Investigating the Innovativeness of Public Transport Systems: The Case of Tshwane Rapid Transit (TRT) 'A Re Yeng'

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Abstract

Globally, towns and cities are changing toward more adventurous technology innovations while improving practical transportation systems. In response to this new dawn, the Bus Rapid Transit concept has emerged as an accepted effective, accessible, and dependable mass transit method for innovative systems. Nevertheless, in spite of extensive efforts, benchmarks, and investments in the creation and enhancement of such systems, relatively little research has been recorded on spatial and operational applications of such an innovative transit systems, particularly in emerging economies. The paper therefore investigates the spatial and operational considerations and outcomes of innovative transit systems in the City of Tshwane. The research design was observational and experimental, with qualitative techniques applied to collect perceptual responses. The sample responded to questionnaires and forty participants were obtained. Despite the reality, which BRT contributes to a better transport network, there seem to be strengths and weaknesses which necessitate further investigation. The integration of different modes of public transportation through use of boarding cards is recommended. The public transportation single ticketing system for the City of Tshwane, which seeks to integrate various public transport systems needs further investigation.

Keywords
Rapid Bus Transit System, City of Tshwane, Tshwane Rapid Transit.

1. Introduction

According to the World Urbanization Prospects reports (2014), half of the world populace of about 3.5 billion people live in cities. It is further anticipated that more than Five (5) billion people will reside in cities by 2030. Therefore, overseeing urban areas has begun to emerge as the most pressing development of the twenty-first century. This is confirmed by the World Urbanization Prospects Report (2018), which notes that cities are perceived as areas of high economic activities as well as population concentration. They are also complex spatial formations, which are supported by mobility and service infrastructures (Ritchie et al. 2018). Moreover, the higher the prospects for disturbance in a city, the higher its complexity, particularly when this complexity is not managed effectively. This same effectiveness of a city's provision for services systems has a major impact on its economic and social output. At the local, regional, and global levels, transport infrastructure also has a significant impact on spatial structure. Modern economic processes are characterized by an enormous increase in mobility and accessibility essentials. Therefore, given that cities are home to a significant percentage of the global population, urban transportation issues are critical in facilitating commuter mobility through major urban centres (Gumbo and Moyo 2020). Due to the different modes of transport involved, the variations in origin-destinations, and the volume and variety of traffic, transportation in metropolitan areas is extremely complex (Rodrigue 2020). In many

metropolitan areas across the emerging world, the informal public transit industry contains a large quantity of passenger services (paratransit). These same vehicles are minibuses, privately funded and subject to little regulation. This is in line with the progress of a smarter public innovative system which concentrates on the issue of sustainable public transportation. The South African government has compared itself against all other regions of the world and has opted to follow a universal approach to public transport and its approachability complications through the introduction of the BRT system model (National Treasury Report 2016). Based on the above reviews, the current public transportation system has been revealed as inefficient and lacking integration between the supplementary modes of public transportation such as taxis, and the railway networks. However, despite the introduction of the innovative BRT system, research has shown that only 22% of commuters prefer it. Thus, even though efforts and investments are prepared to improve public transport systems, very little is known about the efficiencies and spatial connectivity of these newly developed and implemented innovations.

The paper starts by presenting the overall introduction and objectives of the study. Research into the BRT concept and existing innovative public transport systems is reviewed. The paper further reviews the spatial planning and integration considerations of innovative public transport systems and focuses on the operational outcomes of innovative public transport systems. The proposed methodology will be discuss, as well as the design approach methods applied to data collection. Presentation and discussion of Tshwane Rapid Transit (TRT) 'A Re Yeng' innovativeness of public transport systems approach. Also the system price scheme in comparison to other modes of Public Transportation in the City of Tshwane. The paper ends by presenting the lessons learned, challenges in data collection and conclusion.

1.1 Objectives
The paper investigates the spatial and operational outcomes of innovative public transport systems: Experiences of Tshwane Rapid Transit (TRT) formally known as 'A Re Yeng'. Its objectives are as follows:;
   a) To review the policy and legislative frameworks of innovative public transport systems, particularly the Tshwane Rapid Transit in South Africa.
   b) To examine the spatial planning and integration considerations of innovative public transport systems, particularly the Tshwane Rapid Transit 'A Re Yeng' in the City of Tshwane.
   c) To assess the operational outcomes of innovative public transport systems, particularly the Tshwane Rapid Transit 'A Re Yeng' in the City of Tshwane.
   d) Examine the possibility of developing a theoretical framework that better informs the spatial and operational considerations and outcomes of innovative public transport systems.

2. Literature Review
Historically, the focus of urban transportation has been on passengers, since cities are perceived as locations of heightened social contact, with complicated traffic patterns related to commuting, money transmitters, and leisure/cultural behaviours (Musakwa and Gumbo 2017). The United Nations (2009) conducted a comprehensive assessment of global planning regimes, which revealed an urgent need to rethink planning for the twenty-first century. There is also an overwhelming majority of emerging metropolis occupants for which public transportation is the only feasible way of gaining access to work, education, social, and economic opportunities. This is especially so since these services are more than a reasonable walking or riding distance away (Adewumi et al. 2013). On the other hand, cities are also hubs of production, consumption, and distribution, all of which are linked by freight transportation. In principle, buses and subway trains make up urban transportation. Cities around the world are therefore collectively shifting toward more innovative technological inventions through the development of viable transportation systems (Deng and Nelson 2011). As part of the response strategy to growing densities experienced by cities, this switch promotes components of convenience, frequency, affordability, and safety.

This innovative rapid transit system had already come a very long way when the first high-level implementations were established in 1974 in Curitiba, Brazil. The system has now been recognized and implemented in more than one hundred and twenty (120) cities worldwide, producing short term intense growth in emerging countries. The innovative transit system model further responds to the provision of innovative public transportation that is more accessible to the larger communities. It makes use of modified transit vehicles, operates in public transit occupancy lanes, and monitors traffic patterns. BRT is a convenient and rapid access to public transport, with the flexibility of a regular and technologically advanced bus network that combines rail and bus transit (Ni 2018). The holistic approach in implementing the system encourages collective efforts for countries to work together to achieve a more integrated approach in providing accessible and affordable public transport systems (Satiennam 2016). The National Bus Rapid Transit Institute (NBRTI) defines BRT as an '*innovative, high capacity, lower-*

cost public transit solution that can achieve the performance and benefits of more expensive rail modes. This integrated system uses buses, specialized vehicles on roadways, or dedicated lanes to rapidly and efficiently transport passengers to their destinations, while offering the flexibility to meet a variety of local conditions. The aforementioned is largely a form of train service utilizing buses'. The system is therefore characterized by a flexible, accessible affordable and Intelligent Transportation System (ITS) that has a unique identity. The transit approach is therefore a facility that only has bus priority lanes and no other system components (Duduta et al. 2015).

2.1 Institution of Innovative Public Transport Systems

Nationwide, ongoing urban growth has led to an increasing burden on cities and towns (United Nations Report 2014). Through this, there is a significant opportunity for better and more efficient infrastructure and range of motion. Thus, the development of public transport infrastructure investment by institutions has become a very important opportunity. To take advantage of such incentives, advanced measures to improve existing urban centres' public transportation will provide a wide range of possibilities. These are beneficial, secure, as well as potentially affordable when compared to the alternative of using automobiles. Effectively, public transport does have the opportunity to connect completely separate cities. Moreover, innovative, well-designed public transit modes are expected to be rapid, pleasant, sustainable, and accessible. Access to affordable, modern technology does provide a viable alternative to vehicle ownership. It may be a significant source of economic and social benefit as well as a contributory factor to greenhouse gas emissions in cities worldwide (Zhang et al. 2020). In terms of policy and legislation background, effective BRT projects are built as part of well-integrated master plans and legislations, which include both a land use strategy and a transportation system.

The Innovative 2030 Urban Agenda (Habitat III) was set by the United Nations. It focused on Housing and Sustainable Urban Development and was designed for cities and municipalities for the coming 20 years. This Agenda 2030 Goal 11 addresses the issue of Sustainable cities and communities, and emphases the need to produce inclusive, resilient, safe, as well as sustainable cities. Its activities are directed to carbon emissions, especially in megacities (Anderson et al. 2017). Innovative public transport systems are heading in the direction of well-defined bus routes sideways exclusive busways, and significant cooperation between spatial strategies and road network design. October 2016 witnessed the innovative public transport system concept approved by Cabinet, together with the instrumental tool titled the Public Transport Strategy which was approved in 2007. The strategy intends to transport enormous numbers of people swiftly and safely to all sections of a metropolis. The BRT system's goal is to link various regions of a city into a network. Furthermore, the administration wants to guarantee that the majority of cities households are no more than 500 metres distant from the bus transit station by 2020 (DOT).

Globally, transportation policymakers seek efficient, sustainable, reliable, as well as equitable transportation networks customized towards local socioeconomic conditions (Gumbo et al. 2021). The system must be comprised of buses which are frequent and have high-capacity lines. The BRT was first introduced in Curitiba, Brazil in 1974 as part of the transportation landscape. Today it includes over 170 cities worldwide and highlights how the Global North may benefit from developing nations' creative transportation solutions (Niezgoda 2019). One of the guiding and informative sources of information is the 2017 BRT Guiding Manual which holistically outlines the BRT standards. For that reason, the transit is defined as a plan to provide sustainable urban transportation of excellent quality (Auer et al. 2016). Only if private car ownership is considered unattractive, will car owners consider the switch to other public modes of transportation, especially Bus Rapid Transit (Bus Rapid Transit Planning Guide 2007). According to Adewumi et al. (2013), the following aspects set BRT apart from current modes of public transportation:

- *BRT integrates buses, stations, and exclusive segregated busways; various intelligent transportation system elements combined to form a strong integrated transit system.*
- *Monitors user views and experiences with public transportation systems.*
- *The constructed environment around transportation station stops and corridors of operation.*

The public transport system has been fundamental in enabling users to access destinations of economic opportunity and flexibility. According to the Statistics South Africa National household travel survey Report (2013), an average working person gets to spend 70% of their income on commuting to work and institutes of economic prosperity. Thus, the main objective of BRT planning is to enhance the desirability of public transportation. The TRT planning intends to boost the attractiveness of public transportation while producing a flexible shift away from private vehicle ridership (TRT report 2019).

2.2 Spatial Planning and Integrations Considerations and Consequences of Innovative Public Transport Systems

Over the last two decades, urbanization has been a major contributor to Southern Africa's economic growth, and this phenomenon is expected to continue, along with high rates of population growth. It is thus estimated that by 2050, more than half of the population of the earth will be living in cities World Urbanization Prospects Report (2018). Therefore, the demand for integration of transportation has increased as a consequence of rising spatial planning patterns and demands. Sustainable transport in general is an integration of viable planning and growth. On the other hand, sustainable Innovative Public Transport Systems are a process that serves commuters desires in terms of flexibility, movement, intelligent technology as well as safety (Wright and Hook 2007). This illustrates even the theory of sustainable development and encompasses application of this same concept of sustainability to a transportation system. The system is then sufficient to service the essential travel needs of the general public without obstruction, with accessibility, and efficiency, interconnecting movement within cities without compromising environmental and human values and in the short and longer terms (Hensher 2016).

The application of innovative public transport systems worldwide is based on the multiple development and testing of primary and secondary data. The outcome of the data then influences the official approval of the innovative system. Additional international structures comprised of the United Nations Development Programme (UNDP), acting through the New Urban Agenda 2030, demonstrate support for the Sustainable Urbanization Strategy Urban Agenda SDG 11. BRT systems thus can be seen to promote and address challenges of the spatial, as well as operational components of the provision of public transport systems. Issues of transformation and integration of cities development are aligned and addressed by the Sustainability Development Goals (SDG). Moreover, a new solution is fashioned through the interchange of ideas, knowledge, and technology between distinct parts of the world, from conception to execution.

2.3 Operational outcomes of Innovative Public Transport Systems

The use of Rapid Transit as a cost effective, feasible public transportation system has grown in favour across the world. Cities throughout the world are moving to more sophisticated, innovative techniques of creating sustainable public transportation networks that offer convenient, fast, efficient, and safe components. These networks were established in response to the growing concerns about the population of the city, and land expansion, especially traffic congestion. Consistent with the Transportation and Development Policy Institute report, planned transit systems had also surpassed expectations whilst also reducing traffic congestion. As a result, time spent on traveling was cut, creating a more convenient, attractive, and reliable city transit system, with a growing habit of preference of commuting through public transportation. When established operators were incorporated into BRT systems, global best practices demonstrated that conflict was reduced resulting in an effective management approach which connected market features to current rights-of-way. The transit system is thus regarded as a cohesive system consisting of facilities, amenities, structures, operations, as well as Intelligent Transportation Systems (ITS) Bus Rapid Transit Planning Guide (2013).

The system has the potential to be a cost-effective mode of transportation for a wide range of cities and suburbs' settings. Furthermore, the systems provide a diverse range of express, limited-stop, or resident all-stop services, thus eliminating the need for sophisticated signal and guideway switching systems Bus Rapid Transit Planning Guide (2013). The transit system may be incorporated into urban surroundings through ways which promote economic growth as well as transit and pedestrian-friendly design. BRT, for example, is used as part of integrated transportation and land-use policies. The ITS smart system is a key factor in the success of the transit system, and it replaces several tasks supplied by physical infrastructure (Auer et al. 2016). The smart system features are utilized to provide passengers with information about the number of seats to monitor bus operations, to offer priority signalized intersections, and to improve security and safety on bus stations, boarding and departing. This also assists in providing track and timing for the previous or future bus (Features of Bus Rapid Transit for Decision-Making 2004).

The innovative transit system uses dedicated traffic flow lanes, which are unlawful for other modes of transportation to use. This protects and specifically excludes the system from peak-period road traffic, particularly at congested crossings. Time-sensitive individuals, such as professionals, students, and those rushing for meetings and other time constrained situations are then able to find the transit system for viable and rapid transport, thus contributing to the marketing of the system.

3. Methodology

The study design was observational and experimental, with qualitative methods applied to collect perceptual information. Both primary and secondary data collection were interfaced between theory and practice. The data was collected through responses to questionnaires and a sample of forty participants. The study investigated the spatial and operational considerations and outcomes of innovative public transport systems, particularly the Tshwane Rapid Transit (TRT). A range of resources were used, such as scholarly books, journals, reports, census reports, and transportation department reports. Secondary data from multiple sources contributed to the argument. The secondary data included existing literature comparing the City of Tshwane to other metropolitan cities and emphasized both the social and economic implications.

4. Data Collection

The collection of data involved a cross sectional, one-time interaction with groups of people. It involved the use of surveys, questionnaires, and interviews which enabled the collection of essential information. Questionnaires were prepared for the commuters using the A Re Yeng system. The sampling method included two groups, the first of these being twenty commuters who were using the system for work purposes. The second group consisted of twenty random commuters such as scholars and others who used the system, and who were questioned either in person or online. The commuters were approached after they exited the bus premises and were asked what their preferred method was for answering the questionnaire, whether in person, over the phone, or by email. Survey and site visits were part of the study to witness and collect information physically.

5. Presentation and Discussion of Results: Tshwane Rapid Transit (TRT) 'A Re Yeng' Innovativeness of Public Transport Systems Approach

Considering the long and complex investments involving transportation systems and infrastructure, South Africa strives to provide a prudent fiscal foundation for the development, operation, and modernization of the essential transportation infrastructure. The public transport within the City of Tshwane (CoT) is known as the Tshwane Rapid Transit (TRT) system. The project's Inception Phase has connected the city centre to Hatfield. The system second phase further connects the Tshwane CBD to Akasia and Hatfield to Menlyn. The TRT has become a high-quality, efficient transportation system which provides rapid and convenient transit ridership through its implementation with designated right-of-way transportation systems, frequent operational activities, and outstanding customer service. Analysis of the city form is characterized by disadvantaged spatial planning from the far west side of the city, while Pretoria east is dominated by spatial planning transformation that is more residential and business oriented. Agriculture dominates the area and in particular, the northerly part of the city.
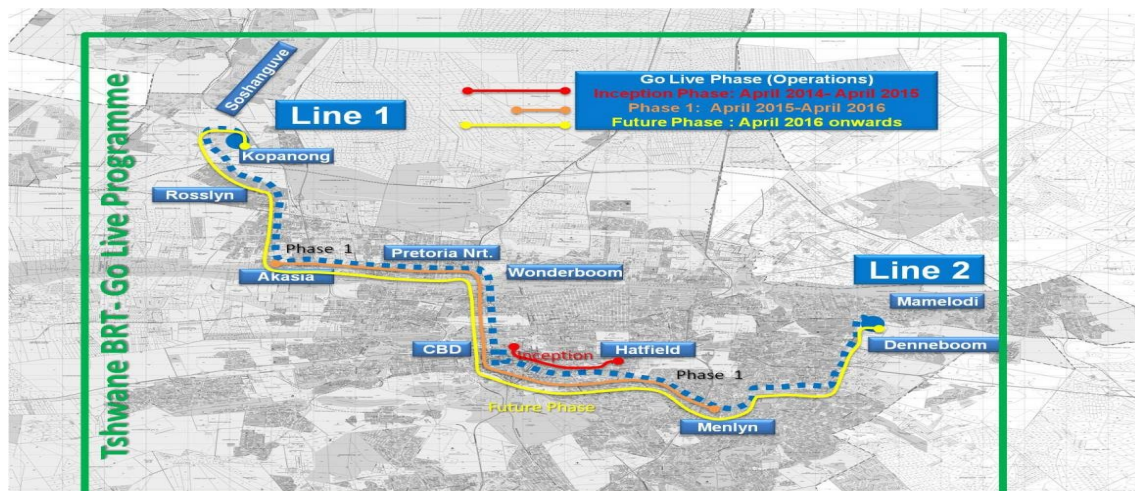

Figure 1: City of Tshwane BRT Network. Source: TRT 'A Re Yeng"

5.1 Policy and Legislative Frameworks on Innovative Public Transport Systems 'A Re Yeng' in the City of Tshwane

In South Africa, various policy and legislative frameworks were adopted or established to effectively govern the delivery of public transport. The White Paper discusses the importance of public transport in increasing mobility and accessibility; *it also certifies public transportation tendering and long-term finance through the tendering*

system). To date, legislation on Integrated Transport Planning, particularly the transport White Paper of 1996, the National Transport Policy, and the 2009 National Land Transport Act (NLTA), have been updated to include in-depth questions about integration of public transport. This transit system advances transport throughout 13 metropolitan cities in all nine provinces; Tshwane is the third city after Cape Town and Johannesburg, to have introduced the transit system. Furthermore, the City of Tshwane through the development of the TRT System is in line with the IRPTN Strategy. This system is described as a *'high quality, efficient transport system that delivers rapid comfortable urban mobility through the provision of dedicated right of way infrastructure, rapid and frequent operations, and excellent customer service'*.

More specifically, the National Department of Transportation (DoT) continues to be the custodian of the BRT system development across the country. The department is also in charge of assisting the development, design, and implementation of the BRT system with policy and law implementation being a critical concept in the system's success. The city has further endorsed the Comprehensive Plan enabling the implementation of the Tshwane Rapid Transit (TRT) system. Within its operating corridors, the TRT service will surpass all competitive road-based public transportation systems. Existing operators who are then affected will be recompensed and otherwise incorporated into the bus operating entity in charge of TRT operations. The Department of Transport. Public Transport Action Plan 2007 remains a fourteen-year-old guiding instrument for public transportation development. It has established guidelines for public transportation networks, so as to increase mobility and accessibility to offer services more efficiently, cheaply, or even sustainably.

The TRT is funded through the National Treasury section under the Division of Revenue Act (DoRA) grant; the Public Transport Infrastructure and system conditional Grant (PTIG) and Public Transport Operation Grant (PTOG) and is overseen and monitored by the National Department of Transport (DoT). The administration made a resolution that a more integrated strategy to support public transportation and a subsidy structure was necessary, and according to the 2015 Division of Revenue Act, has initiated actions in this respect (DORA), Two local public transportation grants were merged into one, and the structure for this new public transportation network award included a promise from the Department of Transportation to produce a draft public transportation subsidy framework (DoT Annual Report 2015/16).

5.2 Spatial Planning and Integration Considerations and Consequences of an Innovative Public Transport System, the 'A Re Yeng' in the City of Tshwane

Historically, inadequate land-use methods, associated with the influence of urban sprawl have significantly influenced the public transportation system. Both of the above are aggravated by public transport services, which are unreliable, unsafe, as well as displaced. The BRT system is an innovative urban public bus transportation plan which reduces congestion, primarily in metropolitan regions and it is a worthwhile public transportation investment, specifically for emerging economies. The technical designs of the BRT fleet as well as features which differentiated them from normal public transport buses were innovative. The city of Tshwane adapted bus rapid transit as a method of swiftly creating a high-quality fast transit system at even a cheap cost. The City of Tshwane continues to follow the National Land Transport Act (NLTA) instructions about how the existing industry may be absorbed and brought under new operating contracts. Moreover, reducing travel times among individuals who reside near BRT stations or feeder lines may provide access to a broader range of work options, resulting in greater availability of jobs, access to advanced quality (or formal) occupations, longer working hours and improved wages.

Walking or cycling has been the most popular means of movement in the Tshwane CBD area, but safety has remained an issue. As a result, the majority of individuals choose to use private automobiles. The A Re Yeng System is one of the city's sustainable, equitable, and traffic-free public transportation options, and its spatial implementation has favourably addressed the distance travelled to access innovative mass transit. The system has been feasible in situating bus stations depending on location, as evidenced by the fact that seventy percent of commuters studied walk to the nearest station. An additional ten percent drive to the nearest station. The frequency with which commuters utilize the A Re Yeng bus is determined by a variety of factors. For example, they reported that they utilize the system for more than one reason, from going to work to shopping and traveling throughout the system. Thus, the percentages reflect not just commuters traveling to work or school purposes but also the total utilization of the bus system. The system's infrastructure thus encourages dedicated lanes and fewer routes for individual automobile owners. A Re Yeng system runs on upgraded routes and intersection infrastructure, furthermore, additional pedestrian walkways at junctions and traffic lights are boosting pedestrian mobility across the city. Some A Re Yeng stations are located in regions with heavy public traffic such as the Nana Sita and Central Stations. The station's spatial implementation has favourably addressed the distance travelled to access

innovative mass transit. Moreover, the system has feasibly situated bus stations depending on location, as evidenced by the fact that seventy percent of sample commuters walk to the nearest station. An additional ten percent drive to the nearest station.

5.3 Operational Outcomes of Innovative Public Transport Systems

The Global BRT best practice demonstrates that incorporating current operators into BRT networks reduces conflict. Subsequently, Tshwane taxi companies have agreed to collaborate on the functioning of the A Re Yeng system, not simply the feeder system. Tshwane Rapid Transit (TRT) is therefore owned by bus and taxi operators who travel on routes served by these two private operators, universally identified through 'Affected Operators.' The TRT operates as a separate business unit, through shareholders benefiting in proportion to market share and is designed to lower travel time and make public transportation "car-competitive". In major cities, this translates to a total trip time of fewer than sixty minutes from door to door (Department of Transport 2007). The TRT is also established through phases to incorporate dedicated bus lanes to median stations that will be strictly utilized by the transit system. The system's primary goal is to ensure that Tshwane residents can travel around and navigate the city conveniently and efficiently by utilizing a modern public transportation system.

5.4 A Re Yeng Price scheme in comparison to other modes of Public Transportation in the City of Tshwane

A Re Yeng operates on a point system with the cost of a journey determined by several points. The commuters utilize a connection card to access the system. The card costs R30, and the cost of journeys is determined by the straight-line distance travelled, and each distance group receives a certain amount of points. The higher the amount loaded on the card, the greater the discount provided by more travel points loaded onto the Connector card. The travel points are valid for three years. (See table 1).

Table 1: A Re Yeng Travel Costs

Km Travelled	Points Per Trip	Price
0 – 3	7	R7.00
3 – 8	8	R8.00
8 – 14	11	R11.00
14 – 21	13	R13.00
21 – 29	15	R15.00
29 – 38	17	R17.00
38 – 48	19	R19.00
48 – 59	21	R21.00
59 – 71	23	R23.00

A Re Yeng Travel cost. Source: https://www.tshwane.gov.za/sites/areyeng Tshwane Rapid Transit 2021

a) Metrorail fares

Metrorail rates are classified into three categories (Metro, MetroPlus, and MetroPlus Express).To board the train; you must purchase a ticket at ticket offices located in the stops. Below is the table that shows the fees per travel according to kilometres.

Table 2: Metrorail Rates Travel Costs

Km Travelled	Price Per Trip			
	Single	Return	Weekly	Monthly
1 - 10km	R7.50	R14.50	R46.00	R142.00
11 - 19km	R7.50	R14.50	R46.00	R142.00
20 - 30km	R8.50	R16.50	R50.00	R160.00
31 - 50km	R9.50	R18.50	R60.00	R190.00
51 - 100km	R11.50	R22.50	R75.00	R235.00
+100km	R12.50	R24.50	R80.00	R252.00

Metrorail Rates. Source: http://www.metrorail.co.za/Newfares.html 2021

b) Tshwane Bus Services

Tshwane Bus Services systems have taken a similar approach to BRT in that commuters may only use the bus if they have a valid card system. To board, you must have a bus card, which can only be purchased at bus offices at strategic places, mostly in the Tshwane CBD. Below is the bus cost per trip.

Table 3: Tshwane Bus Travel Costs

	Up to CBD Point	Beyond	Connection Ticket
	Tickets: Monthly		
Adults	R225.00	R490.00	R635.00
Scholars	R185.00	R150.00	R315.00
Disabled	R195.00	R195.00	R315.00
Pensioner	R 175.00		Not specified
	Tickets: Weekly		
Adults	R80.00	160	R310.00
Scholars	R50.00	*not specified*	R100.00
Disabled	R55.00	*not specified*	R110.00
Pensioner	***Not specified***		

Tshwane Bus Services Systems Rates. Source: https://www.tshwane.gov.za/sites/Residents/TshwaneBusSerivces/Pages/Bus-Routes

c) Taxi Industry

Taxi rates are fixed and are not based on the distance travelled, and the basic rate does not consider the passenger's destination. The use of cash is appropriate for all journeys. The below table also shows the standard which is not based on kilometres per trip but the overall journey.

Table 4: Taxi Travel Costs

Km Travelled	Price
Central to Sunnyside	R18.00
Sunnyside to Hatfield	R18.00
Central to Hatfield	R18.00

Taxi Rates. Source Taxi Industry services 2021

d) Metered taxis and e-hailing

A taximeter is a mechanical or electrical device fitted in taxicabs and auto rickshaws to compute passenger fees based on distance travelled and waiting time. Its abbreviation, "taxi," is also a metonym for the rented automobiles that utilize it. This method of travelling is only based on the travel per distance.

5.5 Summary of the tables

When compared to typical metro transit systems, innovative transit systems offer a significant improvement. They employ modern buses and stations; and dedicated lanes including smartcard payments which improve public transport as well as provide better service to passengers. However, Technology can also be costly. The rapid system costs are more than the Metrorail and municipal buses systems but are expected to be comparable with the minibus-taxi service. Ten percent of commuters interviewed stated that there have been breakdowns or delays on the buses at times, but ninety percent stated that they had never had trouble. Thus, despite the additional expenses, South Africa's investment in rapid systems is already on par with several systems in Latin America and Asia, per kilometre of the busway. In addition, compared to other modes of public transport, the majority of users find the A Re Yeng system to be very affordable. The greatest portion of the sample indicated that travel time is reduced since bus lanes are more exclusive, allowing the bus to move faster than other modes. Commuters are also satisfied with the system's reliability and performance when compared to other modes. Nevertheless, even though transit contributes to a better transportation system, there are triumphs and failures to be considered.

The top functioning innovative transit systems around the world, according to ITDP (2013), are mostly in Bogota, Colombia, as well as Guangzhou, China, with scores of 93/100 and 89/100, respectively, considered to be the gold standard. Global south cities such as Lagos, Nigeria's capital have developed an innovative transit system that is based on the public transport needs and provision of infrastructure according to what the city can afford (Amiegbebhor and Boluwatife 2018). The transit system has been inspired by the practices in Bogotá, Colombia, and other cities, however, it has been altered to fit a Nigerian budget but with commuting time constraints (Amiegbebhor et al. 2014). The whole method enables the collaboration of multiple agencies, as well as the land use and spatial master plan for the state (Omoruyi et al. 2018). More locally, the establishment, consideration, and development of the innovative transit system in South Africa was based on benchmarking, examination, and survey finds. Following these findings, a decision was made to develop and implement this concept. The implementation so far has been designed to intensify the popularity of bus public transportation including the impact on the modal shift away from individual passenger cars within Tshwane. The operating performance of

the innovative transit system surpasses all competitive road-based public transportation systems. When it comes to the number of passengers served by each city's innovative transit system, Guangzhou, Curitiba, and Brisbane have the highest daily totals of BRT passengers according to the statistics on key metrics per city (See Table 5 below). Nigeria, on the other hand, is ranked second-to-last on the table. Tshwane is categorized as substantial but also has lower passenger numbers. Thus, despite Transit's potential to contribute to a successful public transport system, passenger demand varies significantly throughout different cities, depending on the socioeconomic as well as the spatial location of such an innovative transit system.

Table 5. Key Indicators per City

Cities	Passengers Per Day	Number of Cities	Length (Km)
Guangzhou	850,000 (19.42%)	1 (2.63%)	23 (3.4%)
Brisbane	356,800 (86.32%)	3 (42.85%)	28 (31.73%)
Curitiba	721,500 (6.68%)	7 (7.44%)	74 (8.82%)
Nigeria	200,000 (40.68%)	1 (20%)	22 (16.74%)
Tshwane	3,400 (3.04%)	2 (33.33%)	14 (15.85%)

BRT System Statistics. Source: www.brtdata.org, January 2022

6. Lessons learnt and implications

The current growth as well as operation of BRT systems across South African municipalities has experienced challenges regarding sustainability and profitability. Governments will need to explore different methods to fund mass transit. Solutions also include charges for automobile usage including parking in urban locations but also collaboration with property developers to create public transportation interchanges as a business enterprise. Achieving these goals will necessitate a broader discussion as to whether South Africa desires the overall benefits of enhanced mass transit as well as how to compensate for it. The funding level provided by the National Treasury through grant allocations is adequate to supply the system. There is a larger need, however, to establish a strategic plan that will govern the use of these funds, ensuring that they are spent efficiently and reliably and reported properly. When compared to other Southern African developing countries, South Africa has already progressed in terms of public transport provision. A significant amount of capital has been directed into advancing the public transport industry to convey South African commuters cheaply, safely and efficiently (Mwanyepedza (2017). The successful A Re Yeng phase may adopt a more bottom-up approach, in which public transportation is characterized as a communal system which includes different modes and the public's active involvement. Such will be critical for future phases of any public transportation system. Operational planning and management, as well as alignment, are thus critical to the overall performance of public transportation.

6.1 Challenges in Data Collection

The A Re Yeng implications for the spatial and operational components of Tshwane's transit system has been the subject of this research. The study sample was not scientifically representative of other modes of public transport such as private automobile users; though data offer interpretation of a variety of concerns the City of Tshwane may wish to address.

7. Conclusion

A sustainable public transport system is socially acceptable, satisfies passenger requirements, is affordable to the poor, and is financially sustainable (Adewumi et al. 2013).

7.1 Policy and legislative frameworks on innovative public transport systems, particularly the Tshwane Rapid Transit in South Africa

Various policy and legislative frameworks have guided effective governance and delivery of public transport. The White Paper discusses the importance of public transportation in increasing mobility and accessibility; it also certifies public transportation tendering and long-term finance through the tendering system. A Re Yeng is well defined as a high quality, efficient innovative transportation structure providing quick, pleasant urban travel using dedicated lanes and is funded by the National Treasury under the Division of Revenue Act (DoRA). Long-term plans, such as the National Master Plan (NATMAP) 2050 and the Gauteng Master Plan are what transportation-planning systems must address. This planning process should not only address the short term but should also give an impression for long term planning which acknowledges the spatial patterns within South African cities, and also how this pattern can be aligned and changed to accommodate an integrated, accessible transport system.

7.2 Spatial planning and integration considerations and consequences of innovative public transport systems: 'A Re Yeng' in the City of Tshwane

A Re Yeng system is a component of the approach addressing mechanism which views public transportation as a system. The system will be a comprehensive answer to the City of Tshwane's difficulties in the creation of

enhanced public transportation. Public transportation is a critical component of urban sustainability, and its quality needs maintenance to retain current customers and attract new ones. Enhancing operational efficiency, standardizing prices but also timetables, and improving accessibility with interchange facilities are all ways to make public transportation more appealing.

7.3 Operational outcomes of innovative public transport systems, particularly the Tshwane Rapid Transit 'A Re Yeng'

The goal of integrated transportation planning is not only to add new modes or to guarantee that there are many modes available. Rather, the goal is to influence some sort of "competition" between the various modes based on their distinct benefits and drawbacks. African Cities began to construct BRT systems in the 2000s to create or supplement foundations of transportation networks. Cities such as Lagos and the City of Tshwane pioneered BRT as an inexpensive but dependable substitute to railways and mini taxis (Finn et al. 2011). Other countries such as China contributed significantly to BRT acceptance by introducing completely electric fleets, which demonstrated to be extremely cost-effective. Overall, one of the most successful and effective implementations found has been Australia. Where ridership on Brisbane's BRT has now exceeded expectations, increased the proportion of people who utilize public transportation and cut passengers' trip time (Mallqui and Pojani 2017).

7.4 Proposed model informs the spatial and operational considerations and outcomes of innovative public transport systems

BRT should be properly linked with other public transit systems throughout to enable further passengers to use it and support its operation. Further, to extend the network of BRT utilization, the system should particularly collaborate with minibus-taxis and other municipal bus services. Thirty percent of the total commuters disagree that the bus is more accessible than some other modes of transportation, while a majority of seventy percent agree. The study proposed the development of an integrated approach to the City of Tshwane public transport network in achieving integrated sustainable public transport. This proposed model informs the spatial and operational considerations and outcomes of innovative public transport systems. The A Re Yeng transportation system in itself will not be a comprehensive solution to the City of Tshwane's difficulties in the creation of enhanced public transportation. Public transportation is a critical component of urban sustainability, and its quality needs maintenance to retain current customers and attract new ones. Enhancing operational efficiency, standardizing prices and timetables and improving accessibility with interchange facilities are all ways to make public transportation more appealing. The goal of integrated transportation planning is not only to add new modes or to guarantee that there are many modes available. Rather, the goal is to influence some sort of "competition" between the various modes based on their distinct benefits and drawbacks.

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