultural factors. The degree to which people or stakeholders are willing to accept technologies has implications for the potential benefactors. Theory reflects on the possibilities of technology acceptance and its reliance on human psychology, especially for decision-making. As the diffusion of innovations theory implies, the decision to adopt or reject developments in public transportation would be based on the perceived benefits. Public transportation contributes positively to people being able to access jobs or education, especially for people without other means of travel, thus improving their mobility. Improved accessibility and mobility lead to reduced waiting times, reduced travelling time and often even to the reduced cost of travel. Improved efficiency brought about by ICT-enabled tools or systems can benefit users and other stakeholders of the public transportation system.

6.3.2 Identification of priority areas

The areas within the public transportation system that need to be sustained, developed or maintained for ICT-enablement should be identified by the cities. Improvement of systems should not mean the redundancy of the existing system. Public transportation, though marred by negative reviews from users, has its distinct advantages, which should be incorporated into any new system. The elimination of safety and security concerns as well as concerns regarding convenience and flexibility should be considered as priority areas for a new sustainable system. The current cost of public transportation systems should be maintained as far as possible, without degrading the quality of the system. A balance between affordable, convenient, ICT-enabled public transportation systems should be established. It will be challenging for public transportation to ensure affordable trips for passengers, while rising costs of fuel, personnel and maintenance have to be taken into consideration. However, car users will be faced with the same challenges of rising costs and may consider changing to public transport, especially if such option is “more” affordable than the use of their own vehicle, and offers them the option of a safe, convenient and pleasant trip for their daily trips to and from work or education venues.

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6.3.3 Inclusive public transportation systems

Public transportation systems should serve all demographic groups within a city. However, modern day cities are segregated by economic and social status, which is also reflected in the urban transportation systems. Contention over the use of private vehicles and public transportation is a matter of social and economic status as well as personal convenience for travellers. Vehicle ownership is prevalent in affluent areas, while the use of public transportation is evident in middle-class and poorer communities. Moreover, the poorest communities of a city and informal settlements have limited access to any transportation services because of a lack of road infrastructure and, to some degree, a lack of official recognition by governments as being residential areas. The segregation has resulted in high private vehicle ownership in affluent communities for convenient access to activities, while the poor are faced with long walking distances and more waiting time to access public transportation. Social exclusion, which is the unequal experience of different population groups in a community based on economic structures is prevalent in all transportation systems and will probably remain so because of affordability. Poor people also aspire to owning a private vehicle, but this will always be based on income.

At the same time, governments have the responsibility to look after the poor and enable them to reach their jobs, education venues or shops. Inclusivity should extend to policymaking. In addition to social inclusivity, stakeholders should be included in the planning of an urban transportation system. This becomes more challenging in cities where public transportation businesses are privately owned and not subsidised. Governments are largely responsible for transportation policies and their implementation, but the operation of passenger transportation systems depends on the operators and users. The stake held by public transportation operators (combi, taxi and bus owners) serves as a proxy of the public transportation system. Governments should not create legislation and policies without involving operators, who are the service providers. Planning should also involve the public users and customers of the system, to assess the feasibility of the planned policies. Prior to implementation, policies should be subjected to scrutiny by all stakeholders involved. Thereafter, once policies have been adopted, their successful implementation will be paramount.

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6.3.4 Accessible land-use and zoning measures

Travel patterns indicate the lack of spatial coordination due to the form of movements by both public transportation and private vehicle users. Centralisation of land-uses that attract regular trips in specific areas derail the efforts towards sustainable travel. Dispersion of different land-uses throughout the city combined with mixed land-use zoning is likely to evenly re-distribute vehicular traffic to various areas of the cities at different times of the day. This will also necessitate better road planning (for example, ring roads) and zones that will limit vehicle access altogether. The current centralised destination and departure use of public transportation nodes is not sustainable, where vehicular traffic is directed to a central zone, leading to traffic congestion, delays and increased travel times. It also means high levels of noxious emissions in those areas and creates an unhealthy atmosphere for the citizens. To address this challenge, roads in the city could be blocked to private vehicle users, and special lanes be created for buses, taxis and even bicycle users. Decentralised Park-and-Ride areas should be provided in several areas outside the city centre to accommodate transportation facilities adequate to house and manage organised public transportation operations, including fleet support infrastructure, and ablution facilities. Sustainable road transportation should be accessible, and complementary to the land-use zoning in urban areas.

Travel patterns investigated in the study have shown that the current patterns are unsustainable for the following reasons;

a) Travelling towards a single centralised location by high numbers of travellers indicates the centralised distribution of commercial and educational functions in an urban area. Areas that attract more people simultaneously attract high volumes of vehicular traffic, hence more problems associated with unsustainability practices. At the same time, such centralisation also encourages the use of public transport, as destinations are clustered and easy to reach.
b) Performing activities at different locations in the cities also shows that there is a need for some more sporadic travel. Clustered but decentralised land-use could also be adopted to promote sustainable travel by public transportation to other locations. Having commercial zones (or land-uses that attract significant

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travel) within each area that serves as places for employment and commercial activity could also dictate the future placement of public transportation facilities.

Cities already exist in their current form, so the destruction of the existing infrastructure to re-plan land-use and transportation systems for co-dependency and seamless integration is unwarranted. However, new zoning to create mixed land uses for compatible functions should be considered to facilitate sustainability of other areas beyond the city centres.

Future planning should consider transportation infrastructure integrated with, or leaving room for, future technologies. Land-use zoning that will encourage commercial, industrial and educational development in outlying areas of the city will reduce the need for people to travel into the city centre, prioritising public transportation infrastructure, and it will create an environment that accommodates ICT-enabled sustainable public transportation systems. Apart from ICT as an enabler to sustainable transportation, zoning measures that accommodate NMT should also be accommodated with walkable distances to reduce travel distance or the need for motorised transportation.

6.3.5 Accessible public transportation systems

Accessible public transportation facilities that provide direct public transportation between zones would reduce the number of daily trips taken by individuals. Direct transportation available is dominated by cabs, which operate in response to demand. The current modal split is dependent on what is available to people, so they use the mode that is the most accessible. Making public transportation more accessible by increasing vehicle capacity and the fleet of public transportation vehicles and routes would reduce waiting times for passengers. It will create the need for additional routes and more bus stops or points where taxis/combis are allowed to stop, thereby reducing travellers' walking distances to the nearest public transportation access point. Physical proximity to public transportation services alone does not constitute accessibility, factors such as the cost of travel pertaining to public transportation also contribute to the ease of use of the public transportation system.

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6.3.6 Investment in ICT-enabled public transportation systems

The public transportation system requires continuous infrastructural developments, which are backed by financial investment. Improvement of the quality of service relies heavily on substantial infrastructure. Not only does the infrastructure serve public transportation stakeholders, but the appropriate infrastructure also improves the urban form of a city and its aesthetics, potentially improving social and economic activity. Prioritising public transportation can contribute to an attractive smart city system that will affect a modal shift. Safety concerns and long walking distances to access public transportation can be solved by improvements in infrastructure. Construction of roads in areas where public transportation is currently inaccessible because of roads in poor condition, construction of safe public transportation stops, and platforms with security measures to improve access and safety will contribute greatly. Priority lanes for taxis, buses and combis would reduce the congestion and reduce travel times.

New investment in ICT infrastructure will be needed for ICT-enablement of the public transportation systems, even if such system will merely consider smartcard payments and route planning/updates on congestion and delays. Development and sourcing and eventually operation of systems and applications for public transportation systems will require financial and human capital investments. Under-investment in public transportation could result in reduced chances of achieving sustainability. Given the benefits of ICT, the cities of Bloemfontein and Gaborone should reconsider their planning and investments in public transportation infrastructure and its operation towards achieving an improved, efficient public transportation system.

6.3.7 Facilitation of ICT integration

Technology is promoted as a possible solution to public transportation problems, but its success is not guaranteed. Therefore, the two cities should develop feasible ICT integration plans for public transportation systems. Technologies that would be useful to travellers and the stages at which the technologies would be useful would help to identify the types of technologies that should be considered first. Even though technology is greatly advancing, its adoption has not always been instantaneous. The adoption process can be lengthy, mostly based on the purpose a particular technology is anticipated to serve and whether individuals deem it necessary or useful.

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First, there is already a high level of knowledge and use of ICT in the cities that indicate the awareness and willingness of residents to use some technologies. Second, ICT integration is inevitably costly, so the cost of access to basic ICT systems has to be considered in order for ICT incorporation to be feasible. Use of the ICT also depends on its affordability by the ultimate users. Affordability of larger ICT components for vehicles and public transportation platforms, and how they will be funded, will play an integral part in determining such feasibility. Third, the technologies selected must be those that will be immediately accessible and usable. Both cities in the study area have minimal ICT usage in public transportation. Therefore, this introduction should be accompanied by measures to create awareness of the technologies, which can also be achieved through technologies. While it may not be feasible to provide free Wi-Fi access in buses and taxis, technology could start with smartcards for payment, increasing the drivers' and passengers' financial safety and convenience. Websites could also be created that update travel routes and times, locations of bus stops and taxi ranks, and so forth. Travellers can access these sites via their mobile communication devices. ICT integration could be facilitated and made feasible by employing the use of affordable innovations and the use of mobile phones.

6.3.8 Relevance and acceptability of technology

The adoption of technology starts with users' willingness to use such technology. Growing adoption of technology in the developing world has also raised acceptability concerns. Social acceptance of technologies is often slow or rejected by conservative communities or those mostly concerned about affordability and the usefulness or necessity of the technology. Therefore, the positive effect the technologies will have on the transportation system must be communicated to the users.

The results of the study provided a perspective on which technologies would be acceptable and the purposes for which they would be deemed necessary by users for or during their trips. Different periods during trip-making also require the use of varying technologies as deemed relevant by the users. Based on the results of this study, travellers are interested in information for different reasons before, during and after their travel. They are mostly interested in the use of ICT for information before starting their journeys, so investing in information platforms, websites and applications would be more sustainable and beneficial to the systems.

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It is important to highlight that mobility, as the most important aspect of travel, is often achieved through the mechanical systems of vehicles or bipedalism for travel by walking. This does not require ICT; a traveller making a trip can still move from origin to destination without the use of ICT. Technologies have been hailed as promoting smart cities through their incorporation into various systems of a city; hence, the need to include them into road public transportation systems. As much as incorporation of technologies into public transportation systems is subject to users' acceptance and use, efforts need to be directed towards technologies that are the most relevant.

6.3.9 Effective policymaking and implementation

Governments are custodians of cities, their inhabitants as well as the transportation systems that ferry people and goods to the city's other functionalities. The role of governments, at all spheres in the effectiveness of a transportation system, is crucial. Therefore, governments must spearhead the process towards sustainable transportation systems and technology integration. The existing policies, though acknowledging the need for better transportation, are slow to implement measures towards achieving more efficient public transport systems. They do not sufficiently outline the concrete steps, timelines and accountabilities needed to achieve the goals. Policies are often tabled and passed, but less often implemented. This created stagnancy of development, as it is visible with the policies reviewed in the study. The many safety, reliability, efficiency, effectiveness goals of transportation policy in South Africa have not yet been achieved. Accessibility and good quality public transportation in Botswana have not been achieved either, but the policies towards their attainment exist. Policies to achieve the goals should put systems in place that allow for the ultimate modal shift from an increasing private vehicle use to public transportation use, promote NMT and enable ICT integration within a smart city environment. Better zoning plans, allowing for commercial, industrial and educational zones to be developed in outlying areas, closer to mushrooming new residential areas, will also ease future travel demands. A culmination of such policies should result in improved sustainability of public transportation systems.

6.3.10 Vehicle ownership regulation and congestion elimination

Private vehicle ownership is one of the factors that contribute to increasing levels of congestion, accidents and noxious emissions, endangering the health of citizens, and countering any efforts for environmental sustainability. Regulating the numbers of

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vehicles with access to city centres could reduce congestion and road traffic. While it is impossible to limit the ownership of private cars, affordability will serve as a limitation. This will have to be weighed up against the cost, safety and convenience of travelling by public transportation. The factors that would promote modal shift from private to public transportation by regular users of private vehicles were investigated in this study. The results indicated that although some people were willing to shift, others will not shift even if public transportation is improved.

Measures to reduce traffic congestion on the roads should be employed. These measures should take into consideration flexibility and convenience without compromising travellers' comfort. For travellers to reach their destination with maximum comfort, efficiency should not be compromised. This can be achieved by better road planning, using ring roads, one-way traffic road systems, traffic circles and limited access for cars into city centres. Past efforts to eliminate congestion of traffic caused by private vehicles as well as taxis/combis and other vehicles as a way of effecting a voluntary mode change to public transportation has not yielded sufficiently positive results or a willingness by drivers to give up their convenience and comfort.

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CHAPTER 7: SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

This chapter contains the conclusions and recommendations for the development of an ICT-enabled road-based public transportation, based on the theory and findings of this thesis. It includes recommendations for future studies.

Southern African countries are developing fast, but many of the smaller cities in these regions have been left behind regarding the application of the technologies developed countries have leveraged for efficient public transport systems. Change in transportation systems is a gradual process, especially so in public transportation systems of Southern African countries, which are marred by complex socioeconomic, political and organisational dysfunctions. The operation of transportation systems by private entities under government policies has been shown in many cases not to take into account the users' needs. Although regulations exist for vehicle registration, monitoring and overseeing road infrastructure, they do not influence the daily operations of the system. Present regulations cannot enforce the uptake of ICT-enabled road public transportation. New policies and regulations will have to be formulated to accommodate technological developments in public transport and the use of ICT to support road infrastructure.

The findings of this study will assist policymakers and other public transportation stakeholders in decision-making towards introducing and implementing ICT in the public transportation systems to achieve efficiencies and a modal change. The problems with the current systems regarding ICT-based measures to improve the travel experience have been outlined in the study. Also, human movement in two cities has been visualised in the study, which will help planners and operators to plan public transportation routes for users' optimal accessibility to activities.

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7.2 Summary

The study provides evidence that the current road public transportation systems in Gaborone and Bloemfontein lack the consequent broader implementation of and access to ICT. The present focus and primary function of the transport systems is to transport people from one place to the other with minimal effort, convenience, reliability, safety, and a limited use of ICT. Transportation in developing Southern African cities is focused on moving people from one place to another. The systems were developed as a means to enable movement by the middle-class and poor populations. Private car ownership indicates having achieved an aspired social status in communities. Where access to technology is still a luxury, its incorporation into public transportation systems to create an ICT-enabled road public transportation system might be hindered by social constructs such as limited access to smartphones, tablets or other devices, and limited money available for fares.

Travel behaviour and travel decision-making influence travel patterns, which are important to consider in developing improved public transportation. The decision to travel by NMT is based on convenience, safety and reliability. A modal shift has been hindered by the lack of an equally convenient and reliable alternative in public transportation. A low use of NMT was revealed in the study, which clearly indicated that aiming for sustainability in public transportation will not be achieved coming from NMT users (bicycles and walking). At the same time, the spatial settings, infrastructure and road networks lack the factors that would enhance the use of NMT to travel to work or university.

The study showed that the facilitation of human movement is not optimised in these two cities. Movement using private vehicles is environmentally detrimental, yet, it is believed by many to be the most convenient method for travellers. However, except for Gaborone, movement by public transportation is the only option available to most residents who do not have access to private transportation. Travellers use public transportation on a captive basis, despite its undesirable aspects. Public transportation attracts most of its users, who are of lower socioeconomic status, through its affordability. However, affordability alone is not a compelling enough factor to effect modal shift away from private car use. The other components of the public

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transportation system (reliability, convenience, accessibility) have not been prioritised but any complaints against their undesirable state cannot deter captive users from the system. More people opt for private transportation as they become financially able to do so. Therefore, there is an apparent need for an attractive public transportation system offering convenience, safety and reliability at an affordable rate. To improve the public transportation system, many infrastructural aspects have to be addressed, while ICT can assist to reduce some of the undesirable aspects of public transportation. ICT is suitable to provide instant communication, enhanced trip planning, safety and security, as well as reducing traffic congestion and excessive time spent waiting for transport.

The summary is based on the following research objectives as fulfilled in the study.

i. **Develop a theoretical review based on existing literature to create contextual understanding of concepts and how their application can contribute to ICT-enabled road public transportation systems.**

A review of theories that draws from past literary theories and the extensive literature guiding the study was developed. The theories used to contextualise the study vary and are multi-faceted, based on the fact that travel is fundamentally a function of geography and temporal dimensions of moving from one place to the other. These theories have put forward reasons for traversing from point to point and the decisions that influence or lead to specific behaviours and choices before and during travel. Finally, theories informing technology acceptance, use, dissemination; how ICT is viewed by individuals or devised in organisational or group settings also provide context into the ICT-enabled public transportation and provide the insight that solutions to making public transport sustainability go beyond the scope of ICT and include a host of other factors.

ii. **To explore the current travel behaviour and travel patterns of people in the study areas.**

Geospatial characteristics influencing travel patterns were identified in the study through the use of GIS and questionnaires. Areas within the study areas where participants performed various activities were identified, enabling the identification of

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areas of activity concentration and the assessment of accessibility between the areas using origin-destination matrices. Geographical coordinates where public transportation users boarded, and alighted public transportation vehicles were used to highlight areas with a high concentration of public transportation. Vector routes connecting each individual's origins and destinations were created, formulating patterns of movement. Factors that influence travel behaviour, such as choice of mode, travel time, and reason for travel were also established.

iii. To examine the geographical relationship between road public transportation users' travel patterns and land-use.

GIS was used to identify the travel patterns of public transportation users. Travel patterns of private mode users, from residential areas to areas where activities are performed, were identified using questionnaires. It is clear from both studies that the geographical relationship of travel patterns is related to land-use. The activity locations established in Chapter 4 were further corroborated by the patterns of movement by public transportation users in Chapter 5. Dispersion of journey origins and destinations in residential areas and the concentration of morning trip destinations and afternoon trip origins in commercial and mixed-use zones highlighted the zoning influences to travel patterns.

iv. To examine the influence of various contributors towards ICT-enabled road public transportation systems

Binary probit regression models were developed to examine the possible contributors that influence ICT-enabled public transportation. Various factors contribute to the ultimate use of ICT in public transportation. These include the existing assimilation with ICT use by the transportation system users, internet access, data usage and use of devices and technologies during trips, mostly for entertainment and very seldom for transport-related aspects.

v. To identify major socioeconomic, infrastructural, environmental and technology-related indicators that could influence ICT-enabled road public transportation

Socioeconomic and infrastructural indicators that could contribute towards ICT-enabled public transportation were identified from questionnaires and a review of

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existing literature. The indicators include reduction of private vehicle use and the need for travel, increased access to ICT (systems, components, devices), which will promote growth and advancement towards ICT integration in public transportation. Increased use of public transportation as a result of successful integration and acceptance of ICT would indicate a positive adoption of ICT-enabled public transport. The study identified the need to have the appropriate ICT infrastructure, transportation infrastructure and improvement of public transportation vehicles, equipping them with relevant technologies.

vi. To develop a set of guidelines and a framework for sustainable, ICT-enabled road public transportation systems in the study areas

Guidelines were developed, based on the data gathered through questionnaires and an extensive literature review. The guidelines encompass considerations for inclusive and accessible public transportation systems, prospects and considerations for ICT integration into public transportation. The benefits of sustainable ICT-enabled public transportation systems and how they could potentially be achieved are outlined to provide direction and possible insights for policymaking in the study areas.

7.3 Findings

The research questions of the study were answered as follows.

i. What is the impact of the urban characteristics of the cities of Bloemfontein and Gaborone on travel behaviour and patterns?

The land-use and zoning characteristics of both cities do not favour sustainable urban road public transportation due to their complexities. The permanence of zoning, urban characteristics and land-uses inherently determine land transportation systems' operations, including road transportation networks. Road transportation conforms to the pre-set characteristics of the networks, including public transportation facilities, ranks as well as bus stops. Therefore, trip-making is geographically restricted to these pre-set characteristics of the city's urban form. The cities investigated by this study have distinct urban forms, the impacts of their characteristics on travel behaviour and patterns are detailed below.

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- **Effects of urban characteristics on travel behaviour and patterns in Bloemfontein**

Land-use zoning and the urban system of Bloemfontein is a result of political and socioeconomic influences. Socioeconomic disparities in residential land zoning, which are evident in Bloemfontein as a result of historical inequalities, have a visible influence on travel behaviour and patterns. Historically, apartheid policies segregated people according to race, which led to changes in land distribution and subsequently land-use and zoning practices that did not serve the needs for mobility and accessibility of all equally. Residential areas are separated by economic status, influencing the accessibility of transportation and type of transportation available. Affluent communities are located in the northern and eastern parts of the city where the use of private vehicles is prevalent. Movement from these parts of the city is characterised by frequent use of private vehicles by residents and use of public transportation by non-residents. Users of public transportation who make more than two public transportation trips per day are workers travelling from the south end of the city to the northern and western suburbs for work. High population density in the southern residential areas is associated with the availability of public transportation during morning peak hours, moving from the south to north-western parts of the city and the afternoon and evening peak hours from the northern and western parts of the city to the south.

Trip generating activities in the city of Bloemfontein are highly centralised; hence, the location of major public transportation nodes lies in the centre of the city. The city's CBD area accommodates public transportation nodes, being the main bus terminal and a number of taxi ranks in close proximity to each other. There are other prominent public transportation nodes dispersed around the city, these nodes all connect to the central nodes. They are located in high-activity areas such as hospitals, educational institutions and shopping areas. Even with the existence of these nodes, there is a lack of easily accessible direct public transportation connecting various suburbs and residential areas without first traveling to these central points. The lack of direct public transportation from each area of the city increases the number of trips because travellers first have to travel from their residential areas or areas of work to the CBD before making other trips beginning in the CBD. The trips also include walking between public transportation nodes or terminals.

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- **Effects of urban characteristics on travel behaviour and patterns in Gaborone**

Gaborone is a decentralised urban area, with clustered regular activities occurring in areas of the city that are closely knit together. There is centripetal movement towards the city centre, showing a flocking pattern, closely concentrated in areas of the city with high spatial density. These areas also represent a concentration of economic activity. The opposite, centrifugal movement and a decentralised dispersion of origins and destinations is noted with residential, low spatial density areas. There is a low density of built environment and urban infrastructure in residential areas and even the city's commercial and industrial areas, which are considered to be busy and dense, are relatively less dense compared with major capital cities in other countries. Therefore, human movement at peak hours results in most vehicles moving into or out of the city. During off-peak hours of the day, there is less traffic moving in or out of the city centre. The movement of vehicles indicates an imbalance in urban form and land-use. The villages surrounding Gaborone contribute to travel patterns in the city. There is a noteworthy number of people living in Mochudi, Mogoditshane, Tlokweng and Ramotswa, who commute into the city daily, using both private and public transportation. Traffic flow from these areas, especially by public transportation, feeds into the city's public transportation system for passengers to complete their journeys. The lack of direct public transportation connecting all areas has a negative impact on the sustainability of the system, mostly in the form of consequence to users of public transportation who have to spend more on trips and travel time. Travel between residential and areas of work and education, which involves the most regular and frequent trips, is therefore not sustainable.

ii. How can ICT-enabled public transportation systems contribute to sustainable transportation?

Functional sustainable public transportation systems will contribute to the general sustainability of transportation. The results of the study indicated an interest in ICT-enabled public transportation; however, systemic concerns regarding access to ICT, such as internet and data costs and availability of options to substitute ICT activities for travel, must be addressed prior to activating ICT in public transportation. ICT-enabled road public transportation has the potential to promote sustainability in public transportation by increasing the accessibility to information regarding transportation

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and activities. Interactivity between people and technologies can be leveraged to ease access. ICT increases the chance of travellers replacing travel with ICT-enabled situations of working from home or studying remotely – as long as employers set up the relevant structures.

The potential of ICT through timely information transfer would be to enable ease of information relay in the form of geographical data, smartcard payment systems, as well as prompt, real-time updates. Regular local travel in cities could benefit from payments made easier by ICT, which will, in turn, promote safer monetary transactions between travellers and public transportation operators.

There are positive prospects for ICT-enabled public transportation in both cities, which can be leveraged to promote sustainable transportation, as long as the relevant infrastructure improvements and network expansions have been attended to.

Socioeconomic equality: Easing access to services, activities and locations, which would otherwise be inaccessible due to costs, distance and travel time. Monetary costs incurred as a result of multiple trips will be reduced by direct transportation services enabling single trip journeys.

Efficiency: Improved efficiency of the public transportation system can be achieved by employing technologies. ICT has the potential to reduce queueing and waiting times as well as travel times. With the availability of real-time information and its enabling technologies, travellers will be able to know when to leave their places of residence or work to go to public transportation stops and platforms to coincide with the arrival and departure of vehicles at those particular stops. Monitoring of journeys and transportation operations by authorities using ICT will also improve the safety of public transportation systems.

Improved accessibility and mobility: ICT in transportation improves efficiency, as technological solutions have improved access to transportation through various innovations, such as shared mobility, e-hailing and general information dispensation brought by ICT. This is also substantiated by evidence from the study that shows that participants are willing to shift to public transportation for on-demand services and capabilities of public transportation dropping them off at their respective destinations. A modal shift resulting from users migrating to the improved ICT-enabled public

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transportation; improved accessibility to transportation services and locations or activities due to availability of information; and the ability to instantaneously relay and receive messages between travellers, operators, vehicles and their ICT infrastructure would indicate users' wishes for easily accessible and efficient transportation.

Sustainable environment: Creating safer public transportation systems will encourage and promote their use, which might reduce the need for private vehicle usage and their numbers on the road. Reduced traffic will ultimately contribute to less congestion and reduced carbon emissions, which will contribute towards a better, healthier environment.

Policy development: Until policy accommodates the use of ICT, and addresses the backlog of structural improvements of the public transportation systems, any noteworthy change might be unachievable. Private operators might incorporate technologies in their private capacity to improve their services, but effective government oversight is still essential. It was found in the study that there was interest in ICT in public transportation, although mostly for entertainment purposes, private communication, and information on travelling aspects, which could be leveraged to attract users.

The three dimensions of sustainability, social, environmental and economic dimensions, are fully encompassed in ICT-enabled public transportation; social sustainability being the issues of equal access to transportation by all, environmental sustainability would be characterised by decreasing the number of vehicles on the roads through a modal shift, while the economic aspect would be affordable travel or access to activities. Successful ICT integration in road public transportation will therefore promote sustainable transportation in all its dimensions.

7.4 Recommendations

The supply of public transportation is based on the demand from individuals who need to travel and are dependent on the public transportation. The demand will exist for as long as they are dependent on public transportation. Even though it is evident that captive users will still use public transportation despite discomfort and unsafe

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environments because they have no other options, this captive hold should not be used as a basis for sub-par services. Sustainability is a complex phenomenon and, for it to be achievable, social, economic and environmental perspectives should be taken into consideration. The integrative nature of sustainability also requires maintenance and improvement of the existing status to keep systems functional for extended periods of time.

The following recommendations were developed, based on the study's findings and conclusions.

a) Future planning, land-use and zoning measures should accommodate accessibility of transportation and accessibility of various land-use areas. Mixed land-use areas should be prioritised and should include residential and commercial zones to reduce the need for extended travel by vehicles, and shorter travelling time using NMT. Such areas should also accommodate basic needs such as educational and shopping facilities. This will reduce the movement from residential zones to central areas of the city. However, the most frequent travel was caused by travellers going to work, thus, commercial and industrial areas would also have to be in closer proximity to some residential areas.
b) Different technologies should be introduced into the public transportation system, in different phases, which will also be instrumental in integrating ICT into public transportation. Priority areas should be identified based on problems that need to be addressed urgently. The first phase should be focused on introducing technologies to assist regular public transportation operations and transactions, information for trip planning, public transportation monitoring, as well as smartcard payment solutions. This could be focused on the safety and efficiency of the system. The second phase should be focused on real-time travel information, such as traffic updates, and route planning technologies. The third phase should be focused on advanced technology and integrating non-critical ICT for aesthetic enhancement of the system, such as entertainment.
c) Incentivised technology rollouts to public transportation operators, suggesting the uptake of technologies at the operators' costs is likely to be rejected. These proposed solutions should be of most benefit to the operators. For example,

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applications that would notify taxi drivers and operators of potential passengers in the vicinity, prompting the driver to wait for the passengers or take a detour to meet the passengers. Such a technology is more likely to be adopted, as the drivers are getting more business from the technology. The technology would be complementary to demand-responsive travel and e-hailing, but would not create an entirely new market or competitor for the existing public transportation operators.

d) Public transportation infrastructure in both cities should be developed to support ICT-enabled public transportation. There are positive prospects for ICT-enabled public transportation.

e) Instead of discouraging the use of private vehicles to promote public transportation, measures should be taken to equip public transportation with more convenient, safer, comfortable, flexible and privacy features, where technologies can attract more people to use public transportation instead of private vehicles. Changes to the road infrastructure, limiting access by cars to the city centres, building ring roads, bus lanes and taxi lanes will also address congestion problems, and Park-and-Ride options could keep private cars out of the city centres.

f) Considering the limited public transportation modes and the lack of integrated efficient mass transit in the two study areas, difficulties in the use of advanced ICT are probable. Therefore, introducing improved vehicles with larger carrying capacity to cooperate with the existing taxis, buses and combis is likely to improve the efficiency of the system. It will be essential to prioritise improved road facilities and their capacity to support public transportation.

7.4.1 Policy recommendations

The following recommendations are proposed for incorporation into policy towards improved ICT-enabled public transportation systems:

Policy 1: Dedicate land for public transportation facilities and operations in all areas of the city

Land for public transportation facilities in each areas of the city should be provided to address the current lack of infrastructure, and reduce the need for multiple trips. Public

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transportation hubs can act as nodes, which will improve connectivity between residential areas and other land uses. Facilities created in these hubs should provide for NMT as part of the public transportation system, integrated into the multimodal system. Infrastructure for cycling and walking to public transportation hubs should be provided. Provision of such facilities will also improve connectivity between residential areas and other land uses.

Policy 2: Create multimodal public transportation priority routes and supporting infrastructure

Transportation planning, together with land-use and zoning authorities should plan for and allocate priority routes for a multimodal public transportation system to ease access to public transportation, reduce waiting and travel time, prevent delays and allow for a seamless transfer of each mode at different stages of a journey. New routes would reduce multiple trips per journey by connecting various areas of a city. Routes will have to be planned in such a way that they reduce the central movement towards the city, while creating physical connectivity between residential areas and other land uses. Sheltered waiting stops will have to be provided along a route, and multimodal terminals where all modes of public transportation will be located in one area.

Policy 3: Provide free access to the internet at all public transportation access points, bus stops, taxi ranks, bus terminals and in vehicles

Accessible free Wi-Fi access for public transportation users is needed to facilitate access to the internet, mobile applications, public transportation company websites and social networking platforms. This will reduce the access cost to the customers (passengers), as they would not need to spend a lot of money on data, while paying for the travel fees. Financially enabling users from different demographic backgrounds to access public transportation services electronically will be an added socioeconomic benefit to society.

Policy 4: Reduce the cost of access to data

Reduction of data cost and regulation of mobile data and internet connectivity prices will increase ICT access. It will also reduce ICT-enablement and operation cost to

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operators. Affordable internet and ICT access will reduce the financial burden to users, therefore improving socioeconomic sustainability.

Policy 5: Multimodal integration of all available public transportation modes and NMT

Public transportation operations should be integrated and operate under one system of various modes, including incorporation of NMT, specifically cycling, into the integrated public transportation system. Integration will promote seamlessness of the system, allowing for easy operation and management.

Policy 6: Incentivise public transportation usage

Rewards should be offered to attract people to use the public transportation system. People who would ordinarily use private vehicles because of their convenience, comfort and other factors should be attracted to the public transportation by incentives. Existing public transportation users should also be provided with incentives to continue using public transport. Incentives would reduce the likelihood of travellers wanting to use private vehicles.

Policy 7: Reduce private vehicle ownership

Reducing or restricting usage of private vehicles in certain areas (for example, in the inner city) to create the need for public transportation means that there would be an increased demand for public transportation. Besides the socioeconomic sustainability benefit, the reduction will lead to reduced congestion and reduction in associated negative environmental impacts.

Policy 8: Provide resources for public transportation service providers to facilitate ICT integration into service operations

Public transportation operators will have to be equipped with resources for the adoption of ICT into their daily operations. The relevant informational resources, and ICT education should be provided to all public transportation operators and employees. Skills development will enable anticipation, willingness and acceptance and ability to use the technologies. Equipment: The provision of resources, hardware for installation in vehicles and office areas is also essential. Computers and all

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hardware necessary to grow public transportation service provider's online accessibility, ease communication between service providers and users, convey real-time information, enable effective cashless transactions and offer security surveillance should therefore be provided.

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7.5 Contribution Statement

This study contributes to the existing body of knowledge in public transportation, specifically in developing cities in Southern Africa. Public transportation in many cities faces some operational and developmental challenges, which can be addressed by ICT. The study focuses on improving public transportation systems in Bloemfontein and Gaborone, two cities whose public transportation systems are still conventional, but have the potential to accommodate ICT technologies for improved efficiency.

First, the study explored the relationship between socioeconomic characteristics of travel behaviour and established the spatio-temporal travel patterns as influenced by purposes and activities for which people travel. Through interrogating the behaviours of public transportation and private vehicle users in the cities from a socioeconomic perspective together with the role that ICT currently plays towards travel, the potential for ICT-enabled public transportation to improve efficiency was determined.

Second, the study evaluated people's travel needs, based on perceptions of level of importance that were used as to determine the use of technologies, based on the problem they are perceived to solve. ICT-enabled public transportation was perceived as a solution to efficiency problems by providing information, convenience, reliability, and flexibility, which the present public transportation systems lack.

The existing public transportation research in the study areas is very limited and this presented a geographical gap in the research. Public transportation systems in most well-researched locations use different modes of public transportation to those used in the study areas, so the contexts of application of technologies also vary, based on their already existing and advanced technologies. The areas of focus for the study; Bloemfontein and Gaborone, have less developed transportation systems, transport networks, infrastructure and vehicles. The minimal use of ICT in transportation revealed a need to investigate the types of technologies that would be useful in Bloemfontein and Gaborone, and whether these technologies would be acceptable and for what purposes. The degree of development of public transportation systems and travel data varies vastly, which presented a gap of applicability that the study

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addressed by exploring relevant and appropriate means to ICT-enablement of the public transportation systems.

Further, the study developed models for establishing the relationship between ICT use and various contributing factors as possible indicators for ICT-enabled public transportation. Using models for the present use of ICT for travel, substitution travel by ICT and future use of public transportation, it is apparent that the present state of ICT in transportation will highly influence future acceptance, use and integration of ICT in public transport. These new models can be used towards determining the influence and potential performance of ICT-enabled public transportation.

Lastly, new knowledge applicable to public transportation in the cities of Bloemfontein and Gaborone and how they can be improved using ICT has been contributed, establishing how ICT-enabled public transportation can be leveraged to support and promote sustainable transportation in these cities. The study thus produced guidelines and recommendations based on the primary data gathered from societies who will benefit from ICT-enabled public transportation in the study area. The results of the study will be helpful in expediting the implementation of policy that relates to the study areas.

7.6 Future Research

Insight into the state of travel and travel behaviour in the cities of Bloemfontein and Gaborone has been provided in this study, which presents a foundation for future public transportation research and developments. The rapid advancement of ICT gives rise to new and more effective technologies, which could assist in developing sustainable public transportation in developing countries. However, there is scope for further investigation and research based on issues identified in this study as follows:

a) A study that takes into consideration the travellers' complete route, mapping real-time location throughout the trip.

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b) The potential for extensive research tracking individual movement and trips for extended periods of time to capture fully the movement of people within the city, which would provide scope for in-depth analysis.

7.7 Limitations of the Study

The following limitations to this study were noted:

a) Participation of private vehicle users in the study was limited because of their unavailability and unwillingness to participate in the study. Public transportation users were more accessible at public transportation platforms during their waiting times.

b) Hesitancy or unwillingness to disclose monthly income data was noted among full-time employees in Gaborone.

c) The desperate need of public transportation users for a better system might have led to biased or exaggerated responses to questions highlighting unpleasant or negative aspects of the public transportation system and their willingness to change mode of transport because of ICT.

d) The travel routes and complete journeys of individual travellers could not be tracked during the study, because of limited resources and technology. Future studies should consider an extended period of study to reach more people, and increase data distribution and viability.

e) Secondary data and previously published studies focusing on both study areas were limited, hence there is a limited body of knowledge that is specifically providing context into the areas.

f) The study recognises the primary quantitative and qualitative data on an individualistic basis, whereas theories mostly focus on collective practices and behaviours. Data on future use of technologies and envisions of future travel may be vulnerable to bias, based on the hopes of the participants. Desires for better transportation systems, improved vehicles or the desire for access to ICT could influence biased responses.

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7.8 Conclusion

From this study, it is evident that the existing public transportation systems in the cities of Bloemfontein and Gaborone are in a state that asks for better upgrading and development. The study has established that the urban form of both cities has a significant impact on the transportation systems and their lack of development, based on the geographical travel patterns identified by the study. Travel patterns identified by activity location, placement of areas of residence and those where participants performed various essential and leisure activities show a fixed need for travel. The need for travel is fulfilled through the use of private vehicles, public transportation modes, and to some degree, NMT modes, which the study has established as being unsustainable. The existing frequent use of private vehicles of low occupancy, especially in Gaborone, and their contribution to congestion, countless problems with minimal resolutions experienced in the public transportation system and the lacking use of NMT do not benefit the cities' mobility.

Dissatisfaction with public transportation caused by inefficiencies of the system can be potentially addressed by employing a number of ICT to be used at different stages of trip-making by travellers. The interest in ICT for personal communication and entertainment can be leveraged to initiate incorporation of technologies in the existing public transportation system. ICTs presents opportunities for operators and regulators to improve their service efficiency as the results indicated that ICT-based services, such as trip planning, inquiries, smartcard payments platforms, trip and service evaluation were considered interesting by users. Provision of such services also provides opportunities for improved service delivery and modal shift. However, prospects for modal shift and ICT use until achievement of a fully ICT-enabled public transportation system is also strongly dependent on improvements to the public transport infrastructure, better route planning, and all other proposed improvements. Users' perceptions towards substituting travel for ICT-based alternatives and the willingness to accept and adopt technologies requires not only a behavioural change, but first, the willingness of employers and universities to allow remote work or study. The study concludes that there are opportunities for ICT-enablement and improvement of both cities' public transportation systems.

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APPENDICES

The appendices contain data that support the study.

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Appendix 1: Questionnaires

Questionnaire 1 - Bloemfontein

ICT FOR SUSTAINABLE PUBLIC TRANSPORTATION SYSTEMS IN SOUTHERN AFRICAN CITIES

I am pleased to invite you to participate in my data-gathering survey for my Doctoral Studies. I am carrying out research on Information Communication Technologies for sustainable public transportation systems in Southern African cities. The study aims at finding out the role played by ICT in public transportation and how they can lead to a more environmental, social and economic sustainable transportation system.

The information you provide for the study will only be used for purposes of this research. Your personal information (Names and contact details) will not be used in any publication, providing them is optional and only for purposes of enquires when permitted by you.

I HAVE READ AND UNDERSTOOD THE PURPOSE OF THIS QUESTIONNAIRE

Signature: _____ Date: _____

QUESTIONNAIRE ADMINISTERED BY:

Name:_____Signature:_____

I WOULD LIKE YOU TO FOLLOW UP OR ENQUIRE WITH ME IF YOU NEED FURTHER INFORMATION FOR THE STUDY

YES NO

Name: _____ Contact number / Email: _____

~~~~~~~~~~~~~~Thank you for participating on this study~~~~~~~~~~~~~~~~~~~~

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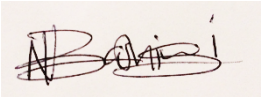

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Section 1: Demographic Information: Use (x or ✓) once where appropriate

Age		Gender		Race		Occupation	
18 - 25		Male		African		Student	
25 - 35		Female		White		Part-Time employee	
36 - 45				Coloured		Self-Employed	
46 - 55				Asian		Full-time employee	
60+						Unemployed	
How much is you monthly income? _____							
Number of Vehicles in Your Household: _____							

Section 2: Land-use, travel patterns and traffic

QUESTION	SHORT ANSWER
Which Suburb in Bloemfontein do you live in?	
General land-use of area you live in? Choose one of the following:(Residential/ Industrial/ Agricultural/ Commercial area, mixed land-use)	
Which Suburb do you spend most of your day? (Average work hour/ day)	
General land-use of area you spend most of your day? Choose one of the following:(Residential/ Industrial/ Agricultural/ Commercial area, mixed land-use)	
Is there direct public transportation service from your home to place of work/ school?	
If answer to above question is YES, which mode of public transportation? (Bus/Minibus Taxi/Sedan Taxi/Cab)	

In which area of the city are the following located?

	Location		Location
Home		Park	
Shopping		Clubs	
Education centre (school /college/ university)		Public services (municipality, post office)	
Religious centre		Stadium	
Banking		Others: (specify)	
Sporting activities			

Illustrate your typical trips per day and mode of transportation.

Weekdays				Weekends			
Trip	From (area)	To (area)	Using (transport)	Trip	From (area)	To (area)	Using (transport)
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			

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For what purposes are most of your trips using your preferred mode of transport?

Use (x or ✓) once or more where appropriate							
	Bus	Taxi (minibus)	Cab / Sedan taxi	Private car	Motorcycle	Bicycle	Walking
Shopping							
Work							
School							
Personal							
Leisure							
Sports							
Sightseeing							
Family obligations							
Other: (specify) _____							

Choose the frequency at which you use the following modes of transportation.

Use (x or ✓) once or more under each mode								
	Private car	Car Sharing	Bus	Taxi	Motorcycle	Walking	Bicycle	Cab
Daily								
Once a week								
2 - 3 Days a week								
Weekdays only								
Once a month								

Please indicate time and distance taken during your trips where appropriate and specify mode of transport.

	Distance (Kilometres)	**Average time**	**Mode of transport**
From home to bus stop			
Bus stop to work/school			
From work/school going home			
Home to work/school			

What are your typical travel times? (Use (x or ✓) once or more where appropriate)	**Traffic conditions during these times (1=No congestion at all, 2= slightly congested, 3= Moderate congestion 4=Very Congested 5= Extremely congested) (1 or more options based on you travel times)**	**Average time spent travelling during these times (Specify time in minutes or hours)**

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05:00 - 07:00			
07:00 - 09:00			
09:00 - 11:00			
11:00 - 13:00			
13:00 - 15:00			
15:00 -17:00			
17:00 - 19:00			
19:00 - 21:00			
21:00 - 23:00			
23:00 - 05:00			

How often are you delayed in traffic?		**How much time do the delays add up to your travelling time?**	
Never		5 minutes or less	
Rarely		5 - 10 minutes	
Daily		10 - 15 minutes	
Weekly		15 - 20 minutes	
Monthly		20 - 25 minutes	
		25 - 30 minutes	
		Other (specify)	

Rate the following factors as relevant to your mode choice when using the given modes of transportation using the following:
1=Not important at all, 2= slightly important, 3= of average importance, 4= Very Important, 5= absolutely essential

	Bus	**Taxi**	**Private Vehicles**	**Walking**
Affordability				
Convenience				
Safety				
Flexibility				
Accessibility				
Travel time				
Traveller Information Services				
Comfort				
On-board internet / Wi-Fi availability				
Fuel efficiency				
Privacy				
Infrastructure (Bus stops, roads and stations)				
Freedom for personal entertainment choice				
Other: (Specify and rate) _____ _____				

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How much do you spend on transportation monthly?

Private car / motorbike	Bus	Taxi
R_____	R_____	R_____

Section 3: Public transportation

Which of the following problems have you experienced while using public transportation?

(Use (x or✓) once or more where appropriate)

	Bus	Taxi	Cab		Bus	Cab	Taxi
Lost luggage				Vehicle breakdown			
Did not get my change				Could not find stop			
Long waiting time at taxi rank				Bus stop far from my destination			
Loud music in vehicle				Harassment			
Overcrowded							
Delays				Others: (specify)			

How was the problem above resolved?

_____

_____

_____

What are your general perceptions of public transportation system in the city?

_____

_____

_____

Section 4: Private Vehicle Users Only

What are the main reasons for using your vehicle?

_____

_____

Do you usually drive around for pleasure or sightseeing purposes?

What knowledge do you have on the impact of increasing number of cars on the environment?

Would you stop using your car and use public transportation if it _____?

Use (x or ✓) once or more where appropriate	YES	NO
Was cheaper		
Was safer		
Could pick you off at your home/ place of work/ mall etc.?		
Could drop you off exactly to your destination?		
Had free Wi-Fi		
Had games to keep you busy during travel		
Had Traveller Information Systems		

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Section 5: Information Communication Technologies

Do your public transportation service providers have web presence? Use (x or ✓) once where appropriate

☐Yes ☐No

If yes, specify websites or social networks your public transportation service provider uses?

_____

How do you communicate with your public transportation service provider?

_____

	YES	NO
Do you have knowledge of ICT?		
Do you have access to internet?		
Do you use your cell phone or other devices for public transportation-related reasons?		

Which of the following ICT components do you use for travel purposes? Use (x or ✓) once or more where appropriate and indicate what you use each ICT for.

ICT		PURPOSE
Devices		
Smart phone		
Tablet		
Computer		
Phone (non- smart phone)		
Applications		
Call / SMS		
Social Networks		
Web-browsing		
Systems		
Internet		
Cloud computing / storage		
Payments / transaction systems		

How much time to you spend using your phone, computer, tablet to access the internet daily?

_____

How much time daily do you spend on the internet for transportation-related purposes only?

_____

How much do you spend on data per month?

_____

How much data do you use per month?

_____

How much of the following do you use on transportation-related purposes per month?
Data (Megabytes) Airtime (Rands)

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How do you pay for your travel? Use (x or ✓) once or more where appropriate.

☐Cash before/ during/ after trip ☐Smart Card ☐Online Ticket

☐Mobile application ☐Ticket at counter before travel

☐ Other (specify): _____

Would ICT be useful at different stages of a trip? (Yes/ No) For what purposes would you use ICT?

(Rate the importance of the purposes using a five-point scale as explained below, you can use a number multiple times)
1: Not important
2: Slightly important
3: Fairly important
4: Important
5: Very important

Before Trip		Trip planning	
Yes		Inquiries	
No		Route mapping	
		Information about destination	
		Travel Mode comparisons	
		Traffic information	
During Trip		Trip planning	
Yes		Travel Monitoring	
No		Entertainment	
		Real-time traffic updates	
		Work	
		Trip duration or travel monitoring	
After Trip		Payment	
Yes		Evaluating trip	
No		Evaluating services offered	
		Queries	
		Evaluating satisfaction with trip	

Does ICT influence the way you travel? ☐Yes☐ No
If yes, how does ICT influence the way you travel?

_____
_____
_____
_____

Do you think ICT is important for transportation sustainability? Why?

_____
_____
_____

~~~~~~~~~~~~~~~~~~~~~~~~ THE END ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

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Questionnaire 1: Gaborone

ICT FOR SUSTAINABLE PUBLIC TRANSPORTATION SYSTEMS IN SOUTHERN AFRICAN CITIES

I am pleased to invite you to participate in my data-gathering survey for my Doctoral Studies. I am carrying out research on Information Communication Technologies for sustainable public transportation systems in Southern African cities. The study aims at finding out the role played by ICT in public transportation and how they can lead to a more environmental, social and economic sustainable transportation system.

The information you provide for the study will only be used for purposes of this research. Your personal information (Names and contact details) will not be used in any publication, providing them is optional and only for purposes of enquires when permitted by you.

I HAVE READ AND UNDERSTOOD THE PURPOSE OF THIS QUESTIONNAIRE

Signature:_____Date:_____

QUESTIONNAIRE ADMINISTERED BY:

Name:_____Signature:_____

I WOULD LIKE YOU TO FOLLOW UP OR ENQUIRE WITH ME IF YOU NEED FURTHER INFORMATION FOR THE STUDY

YES NO

Name:_____Contact number/Email:_____

~~~~~~~~~~~~~~Thank you for participating on this study~~~~~~~~~~~~~~~~~~~~

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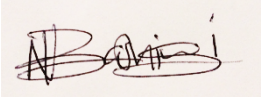

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Section 1: Demographic Information: Use (x or ✓) once where appropriate

Age		Gender		Race		Occupation	
18 - 25		Male		African		Student	
25 - 35		Female		White		Part-Time employee	
36 - 45				Coloured		Self-Employed	
46 - 55				Asian		Full-time employee	
60+						Unemployed	
How much is you monthly income? _____							
Number of Vehicles in Your Household: _____							

Section 2: Land-use, travel patterns and traffic

QUESTION	SHORT ANSWER
Which Suburb in Gaborone do you live in?	
General land-use of area you live in? Choose one of the following:(Residential/ Industrial/ Agricultural/ Commercial area, mixed land-use)	
Which Suburb do you spend most of your day? (Average work hour/ day)	
General land-use of area you spend most of your day? Choose one of the following:(Residential/ Industrial/ Agricultural/ Commercial area, mixed land-use)	
Is there direct public transportation service from your home to place of work/school?	
If answer to above question is YES, which mode of public transportation? (Bus/Minibus Taxi/Sedan Taxi/Cab)	

In which area of the city are the following located?

	Location		Location
Home		Park	
Shopping		Clubs	
Education centre (school /college/ university)		Public services (municipality, post office)	
Religious centre		Stadium	
Banking		Others: (specify)	
Sporting activities			

Illustrate your typical trips per day and mode of transportation.

Weekdays				Weekends			
Trip	From (area)	To (area)	Using (transport)	Trip	From (area)	To (area)	Using (transport)
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			

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For what purposes are most of your trips using your preferred mode of transport?

Use (x or ✓) once or more where appropriate							
	Bus	Taxi (minibus)	Cab / Sedan taxi	Private car	Motorcycle	Bicycle	Walking
Shopping							
Work							
School							
Personal							
Leisure							
Sports							
Sightseeing							
Family obligations							
Other: (specify) _____							

Choose the frequency at which you use the following modes of transportation.

Use (x or ✓) once or more under each mode								
	Private car	Car Sharing	Bus	Taxi	Motorcycle	Walking	Bicycle	Cab
Daily								
Once a week								
2 - 3 Days a week								
Weekdays only								
Once a month								

Please indicate time and distance taken during your trips where appropriate and specify mode of transport.

	Distance (Kilometres)	**Average time**	**Mode of transport**
From home to bus stop			
Bus stop to work/school			
From work/school going home			
Home to work/school			

What are your typical travel times?	**Traffic conditions during these times (1=No congestion at all, 2= slightly congested, 3= Moderate congestion 4=Very Congested 5= Extremely**	**Average time spent travelling during these times (Specify time in minutes or hours)**

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(Use (x or ✓) once or more where appropriate)		congested) (1 or more options based on you travel times)	
05:00 - 07:00			
07:00 - 09:00			
09:00 - 11:00			
11:00 - 13:00			
13:00 - 15:00			
15:00 - 17:00			
17:00 - 19:00			
19:00 - 21:00			
21:00 - 23:00			
23:00 - 05:00			

How often are you delayed in traffic?		**How much time do the delays add up to your travelling time?**	
Never		5 minutes or less	
Rarely		5 - 10 minutes	
Daily		10 - 15 minutes	
Weekly		15 - 20 minutes	
Monthly		20 - 25 minutes	
		25 - 30 minutes	
		Other (specify)	

Rate the following factors as relevant to your mode choice when using the given modes of transportation using the following:
1=Not important at all, 2= slightly important, 3= of average importance, 4= Very Important, 5= absolutely essential

	Bus	**Taxi**	**Private Vehicles**	**Walking**
Affordability				
Convenience				
Safety				
Flexibility				
Accessibility				
Travel time				
Traveller Information Services				
Comfort				
On-board internet / Wi-Fi availability				
Fuel efficiency				
Privacy				
Infrastructure (Bus stops, roads and stations)				
Freedom for personal entertainment choice				
Other: (Specify and rate) _____				

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How much do you spend on transportation monthly?

Private car / motorbike	Bus	Taxi
R_____	R_____	R_____

Section 3: Public transportation

Which of the following problems have you experienced while using public transportation?

(Use (x or✓) once or more where appropriate)

	Bus	Taxi	Cab		Bus	Cab	Taxi
Lost luggage				Vehicle breakdown			
Did not get my change				Could not find stop			
Long waiting time at taxi rank				Bus stop far from my destination			
Loud music in vehicle				Harassment			
Overcrowded							
Delays				Others: (specify)			

How was the problem above resolved?

_____

_____

_____

What are your general perceptions of public transportation system in the city?

Section 4: Private Vehicle Users Only

What are the main reasons for using your vehicle?

_____

_____

Do you usually drive around for pleasure or sightseeing purposes?

What knowledge do you have on the impact of increasing number of cars on the environment?

Would you stop using your car and use public transportation if it _____?

Use (x or ✓) once or more where appropriate	YES	NO
Was cheaper		
Was safer		
Could pick you off at your home/ place of work/ mall etc.?		
Could drop you off exactly to your destination?		
Had free Wi-Fi		
Had games to keep you busy during travel		
Had Traveller Information Systems		

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Section 5: Information Communication Technologies

Do your public transportation service providers have web presence? Use (x or ✓) once where appropriate

☐Yes ☐No

If yes, specify websites or social networks your public transportation service provider uses?

_____

How do you communicate with your public transportation service provider?

_____

	YES	NO
Do you have knowledge of ICT?		
Do you have access to internet?		
Do you use your cell phone or other devices for public transportation-related reasons?		

Which of the following ICT components do you use for travel purposes? Use (x or ✓) once or more where appropriate and indicate what you use each ICT for.

ICT		PURPOSE
Devices		
Smart phone		
Tablet		
Computer		
Phone (non- smart phone)		
Applications		
Call / SMS		
Social Networks		
Web-browsing		
Systems		
Internet		
Cloud computing / storage		
Payments / transaction systems		

How much time to you spend using your phone, computer, tablet to access the internet daily?

_____

How much time daily do you spend on the internet for transportation-related purposes only?

_____

How much do you spend on data per month?

_____

How much data do you use per month?

_____

How much of the following do you use on transportation-related purposes per month?

Data (Megabytes) Airtime (Rands)

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How do you pay for your travel? Use (x or ✓) once or more where appropriate.

☐Cash before/ during/ after trip ☐Smart Card ☐Online Ticket

☐Mobile application ☐Ticket at counter before travel

☐ Other (specify): _____

Would ICT be useful at different stages of a trip? (Yes/ No) For what purposes would you use ICT?

(Rate the importance of the purposes using a five-point scale as explained below, you can use a number multiple times)
1: Not important
2: Slightly important
3: Fairly important
4: Important
5: Very important

Before Trip		Trip planning	
Yes		Inquiries	
No		Route mapping	
		Information about destination	
		Travel Mode comparisons	
		Traffic information	
During Trip		Trip planning	
Yes		Travel Monitoring	
No		Entertainment	
		Real-time traffic updates	
		Work	
		Trip duration or travel monitoring	
After Trip		Payment	
Yes		Evaluating trip	
No		Evaluating services offered	
		Queries	
		Evaluating satisfaction with trip	

Does ICT influence the way you travel? ☐Yes☐ No

If yes, how does ICT influence the way you travel?

_____

_____

_____

_____

Do you think ICT is important for transportation sustainability? Why?

_____

_____

~~~~~~~~~~~~~~~~~~~~~~~~ THE END ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

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Origin – Destination Survey: Bloemfontein

ICT FOR SUSTAINABLE PUBLIC TRANSPORTATION SYSTEMS IN SOUTHERN AFRICAN CITIES

Dear public transportation user, I am pleased to invite you to participate in my data-gathering survey for my Doctoral Studies. I am carrying out research on Information Communication Technologies for sustainable public transportation systems in Southern African cities. The study aims at mapping travel patterns and understanding travel behaviour of public transportation users in the city of Bloemfontein and the role played by ICT in public transportation users travel behaviour and patterns.

The information you provide for the study will only be used for purposes of this research. Your personal information (Names and contact details) will not be used in any publication, providing them is optional and only for purposes of enquires when permitted by you.

I HAVE READ AND UNDERSTOOD THE PURPOSE OF THIS QUESTIONNAIRE

Signature:_____ Date: _____

QUESTIONNAIRE ADMINISTERED BY:

Name:_____Signature:_____

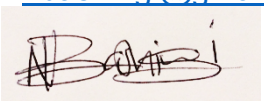
I WOULD LIKE YOU TO FOLLOW UP OR ENQUIRE WITH ME IF YOU NEED FURTHER INFORMATION FOR THE STUDY

YES NO

Name:_____Contact number/Email:_____

~~~~~~~~~~~~~~~Thank you for participating on this study~~~~~~~~~~~~~~~~~~~~

For further information, please contact
Ndakhona Bashingi
Doctor of engineering candidate
Department of civil engineering, Central University of Technology,
Free State, South Africa
Contact: +27 78 292 3925
Email: nbashingi@gmail.com



Or
Prof M Mostafa
Research supervisor on 051 507 3454 / email: mmostafa@cut.ac.za

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Section 1: Demographic Information: (Tick where appropriate)

Gender	Female				Male							
Age	18 - 25		26 - 35		36- 45		46 - 55		56 - 65		65 +	
Occupation	Student				Self-employed		Pensioner					
	Part-time employee				Full-time employee		Unemployed					

REGULAR TRIPS

Indicate your travel patterns per typical travel day (Day of interview or previous day). If you do not travel often, pick a day you travelled within Bloemfontein over the last 30 days.

Trip 1	Origin			Destination		
Transport mode : _____	Suburb			Suburb		
	Street			Street		
Trip purpose: _____	Departure time			Arrival time		
Trip cost R_____	GPS Coordinates			GPS Coordinates		

Trip 2	Origin			Destination		
Transport mode : _____	Suburb			Suburb		
	Street			Street		
Trip purpose: _____	Departure time			Arrival time		
Trip cost R_____	GPS Coordinates			GPS Coordinates		

Trip 3	Origin			Destination		
Transport mode : _____	Suburb			Suburb		
	Street			Street		
Trip purpose: _____	Departure time			Arrival time		
Trip cost R_____	GPS Coordinates			GPS Coordinates		

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Trip 4	Origin			Destination		
Transport mode : _____	Suburb			Suburb		
	Street			Street		
Trip purpose: _____	Departure time			Arrival time		
Trip cost R_____	GPS Coordinates			GPS Coordinates		

Trip frequency							
		Weekdays (Mon – Friday)				Every day (7 Days a week)	
Every Saturday		Every Sunday		2 - 3 times a week		First time ever taking the trip	

Trip purpose	Work		Shopping		Educational		Public services				Recreation	
	Sports		Banking		Family		Leisure		Religious		Home	

Activity during travel:	Reading		Emails		Facebook/ Twitter		WhatsApp	
	Phone call		Playing games		Any other activity:_____			

Do you use any technological devices during trip?	Yes		No	
Technological device/application or system used:				
Was technology used for any travel-related reasons?	Yes		No	

If you had any technology-based alternative, would you still have undertaken this trip?	Yes		No	

How long have you been using the public transportation system?	- 3 yrs.		3 - 5 yrs.		5 - 10 yrs.		15 + yrs.	

How has the public transportation system changed over the years?	Improved a lot		Slight improvement	
	No visible change		Degraded / worsened	

If the system remains in the state it is in today, will you still be using it in the next 10yrs?	Yes		No	

~~~~~~~~~~~~~~~~~~~~~~~~~Thank you~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

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Origin – Destination Survey: Gaborone

ICT FOR SUSTAINABLE PUBLIC TRANSPORTATION SYSTEMS IN SOUTHERN AFRICAN CITIES

Dear public transportation user, I am pleased to invite you to participate in my data-gathering survey for my Doctoral Studies. I am carrying out research on Information Communication Technologies for sustainable public transportation systems in Southern African cities. The study aims at mapping travel patterns and understanding travel behaviour of public transportation users in the City of Gaborone and the role played by ICT in public transportation users travel behaviour and patterns.

The information you provide for the study will only be used for purposes of this research. Your personal information (Names and contact details) will not be used in any publication, providing them is optional and only for purposes of enquires when permitted by you.

I HAVE READ AND UNDERSTOOD THE PURPOSE OF THIS QUESTIONNAIRE

Signature:_____Date:_____

QUESTIONNAIRE ADMINISTERED BY:

Name:_____Signature:_____

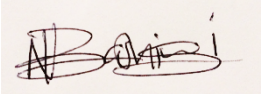
I WOULD LIKE YOU TO FOLLOW UP OR ENQUIRE WITH ME IF YOU NEED FURTHER INFORMATION FOR THE STUDY

YES NO

Name:_____Contact number/Email: _____

~~~~~~~~~~~~~~~Thank you for participating on this study~~~~~~~~~~~~~~~~~~~~

For further information, please contact
Ndakhona Bashingi
Doctor of engineering candidate
Department of civil engineering, Central University of Technology,
Free State, South Africa
Contact: +27 78 292 3925
Email: nbashingi@gmail.com



Or
Prof M Mostafa
Research supervisor on 051 507 3454 / email: mmostafa@cut.ac.za

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~~~~~~~~~~~~~~~

Central University of Technology, Free State

Section 1: Demographic Information: (Tick where appropriate)

Gender	Female				Male						
Age	18 - 25		26 - 35		36- 45		46 - 55		56 - 65		65 +
Occupation	Student				Self-employed		Pensioner				
	Part-time employee				Full-time employee		Unemployed				

REGULAR TRIPS

Indicate your travel patterns per typical travel day (Day of interview or previous day). If you do not travel often, pick a day you travelled within Gaborone over the last 30 days.

Trip 1	Origin			Destination		
Transport mode : _____	Suburb			Suburb		
	Street			Street		
Trip purpose: _____	Departure time			Arrival time		
Trip cost P_____	GPS Coordinates			GPS Coordinates		

Trip 2	Origin			Destination		
Transport mode : _____	Suburb			Suburb		
	Street			Street		
Trip purpose: _____	Departure time			Arrival time		
Trip cost P_____	GPS Coordinates			GPS Coordinates		

Trip 3	Origin			Destination		
Transport mode : _____	Suburb			Suburb		
	Street			Street		
Trip purpose: _____	Departure time			Arrival time		
Trip cost P_____	GPS Coordinates			GPS Coordinates		

Trip 4	Origin			Destination		
Transport mode : _____	Suburb			Suburb		
	Street			Street		
Trip purpose: _____	Departure time			Arrival time		
Trip cost P_____	GPS Coordinates			GPS Coordinates		

Trip frequency				Weekdays (Mon - Friday)		Every day (7 Days a week)	
Every Saturday		Every Sunday		2 - 3 times a week		First time ever taking the trip	

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Trip purpose	Work		Shopping		Educational		Public services				Recreation	
	Sports		Banking		Family		Leisure		Religious		Home	

Activity during travel:	Reading		Emails		Facebook/ Twitter		WhatsApp	
	Phone call		Playing games		Any other activity:_____			

Do you use any technological devices during trip?	Yes		No	
Technological device/application or system used:				
Was technology used for any travel-related reasons?	Yes		No	

If you had any technology-based alternative, would you still have undertaken this trip?	Yes		No	

How long have you been using the public transportation system?	- 3 yrs.		3 - 5 yrs.		5 - 10yrs.		15 + yrs.	

How has the public transportation system changed over the years?	Improved a lot		Slight improvement	
	No visible change		Degraded / worsened	

If the system remains in the state it is in today, will you still be using it in the next 10yrs?	Yes		No	

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~Thank you~~~~~~~~~~~~~~~~~~~~~~~~~~~~

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~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Appendix 2: Areas of Residence and Areas where participants spent most of the workday

Appendix Table 1: Areas of residence and areas where participants spent the day in Gaborone

Area of residence N = 415		Area where participants spend workday N = 415	
Area	Percentage (%)	Area	Percentage (%)
Albert Lithuli	0,2	Bainsvlei	0,5
Bainsvlei	0,2	Batho	1,0
Batho	2,4	Bayswater	0,5
Bayswater	0,2	Bloemanda	1,7
Bayswater	0,2	Brandfort	0,2
Bergman	1,4	Brandwag	5,1
Bloemanda	5,1	Buitesig	0,2
Bloemside	0,2	Caleb Motshabi	0,2
Bloemside 2	0,2	CBD	26,7
Bochabela	4,6	Dan Pienaar	0,2
Bophelong	0,5	Fichardt Park	0,2
Botshabelo	4,1	Freedom Square	0,7
Brandford	1,0	Grasslands	0,2
Brandwag	3,6	Hamilton	0,2
Buitesig	0,2	Heuwelsig	0,5
Caleb Motshabi	2,2	Hillside View	1,2
Cape Stands	0,5	Hilton	0,2
CBD	2,4	Hospitaal Park	0,2
Chris Hani	0,7	J.B. Mafora	0,2
Fauna	0,7	Langenhoven Park	0,7
Fichardt Park	0,7	Legae	0,2
Freedom Square	1,9	Navalsig	0,5
Generaal De Wet	0,2	Noordhoek	0,2
Grassland	1,4	Old East End	0,2
Heidedal	2,4	Oranjesig	0,5
Heuwelsig	0,5	Park West	2,2
Hillside View	1,4	Pellissier	0,5
Hilton	0,5	Peter Swarts	0,5
Hospitaal Park	0,2	Phahameng	0,5
Ipopeng	0,5	Phase 2	0,5
J.B Mafora	1,4	Phase 4	0,5
Kagisho square	0,2	Phase 6	0,5
Kgotsong	0,2	Phelindaba	0,2
Khayelitsha	0,7	Rayton	0,2
Langenhoven Park	1,0	Rocklands	2,7
Lourier Park	0,5	Sports	0,2
Lusaka Square	0,5	Thaba Nchu	0,5
		Turflaagte	0,5
Mandela View	0,2	Universitas	2,9

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Mangaung	0,2	Vista Park	0,5
Namibia	0,2	Westdene	9,6
Navalsig	1,4	Wilgehof	0,7
Noordhoek	0,2	Willows	33,7
Oranjesig	1,9	Woodlands	0,5
Park West	0,2		
Peter Swarts	0,7		
Phahameng	2,2		
Phase 10	0,2		
Phase 2	2,2		
Phase 3	1,0		
Phase 4	1,2		
Phase 5	0,2		
Phase 6	2,7		
Phase 7	0,2		
Phase 9	1,2		
Phelindaba	2,2		
Pine Haven	0,2		
Rocklands	6,0		
Sejake Square	0,7		
Shannon	0,7		
Sports	4,1		
Tempe	0,2		
Thaba Nchu	3,4		
Turflaagte	1,9		
Uitsig	0,2		
Universitas	1,7		
Vista Park	1,4		
Westdene	2,9		
Wilgehof	2.0		
Willows	10,6		
Total	100	Total	100

Appendix Table 2: Areas of residence and areas where residents spend the day in Gaborone

Area of residence (N = 388)		Area where participants spend workday (N = 388)	
Area	Percent (%)	Area	Percent (%)
Block 10	1,5	African Mall	0,3
Block 3	5,4	Block 10	0,3
Block 5	1,8	Block 3	1,3
Block 6	2,6	Block 3 Industrial	0,5
Block 7	2,6	Block 5	0,3
Block 8	6,2	Block 6	1,8
Block 9	3,9	Block 7	1,5
Bokaa	0,5	Block 8	2,3
Bontleng	1,8	Block 9	0,3

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Broadhurst	6,2	Boatle	0,3
Extension 10	0,3	Bontleng	0,5
Extension 11	0,5	Broadhurst	9,3
Extension 12	0,3	Broadhurst Extension 26	0,3
Extension 14	1,5	Broadhurst Industrial	0,3
Extension 2	0,5	CBD	4,9
Extension 20	0,3	City Centre	1,5
Extension 27	0,3	Commerce Park	3,9
Extension 4	0,5	Extension 2	0,3
Extension 9	0,3	Extension 10	1,3
Gabane	2,3	Extension 11	0,3
Gaborone North	0,8	Extension 12	1,3
Gakuto	0,5	Extension 14	0,8
Ginger	0,8	Extension 2	1,0
Kgale View	0,3	Extension 9	0,3
Kgale view	0,3	Fairgrounds	10,8
Kgale View	1,5	Finance Park	0,5
Kopong	0,8	Gaborone North	0,3
Kumakwane	0,5	Gaborone West Industrial	1,6
Ledumadumane	0,8	Game City	0,3
Ledumang	1,3	Government Enclave	5,7
Maruapula	1,3	Kgale View	6,9
Metsimotlhabe	1,5	Ledumang	0,5
Mmopane	1,8	Main Mall	7,0
Mmopane Block 1	0,5	Maruapula	1,0
Mochudi	0,3	Mmopane Block 1	0,3
Modipane	1,0	Mogoditshane	3,4
Mogoditshane	6,7	Molepolole	0,3
Mogoditshane Block 10	0,3	New Canada	0,3
Mogoditshane Block 9	0,5	New Stands	0,3
Mopane Block 1	0,3	Old Lobatse Industrial	0,3
New Canada	1,0	Old Naledi	0,3
New Stands	0,3	Phakalane	1,8
Old Naledi	1,0	Phase 1	1,5
Partial	1,3	Phase 2	2,3
Phakalane	6,2	Phase 4	2,1
Phase 1	2,6	Pilane	0,3
Phase 2	3,6	Riverwalk	0,5
Phase 4	3,6	Station	0,3
Pilane	0,3	Tlokweng	2,8
Ramotswa	0,3	UB	6,4
South Ring	0,3	Village	8,0
Taung	0,3		
Tawana	0,8		
Tlokweng	12,6		
Tsholofelo	0,5		

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UB Village White City	0,3 3,4 1,0		
Total	100	Total	100

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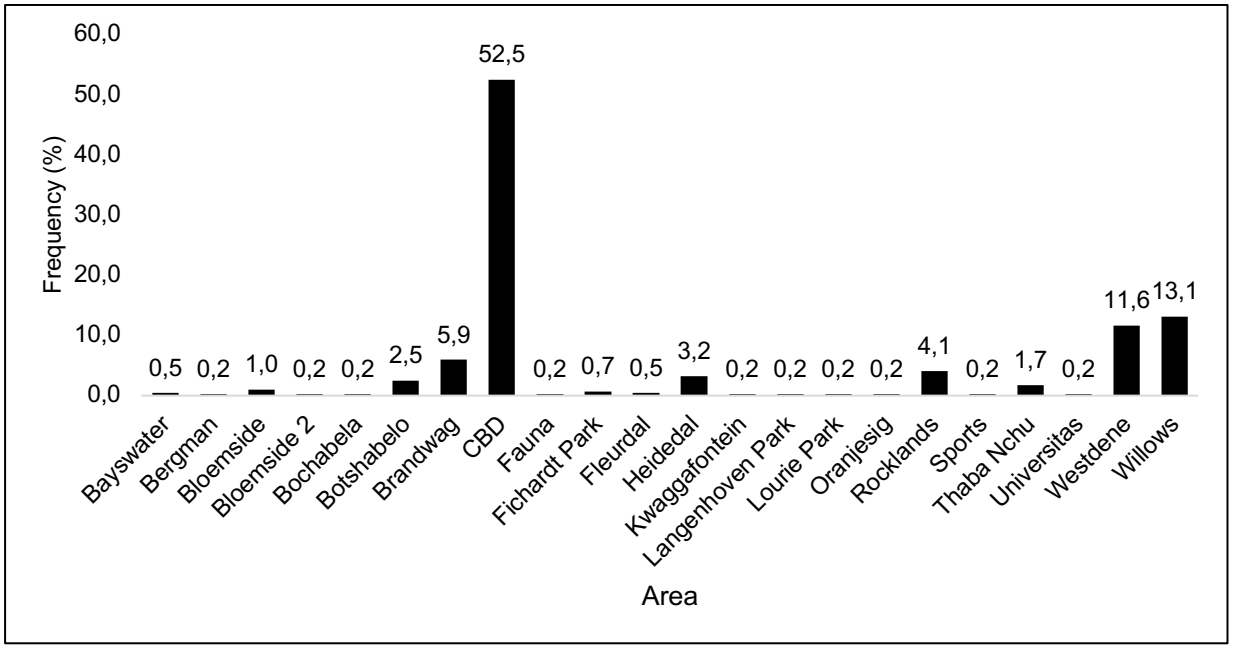
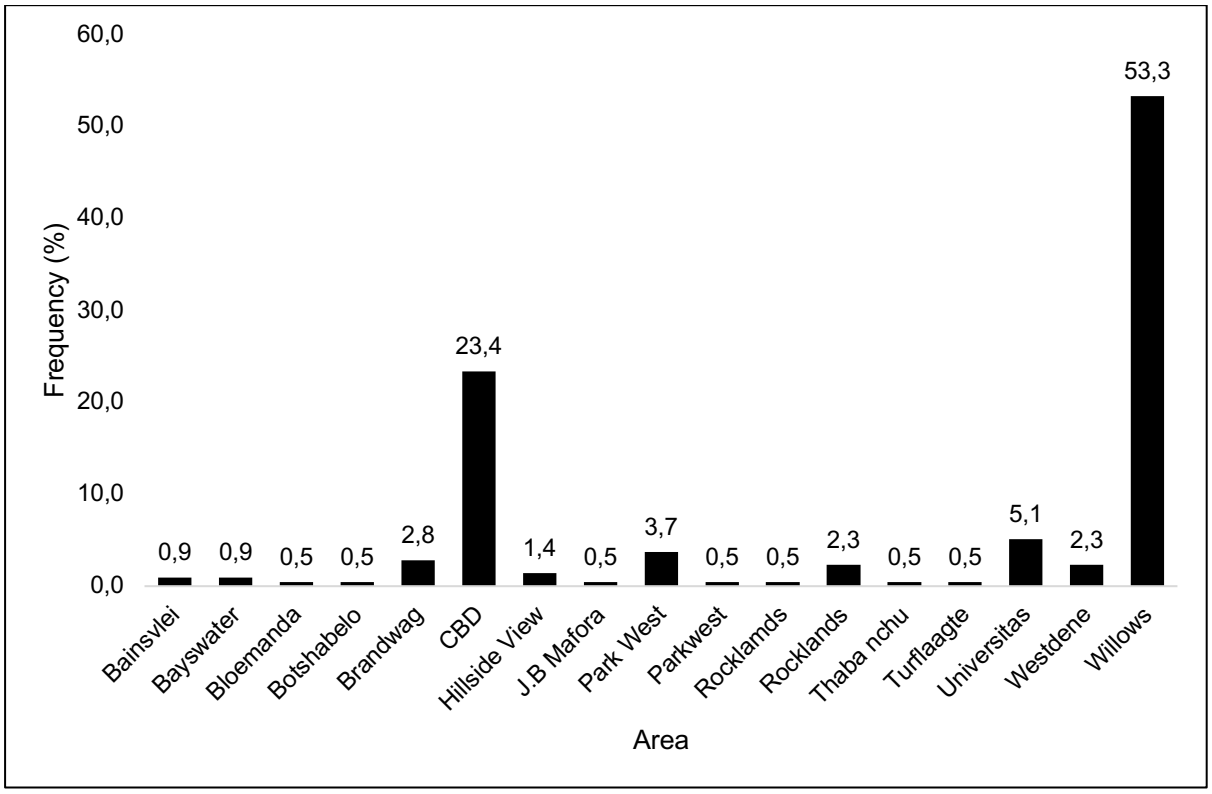
Appendix 3: Activity Location in Bloemfontein – Frequency Charts



Appendix Figure 1: Percentage of participants who carried out shopping activities in each area in Bloemfontein



Appendix Figure 2: Percentage of participants whose education centres where located in each are in Bloemfontein

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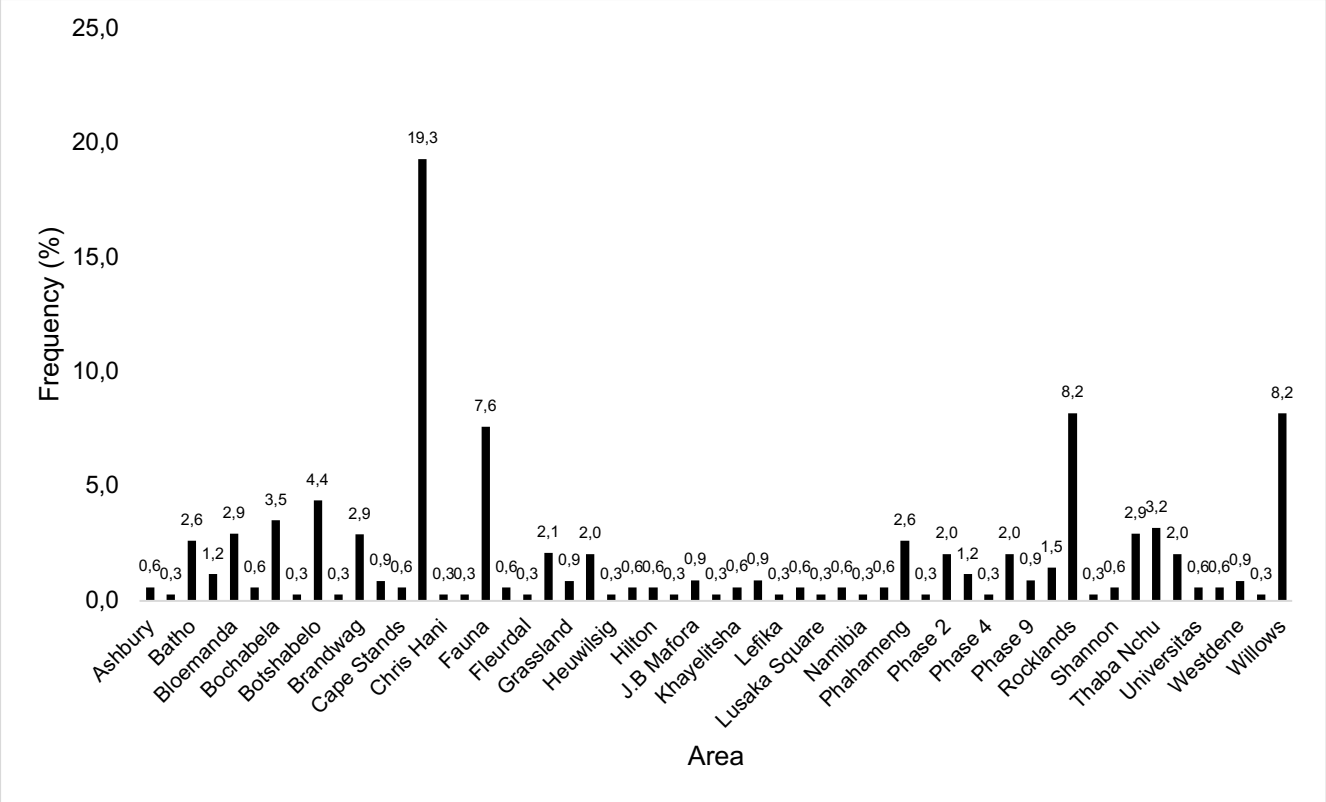
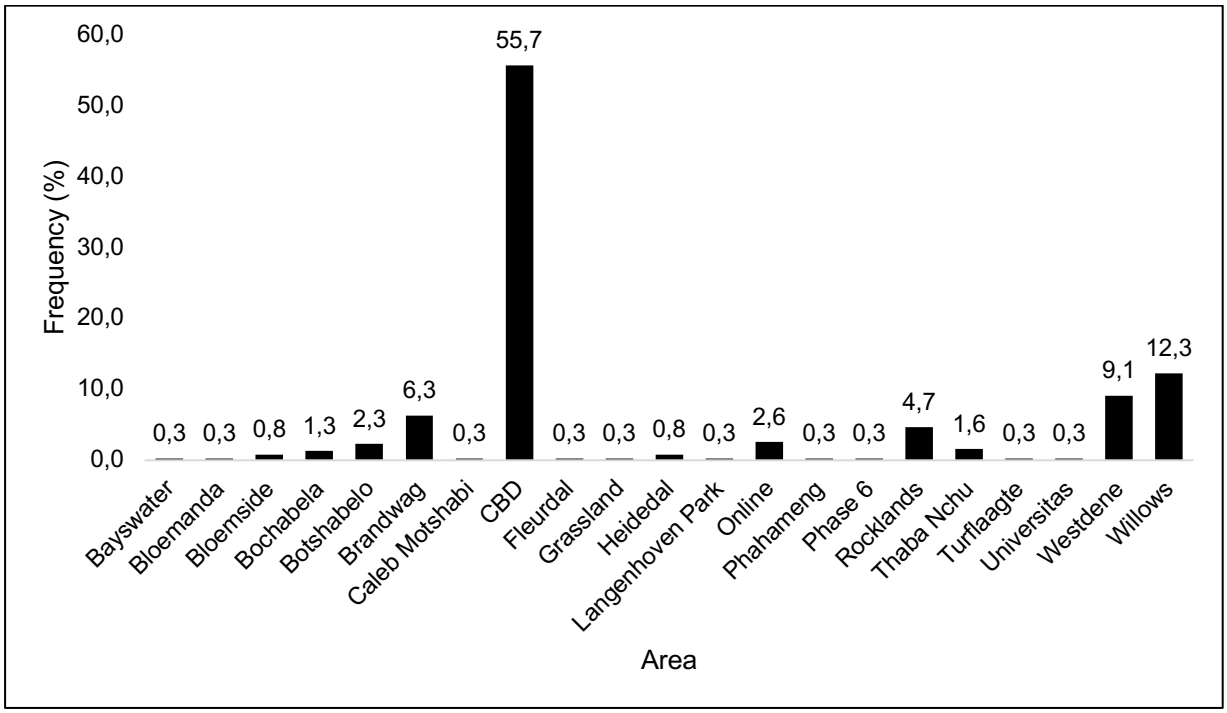


Appendix Figure 3: Percentages of participants whose religious centres were located in each area in Bloemfontein



Appendix Figure 4: Percentage of participants whose banking institutions were located in each area in Bloemfontein

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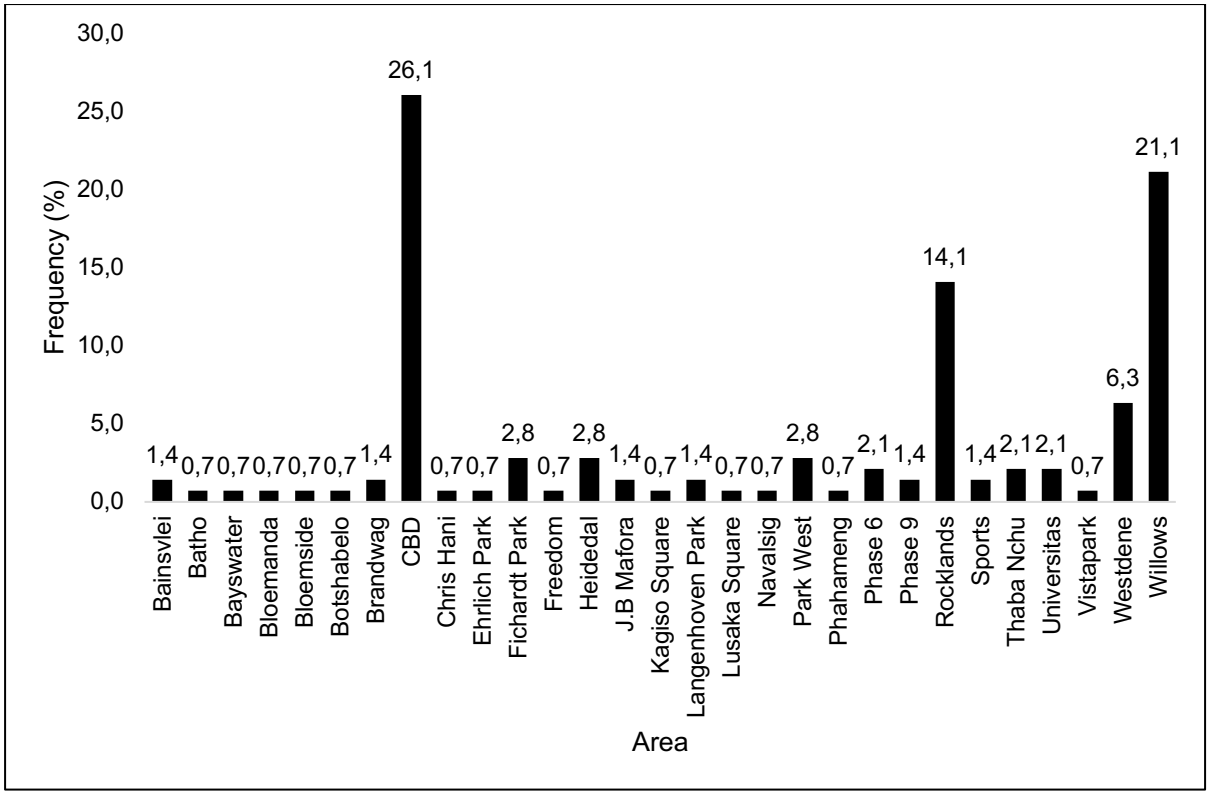
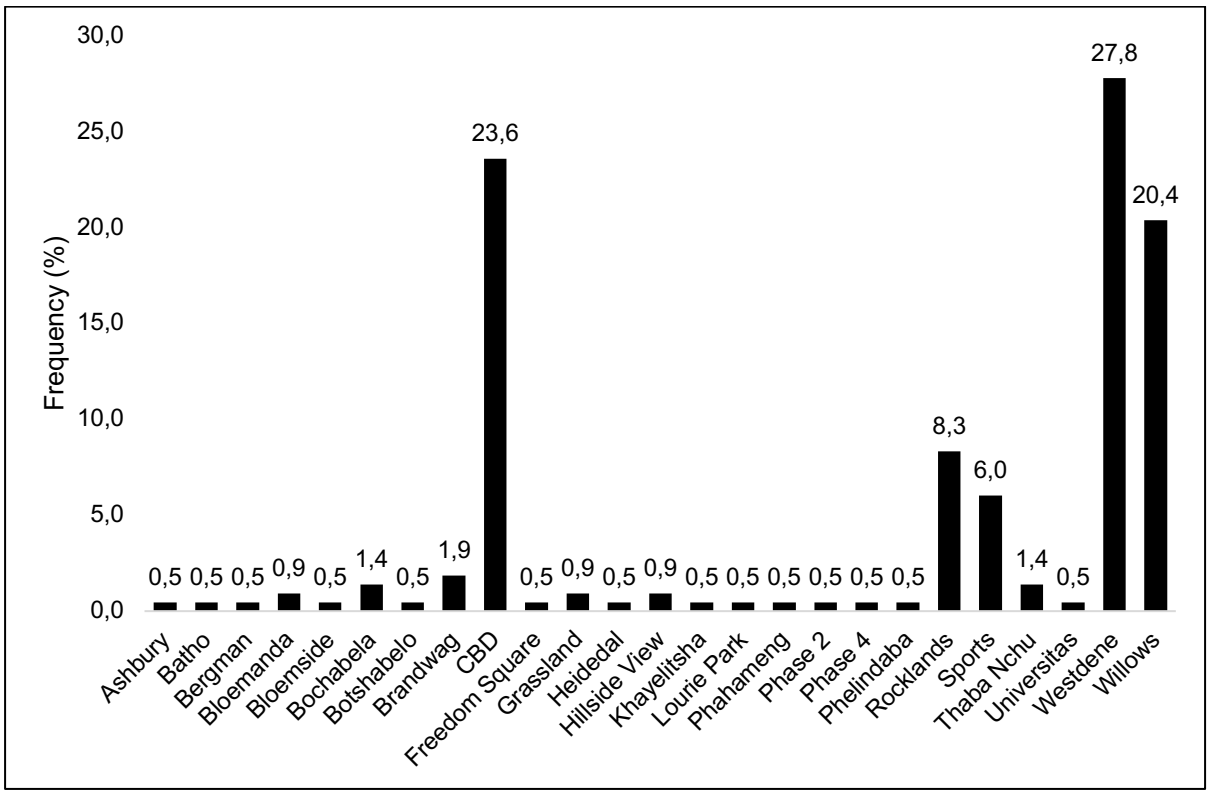


Appendix Figure 5: Percentage of participants whose sports centres were located in each area in Bloemfontein



Appendix Figure 6: Percentage of participants who visited clubs located in each area in Bloemfontein

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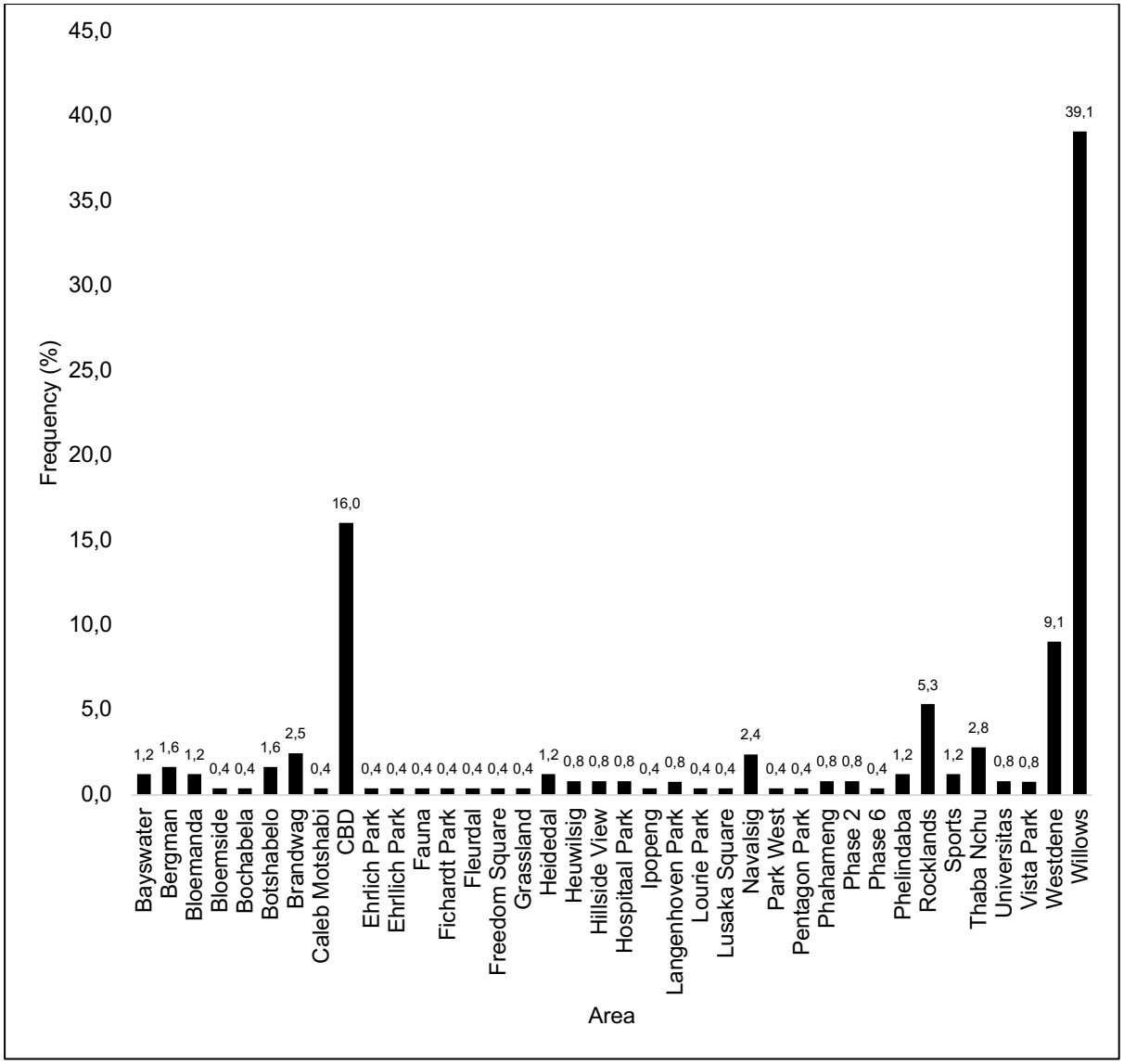

Appendix Figure 7: Percentage of participants who visited parks located in each area in Bloemfontein

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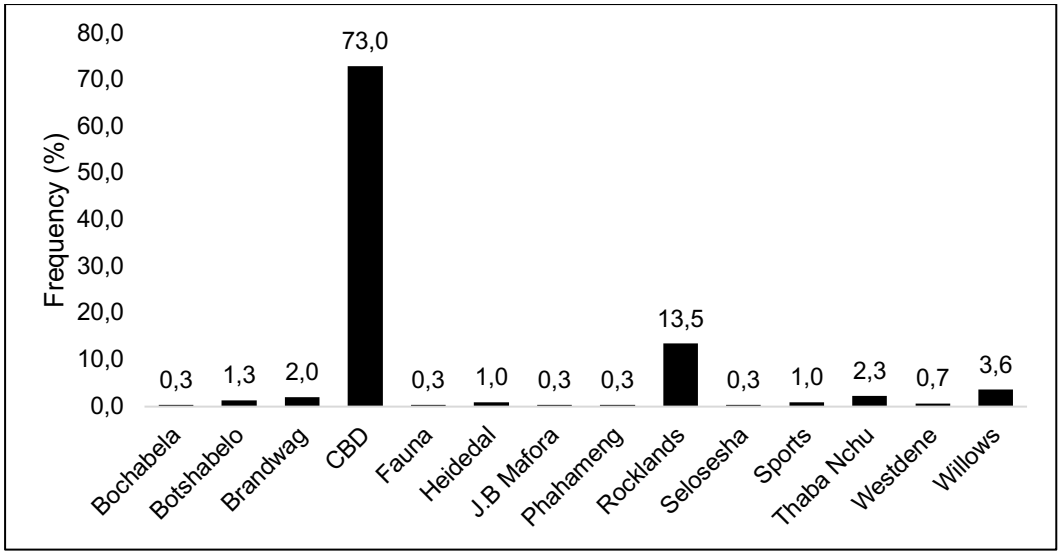
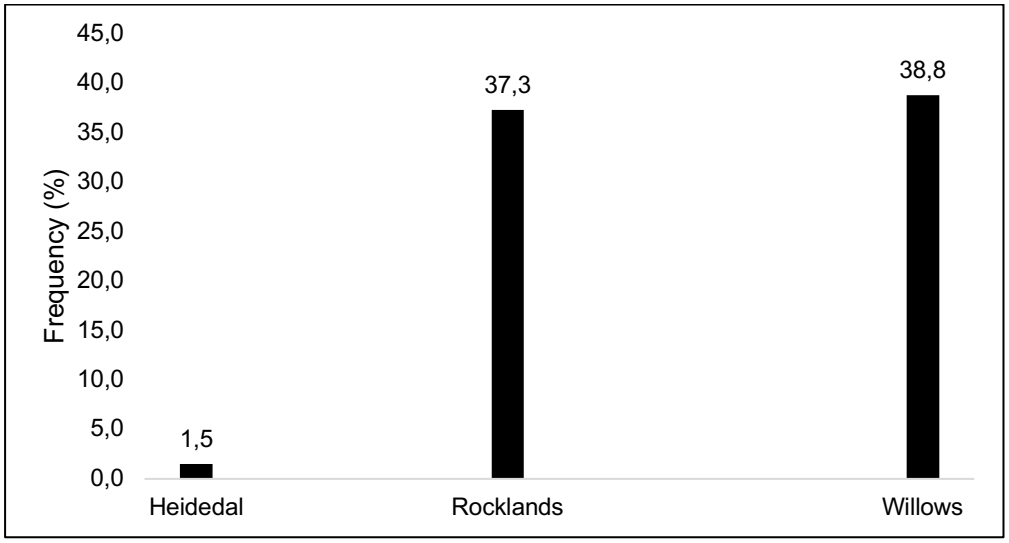


Appendix Figure 8: Percentage of participants who used public service facilities located in each area in Bloemfontein



Appendix Figure 9: Percentage of participants who visited stadiums located in each area in Bloemfontein

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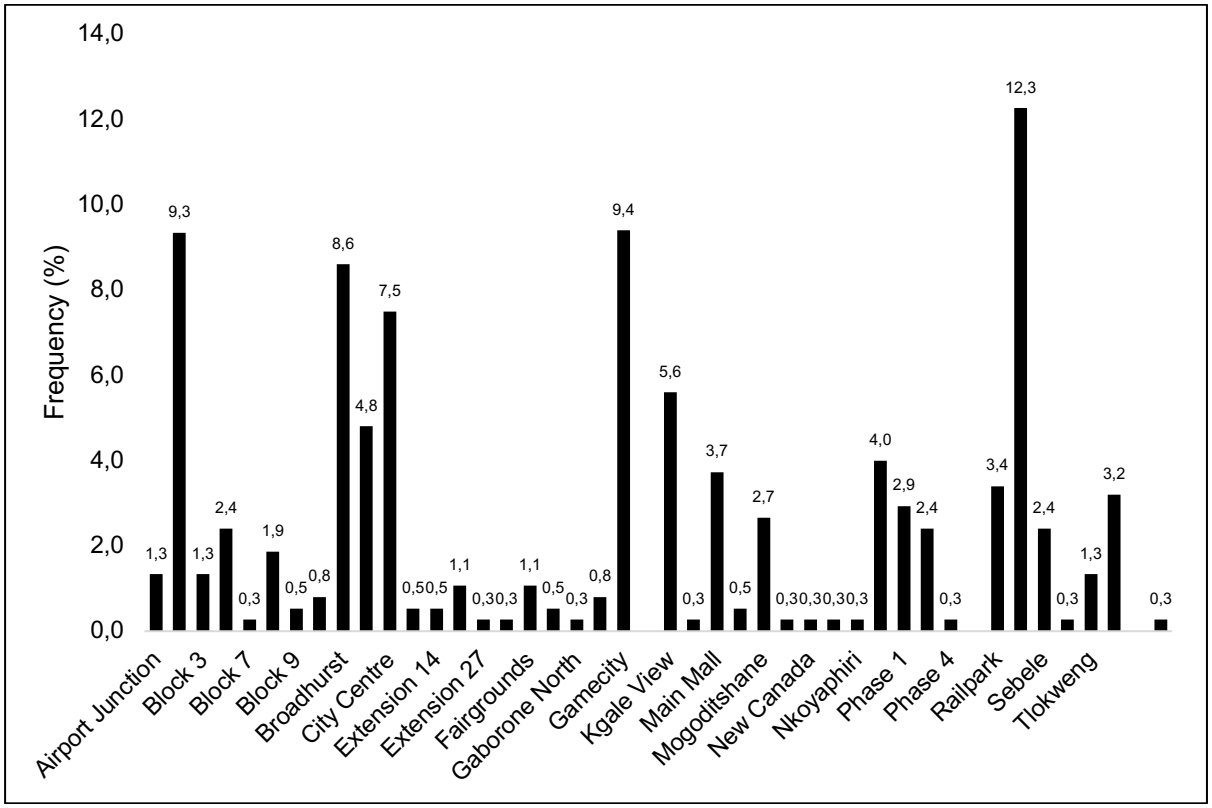
Appendix 4: Activity Location in Gaborone – Frequency Charts



Appendix Figure 10: Percentage of participants who carried out shopping activities in each area in Gaborone

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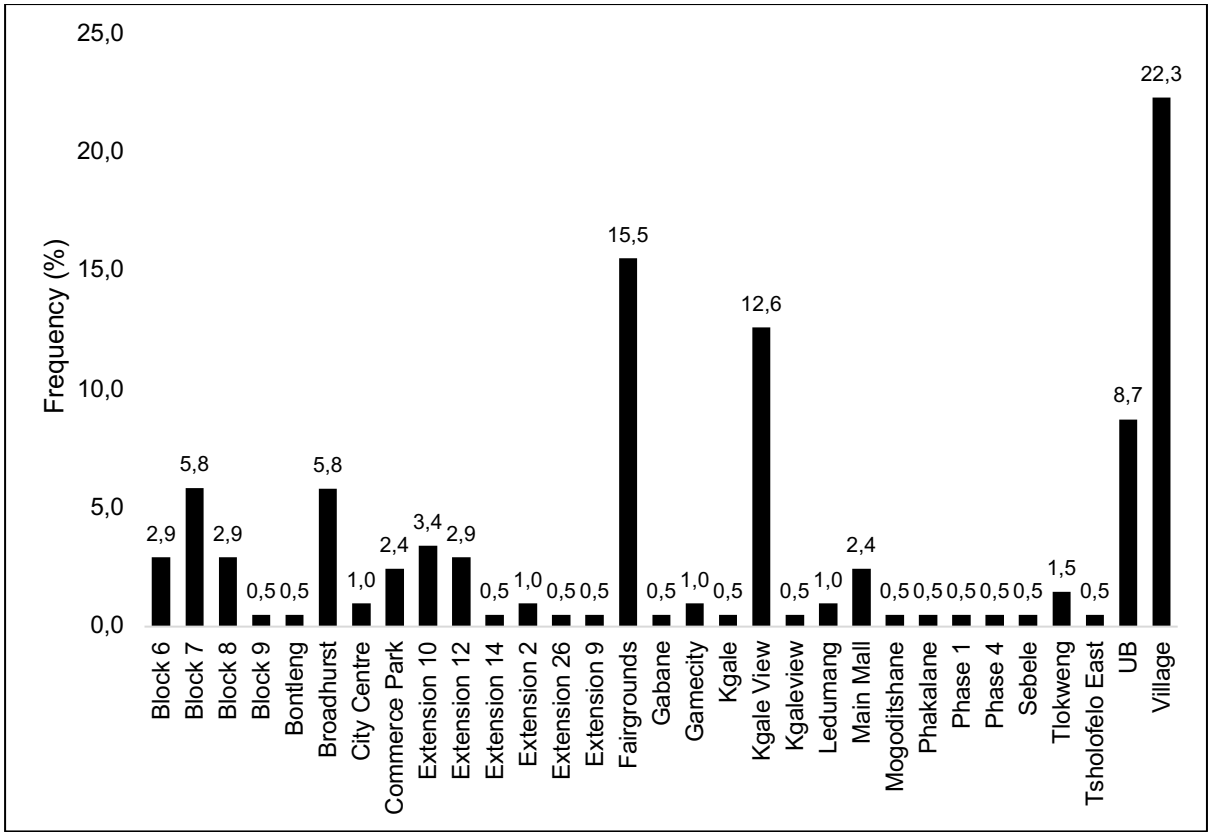
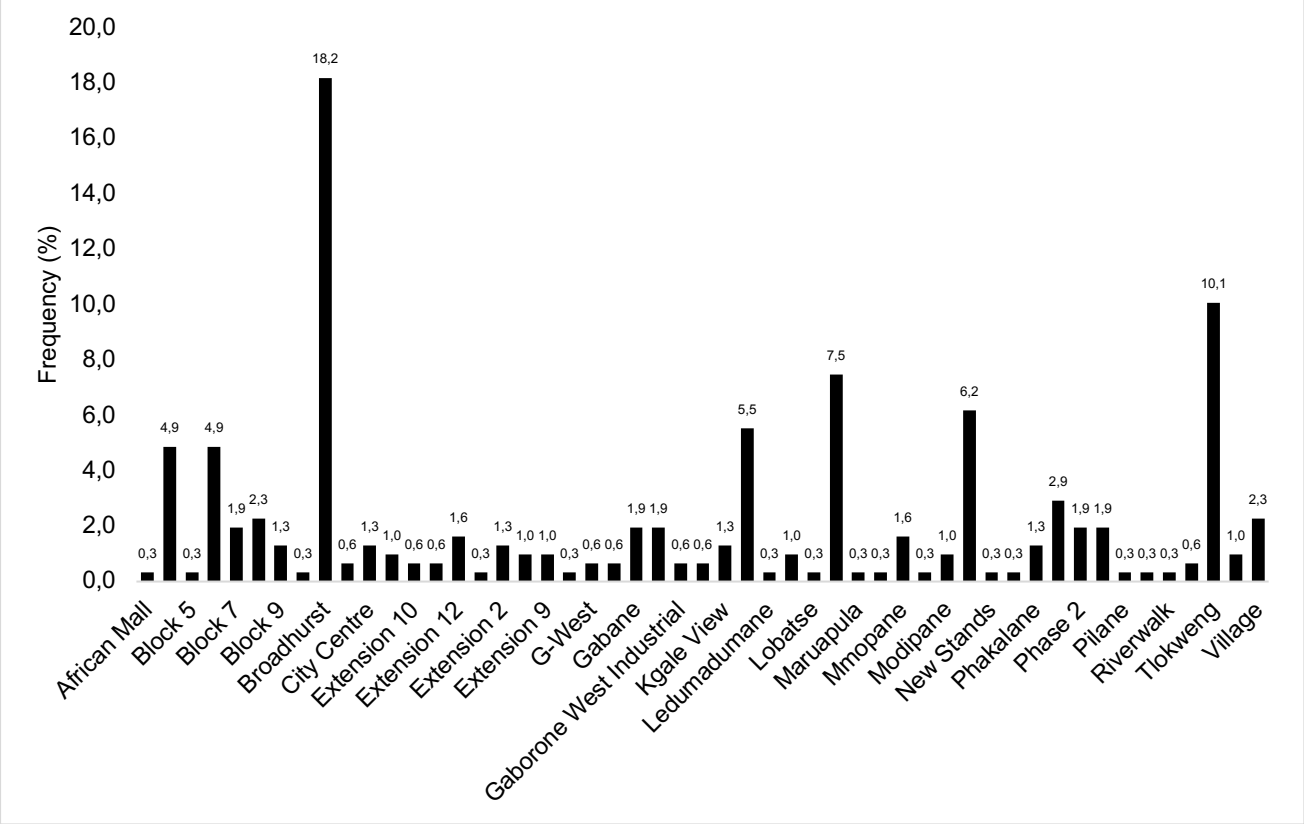


Appendix Figure 11: Percentage of participants whose education centres were located in each area in Gaborone



Appendix Figure 12: Percentage of participants whose religious centres are located in each area in Gaborone

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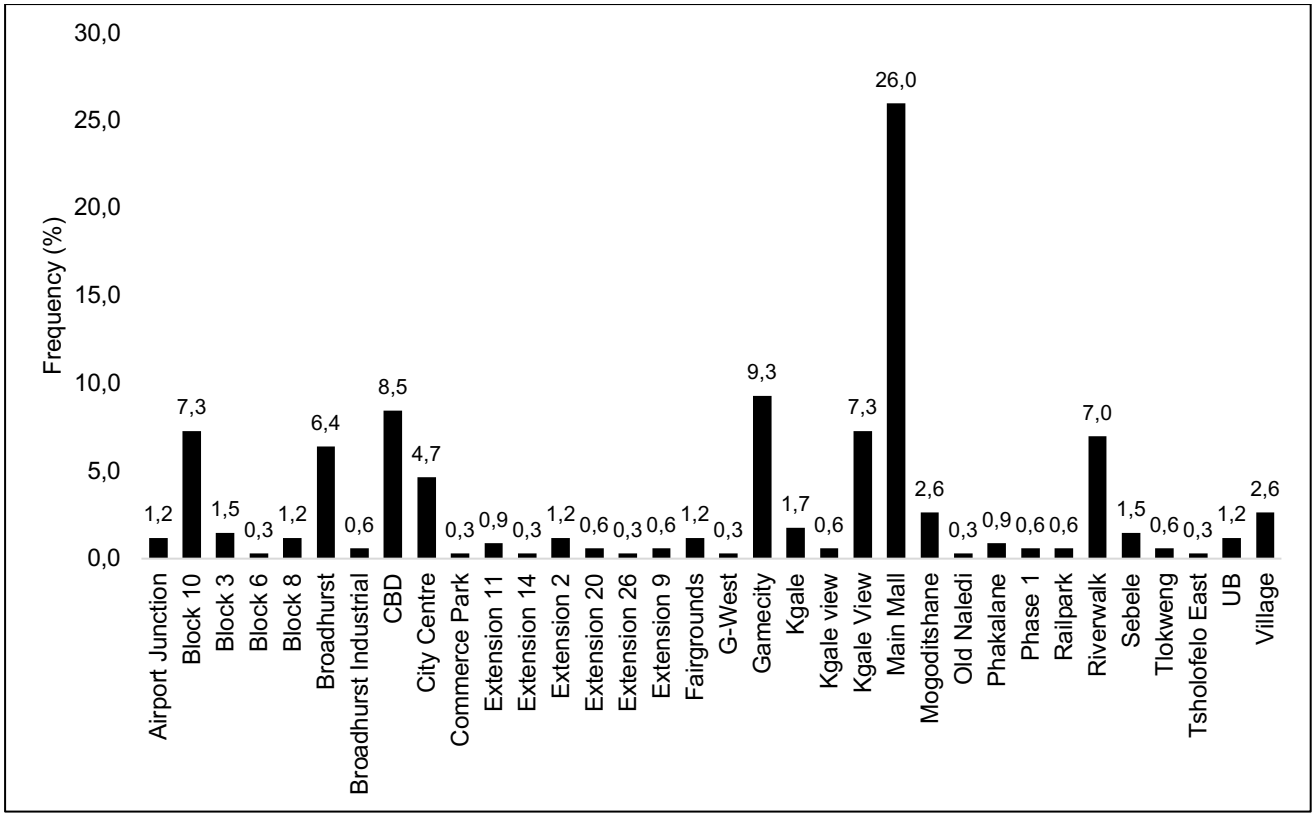
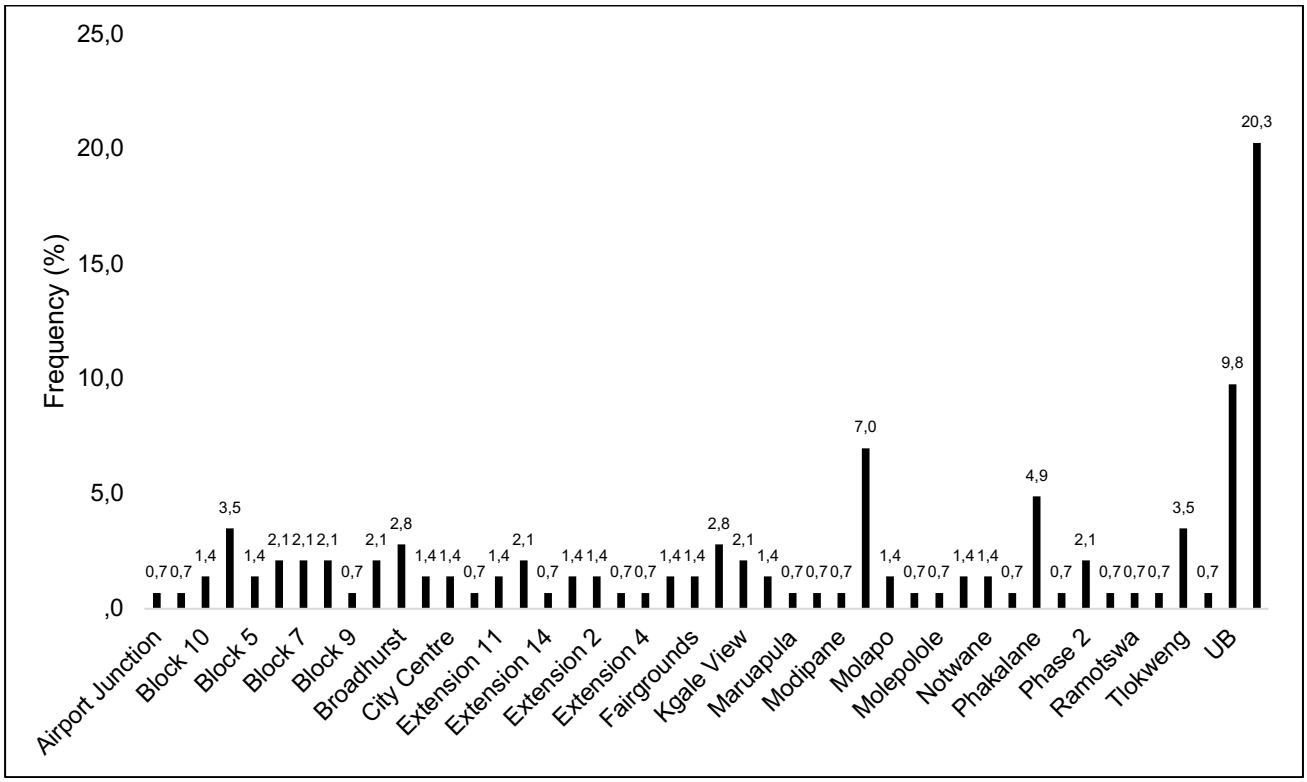


Appendix Figure 13: Location of banking institutions in Gaborone



Appendix Figure 14: Percentage of participants whose sports centres were located in each area in Gaborone

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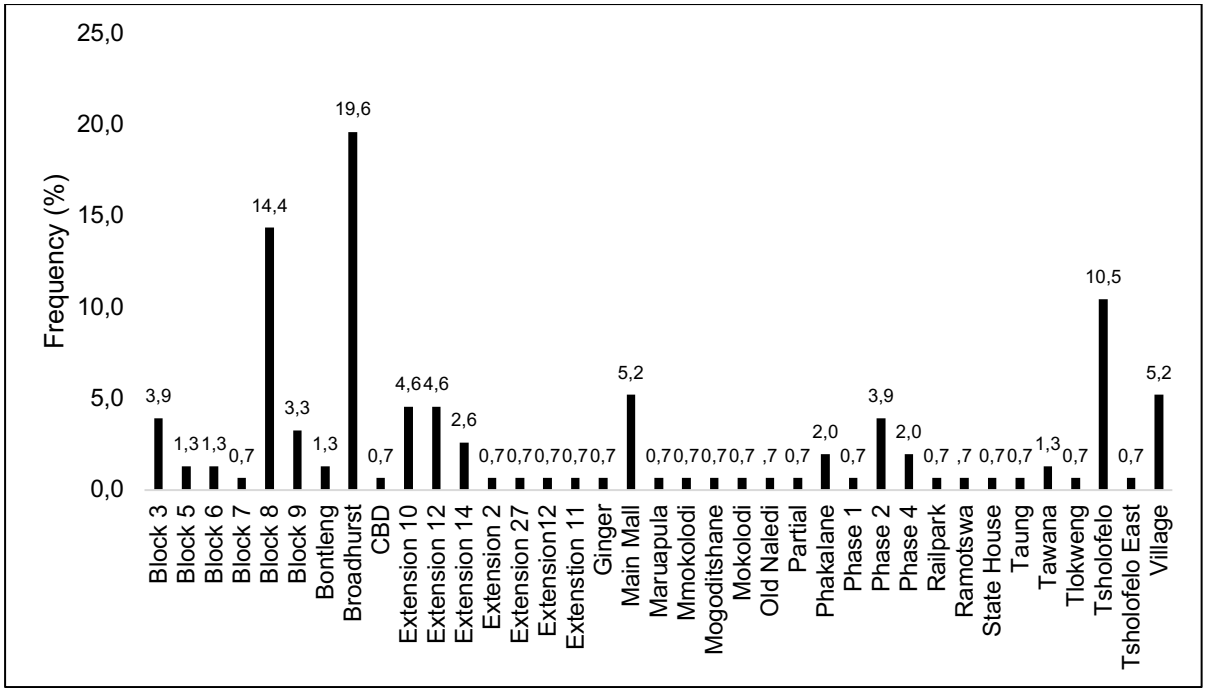
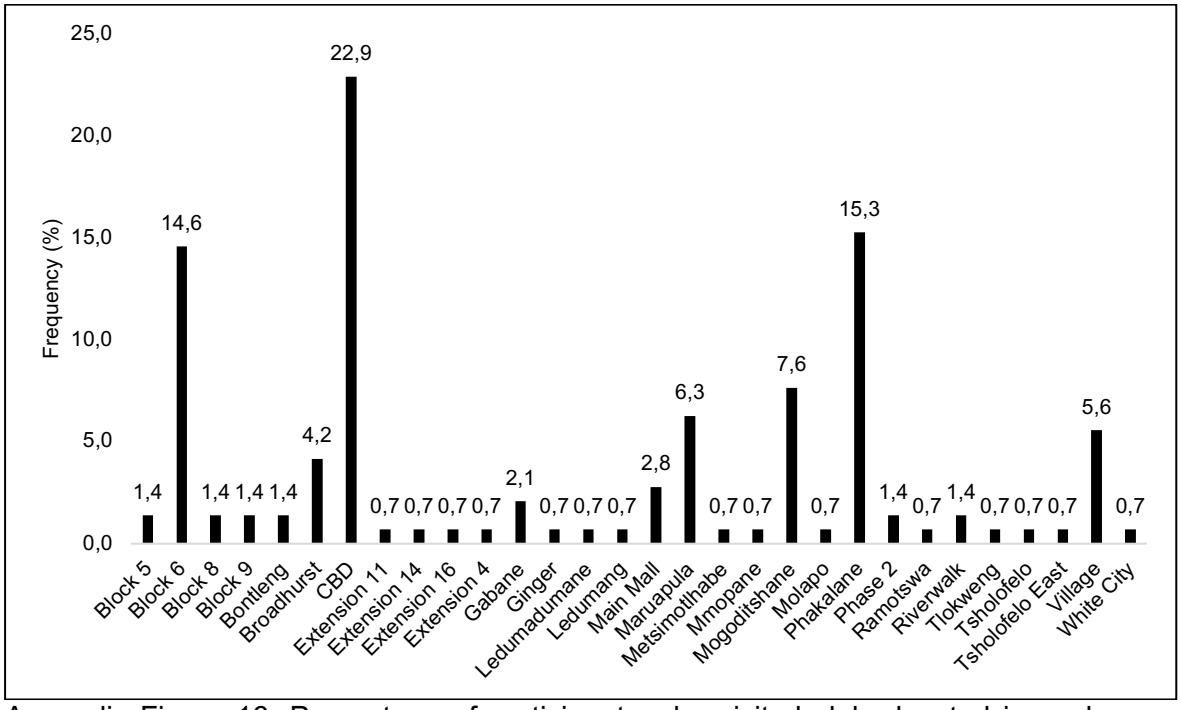


Appendix Figure 15: Percentage of participants who visited parks located in each area in Gaborone



Appendix Figure 16: Percentage of participants who visited clubs located in each area in Gaborone

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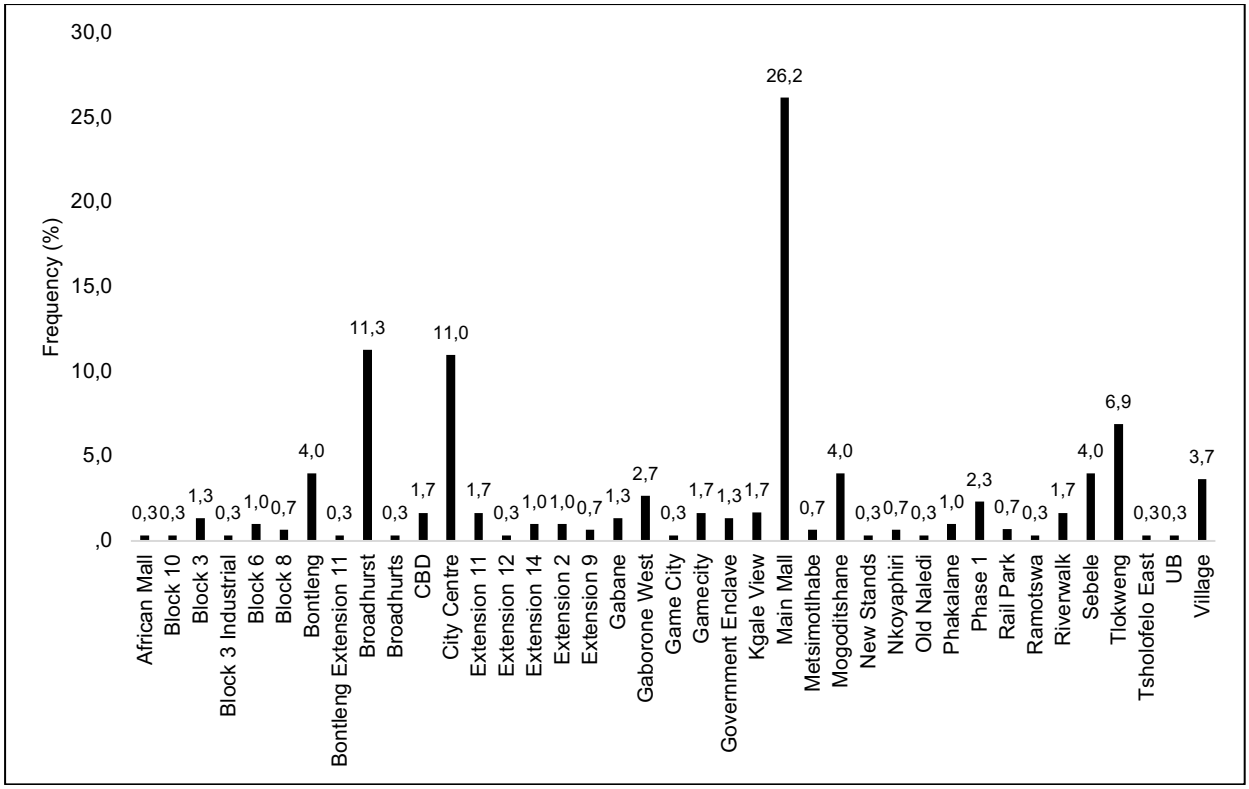
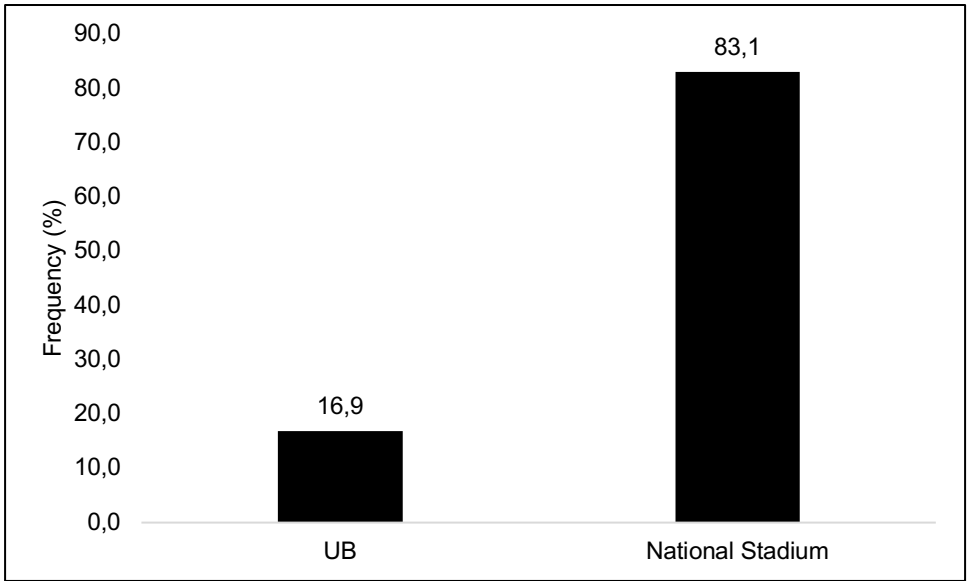


Appendix Figure 17: Percentage of participants who visited public service facilities located in each area in Gaborone



Appendix Figure 18: Percentage of participants who visited stadiums located in each area in Gaborone

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Appendix 5: Solutions to public transportation problems

Appendix Table 3: Resolutions to public transportation problems in Bloemfontein

Response	Frequency	Percentage
Alternative vehicle was provided	1	0,3
Another vehicle was provided	1	0,3
Another cab was availed and other passengers offloaded to it	1	0,3
Another taxi was sent to pick passengers	1	0,3
Asked for driver's contact details and got luggage back	1	0,3
Asked the driver to reduce the volume	1	0,3
Assured by taxi driver that it will never happen again	1	0,3
Bought a car and stopped using public transport	1	0,3
Bus stops have no shelter	1	0,3
Bus was fixed on scene, passengers had to wait for it to be fixed	1	0,3
Buses overcrowded during peak hours	1	0,3
Buses still overcrowded in the evenings	3	1,3
Buses still overcrowded, especially at peak hours	1	0,3
By using private vehicle	1	0,3
Cab delays when they are dropping off other passengers	1	0,3
Called another cab	1	0,3
Called the driver	3	1,0
Called the taxi association and reported the missing bag	1	0,3
Called the taxi owner	1	0,3
Cannot be solved because of traffic jams	1	0,3
Change still not resolved	1	0,3
Changed vehicles after breakdown	1	0,3
Chose another taxi	1	0,3
Complained to the driver	1	0,3
Contacted driver but could not find my stuff in the taxi	1	0,3
Contacted the driver	1	0,3
Decided to stop using taxi and walk	1	0,3
Delay due to construction work	1	0,3
Did not get lost wallet	1	0,3
Did not get luggage back	1	0,3
Did not get the luggage back	1	0,3
Did not lay a complaint	1	0,3
Did not report it	1	0,3
Does not happen often	1	0,3
Does not happen regularly	1	0,3
Does not happen often	1	0,3
Driver agreed to turn down music	1	0,3
Driver apologised for loud music	1	0,3
Driver controlled the situation	1	0,3
Driver did not care	1	0,3
Driver gave change from his own money	1	0,3
Driver promised to replace the lost items	1	0,3

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Driver said he cannot drive an empty taxi so waited until the taxi was full	1	0,3
Driver was asked to turn down music	1	0,3
Driver was unbothered	1	0,3
Drove bicycle on pavements when it was overcrowded	1	0,3
Extended own time so I would not be late	1	0,3
Found the phone the next day at the taxi rank	1	0,3
Got luggage back	1	0,3
Had a meeting with the taxi association and they talked to the drivers	1	0,3
Had driver's contact number and called on time and he kept the lost items	1	0,3
Have not experienced any problems	1	0,3
I avoid some taxis	1	0,3
Ignored some issues	1	0,3
Ignored the taxi driver and walked away	1	0,3
It has not been resolved	1	0,3
It was addressed, drivers promised not to do it again	1	0,3
It was resolved by management	1	0,3
It is affordable and convenient	1	0,3
It is helpful to people with no cars	1	0,3
It is okay	1	0,3
Logged a complaint	1	0,3
Lost belongings were replaced	1	0,3
Lost phone in taxi and never got it back	1	0,3
Luggage was never found	1	0,3
Matter not resolved	1	0,3
Matter taken to taxi association	1	0,3
Matter was reported to the bus company	1	0,3
Mechanics were called to fix problem	1	0,3
More taxis were called to transport other passengers	1	0,3
More taxis were made available	1	0,3
Most passengers complained and management addressed the drivers	1	0,3
Never got my items back	1	0,3
Never got my luggage back	1	0,3
Never got the lost luggage back	1	0,3
Never reported it	1	0,3
No changes, buses still overcrowded	1	0,3
No one complained about loud music	1	0,3
Nobody in the vehicle knew who took my items	1	0,3
Not Resolved	162	55,1
Notified the driver and he was disrespectful and rude	1	0,3
Organised a meeting with taxi association to tell them to stop doing silly things	1	0,3
Passengers notified beforehand that there would be a delay	1	0,3
Police officers were informed	1	0,3
Problems are watered down	1	0,3

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Queue marshals called another taxi	1	0,3
Reported matter to Interstate offices and bag was found	1	0,3
Reported the matter to the owner	1	0,3
Reported the matter to the taxi rank office	1	0,3
Reported to driver and he found the luggage and returned it	1	0,3
Requested driver to lower the volume and he obliged	1	0,3
Services improved	1	0,3
Some cab drivers are harsh and unfriendly	1	0,3
Started only taking taxi at off-peak times	1	0,3
Started using a private car	1	0,3
Started using a private vehicle	1	0,3
Started using private car when late	1	0,3
Started waking up 30 minutes earlier	1	0,3
Started waking up early	1	0,3
Stopped using public transport	1	0,3
Talked to the driver	2	0,7
Talked to the taxi association	1	0,3
Taxi broke down and driver stopped another taxi for passengers to continue their journey	1	0,3
Taxi driver called another taxi when his taxi broke down	1	0,3
Taxi driver controlled the situation by telling people to form queues	1	0,3
Taxi driver returned passengers to the taxi rank when change was short	1	0,3
The driver apologised	1	0,3
The driver was respectful, so we managed to solve it	1	0,3
Capacity of buses during peak hours was increased	1	0,3
The system is okay	1	0,3
Told cab driver to be on time	1	0,3
Told driver not to be late again	1	0,3
Told the driver about it	1	0,3
Took a cab after waiting a long time for a taxi	1	0,3
Traffic department intervened	1	0,3
Traffic officers intervened	1	0,3
Use taxis at your own risk	1	0,3
Used private car	1	0,3
Continued waiting	6	1,9
Walk because taxis are full in the morning	1	0,3
Was taken to hospital	1	0,3
Total	293	100,0

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Appendix Table 4: Resolutions to public transportation problems in Gaborone

Response	Frequency	Percentage
Adjusted own time schedule to accommodate delays	2	0,6
Ask family members to pick up at bus stop using a private vehicle	2	0,6
Asked a family member to transport me	1	0,3
Asked conductor to reduce volume and he refused	2	0,6
Asked driver to turn down the volume and he agreed	2	0,6
Asking the driver to cooperate	2	0,6
Bought own car	10	2,9
Called a cab	2	0,6
Called a friend to pick me up	2	0,6
Cash refund to the value of lost items	2	0,6
Changed combis	4	1,1
Combi driver drove off with change	1	0,3
Combi ranks now have timers tracking the time a combi is supposed to wait while loading at the rank	2	0,6
Combi returned luggage to the rank	2	0,6
Coming to the bus stop earlier to wait in the queue	1	0,3
Common problem that cannot be changed	2	0,6
Contacted the Department of Transport for intervention	2	0,6
Continued waiting	1	0,3
Continued waiting in line	1	0,3
Currently, there is an increase of public transportation vehicles in the city	1	0,3
Delays still prevalent especially in the mornings	1	0,3
Delays unresolved	1	0,3
Did not log complaint with authorities	2	0,6
Driver promised not to repeat	2	0,6
Driver promised to stop overloading people and wasting time	2	0,6
Driver reduced number of people in vehicle	2	0,6
Found the next stop	2	0,6
Got a refund after vehicle broke down	2	0,6
Got change the next day after raising a complaint	2	0,6
Harassment still persistent in combis	2	0,6
Just walked away	2	0,6
Lacks professionalism	1	0,3
Lost luggage never recovered	2	0,6
Lost phone recovered with the help of the driver	1	0,3
Loud music also not resolved	1	0,3
Luggage was found	2	0,6
Music volume was turned down at passengers' requests	1	0,3
Never been resolved	2	0,6
Never resolved	6	1,7
New combis are currently being introduced into the system	2	0,6
No effective remedies to combi problems	1	0,3
No option to report incident	1	0,3
Not resolved	193	54,9

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Notified driver about urgency to get to work and he complied	2	0,6
Notified the combi driver but was not resolved	2	0,6
Other issues not resolved	1	0,3
Overlooked	2	0,6
Passengers were transferred to another combi after a breakdown	2	0,6
Poor	1	0,3
Problem still persists	1	0,3
Reported to DRTS but it was not resolved	2	0,6
Reported to police	2	0,6
Reported to the police and the Department of Transport	2	0,6
Reported to the Department of Transport	2	0,6
Resorted to walking	2	0,6
Solved by DRTS	2	0,6
Spoke to the driver	2	0,6
Start journey earlier	1	0,3
Switched to private transportation	2	0,6
Talked to the driver	14	4,0
There is increased number of combis	2	0,6
Told the combi driver to speed up	2	0,6
Too many people using public transport but not enough combis	1	0,3
Transferred to another combi during a breakdown	1	0,3
Transferred to another vehicle	1	0,3
Transport department introduced a law against overcrowding	1	0,3
Unsatisfactorily resolved	2	0,6
Use private vehicle	2	0,6
Very common problems, no chance of them being resolved	2	0,6
Continued waiting	13	3,7
Walked to finish the trip	6	1,8
Was not resolved, could not reach the service provider	1	0,3
Was told to use a different combi when complaining about the music	1	0,3
Total	352	100,0

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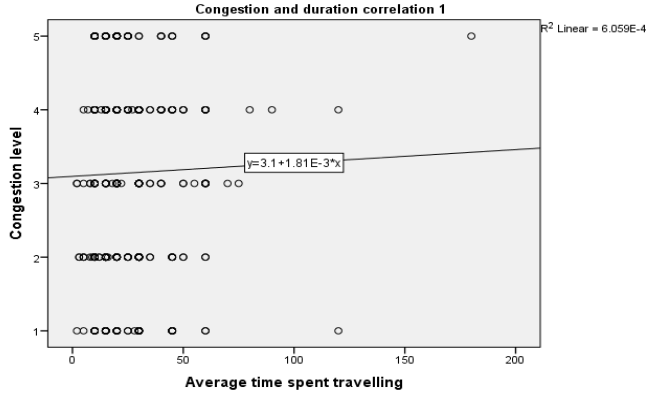
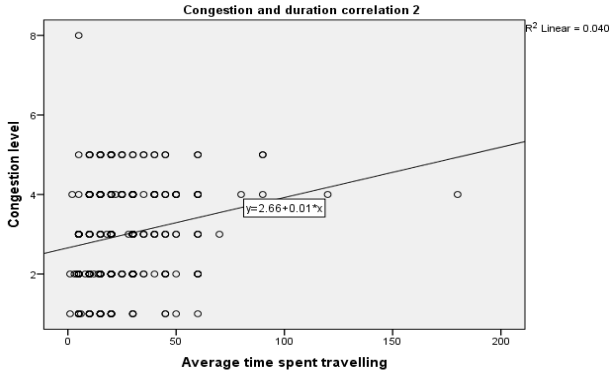
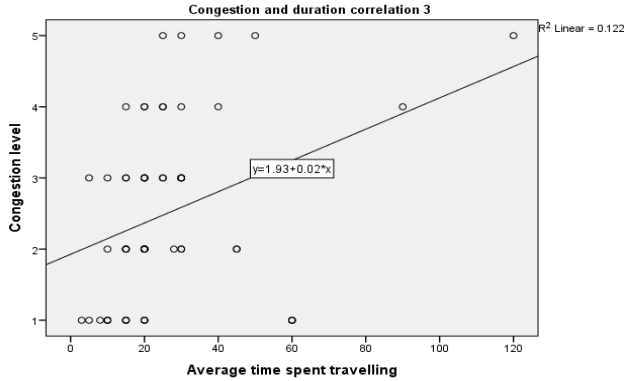
Appendix 6: Congestion perception and trip duration correlation graphs







Appendix Figure 19: Congestion and trip duration correlation graphs - Bloemfontein

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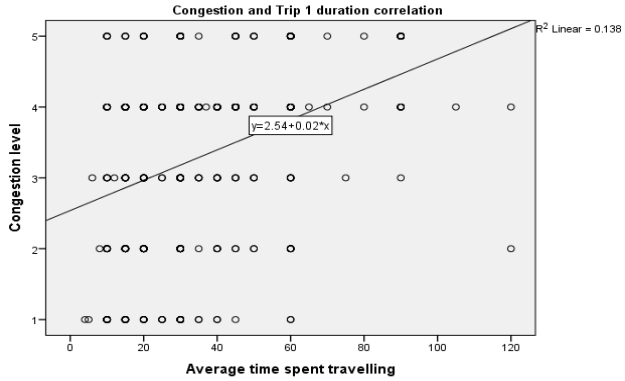

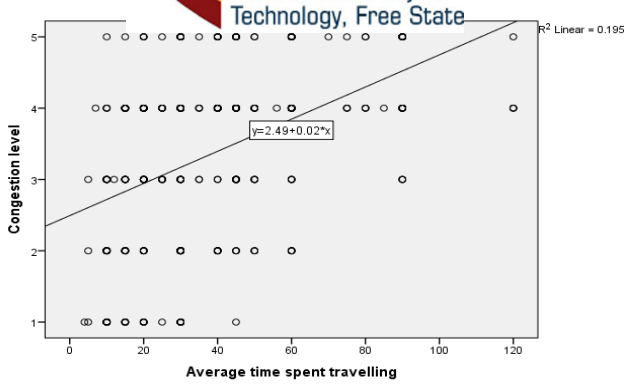

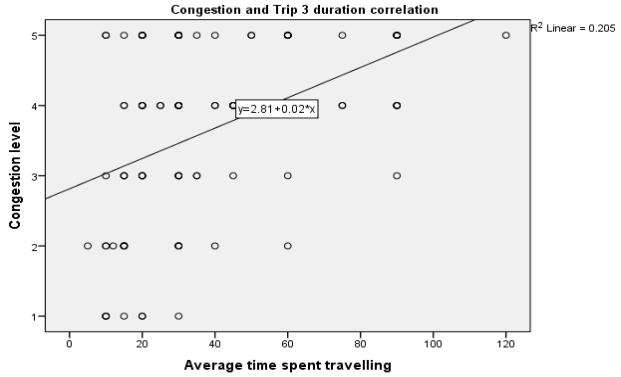

Appendix Figure 20: Congestion and trip duration correlation graphs – Gaborone

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