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Challenges and Opportunities for Private-to-Public Transportation Modal Shift and Integrated Multimodal Passenger Transportation Systems in Gaborone

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Abstract

Modal shift from private to public transportation has the potential to reduce problems threatening sustainability of urban transportation systems. Discouraging the use of private vehicles in favour of public transportation has been promoted to reduce numbers of vehicles on the road and alleviate traffic congestion. Integrated public transportation systems, incorporating all available modes into a single operational system provides seamless functionalities and convenience. It is crucial to understand mode choice factors, for both public and private vehicle users before promoting multimodal transportation systems. Understanding the current operational state of the public transportation systems as well as perceptions of private vehicle users towards public transportation will enable evaluation of susceptibility to modal shift and multi-mode integration.

The aim of the study is to explore prospects of an integrated multimodal public transportation system as well as evaluate possibilities of modal shift by private vehicle users. These are achieved through evaluating perceptions of private vehicle users towards the public transportation system in Gaborone, Botswana. The study uses data gathered through a questionnaire survey; reviewing the state of public transportation based on users' experiences and perceptions, assessing reasons influencing the use of private vehicles, users' understanding of sustainability and the role played by the increasing number of vehicles on the environment. Availability and effectiveness of public transportation services is evaluated, and the study also explores factors that would lead to modal shift. Results of the study showed that safety and convenience were the most influential factors which may influence modal change while financial and technological factors are least influential. It is further determined that the current state of the public transportation system is detrimental to modal shift, therefore improvement is needed to the system to discourage use of private vehicles while promoting inter-modality between public modes and Non-Motorised Transportation.

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1. Introduction

Raising car ownership is a challenge towards sustainability efforts hence the need for sustainable public transportation systems. Most developed countries public transportation systems' effectiveness is based on high occupancy, high speed and ultimately the convenience rendered. This particular narrative however, is not the case with developing Southern African countries, Botswana included. The public transportation levels of operation, organization and efficiency have propelled the need for private vehicles. Developing countries in Southern Africa must mitigate urban transportation problems as they occur.

High levels of car ownership are linked to increased traffic volumes, congestion, and increased emissions, which will lead to ongoing issues of unsustainability in future if no mediation measures are put in place (Luke, 2018). Modal shift to public transportation has been suggested as a way to reduce the volume of private vehicles on the roads. The purpose of modal shift to public transportation is to promote sustainable travel patterns and behavior.

In recent years, the focus on modal shift has grown to include information and technological interventions such as technology replacing travel and using ICT to influence modal shift from private to public transportation. Public transportation integrated with ITS is considered to be the key to achieving sustainable transportation (Pronello and Camusso, 2017). Even though high-quality public transportation does not guarantee a modal shift from the use of regular private vehicles, combining it with the provision of high-quality, reliable information could persuade people to consider shifting to public transportation. Even so, individuals' daily activities and habits can result in resistance to a change of mode of transportation.

1.1. Study Area

The study was conducted in Gaborone, the capital city of Botswana. The city is geographically located in the South-Eastern part of Botswana, positioned at 24°39'29"S and 25°54'44"E. The map of Botswana and the city of Gaborone as well as the road network map of Gaborone are provided in Figures 1a,b and c respectively. The city has seen a surge in vehicle increases in recent years. Gaborone is the most urbanized and industrialized area in Botswana (Sebego and Gwebu, 2013). The population of Gaborone increased from 186 000 in 2001 to 231 626 in 2011, and approximately 232 000 in 2017, and was predicted to reach 250 000 by 2021 (Statistics Botswana, 2015; World Population Review, 2017). This rapid growth is putting Gaborone's urban resources under strain, including transportation, as the city has seen a rapid increase in car ownership as a result of an influx of imported cars, which are more affordable to people with an average income (Ranko and Bolaane, 2011). This rapid growth in car ownership makes sustainable development relatively difficult.

Passenger transportation is dominated by high volumes of private vehicles and the use of public transportation. Local rail and bus passenger services are not available. In a study by Keiner and Cavric (2006), it was found that, at the time of the study, private cars were the preferred mode of travel and public transportation was less popular (Keiner and Cavric, 2006; Ranko and Bolaane, 2011). Licensed vehicle ownership increased from 500 316 to 527 901 between 2016 and 2017, an increase of 5.5%, and a growth of 9.7% in national car stock was recorded between 2008 and 2017 (Statistics Botswana, 2019: 5). Public transportation systems within the city were made up of 15-seater mini-buses known as "Combis", as classified by the Department of Roads Transport and Safety (DRTS), and 5-seater taxis. Ranko and Bolaane (2011) referred to the systems as being inefficient because the infrastructure was inadequate and unattractive.

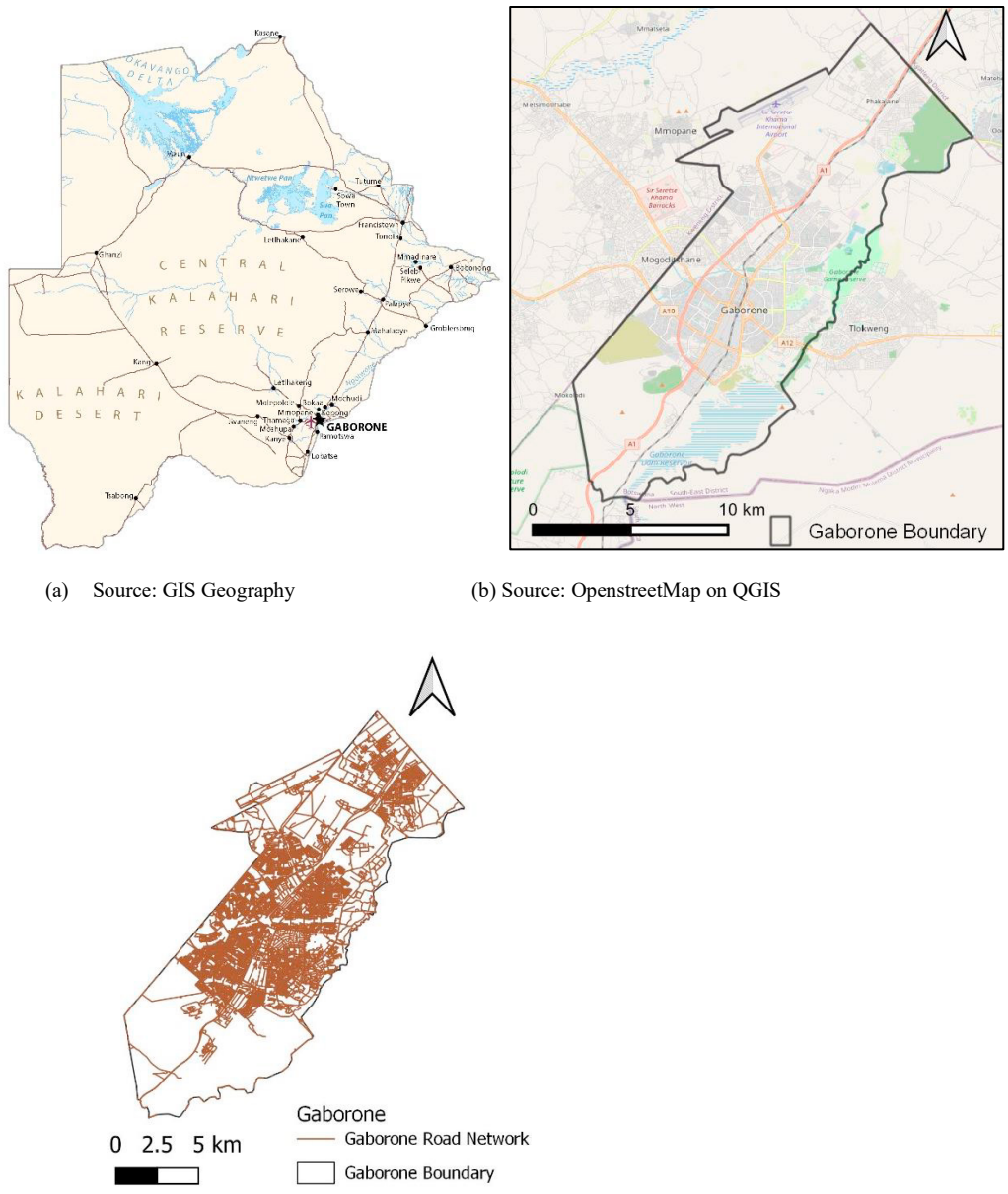


Figure 1: Maps of (a) Botswana showing the location of the capital city, Gaborone, (b) Gaborone, (c) Gaborone Road Network

2. Literature Review

Modal shift to public transportation has been suggested as a way to reduce the volume of private vehicles on the roads. Increasing car ownership is one of the main reasons for the unsustainability of transportation, and it has been concluded in many studies that switching modes from private to public transportation can remedy the situation and improve sustainability by reducing carbon emissions (Conti, 2018; Amatuni, Ottelin, Steubing and Mogollón, 2020). Banister (2008) had previously stated that dependence on cars has become a difficult process to reverse. However,

(Batty, Palacin and González-Gil, 2015) emphasized that a modal shift from private to public transportation is essential, citing that increased use of private vehicles over public transportation may lead to higher levels of congestion and air pollution in urban areas if it persists. Additionally, Ranko and Bolaane (2011), attributed traffic congestion in the city of Gaborone to increased car ownership, inefficiencies in the public transportation system, and insufficient road infrastructure.

Public transportation, cycling and walking have become unattractive and people have resorted to the use of cars, which is more utilitarian (Banister, 2008; Garcia-Sierra et al., 2015). Public transportation users expect satisfaction from the service (Dell’Olio, Ibeas and Cecin, 2010) through reduced waiting times, cleanliness and comfort. Low use of public transportation is a result of low demand due to user-specific issues such as the lack of public transportation services and, in some cases, the quality of the public transportation service (Luke, 2018). Poor quality services in public transport are attributed to unreliability and lack of safety, among other factors. Dissatisfaction with the systems has thus played a major role in travel behavior and travel patterns. Jansson, Andreasson and Kottenhoff (2016) state that public transport should be reliable and punctual with regular departure times. Undesirable attributes of public transportation such as lack of flexibility, and being unsafe and unreliable, result in more people using private vehicles (Brög, Erl, Ker, Ryle and Wall, 2009; Jansson, Andreasson and Kottenhoff, 2016; Luke, 2018).

Modal shift from private transportation to public transportation has been recommended in various studies as the solution to urban transportation problems by, reducing private vehicle traffic, congestion on roads and, ultimately, contributing to environmental sustainability (Dell’Olio, Ibeas and Cecin, 2011; Gunay, Akgol, Andreasson and Terz, 2016; Anwar and Yang, 2017; Conti, 2018; Urbanek, 2021). Previous research on modal shift has supported the need to develop seamless, accessible, high-capacity, zero emissions models of sustainable urban transportation and to promote the modal shift from private to public transportation, especially high capacity transportation modes (Batty, Palacin and González-Gil, 2015).

This has led to inquiries on how the lack of satisfaction with the system could be addressed to impact a positive private vehicle to public transportation modal shift towards sustainable public transportation. Ellison et al. (2017), lamented that travel mode characteristics, such as “the perceived inconvenience of public transport, poor frequencies, the need to travel to multiple destinations, the inability of public transport to accommodate impromptu decisions” hinder mode switching from car to public transport. Given the many unsatisfactory characteristics of public transportation, especially in developing countries, modal-shift 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 incentives (Zhu, Wang, Chen and Reed, 2020). Abou-Zeid and Ben-Akiva (2012) conducted an experiment which attracted car users to public transportation by offering free transportation and some rewards during the study period, which was successful only for the duration of the experiment. Sustainable means of effecting modal-shift are therefore required. It is worth factoring in that changing from private car use to public transportation is also a psychological issue. People associate car ownership and use with elevated social status and associate public transportation with low income and lower-middle class groups. It is in the same regard that private vehicles are associated with upper-middle income and higher income groups. Emotional and psychological readiness and evaluation of the effects of psychological influences on modal shifts should be taken into consideration (Abou-Zeid and Ben-Akiva, 2012). A preference for cars and lack of willingness to switch to public transportation should therefore be expected (Urbanek, 2021).

Growth in demand for a mode with more advantages will therefore lead to reduced preference for the other mode. The process of modal shift involves decision-making by travelers and service providers, as well as intrinsic factors affecting passengers and providers, and 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 public transportation attractive or unattractive to users (Batty, Palacin and González-Gil, 2015). Private vehicle users might also be willing to compromise on the costs of private travel instead of spending longer time on public transportation travel (Urbanek, 2021). Costs associated with car travel go beyond fuel costs and include costs associated with depreciation of the vehicle, repairs, services and insurance (Urbanek, 2021).

In order to encourage a modal shift, improving the quality and attractiveness of public transportation while discouraging the use of private cars has been proposed (Batty, Palacin and González-Gil, 2015; Ahmad, Puppim and Oliveira, 2016). Rodrigue (2020) proposed factors that could lead to the change of mode of transportation based on

comparative advantage, costs, time, level of service, comfort and reliability. The higher the comparative advantage over one mode, the more incentive there is to switch modes (Rodrigue, 2020). More people would be encouraged to use a public transportation system that provided attractive factors such as safety, cleanliness and convenience. Traveler options and requirements are fundamental to a successful modal shift from private to public transportation (Batty, Palacin and González-Gil, 2015; Ahmad, Puppim and Oliveira, 2016)). 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, Palacin and González-Gil, 2015; Ahmad, Puppim and Oliveira, 2016)).

Urbanek (2021) indicated that lack of proper connections, insufficient frequency and longer travel times are also some of the factors that are regarded as obstacles to the regular use of public transportation. A previous study stated that modal shift was not guaranteed to alleviate congestion in Gaborone, a city whose public transportation was inadequate even for captive users (Bashingi, Mostafa and Das, 2020). Hence the need to improve public transportation should be a priority before encouraging a modal shift. Urbanek (2021) also concluded that strategies to achieve a modal shift should be focused more on improving the quality of public transportation. It is also crucial to acknowledge that public transportation modes available in the city are not Demand Responsive, therefore should be paired with other transportation modes. A recent study suggested multi-modal integration which includes walking, cycling, car-sharing, carpooling, taxis and any other available services (Cottrill et al., 2020).

3. Methodology

A questionnaire survey of 388 respondents who were both public transportation and private transportation users was conducted from August 2017 to November 2017 in Gaborone, Botswana. Simple random sampling of participants was used based on a 95% confidence level and allowing for a 5% margin of error, thus a sample of 388 was adequate. The questionnaire study first inquired about the demographic characteristics (age, gender and occupation) of respondents. The study further enquired about car ownership and household income of the respondents. Questions specific to mode choice and mode used for activities were asked to determine the modal split. Table 1 provides a summary of the questionnaire. Further questions concerning public transportation use, problems encountered, and perceptions were asked to determine satisfaction or dissatisfaction with the public transportation system. Factors that would influence private vehicle users to shift to public transportation were also determined. Finally, to pinpoint what multimodal integration would require, respondents were asked to determine the importance of factors influencing mode choice. The questionnaire data were thereafter analyzed using SPSS and the results presented using MS Excel.

Correlation was used to further understand 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) defines inferential methods as those that characterise and makes general decisions for a population based on information drawn from the sample.

To understand the relationship between respondent demography and the factors influencing their decision on what mode of transportation to travel by a chi-square analysis was conducted. The null and alternative hypotheses for the testing were:

- Ho: “Respondent demography and factors influencing their decision on what to travel by are independent of each other.”
- H_i: “Null hypothesis is not true”

The expected cell frequencies were compared with the observed cell frequencies using the test chi-square, as estimated using equation 1 below.

$$X^2 = \sum \frac{(O_{ij} - E_j)^2}{E_{ij}} \quad (1)$$

where: X^2 = chi-square; O_{ij} = observed frequency of the cell in the i th row and j th column; and E_{ij} = expected frequency of the cell in the i th row and j th column.

Table 1: A summary of questions in the study:

Question	Scale	Question Type
How much is your monthly income?		Open Ended
Number of Vehicles in your Household		Open Ended
Choose the frequency at which you use the following modes of transportation. (Frequency: Do Not Use, Daily, Once a week, 2- 3 days a week, weekends only, Monthly)	<ul style="list-style-type: none"> • Private Vehicle • Car Sharing • Combi • Taxi • Walking • Bicycle • Motorcycle 	Multiple Response
For what purposes are most of your trips using your preferred mode of transport? (Combi, Taxi, Cab, Private Vehicle, Motorcycle, Bicycle, Walking)	<ul style="list-style-type: none"> • Shopping • Work • School • Personal • Leisure • Personal • Sporting activities • Sightseeing • Family obligations 	Multiple Response
Which of the following problems have you experienced while using public transportation? (Tick once or more where appropriate)	<ul style="list-style-type: none"> • Lost luggage, • Did not get my change, • Long waiting time at taxi rank • Loud music in vehicle, • Overcrowded, • Delays, • Vehicle breakdown • Couldn't find stop, • Bus stop far from my destination, • Harassment 	Multiple Response
How was the problem above resolved?		Open Ended
What are your general perceptions of public transportation system in the city?		Open Ended Question
Would you stop using your car and use public transportation if it _____? (Yes, No)	<ul style="list-style-type: none"> • 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 	Multiple Response
Rate the following factors as relevant to your mode choice when using the given modes of transportation using the following: Scale: 1=Not important at all, 2= slightly important, 3= of average importance, 4= Very Important, 5= absolutely essential	<ul style="list-style-type: none"> • Combi • Taxi • Private Vehicle • Walking 	Multiple Response

*Multiple Response Question – Allows for selection of more than one answers

*Open Ended Question – Allows respondents to give a full answer

4. Results and Discussion

4.1. Demographic information of respondents

There were 388 respondents included in the study (Table 2), of the total respondents, 53.4 % were female. Most of the respondents are between the ages of 18-25 (43.0 %) and only 19.6 % are above 36 years old. Occupation characteristics among the respondents were 41.0 % are full-time workers, 33.0 % are students at university and 11.9 % were self-employed. The demography of the respondent thus has a significant impact on the choice of mode of transportation. In addition, the financial status of individuals and household play an integral part in the mode of transportation they use. Table 3 shows the monthly income and car ownership by respondents.

The results showed that only 31.5% of respondents came from households that did not have any vehicle while 68.5% had at least one vehicle. The majority of households, 32.7% and 20.8% were from households with one and two vehicles respectively. Also significant is the 10.1% and 2.4% of respondents coming from households with three and four vehicles. A combined 2.6% of respondents indicated that their households had five or more vehicles. It is clear from the results that car ownership in Gaborone is high. Looking at the individual income of the respondents, the majority of respondents (63.2%) earned less than P2500 while 11.6% earned between P2500 and P5000 and 15.2% earned between P5000 and P10 000. 9.7% of respondents earned between P10 000 and P30 000 and only 0.4% earned above P30 000 and less than P50 000 per month. Affordability of second-hand imported cars in Botswana had made cars accessible, hence the high car-ownership rate. According to Statistics Botswana's (2017) traffic and infrastructure statistics report, 80% of the vehicles bought were used vehicles from Japan (87.3%), while only 19.9% were brand new of which 92.9% were imported from South Africa.

Table 2. Demographic Characteristics of the study sample

Characteristic	Group	Percentage	N = 388	Characteristic	Group	Percentage	N = 388
Age	18 – 25	43 %	167	Occupation	Student	33 %	128
	26 - 35	37 %	145		Part-time	7.5 %	29
	36 - 45	15.5 %	60		Self-Employed	11.9 %	46
	46 - 55	4.1 %	16		Full-time worker	41.0 %	159
Gender	Male	46.6 %	181		Unemployed	5.9 %	23
	Female	53.4 %	207		Student & part-time worker	0.8 %	3

Table 3. Household Income and Car Ownership

Variable	Group	Percentage	N = 277	Variable	Group	Percentage
Monthly Income (BWP)	P0 -P2500	63,2	175	Vehicle Per Household	0	31.5%
	P2500 - P5000	11,6	32		1	32.7%
	P5000 - P10 000	15,2	42		2	20.8%
	P10 000 - P30 000	9,7	27		3	10.1%
	P30 000 - P50 000	0,4	1		4	2.3%
						5
					7	0.3%
					9	0.3%
					10	0.3%

BWP = Currency code for Botswana Pula; P = Currency symbol for Pula

4.2. Transportation Mode Choice/Use

The respondents were asked how frequently they used modes of transportation to determine the modal split. The results are provided in Figure 2. It is explicitly evident that none of the respondents used motorcycles and bicycles were rarely used, with 0.3 % to 1.3% of respondents using them once a week to once a month. The lack of use of motorcycles and low use of bicycles as regular transportation modes can be attributed to a lack of infrastructure, costs and risks associated with motorcycles, social perception and lack of interest in using these modes.

It is also clearly evident from the results that there are high numbers of respondents who do not entirely use each mode. 23.5%, 67.3% and 72.9% of respondents did not use combi, taxi and cabs respectively. These modes are the most common public vehicles. Cabs were the least used mode of public transportation, with most users (17%) using a cab monthly. This is partly attributed to the costs and the Demand-Responsive operational model used by cab operators.

Private vehicles and car-sharing are the two modes directly impacted by rising car ownership. 45.6% and 83.5% of the total respondents did not use private vehicles or car-share with private vehicle users. 54.3% of respondents used private vehicles regularly, either daily, weekly, a few days a week or monthly. Lower percentages of respondents used car-shared at similar frequencies, which highlights the chances of low occupancy in private vehicles. For walking, the results indicate that 38.1% of respondents did not use walking as a mode of transportation, however, 42% of respondents walked daily.

It is important to realize that walking trips to access public transportation are common, therefore, there is a high possibility of these trips being short-distance trips to the nearest bus stop or rank. Students and people making short-distance trips are potential contributors to the number of people who walk on a daily basis as it is the most affordable way to travel. Moreover, 56.7% and 8.5% of respondents used combi and taxis on a daily basis, the most common and affordable modes of public transportation available in the city. These modes, however affordable and accessible, were the least convenient, safe and reliable. Based on the dissatisfaction of public transportation users with combis and taxis, it is presumable that most of the people using these modes were captive users. The use of private vehicles stems mostly from the need for convenience and flexibility rather than affordability and accessibility.

To further understand the purposes for which each mode is used, the respondents were asked to indicate the modes of transportation they used for various activities. Figure 3 shows the distribution and split of modes of transportation amongst activities. The results show that the combi was the most used mode of transportation for the majority of activities in the city, followed by the use of private vehicles. Bicycle and Motorcycle were the least used modes. 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.

Factors relating to flexibility, convenience and freedom may be the reason the respondents chose private vehicles over public transportation for family trips. Taxis and cabs as modes of public transportation were least used for activities, however, a significant 11.1% and 11.6% use of taxis and cabs respectively for shopping was recorded. Due to their demand-responsive nature and ability to operate at any time of day or night, 15% of respondents used cabs for leisure. These are activities that include entertainment, which occurs at night times.

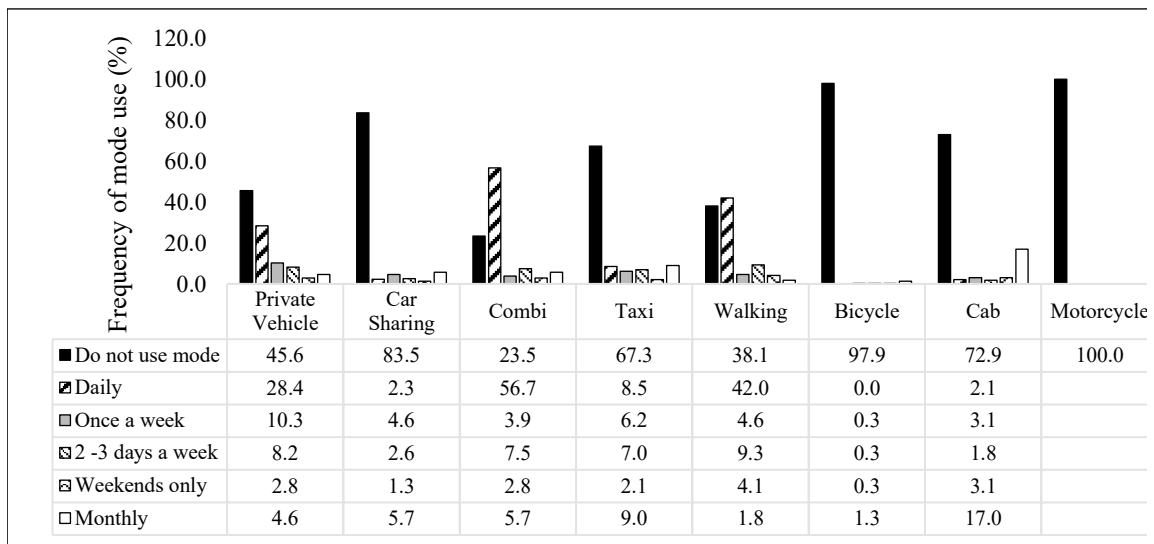


Fig. 2. Frequency of transportation mode use

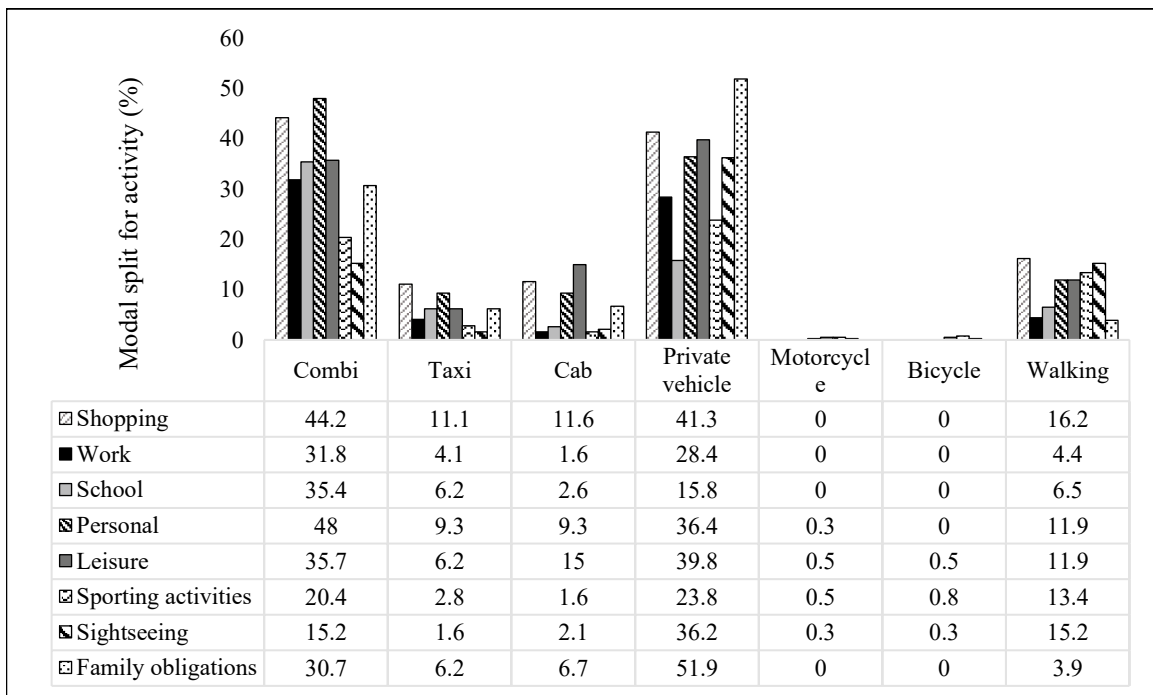


Fig. 3. Modal split for activities

4.3. Current state of Gaborone public transportation

Unsatisfactory public transportation contributes significantly to increased private vehicle ownership. Problems encountered in public transportation are often cited as the reason for acquiring a private vehicle, or a shift from public to private vehicle use. Problems encountered by public transportation users using either combi, taxi or cabs are shown in Figure 4. The study found that combi users have experienced most of the problems with the public transportation system, with overcrowding and delays being the most prevalent. Extended waiting periods for public vehicles, and loud music as well are also common issues experienced by users. Vehicle untidiness was the least encountered problem by users of all modes.

A total of 74.2% of respondents have experienced overcrowding and 72.2% have 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 destinations and 32.5% encountered vehicle breakdowns in combis. In addition, 23.5% of respondents have experienced harassment in combis, 21.1% could not find their bus stops, and 19.3% lost luggage, while 4.9% of combi users have used untidy vehicles. Overall, 12.6% of taxi users wait a long time for taxis, while 9.3% have experienced delays and 8.8% experienced loud music. An additional 5.9% encountered walking long distances from bus 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 bus stops, respectively, while 3.4% were harassed and, lastly, 1.5% of respondents used untidy taxis.

Additionally, 4.9% of cab users have encountered delays while 2.8% experienced long waiting times, and 1.3% encountered loud music and vehicle breakdowns, respectively. A further 1% did not receive their change, while 0.8% experienced harassment and lost luggage, respectively. Next, 0.5% reported not being able to find bus stops, while 0.3% experienced overcrowding and untidy vehicles, respectively. None of the respondents' stops was far from their destinations. The popularity of combis over other modes exposes them to scrutiny from users when expectations are not fully satisfied. Cabs are the least used mode; therefore, fewer people are likely to face any challenges with cabs.

The study further interrogates the resolutions to the problems encountered and only 43.33% of respondents responded indicating that their issues had been resolved to a certain extent, while 1.4% of the respondents did not take any action or pursue the issue further. An alarming 54.9% of respondents indicated that the problems they encountered were never solved.

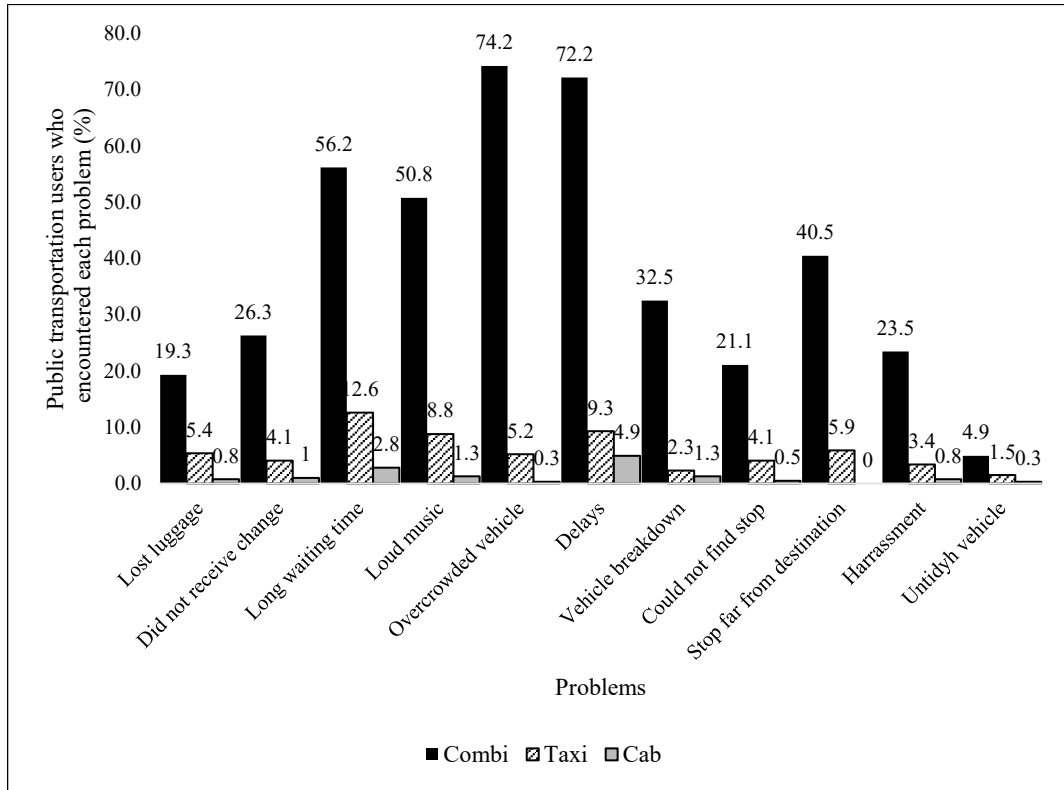


Fig 4. Problems encountered in public transportation

Table 4. Resolutions to problems encountered

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

Out of the respondents who took action to address the problems they encountered, those who had lost luggage in public transport, some indicated that even upon following up and tracking the specific public vehicle they had used for their trips, the luggage was never recovered. Some cited that after contacting the drivers, they could not discover their luggage or items as some passengers were likely to have taken and alighted the vehicle with the misplaced or lost item. Such instances raise safety concerns relating to theft and lack of security.

In instances where the passenger did not receive their change, they spoke directly to the driver and bus conductors who would pay back the change, whereas, in some cases, the passengers would have rendered more money than the fare only to forget until after they had alighted the vehicle and could not go back and identify it. This raises the need for electronic payment systems as well as security features that can show the trail of the money once it leaves the passenger until the payment process is completed.

Long waiting times are one problem which is complex to solve. Respondents indicated that they were left with the option to wait until another combi or taxi vehicle came by, or during morning peak time when most vehicles are capacitated by the time, they reach some bus-stops, the respondents would complete the trip by walking. While some

respondents provided for more travel time to accommodate possibilities of extended waiting time. In most instances, combis and taxis leave their terminals/ taxi rank only when they are fully occupied, hence, some passengers may have to wait until such a vehicle is full, and that may take time. These issues bring to question the convenience and reliability of the public transportation system and as well could lead to deflection to private vehicle use. In instances where respondents had experienced delays, they indicated that they adjusted their schedules by starting their trips earlier to avoid delays.

Loud music in public vehicles, particularly combis, is a source of discomfort to passengers. The music is controlled by the vehicle driver and most often it is for the enjoyment of the driver, often conflicting with passenger interests. Upon asking the drivers to decrease the volume, some respondents indicated that some drivers obliged while some were rude and disrespectful to the passengers and paid no heed to the passengers' requests. One respondent indicated that the driver switched off the music and was apologetic to the passengers. Some respondents indicated that they did not raise any concern about the music with the drivers but rather ignored it even when it made them uncomfortable.

Vehicle breakdowns are inconvenient because they abruptly interrupt trips. In cases where vehicles broke down during a trip, a respondent who used a cab breakdown indicated that the cab company made another vehicle available to complete passengers' trips. Combi and taxi users indicated that vehicles were also made available to replace those that had broken down or boarded other vehicles operating on the route. Some respondents indicated that mechanics were called to attend to the vehicle breakdown on site, while passengers waited before continuing their journey with the same vehicle. Unlike public transportation, private vehicle users are accustomed to their vehicles, they are in charge of maintenance and services of vehicles and although breakdowns are inevitable, vehicle owners still have control of the trip and know the state of their personal cars. Overcrowding was mostly experienced in combis during peak hours, often occurring as a result of lack of vehicles. Passengers resorted to boarding combis which were already full and would ask to share seats with other passengers. Most drivers did not permit the practice as it is punishable by law. Overcrowding causes discomfort and passengers do not enjoy their trips.

4.4. Perceptions of Gaborone public transportation

The respondents' views on public transportation were obtained from both public and private transportation users. 25.1% of respondents had perceptions related to the convenience and reliability of the public transportation system. The perceptions included mostly negative connotations such as “delays most of the times”, “long waiting time” and “it is slow”. Such views could discourage the use of public transportation. One respondent, however, was positively impressed with the reliability of the public transportation system, stating that the system was “reliable”.

The financial perceptions were mostly positive, with 10.9% of respondents indicating that the system was affordable and deemed an essential need. This is particularly the case for those with no access to private vehicles. 3% of respondents indicated that public transportation was a necessity. 4.2% of respondents raised safety and security concerns. Indicating that public transportation facilities were disorderly and lacking security. Respondents further cited the lack of concern for the safety of passengers and other road users displayed by public transportation drivers, stating that the drivers did not usually obey road signs and speed limits. These concerns are also corroborated by the problems that public transportation users had experienced and the lack of solutions, justifying some users' preference for private vehicles.

A further 2.1% of respondents' perceptions were inclined towards psychological factors relating to social interactions when using public transportation as well as personal feelings. Some respondents negatively described public transportation as “depressing” while positive outlooks derived from social interaction among its users who found it useful for socializing and meeting new people were also conveyed. Moreover, some of the perceptions were related to customer service (12.1%) and driver behavior (8.4%), with some respondents explicitly stating, “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. Some of the respondents indicated that the services did not meet their needs as paying customers and that the system was not user-friendly and should provide 24-hour services. Perceptions regarding driver behavior were all negative and included recklessness, disrespectful manners and rude as unpleasant behaviors displayed by the drivers. Respondents indicated that 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.

In relation to infrastructure, 10.9% of respondents indicated that there was a lack of public transportation infrastructure, noting “lack of bus stops”, “limited space at taxi ranks” and “poor infrastructure” as problems. The state of vehicles was cited by 3.5% of the respondents, indicating that the physical state of taxis and combis was not suitable for their daily operation. Responses included “combis too old”, “taxis not roadworthy”, “and “torn chair covers in combis”. These responses also validate safety and comfort concerns, as well as lack of attractiveness, which could derail people from using the public transportation system. Lastly, 2.1% of the respondents expressed negative perceptions relating to comfort in public vehicles. Respondents indicated that the vehicles were “uncomfortable”, while one respondent indicated that the vehicles needed ventilation.

Table 5. Perceptions towards public transportation

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

4.5. Factors affecting modal Shift

Private vehicle users were asked to provide reasons why they preferred using their vehicles rather than public transportation. Most of the respondents used private vehicles for reasons pertaining to 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 visiting clients in remote areas. The respondents also indicated that they used private vehicles for comfort, peace and quiet. Public transportation was not accessible in some areas, leaving respondents with the only option of private transportation. Dislike of the public transportation system was one of the reasons why people chose their personal vehicles in preference to the system.

Private vehicle users were further asked to provide factors that would influence them to shift from private vehicles to regular use of public transportation; these results are presented in Figure 5. Attributes associated with convenience and reliability were the most common among respondents; 67.3% would shift if public vehicles dropped them off at their exact destinations while 65.4% of respondents would be attracted by public transportation offering on-demand services. Safety was also considered an important factor as safer public transportation would attract 56.2% of private vehicle users. A further 41.1% and 35.5% of respondents would be influenced by Wi-Fi and Traveler Information Systems respectively. Wi-Fi provision and availability of Traveler Information Systems are technology-related interventions which can be used to attract more people to the system. 37.1% of respondents indicated that they would change modes if public transportation were cheaper and lastly 21.2% in Gaborone would be attracted by the availability of video games in public transportation vehicles.

Convenience and safety affordability were the most important factors that had the potential of influencing modal shifts. ICT-related factors were the least influential in modal shifts. Reduced public transportation costs and ICT-related components introduced in public transportation would not attract current private vehicle users.

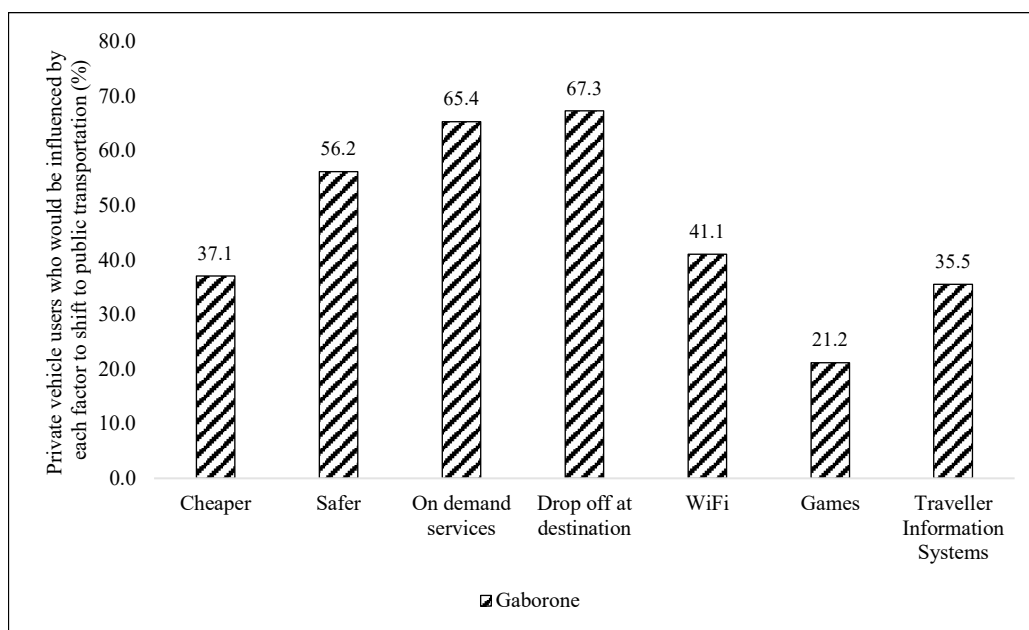


Fig. 5. Factors that could potentially influence modal shift

4.6. Multimodal Integration (Factors influencing mode choice)

Furthermore, respondents were asked to rate the importance of factors that influence their mode choice. These factors were derived from common themes in responses to public transportation problems, factors influencing mode shift and perceptions towards public transportation. The results are presented in Table 6. An integrated multi-modal public transportation system that will provide the most important factors is needed to create a private-to-public transportation modal shift. These factors that affect the choice of transport mode are revealed under three main themes: socio-economic factors (including affordability, convenience, flexibility, privacy, travel time and comfort), physical environmental factors (including accessibility, infrastructure, safety and fuel efficiency), and technological factors (traveler information services, onboard internet, personal entertainment choice).

- Socio-Economic factors

Overall, a significant number of respondents (51.9%, 31.3% and 43.8%) consider the **affordability** of absolute essentials towards using combi, taxi and private vehicles respectively (Table 6) thus, indicating that affordability is important to most mode choice decisions. On the other hand, 39.1%, consider the affordability of no importance towards walking, this may be explained by walking bears no monetary costs. However, over 43.6% of those deeming it absolutely essential may mean that they chose to walk solely because it's free. **Convenience** is very important to absolutely essential for both public and private vehicle users, however, 26.2% of respondents indicated that it was not important when choosing walking as a mode. **Flexibility** was mostly very important and absolutely essential to private vehicle users. With regards to **privacy**, 88.7% of the respondents indicated that privacy was of above average

importance in influencing their decisions to use private vehicles. The results show a great difference when compared to public transportation modes where 67.3% and 71.6% of respondents indicated that privacy was of below average to average importance for combi and taxi use respectively.

Table 6. Factors influencing mode choice

Level of Importance	Factors Influencing decision to travel by												
	Affordability	Convenience	Safety	Flexibility	Accessibility	Travel time	Traveller Information Services	Comfort	On board internet	Fuel efficiency	Privacy	Infrastructure	Personal Entertainment choice
Combi													
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
Average	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
Taxi													
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
Average	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
Private Vehicle													
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
Average	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
Walking													
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

Travel time can be considered a convenience and reliability factor, the results indicate that it is considered by most respondents as of average and above importance. 79.8% as an influencing factor for combi users, 83.4% for taxi use and 87.9% for private car use. Although still highly significant, the lower percentage for combi use might be attributed to high occupancy, longer routes and multiple stops. Taxis are a lower occupancy mode with lower stops hence they are often quicker than combis. Due to the flexibility of private cars, the time taken on trips is lower hence the majority of people would consider the mode to limit the amount of time spent on a trip. Concerning walking, 43% of respondents indicated that travel time was of below average importance whereas 57% indicated that it was of average

importance to absolutely essential. **Comfort** was also found to be of great importance to all public and private mode choices and less important by most respondents concerning walking.

- Physical environmental factors

Infrastructure is also mostly considered average to absolutely essential for all three vehicular modes and walking. Adequate infrastructure will be needed for successful intermodal integration. Parking to accommodate private vehicles in park-and-ride facilities, walking and cycling lanes, and sheltered bus stops are some of the infrastructures that will be needed to accommodate all modes. **Accessibility** of a mode was of average importance to absolute essentiality to public and private vehicle use whereas the results were contradictory with regards to walking, with 31.3% and 30.3% respondents respectively indicating that it was either not important or absolutely essential. Implies that the state of pedestrians' walkways in the city is either "non-existent" to the extent that users do not view it as a need or as integral to their trip making, or the lack of accessibility could be viewed as absolutely essential therefore indicating an absolute need. **Safety** was mostly important to all mode users, showing above average to absolute essentiality to combi, taxi, and private car users as well as walking, even though a significant 25% of respondents indicated that it was not important when deciding to walk. **Fuel efficiency** is important to private vehicle users compared to public transportation users; therefore it can be concluded that a modal shift would eliminate the need for fuel. 76.7% of respondents indicated that it was not important when making decisions to walk, implying that the choice of walking is not related to sustainability awareness.

- Technological factors

Traveler Information Systems were not important to 42.3% of combi users and 27.9 % of taxi users and 25% of private vehicle users. However, a significant 21% and 31.3% of private car users indicated that TIS were very important and absolutely essential. The provision of TIS will therefore be a positive element if integrated into public transportation and could be an opportunity to draw private vehicle users towards public transportation. In-vehicle internet is not important to both public transportation and private vehicle users as well as walking. **Personal entertainment** is less important to public transportation users than it is to private vehicle users. In this regard, public transportation services can incorporate ways to entertain users that attract private vehicle users, but these should not interfere with other passengers' comfort.

4.7. *The Relationship between respondent demography and factors influencing*

Table 7. Cross-classification of mode choice factors by transportation mode and demographic group

Factors Influencing decision to travel by	Age (df = 12) ($\chi^2_{tab} = 21.026$)				Gender (df = 4) ($\chi^2_{tab} = 9.488$)				Occupation (df = 20) ($\chi^2_{tab} = 31.410$) (df = 16) ($\chi^2_{tab} = 26.296$)			
	Combi	Taxi	Private vehicle	Walking	Combi	Taxi	Private vehicle	Walking	Combi (df = 20)	Taxi (df = 16)	Private vehicle (df = 16)	Walking (df = 16)
	χ^2_{cat}				χ^2_{cat}				χ^2_{cat}			
Affordability	12.056	12.30	21.926	17.258	2.710	12.132	2.22	2.589	26.497	21.002	34.668	15.883
Convenience	19.430	1.891	11.246	13.461	2.764	2.744	2.839	0.371	26.151	36.971	39.099	16.926
Safety	10.854	12.704	15.885	22.335	11.156	8.435	1.583	4.924	32.254	22.198	36.875	26.552
Flexibility	25.946	8.470	32.624	19.437	10.600	3.051	1.865	1.044	28.623	19.035	31.366	19.457
Accessibility	13.152	3.647	10.607	17.577	1.088	8.148	7.625	1.984	19.941	26.371	26.171	17.915
Travel time	10.702	7.745	14.665	13.742	2.806	4.137	1.409	4.597	26.161	24.513	34.651	13.433
TIS	17.740	17.500	16.290	31.574	0.542	2.026	2.846	3.143	21.791	28.491	14.55	18.830
Comfort	16.538	12.203	24.630	9.406	3.383	4.468	5.048	6.284	23.498	15.847	34.193	5.902
On board internet	16.946	20.323	32.197	23.609	0.771	4.335	9.563	1.786	29.939	28.329	20.253	16.655
Fuel efficiency	21.697	16.349	14.690	12.979	4.656	2.567	6.417	0.881	22.191	18.934	14.351	15.737
Privacy	15.158	12.314	10.317	10.707	0.431	3.466	11.022	3.734	15.082	14.400	16.917	13.472
Infrastructure	12.794	22.066	24.618	16.161	10.699	5.008	2.010	1.135	30.973	27.663	19.094	18.194
PEC	10.730	14.777	19.830	11.073	5.876	5.020	6.001	3.769	19.515	11.478	7.487	9.954

Shaded portion: associated to each other; Unshaded portion: independent or not associated to each other

- Cross-classification analysis of gender and factors influencing decision

Table 7 is a cross-classification analysis of the respondents' gender and the factors influencing their decision on what to travel by. Considering a 5% level of significance, the chi-square value is 9.488, where the degree of freedom (df) is 4. The calculated chi-square values were higher than the critical value (9.488) for safety and infrastructure as factors influencing their decision to travel by combi, thus indicating there is a significant relationship between the respondents' gender and these factors. Travelling by combi is dependent on gender most especially in terms of safety. The affordability of taxis is related to the gender of the respondent as it influences the respondents' choice. In terms of travelling by private vehicles, privacy and on-board internet is related to respondents' gender as the chi-square values were higher, implying that privacy influences the use of a private vehicle for the respondent. However, no factor influences the choice of walking based on gender basis.

- Cross-classification analysis of occupation status and factors influencing decision

Using cross-tabulation with chi-square analysis, it is worthy to note that there is a relationship between respondent occupation and their choice of what to travel by. Similar to the case of gender, safety and infrastructure are the factors that influence the decision to travel by combi while convenience plays a major role in terms of travelling by taxi. Respondent's occupation might influence the choice to/or not to travel by combi because of safety issues and the current state of infrastructure such as the taxi rank.

Affordability, convenience, safety, travel time and comfort are critical/related factors to be accounted for in terms of respondents' occupation to travel by private vehicle. Respondent's decision to travel by private vehicle in the case of Gaborone is influenced by the aforementioned. Thus, for a successful shift to public transport to take place, there is a need for public transportation to be affordable, convenient, safe, travel time and comfortable for various classes of occupations. Furthermore, it is worth noting that safety is related to respondents' occupation as a critical factor in travelling by walking. Thus, in the case of the respondents for example, students will prefer to walk if it is safe and not necessarily because it is affordable. Overall, it can be re-echoed that age, gender and occupation have an impact on the respondent's choice of what to travel by.

5. Conclusions

The paper established that conventional public transportation in the city of Gaborone is unsatisfactory hence there is a surge in private vehicle use. It is also established that disadvantageous characteristics of public transportation are partly contributory to the surge in private vehicle increase. Although marred by negative perceptions and unresolved problems, the public transportation system is still relevant and largely needed to facilitate human movement within the city. Therefore, within the public transportation systems lies opportunities for improvement through integration with other modes. This begins with reducing the need for private vehicle use and ownership and promoting public transportation as a means to achieving sustainable transportation. Integrated system offering the best of combi attributes, i.e., affordability and the integrating the best of private vehicle attributes into public transportation system, specifically combis. Flexibility, comfort, reduced travelling times and safety. Issues associated with customer service and driver behavior should be addressed by offering customer service training to drivers and conductors.

Lack of constant monitoring of the public transportation system by authorities allows for problems to remain unresolved, as a result, people resort to abandoning the use of public transportation altogether, buying private vehicles as a solution. The high number of unresolved problems in the public transportation system further fuels skepticism towards the mode. General perceptions of public transportation by users and non-users were negative. Positive perceptions were influenced mostly by financial reasons for captive public transportation users. Public transportation was deemed not pleasant and those who had been using the system for extended periods of time were now captive to the conditions. Users referred to the public transportation system as being outdated with a dire need for transformation. Since combi and private cars are mostly in competition for most activities, transforming the public transportation system should result in a system that accommodates all travelers, promotes accessibility and is flexible enough to allow activity participation with no constrictions. Seamless transition between the integrated modes should be incorporated through eased access to facilities.

To reduce the popularity of private cars, use while increasing that of public transportation; common public transportation should be made attractive. To initiate a modal shift, (i) addressing the dissatisfactory elements of the public transportation systems and (ii) integrating new technological and innovative elements into the public transportation system. From the study, dissatisfactory elements identified can be curbed by: Eliminating safety and security threats: this could be achieved by employing security personnel in public transportation platforms and installing security features in vehicles and bus stops and ranks.

Dedicating priority lanes within the road network to public transportation combis and taxis to reduce travelling time and reduce the amount of time vehicles are stuck in traffic. A multi-modal public transportation system integrating innovation and technology should prioritize efficiency and convenience. For example, an integrated payment system which allows for electronic payments will reduce loss of change and improve safety as the need to carry cash will be reduced. Secure Park and Ride facilities to facilitate parking of private vehicles, bicycles and motorbikes in public transportation terminals could promote seamless integration by providing infrastructure and reducing the need for fuel for private vehicles, therefore reducing costs.

Concentrating on providing the best qualities of each mode and eliminating the worst characteristics may enable efficient integration and ultimately the creation of a successful multi-modal integrated public transportation system.

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