THE SOCIAL PERCEPTION AND HOLISTIC ASSESSMENT OF BUS RAPID TRANSIT IN SOWETO

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ABSTRACT

In 2009 the United Nations Environmental Program (UNEP) highlighted the importance of government investment in energy efficient, pollution reducing transport modes and infrastructure. This policy specifically recommended the Bus Rapid Transit (BRT) system as a transport mode to help achieve the United Nation's Sustainable Development Goals (SDGs). BRT is an innovative, bus-based system that integrates the high efficiency of a rail system and the low cost of a bus network. BRT was first developed and implemented in Curitiba, Brazil, in 1974. After the successful adaptation and implementation of the BRT system in Latin America, South Africa saw the planning and implementation of the first BRT systems during the early 2000s, in preparation for the Soccer World Cup in 2010. The first BRT system, named Rea Vaya, meaning "we are going", commenced in 2009, connecting the South Western Township (Soweto) to Johannesburg. A decade after the services started, this paper takes stock of the impacts that the implementation of the Rea Vaya BRT system has had on Soweto residents. A combination of the analysis of secondary economic and environmental data and primary social data provided information to conduct a Multi-Criteria Analysis (MCA). Aggregating phase one and two of Rea Vaya implementation results in a positive Net Present Value (NPV) of R693m, and a Benefit/ Cost-Ratio (BCR) of 1.09. The MCA identifies additional social benefits, giving the BRT a clear advantage over the use of minibus (van) taxis.

1. INTRODUCTION

More than half of the global population lives in urban areas, requiring the consideration and implementation of innovative infrastructure policies and practices to enhance urban living conditions. These policies and practices can contribute to efficient and sustainable development as cities continue to grow (Bassett & Marpillero-Colomina, 2013).

Bus Rapid Transit (BRT) was first developed and implemented in Curitiba, Brazil, in 1974 when the city's mayor, Jaime Lerner, was exploring the possibility of implementing a system that was efficient and low in cost (Patel, 2006). Though the BRT system in Curitiba was not an instant success after the opening of the first line in 1974, it gradually worked its way into the lives of residents. By 1993, the Curitiba BRT was carrying 1.5 million passengers a day (Reed, 2015), and as of July 2019, a total of 170 cities in six continents have implemented 5055 km of BRT lanes, transporting about 33.3 million passengers every day (www.BRTdata.org).

The features of BRT include mixed traffic lanes, curb bus lanes, median busways on city streets, reserved lanes on freeways and bus only roads (Levinson *et al.*, 2003). Reserved lanes are a feature that have been adopted from railway transit, where the road surface is reserved for the exclusive use of the arterial buses (Patel, 2006). This allows the buses to travel at high speeds without motor traffic interference. Stations are situated further apart

than traditional bus stops. Safe and comfortable pedestrian access is provided. Ramps are used instead of stairs for universal access. Station length depends on bus volume, stations typically accommodate two or three buses, whereas busy stations can accommodate four or five buses (Levinson *et al.*, 2003). Ticket purchases are made before entering the platform, this further reduces the time the bus spends at each stop (referred to as 'dwell time'). Similar to train design, bus doorways are wide so that several passengers can get on and off the bus at the same time (Patel, 2006). Station platforms are constructed at the same level as the entry to the bus. This feature, along with the wide doors, significantly reduces the dwell time (Patel, 2006).

The City of Johannesburg (CoJ) Metropolitan Municipality took a landmark decision to support the BRT as its chosen mass transit solution for the city (City of Johannesburg, 2005). In order to improve mobility and accessibility the COJ's *integrated transport plan*, emphasis was shifted to improving public transport systems (City of Johannesburg, 2013). It approved a 122-km network, which would be rolled out in phases until 2013. The long-term vision was to develop Rea Vaya to the extent that it placed over 85 percent of Johannesburg's population within 500 metres of a Rea Vaya trunk or feeder corridor. The objectives of the Rea Vaya project encompassed the fundamental pillars of Johannesburg's competitiveness as a city, including economic, social, and environmental sustainability (City of Johannesburg, 2005).

Traditionally, transport projects are assessed using Cost Benefit Analysis (CBA). In the eighties, Multi-Criteria Analysis (MCA) was developed as a reaction to the limitations posed by a CBA (Levinson *et al.*, 2003). During the nineties environmental considerations were added, followed by the establishment of sustainability assessment, introduced by John Elkington (Elkington, 1998), encompassing a new framework to measure performance in corporate America. This accounting framework was called the 'triple bottom line'.

In 2017, Bruun and Vanderschuren (2017) analysed public transport assessment methods, their ability to assess the effectiveness of transport systems and the differences in indicators included by ten countries in North America, Europe and Africa. Performance indicators, related to the triple bottom line, were used as a guiding principle. Overall, 41 indicators were identified.

Although the study by Bruun and Vanderschuren (2017) established strong trends regarding indicator choice, the available data for the Bus Rapid Transit in Soweto did not provide the required level of information for particular identified indicators. While some of the economic and environmental data was identified, no studies into the social impact of the Soweto BRT had been conducted, thus far, even though Venter and Vaz (2014) hinted that the BRT may 'leverage social benefits in the future'.

2. METHODS

The aim of this study was twofold. Firstly, the study addresses the information vacuum regarding the social impacts of the Soweto BRT. Secondly, the study assesses the impact of the Soweto BRT in a three-pronged approach.

The assessment part of the study applies the traditional Cost Benefit Analysis, calculating the Net Present Value (NPV = Benefits - Costs) and a Benefit/Cost-Ratio (BCR), followed by a more comprehensive (expanded) CBA and a Multi-Criteria Analysis (MCA), to include further environmental and social aspects. A project is considered worth investing in if the

NPV is more than zero or the BCR is larger than one. As public transport projects are implemented for the greater good, the BCR is considered the more important indicator.

The initial CBA includes construction and operational costs, as well as time saving, improved road safety, reduced direct emissions and vehicle operating cost savings. This was followed by a broader CBA, adding land-use and wider economic impacts, such as the contribution to the regions Gross Domestic Product (GDP) and secondary job creation.

Finally, the MCA was conducted to incorporate further impacts, such as user affordability and satisfaction. The weighted sum method, which was applied in this study, is widely used in the MCA for multi-objective optimization. The method transforms multiple objectives into an aggregated objective function by multiplying each objective function by a weighting factor and summing up all weighing's (Kim & De Weck, 2004). The MCA also includes a scenario where services are provided by other modes, such as the minibus taxi, as is prevalent in the case study area.

This study relied extensively on secondary data. An important source of information was the City of Johannesburg website and a study called: 'Economic Assessment of Rea Vaya' conducted by Standish et al. (2012). Where required, these sources were complemented by information for the region available in the South African National Household Travel Survey (Stats SA, 2014).

Primary data was collected during the months of October and November 2017. Surveys were dropped off and collected from random respondents in Pimville, Diepkloof, Orlando, Meadowlands, Kliptown and Jabavu (Figure 1).

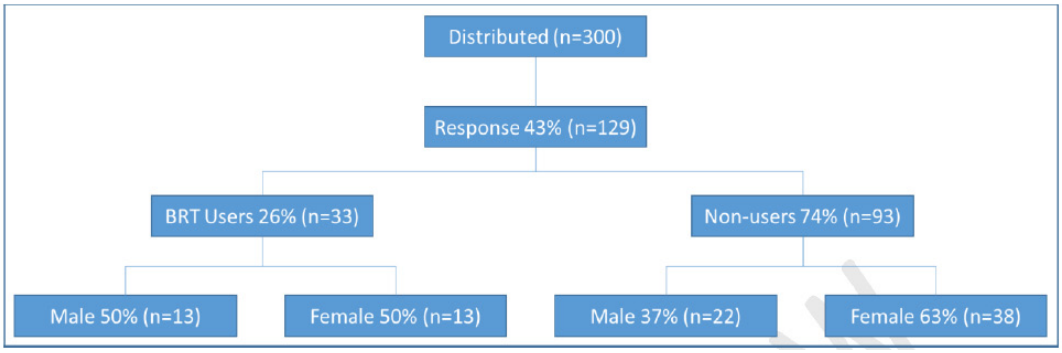

Figure 1: Overview of the Primary Data Response Rates

Data included personal information (gender only), travel information (actual transport modes), as well as opinions (reasons for using/not using Rea Vaya). A sample of 129 usable responses were collected. Although this sample is quite small, statistical analysis on the data revealed a 98% confidence interval for the Rea Vaya (BRT) data, while this was only 85% for minibus taxi related information. As the sample size for the different subareas was not large enough, differences between areas are not analysed in this paper.

In total, 300 surveys were distributed (Figure 2) randomly in the six Soweto areas previously identified. Where possible, people were identified from within their communities to participate in the distribution of surveys. This included individuals utilizing public spaces. The advantage of using a self-completion survey is anonymity, which results in more honest, as well as unbiased responses as the researcher cannot influence how respondents complete the survey. A limitation of this method of data collection was a language barrier, all surveys were completed in English, which may have affected how respondents completed the questionnaire. Overall, 129 useable surveys were received

back, which is a 43% response rate. Considering the way in which the survey was circulated, this is an acceptable amount.

A total of 33 respondents indicated that they use the Rea Vaya, while 93 respondents do not, with 3 respondents who did not indicate whether they use Rea Vaya or not. The gender split for Rea Vaya users was 50:50, excluding 7 respondents who did not disclose their gender, while 63% of non-users were female, compared to 37% male and 33 non-users who did not disclose their gender.

Survey participants had to be 18 years and older, due to the time-consuming method of requiring permission from parents/guardians to interview younger commuters. This presents constraints, since this limit respondents to those who are part of the working class rather than those travelling to educational institutions. Furthermore, over 30% of the population in Soweto is under the age of 18 years old and is thus excluded from the survey.

3. CASE STUDY DESCRIPTION: SOWETO AND THE REA VAYA

Soweto is a township covering approximately 200km2, located in the south west of the city of Johannesburg, Gauteng, South Africa. It is a product of segregationist planning with the objective to house black labourers who worked in mines and other industries in the city centre (City of Johannesburg, 2017). According to the 2011 Census, Soweto had a population of approximately 1.3 million of which 98% was made up of Black Africans. Although the township has a growing middle class, the inhabitants are predominantly low-income, working-class.

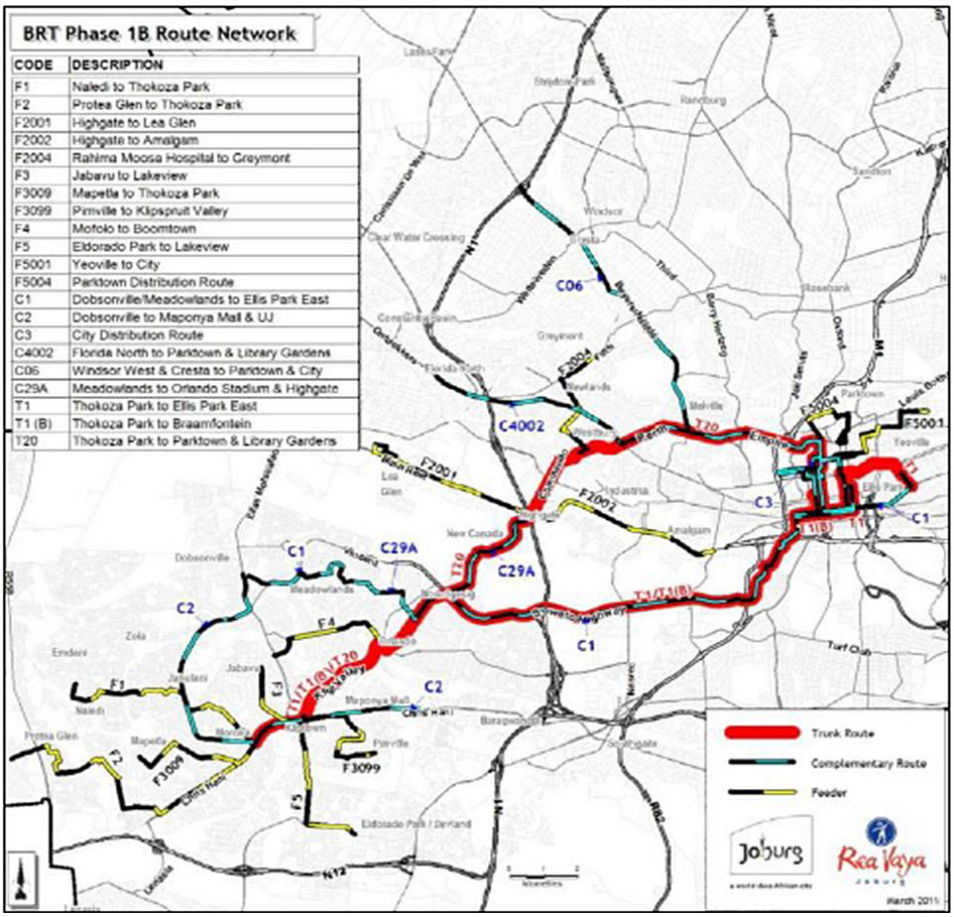

Figure 2: Locality Plan of Phases 1A & 1B including Relevant Suburban Names (Standish et al., 2012)

Operators are paid per vehicle kilometre, while BRT operations across a network of trunk and feeder routes are controlled centrally by the City of Johannesburg. The locality plan includes two phases (1A and 1B), which are included in Figure 2.

4. FINDINGS FROM THE PRIMARY DATA

4.1 Travel Demand of Rea Vaya Users

The majority of Rea Vaya users (85%) use the system four or more days per week. Almost 55% of trips are for work purposes, while 30% of trips are to educational institutions and 12% are shopping trips. Almost 80% of Rea Vaya users indicate that they do have other traveling options. Nearly 67% of Rea Vaya users indicate that minibus taxis would be the most obvious alternative to the Rea Vaya. Not quite 25% of respondents indicate that they (also) have a private vehicle available, while train, bus and Uber are mentioned by a mere 3% of respondents as an alternative.

Almost 55% of respondents indicate that they use Rea Vaya because the travel time is shorter, while 42% of respondents indicate that they travel by Rea Vaya even though the travel time is longer (3% of Rea Vaya users did not respond to this question).

Analysing the time gain or loss for Rea Vaya users, it appears that the majority of users (39%) gain 11 to 15 minutes of time saving, 33% gain 16 to 20 minutes, while another 17% gain more than 20 minutes (See Figure 3a).

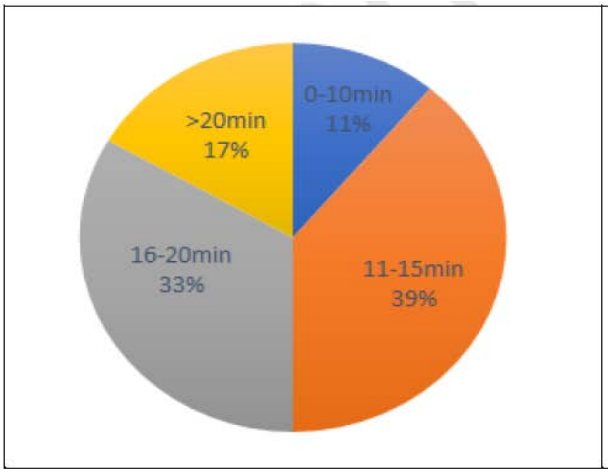

Figure 3a: Time gain for rea vaya users with shorter travel times (n=18)

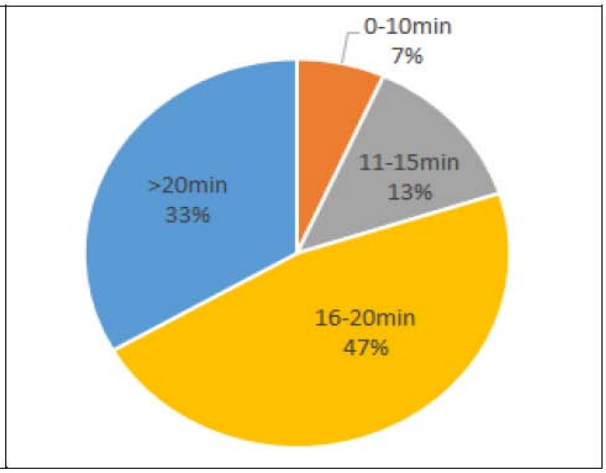

Figure 3b: Time loss for rea vaya users with longer travel times (n=15)

The majority of Rea Vaya users indicate that they use the service despite a longer travel time (see Figure 3b), lose 16 to 20 minutes (47%), followed by more than 20 minutes (33%). Most Rea Vaya users consider the service as affordable. Of these respondents, 14% spent less than R200 per month on transport, 54% spent between R200 and R400, while 32% of respondents who consider the Rea Vaya as affordable, spent more than R400 per month.

4.2 Travel Demand of Rea Vaya Non-Users

The majority (67%) of Rea Vaya non-users did not disclose how often they travel and 66% did not indicate their travel purpose. However, those who disclose their travel frequency,

travel significantly less than Rea Vaya users. Only 31% of the respondents that do not use Rea Vaya travel four days or more per week. Regarding the purpose of the trip, 24% of non-users travel to work, while 10% travel to school.

Respondents who do not use Rea Vaya were asked whether they have used the service before. Some 61% of these participants had tried using the service, however, chose to not continue using the service, as they prefer other modes for their day-to-day travel. The main reasons given by non-users for not using Rea Vaya are displayed in Figure 4.

A lack of convenience (35%) and the distance to the service (33%) are the main reasons cited for not using the Rea Vaya service, followed by the inconvenience of the timetable (8%) and a lack of cover (8%), jeopardizing access to the destination. It is noteworthy that affordability was not indicated more prominently (2%) as significant in the choice of transport mode.

An additional reason affecting choice, communicated by non-users, was that the Rea Vaya timetable did not always coincide with their need to arrive on time to catch their second transport mode in one trip.

Respondents, furthermore, listed accessibility as a reason for not moving to the BRT system as a transport mode. Pensioners also mentioned that the BRT service currently does not offer pensioner discounts, therefore, pensioners have no incentive to move from their current transport mode to Rea Vaya.

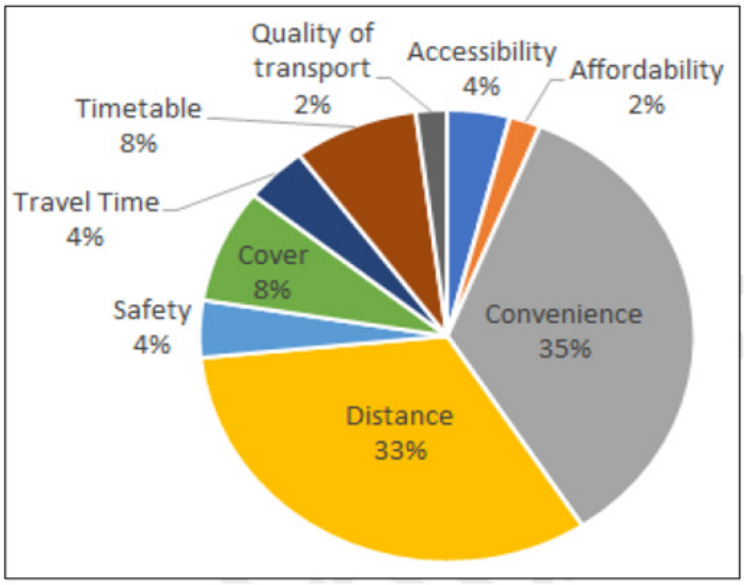

Figure 4: Reasons for Not Using Rea Vaya (n=57)

4.3 Perception of Rea Vaya System

As part of the study, the researchers wanted to establish key reasons why respondents value their transport mode. Safety, affordability, accessibility, travel time and the quality of the transport service were listed as possible choices. Respondents could choose multiple reasons and were given a chance to elaborate whether other reasons were more valuable for them.

Rea Vaya users indicate that they use the BRT service, because of its travel time (33%), its accessibility (33%), the affordability (24%), the quality of the service (15%) and, to a

lesser extent, its safety (12%). It is important to note that multiple reasons were allowed when answering this question.

Respondents that do not use Rea Vaya mostly use a private vehicle (47%) or minibus taxi (42%) to travel. A minority of non-users walk (4%) or take the conventional bus (5%). The reason why nonusers use these modes of transport is given as accessibility (70%), travel time (24%), affordability (20%), safety (16%) and the quality of the service (16%). Respondents indicated that accessibility to the transport system is the leading reason for selecting the transport mode, as commuters are always looking for the most efficient way to travel, especially when traveling to work. This was especially important for commuters using multiple modes to reach their destination, as these commuters may have a small buffer period between moving from one mode to the other.

Affordability is the third most important reason for both Rea Vaya users and non-users when choosing their actual mode. Given the fact that Soweto houses predominantly low-income households, this is not surprising. What is surprising, in the light of previous research (Vanderschuren *et al.*, 2019), was that road safety scores relatively low (12% and 16%, respectively). It must be noted that road safety is distinguished from issues of commuter security during transit and on the way to stations, bus stops and minibus taxi ranks.

The survey data was split between Rea Vaya users and non-users to compare the safety rating of Rea Vaya versus other transport modes (see Figure 5).

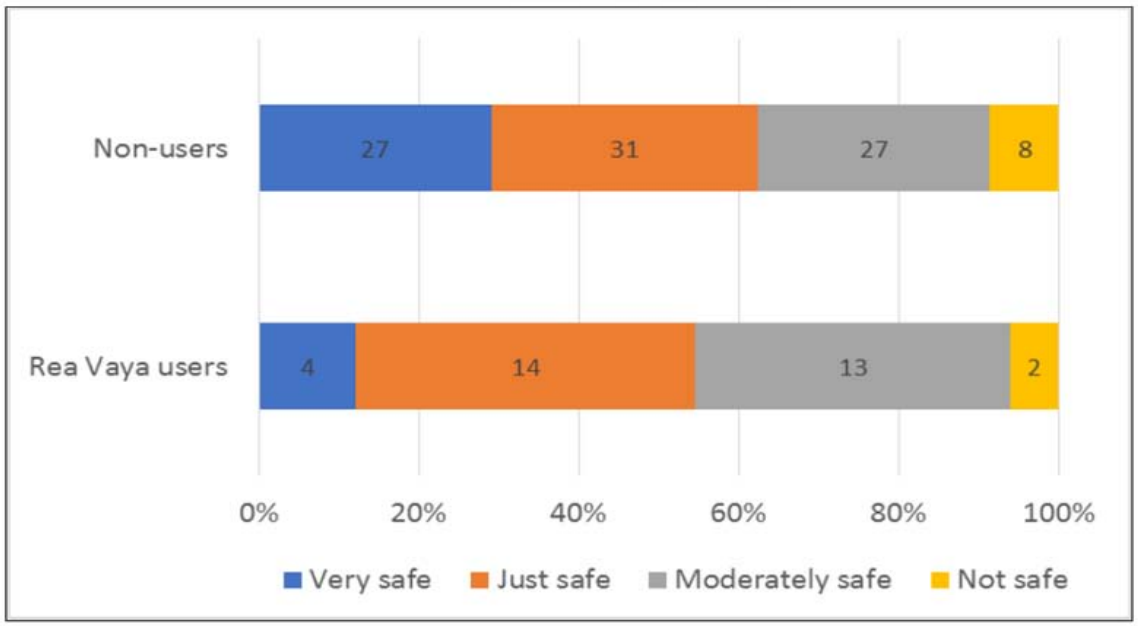

Figure 5: Safety Rating for Rea Vaya Users (n=33) versus Non-Users (n=93)

A larger percentage of non-users feel very safe (29%) or just safe (33%) compared to Rea Vaya users that feel very safe (12%) or just safe (42%).

However, a slightly larger percentage of non-users feel not safe at all (9%), compared to 6% of Rea Vaya users. Respondents indicated that, when commuters choose a transport mode, they are aware of the risks involved with selecting that transport mode. Other aspects are, however, more important.

As part of the survey, the researchers asked participants 1 to estimate the monthly amount of money spent on travelling. The results were split to compare non-users to Rea Vaya users' monthly expenditure on transport (see Figure 6). As mentioned previously, affordability was mentioned as one of the important considerations, both by Rea Vaya users (24%) and non-users (20%).

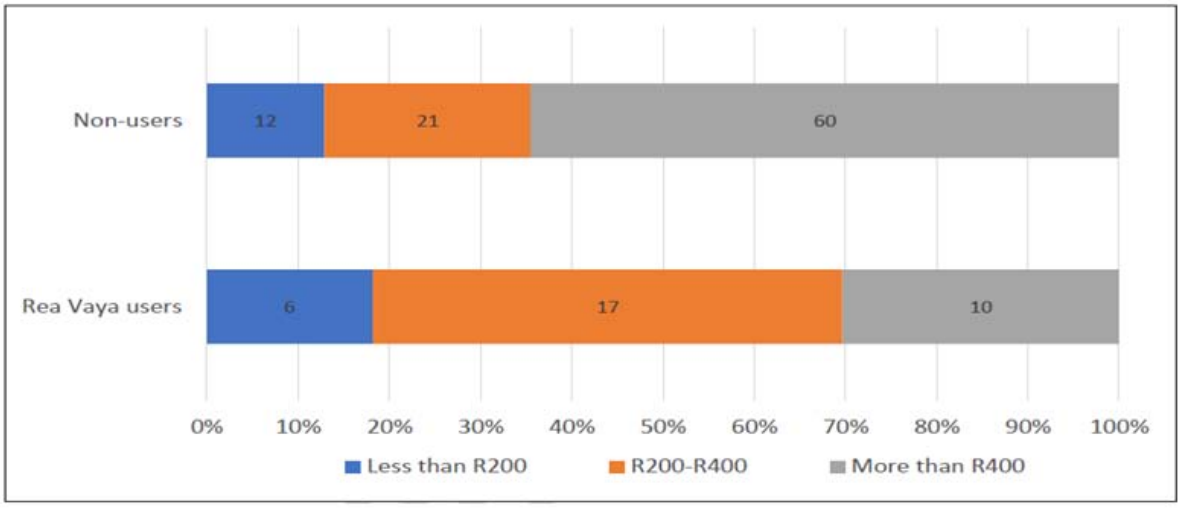

Figure 6: Affordability Rating for Rea Vaya Users (n=33) versus Non-Users (n=93)

Rea Vaya non-users spend significantly more on transport. When analysing the actual costs, it appears that a larger group of non-users spent R400 or more (almost 65%). The majority of the Rea Vaya users spent between R200 and R400 (52%). It is interesting to see that Rea Vaya users travel, on average, more often but spend less on transport. The fact that every journey is charged independent of the number of transfers, is likely to play a role. During the 2017 study period, the maximum charge per BRT trip was R14.10. In the case of the minibus taxi services, users are charged separately in every vehicle.

4.4 Rea Vaya Cost Benefit Analysis and Multi-Criteria Analysis

To justify the implementation of any project, the benefits should outweigh the costs. Based on the information made available to the researcher (Standish *et al.*, 2012), as well as the primary data collected in this study, a CBA and MCA was conducted for the base year 2012.

The total contribution of Rea Vaya to GDP for 2011/12 was R1.91billion. GDP is important, not just because it is income, but because income adds to national wealth (Standish *et al.*, 2012).

Table 1 specifies the categories assessed as either costs or benefits of the BRT initiative. The table compares costs and benefits for the transport related scenario with that of a more elaborate scenario, including land-use impacts, as well as secondary and tertiary employment opportunities. In both columns the construction and operational costs are identical. What differs is the way benefits are calculated. Based on the calculation, the primary transport benefits alone do not warrant the implementation of the Rea Vaya. Only when secondary benefits are added is the BCR for the Rea Vaya elevated to more than 1. A BCR of 1.09 indicates that each Rand invested in the Rea Vaya generates a profit of R0.09 (R1.00 = US$0.07).

Table 1: Cost benefit analysis for transport and elaborated scenario (Standish *et al.*, 2012)

Cost Item	**Transport Related Scenario**	**Elaborate Scenario**
Construction	3 813	3 813
Operational	3 557	3 557
Total	7 370	7 370
Benefits		
Time saving	2 028	2 028
Accident saving	464	464
Reduced emissions	42	42
Vehicle operating savings	3 441	3 441
Land-use changes		197
Wider economic benefits		1 891
Total	5 975	8 063
Net Present Value (NPV)	-1 395	693
Benefit/Cost-Ratio (BCR)	0.81	1.09

An alternative to implementing BRT is to assume that informal minibus taxis provide the transport services. The primary data collected was used to conduct a weighted score analysis for five performance indicators investigated (Table 2). The weighting for each category was also based on the findings of the primary data. Accessibility had the highest weighting as it was valued most highly by the respondents and is, thus, prioritized above other transport mode selection criteria.

Table 2: Weighted sum score for primary data performance indicators

Criteria*	**Weight****	**Rea Vaya**	**Minibus taxis**
Safety	0.10	80	80
Affordability	0.20	80	60
Level of service	0.08	90	80
Travel time	0.22	80	70
Accessibility	0.40	50	70
Total	1.00	69	70

Based on Table 2, it can be concluded that there is no significant difference in the user's evaluation of Rea Vaya's performance from the manner in which non-users value their alternative mode, i.e. the minibus taxis. Combining the secondary (Standish *et al.*, 2012) and primary data, an MCA analysis was conducted. The manner in which the MCA was structured was inspired by literature regarding the triple bottom line (Elkington, 1998). Each of the three criteria were given equal weighting, representing a neutral, academic weighting. Depending on the stakeholder, the weightings can be amended.

In the MCA, the Rea Vaya and the alternative mode were allocated a score based on their combined performance in the data that was received (see also Table 1). Scores were standardized by normalising each criterion out of 100 based on findings from primary and secondary data. Rea Vaya scored 80 for economy, due to its established contributions to the economy. This resulted in the BRT having an overall score of 73, which is 10 points higher than the 63 scored by competing transport systems (Table 3), indicating that Rea Vaya has a higher overall benefit.

Table 3: Weighted sum score using the triple bottom line

Criteria	Weight	Rea Vaya	Minibus Taxis
Economic	0.33	80	60
Environment	0.33	70	60
Social	0.33	70	70
Total	1.00	73	63

5. CONCLUSIONS

Since its first inception in Curitiba in 1974, Bus Rapid Transit (BRT) systems have been developed in various cities around the world. As of July 2019, there are 170 cities with recognized BRT systems (www.BRTdata.org). According to the BRT website, South Africa has 3 cities, i.e. Johannesburg, Pretoria and Cape Town, with recognized BRT systems, moving almost 500 000 passengers in total and including 89 km of dedicated infrastructure. The Rea Vaya, discussed in this paper, is the BRT system running from Soweto to Johannesburg. This system was the first operational corridor in the country.

Rea Vaya users travel mostly for work purposes (55%) and do so for four or more days a week (85%). Most of these respondents (80%) indicate that they do have other mobility options, however, they prefer Rea Vaya. Minibus taxi is considered an alternative mode by most Rea Vaya users (67%). Furthermore, 25% of Rea Vaya users indicate they could use private vehicles.

Most respondents that do not use Rea Vaya, did not declare what their actual mode of transport is, nor what their travel purpose is. Those that were willing to disclose their mode of transport, mostly used minibus taxis. In contrast to Rea Vaya users, only 31% of non-users travel for four days or more and only 24% of non-users travel to work. A total of 61% of non-users indicated that they have used the Rea Vaya service before.

Main reasons for not using the BRT system is a lack of convenience (35%), the distance to the service (33%), an inconvenient timetable (8%) and a lack of cover (8%), i.e. the network does not cover the destinations they want to frequent. Pensioners also mentioned that other services offer pensioners discount, which is not the case with Rea Vaya.

Respondents that do not use Rea Vaya spent significantly more on transport. The majority of nonusers spent R400 or more (almost 65%), compared to Rea Vaya users who spent, on average, between R200 and R400 (52%). The maximum charge per single trip for the Rea Vaya is most probably the reason for this differed, as minibus taxi users will be charged again when transferring to a different vehicle.

Non-Rea Vaya users travel less frequently and not as much for work purposes. It is likely that the percentage expenditure on transport is much higher for non-BRT users. A study conducted one year before this survey concluded that 60% of households in Soweto earn a mere R500/month and spend over 20% on transport (Omarjee, 2016).

The question arises as to whether the BRT system makes socio-economic sense. In this paper, three analyses were conducted to answer this question.

If direct benefits, alone, are compared to the investment and operational costs, it has to be concluded that Rea Vaya is operating at a loss. If secondary benefits, such as indirect job creation and land values, are added, Rea Vaya is making a slight 'profit' of R0.09.

This is much less than the value that was recently established for Gautrain, a high-speed rail connection between Pretoria and Johannesburg, which generates a profit of R1.60 for every Rand invested (Phalama & Mamabolo, 2019). As Gautrain serves a higher income bracket, these results should be compared with caution as high- income travellers are more likely to increase economic benefits.

Using a triple bottom line analysis, the standard economic analysis for Rea Vaya was combined with the primary data, collected in this study, in order to generate a more nuanced tool to assess value. Using the weighted sum method, a more holistic analysis of Rea Vaya, compared to minibus taxis, was conducted. Rea Vaya has a 13.5% higher overall benefit when contrasted with the minibus taxi scenario.

6. REFLECTION

South Africa is a middle-income country, with areas of world-class infrastructure and services contrasting with areas of significant neglect. As a large part of the population lives in relative poverty, the provision of high-level services requires infrastructure and operating subsidies.

Given limited budgets in municipalities and provinces, it is paramount that holistic assessment methods are standardized and applied to identify beneficial projects, including BRT projects. Holistic assessment approaches can also assist in the ranking and prioritizing of investment projects.

In this paper, the triple bottom line was used to assess the sustainability of the Rea Vaya. Bruun and Vanderschuren (2017) identified 41 indicators that would add to the effectiveness of the measurement of the triple bottom line. These were not all incorporated in this study, due to a lack of data availability. Data improvements and a broadening of indicators could provide further insights into the sustainability of Rea Vaya. These initiatives in altering data collection parameters takes time to implement and requires partnerships. In addition, adapting the approach to include sustainable transport indicators, as identified by the United Nations (United Nations, 2016), could also broaden insights.

Last, but not least, the authors are of the opinion that Rea Vaya, and other BRT systems in the country, could consider the use of fare specials to attract and increase passenger numbers. Targeted fare structures could include off-peak discounts for scholars and pensioners. Counterflow discounts, i.e. lower fares for BRT users that travel in the opposite directions to the main peak flows, would also make the system more efficient. The latter might require land-use changes to make travelling counter to the main peak traffic flow more attractive. This is, therefore, a long-term consideration.

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