

## Evaluating the Impact of Innovative Public Transport Systems: a Case of South Africa

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### 1 ABSTRACT

The Fourth industrial revolution has created new realities on the spatial growth of urban areas. One interesting phenomenon is the innovative public transportation systems that have emerged in the developing world. Developing countries such as South Africa have seen a rapid improvement in mobility systems, with the introduction of innovative public transport systems such as bike sharing services, bus rapid transport and high speed trains. Building on these innovations is the concept of big data, which has enhance the development of information dissemination systems. The objective of this paper was to review innovative public transportation systems and develop an index to determine the sustainability of these systems. Using an explorative approach the innovative public transportation systems were assessed in relation to the spatial development of land parcels within their proximity. Preliminary results reveal locations within close proximity to the high speed train stations are highly accessible, as there are connected to more one or two other traditional mobility systems which has increased the rate of multi-modal trips in these zones. Although bike sharing services are present in major metropolitan cities, few commuters utilise these services for commuting trips. In conclusion the innovative public transportation systems have improved mobility in the city, however, currently interchange zones between these modes are still limited which has adversely affected the rate of multi-modal commuting. Also economic opportunities over time for citizens have increased in location within close proximity to routes of these innovative mobility systems.

Keywords: Innovative public transportation, Connectivity, Multi-modal, Sustainability, South Africa.

### 2 INTRODUCTION

Public transportation has over the past decade evolved. Notable examples include the introduction of high speed trains, bus rapid transportation and ride sharing servies. In developing world there has been a growth of interest in the concept of innovative urban public transport systems. Innovative public transportation uses optimal efficiency to improve the commuting experience as a whole. Within the innovation sector of transportation planning, literature focuses on implementation and dissemination of transportation infrastructure and service delivery. However, there is a large gap in the literature related to empirically evaluating the outcomes associated with public transport innovation (Novak, 2015). Whilst there is literature on how innovation can guide policy development, there is still a need for more research that evaluates the impact of innovation on mobility trends. To address this city authorise have developed models to ensure sustainability within the transportation sector (Geurs & van Wee, 2013; Yatskiv & Budilovich, 2017).

With the urban population growing at such a rapid rate, transportation planning is consequently faced with challenges of optimisation of services and infrastructure. Improving the commuting experience is essential in bridging the inequality gap in most developing countries. Developing countries have set a sustainable urban public transport (PT) trend, through the adoption of improved urban PT standards which facilitates transformation through initiatives such as using non-motorised transport, improved urban PT and mobility systems and providing pedestrian walking zones in cities previously dominated by automobiles (Veeneman, 2016; Pojani & Stead, 2015).

### 3 LITERATURE REVIEW

PT is an essential means of mobility for any city and it's dwellers (Potter & Skinner, 2000). Public transport provision provides for the needs of the urban dwellers while providing functionality to a city and it's economy (Cardinale et al., 2014; Ryser, 2014; Schwabergger, 2014). Central to urban public transport is the ability to be accessible, reliable, convenient and affordable to the commuters, making movement from one location to another possible (Scoppetta, 2014; Szczech, 2014; Tan et al., 2008; Zhou, 2014). In this regard,

urban public transport paves a way for economic, social, health and environment aspects of a city and its dwellers to thrive providing better livelihoods. Significantly, urban public transport plays a crucial role in reducing private motor vehicle use, traffic congestion and environmental pollution in cities across the world. (Tanahashi et al., 2012; GMA, 2013; Tillner, 2014).

Urban PT has vastly evolved into a concept of better possibilities. Moreover, it has become the theatre of innovative ideas, opportunities as well as a platform to collaborate with different sectors in development. Although there is no common definition for innovative, there are still many concepts surrounding the term (Cobbinah et al, 2015). The concept needs to be unpacked as it has elements lined to being smart and the Fourth industrial revolution (4iR). Countless authors have exhausted meaningful means to epitomize the concept of innovative public transportation systems and many cities in the global north and south are in the process of implementing the concept as thorough and best as they can (Zhukova & Smirnova, 2014).

Emerging research studies on mobility have focused on factors which have historically reflected the various levels of accessibility such as distance or time between points of origin to destinations (Castillo & Benitez, 2012; Nil & Naciye 2004). In this interplay of public transportation provision, innovation is not limited to creating new services and improving existing ones. Innovation is also required to reduce transactions costs, enabling commuters to reach their target destinations. Improved travel time, connectivity and information dissemination are a few of the innovations that have been introduced to improve the commuting experience (Legara et al, 2014; Novak et al, 2015; Perl & Goetz, 2015).

In an international context, different methods have been created to obtain new knowledge to develop innovative urban PT, with some researchers focusing on smart cities (Giffinger et al., 2007), transport economics and urban geography (Miller, 2013; Gao et al, 2013). Agostino et al., (2014) have articulated in developing urban public transportation for an agglomeration, technology can be instrument for improving mobility. Currently, the state of urban public transport in most developing countries is gradually improving as evident in South Africa and Ethiopia that have implemented innovative public transport systems namely high speed railway systems and bus rapid transportation systems in their metropolitan cities (Wilkinson, 2009; Yatskiv & Budilovich, 2017).

Building on such innovations over the years have been new phenomena such as the concept of big data, which has enhance the development of information dissemination systems. Big data has also been described as “datasets whose size is beyond the ability of commonly used software tools to capture, manage and process the data within a tolerable elapsed time. The integration of urban public transport and big data has significantly enhanced the manner in which authorizes manage and monitor spatial interests. Nonetheless, though the potential merits of implementing urban public transport are vast, most African cities are still to integrate them into their daily practice, as most do not have the required mechanisms to do so (Ambrosin et al, 2014; Cardinale et al, 2014).

Given such a background, the physical structures of PT systems encompass the road networks, railways, routes and stops represented by a multifaceted network of spatial and temporal data (Ceder, 2007; Hadasa et al, 2014). Kittelson & Associates et al., (2003), hence have expressed that in order to measure or analyse the connectivity of PT systems, one needs to focus on three key factors: Firstly, the geographic location, that is area where the service is offered. Secondly, the temporal aspects, that is the time factor associated with the service and lastly focus must be given on information that is how accessible is information regarding the service.

Contemporary, information and communication technologies (ICTs) allow public transportation providers to tap into previously inaccessible sources of demand by establishing an instantaneous connection with the city (Geurs et al, 2013; Maleckia et al, 2014). This opens up new possibilities in origin and destination (O-D) analysis as people move around with various mobile devices which are constantly sending information to the internet, such as cell phones, tablets and smart watches. This will allow for more accurate location of trip distribution and also trace the various movement networks. As internet of things (IoT) has led to nearly every device and human being locatable and interlinked (Farooq, et al., 2015). This has greatly made man’s life simpler and transformed how decision making is done, as information is now shared almost instantaneously and at times automatically. However with this interconnectivity concerns of information security have arisen and a call for new means to ensure data is secure arises (Farooq, et al., 2015). With the right capabilities, technology-driven structural change in public transportation systems, greatly reduced travel-times for

commuter. Notable examples have been the high-speed trains, ride-sharing services, and bus rapid transportation.

#### 4 STUDY AREA

Recognising that developing cities are different, we assess the metropolitan cities namely Johannesburg, Pretoria, Ekurhuleni and Cape Town in South Africa (see figure 1). All the four cities are run by an elected executive mayor from a political party. The Gauteng economic hub is made up of three metropolitan cities namely Johannesburg, Tshwane and Ekurhuleni. The innovative public transportation connecting the Gauteng economic hub is the Gautrain, a high speed train (figure 2). Johannesburg is the commercial capital of South Africa with a population of 957 441 people and a surface area of 1,645km<sup>2</sup> (Stats S.A, 2011). The Rea Vaya is a rapid bus transportation which connects commuters from the south of the city to the central business district of Johannesburg (Figure 3). Pretoria is located to the north of Johannesburg as is known as the administrative capital of South Africa with a surface area of 687,5 km<sup>2</sup> and a population of 741 651 people (Stats S.A, 2011). A Re Yeng is a rapid bus transportation, which connects commuters within central Pretoria (figure 2). Ekurhuleni lies to the east of Johannesburg and is known as South Africa's manufacturing hub with a population nearly 3.2 million and a surface area of 1,975 km<sup>2</sup> (City of Ekurhuleni, 2013). Harambe is a bus rapid transportation currently being implemented in Ekurhuleni, which is still at the initial stages of operations. Cape Town, located in the Western Cape province of South Africa has a population of 433 688 people and a surface area of 400,3 km<sup>2</sup> (Stats S.A, 2011). MyCiti is a rapid bus transportation which connects commuters in central Cape Town (figure 3).

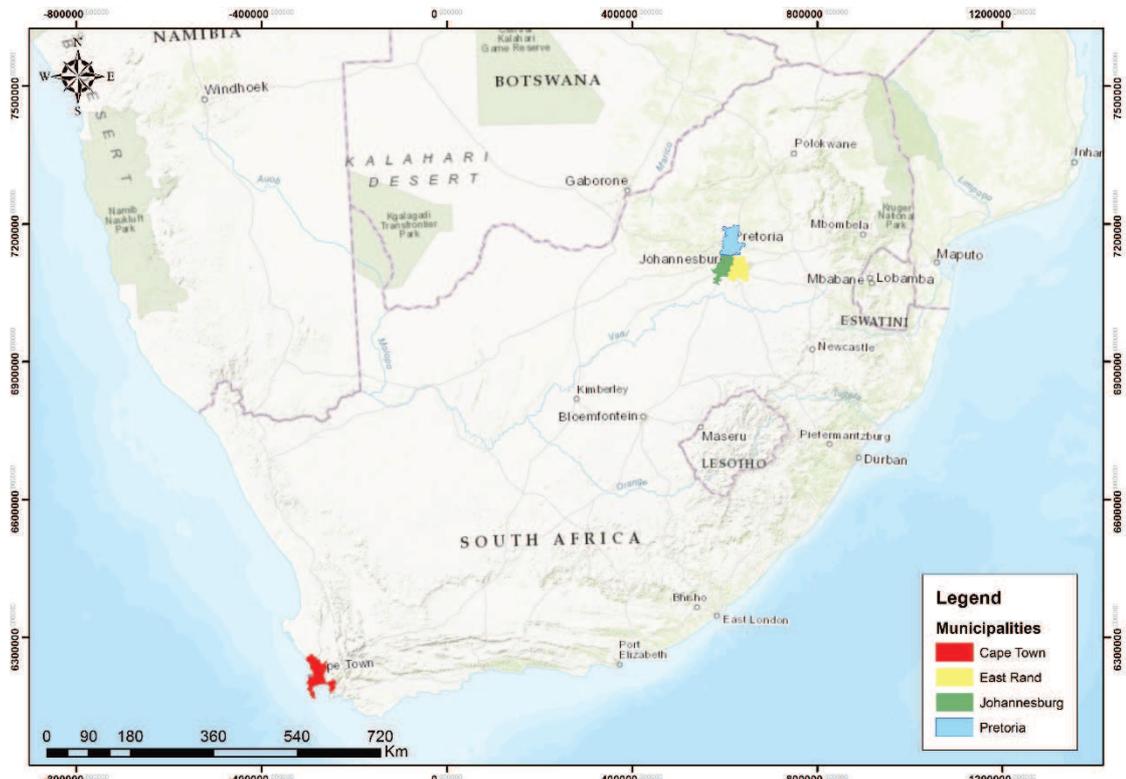


Figure 1: Study Area

#### 5 METHODOLOGY

Using an explorative approach the innovative public transportation systems in the metropolitan cities were assessed in relation to the spatial development of land parcels within their proximity. Key informant interviews were also used to unpack the status quo of urban public transport systems; while spatial data (GIS Shapefiles) are used to visualize rail and road route networks of the urban public transport systems. Consequently a workshop was conducted with a group consisting of four spatial planners (i.e., urban and transport planners) from the four metropolitan cities and 16 masters students from the University of Johannesburg. An index was developed that ranked the public transportation in the cities (see figure 4). For

the various mobility systems each was ranked using the developed Index factors and was given a score from 0 to 100.

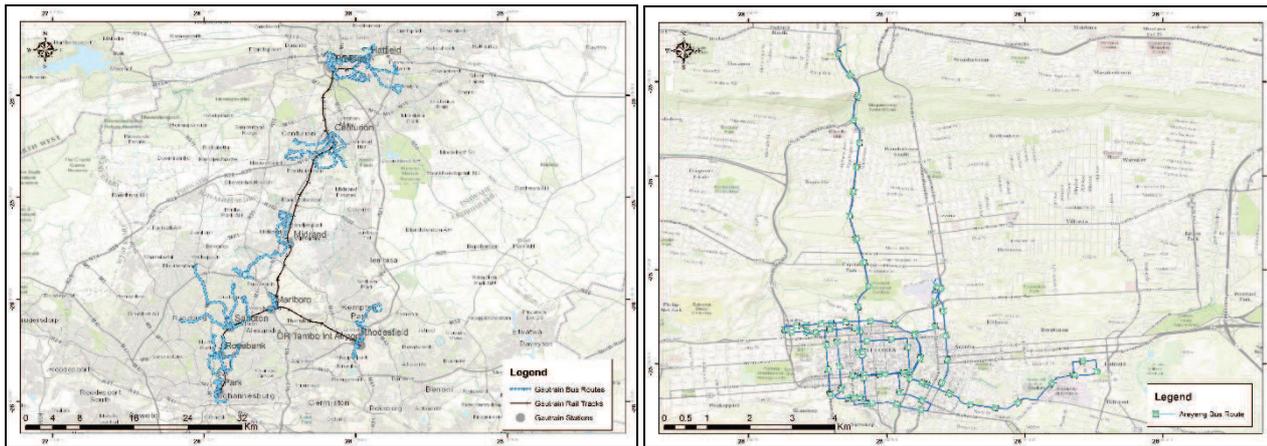


Figure 2: Gautrain (Johannesburg, Pretoria and Ekurhuleni) and A Re Yeng (Pretoria)

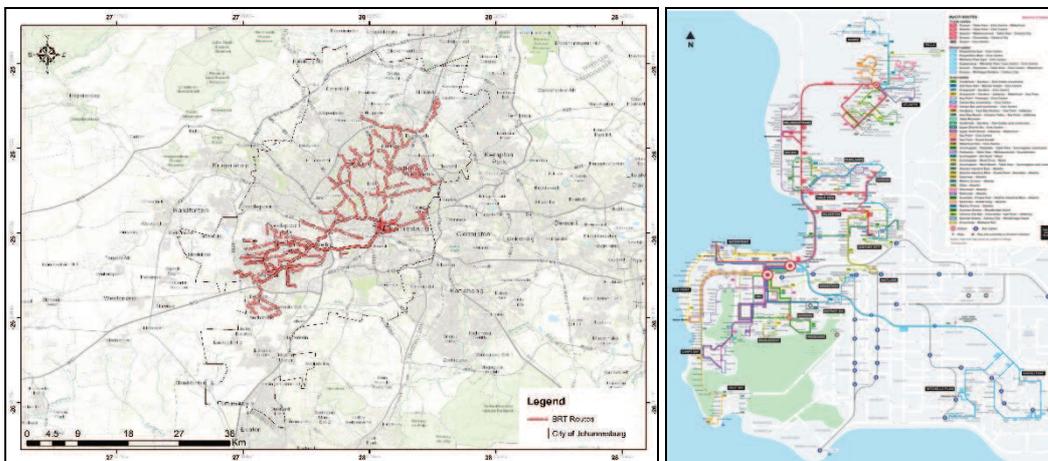


Figure 3: Rea Vaya (Johannesburg) and MyCiti (Cape Town)

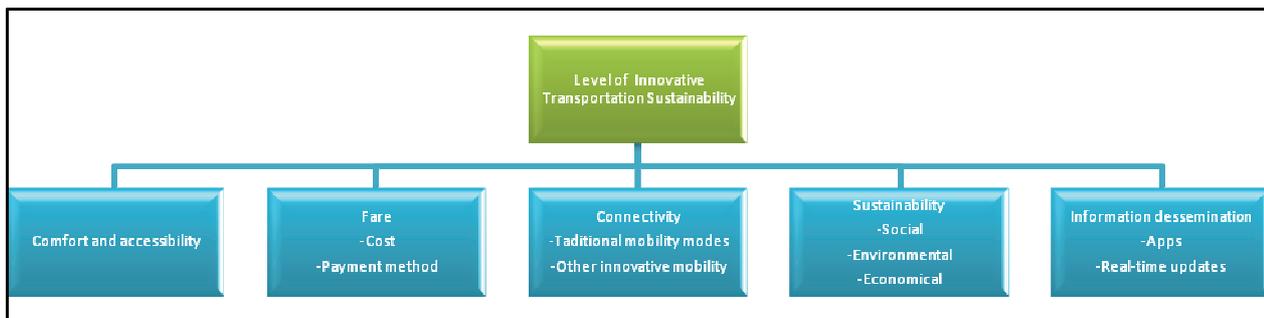


Figure 4: Index factors

## 6 RESULTS AND DISCUSSION

The results from the initial discussion concerning spatial connectivity of within the metropolitan cities (see figure 5) reveal certain locations along the innovative public transportation routes namely Braamfontein, Rosebank CBD, Sandton CBD in Johannesburg, Pretoria CBD and Kempton Park in Ekurhuleni are highly accessible, as there are connected to more than two or three traditional mobility systems (mini-bus taxi and other bus services) this which has increased the rate of multi-modal trips in these locations. Regarding connectivity to alternative mobility modes bike sharing services are present in major metropolitan cities, few commuters utilise these services for commuting trips. This has led to most commuting trips in these cities being undertaken either using road or railway based public transportation systems. The innovative mobility modes were then assessed using the index factors as shown in figure 5. The results reveal variations on the utilisation of technology by the various public transportation providers such as the payment method, with A

Re Yeng and Rea Vaya yet to develop a mobile payment method. Also there are variations in the target groups with the Gautrain targeting commuters within the middle to upper class, whilst all the three rapid transportation targeting all income groups, however with jey focus on the middle income group.



Figure 5 : Innovative mobility modes in relation to Index factors

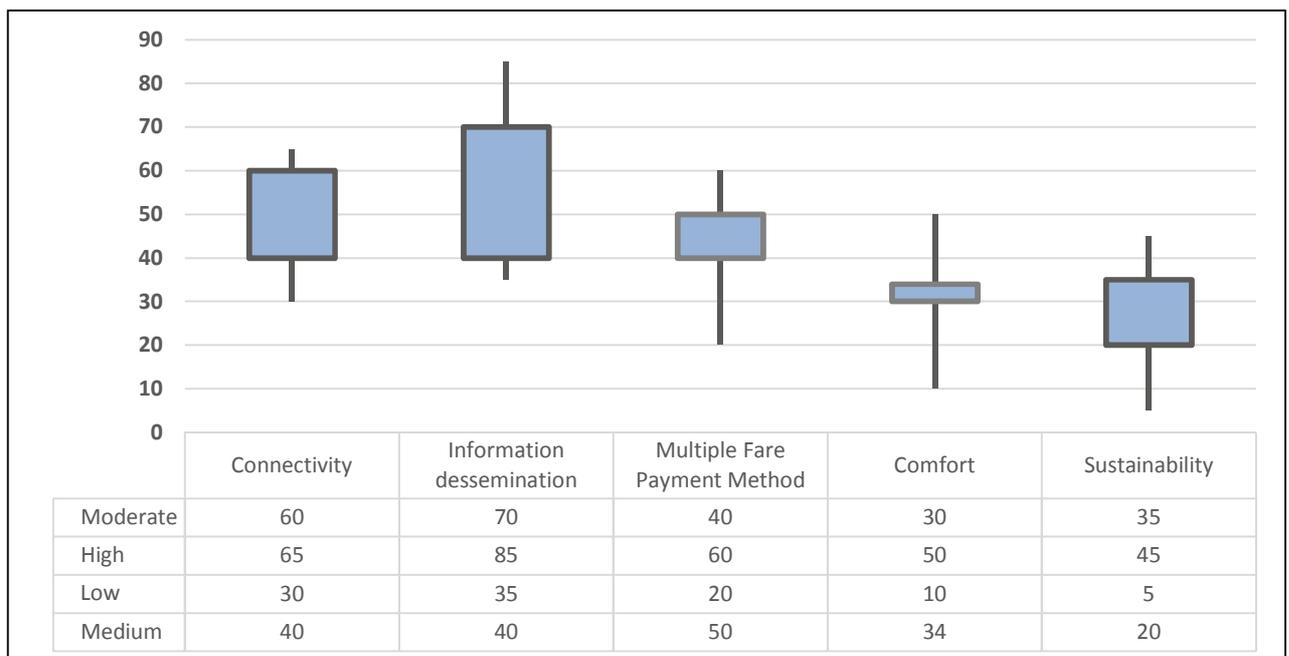


Figure 6: Gautrain

In Gauteng the initial intention for investment in innovative mobility was to improve the economic efficiency of the rail system and consequently enhance the market share of the rail public transportation system compared to road public transportation services. A second goal was to reduce travel time between and within the metropoliatn cities. The creation of high speed train was the innovation introduced. The ineffectiveness of the existing rail public transportation required an introduction of a new railway line, in the form of the Gautrain. Using the index (figure 6), the Gauteng has a high connectivity level to numerous public transportation networks. Investment into social media applications has greatly enhanced information dissemination, which has led to many commuters utilising the Gautrain app, to obtain fare rates, timetables and also to plan their commuting trips. Commuters have also welcomed the tag-in and tag-out system, which can be done with either the train card or bank card. With regards to comfort, the train is reasonable comfort however commuters have expressed the need for more comfortable seats at the train station. Lastly with regards to sustainability over-time, the high speed train has the potential to be the backbone to introduce more innovation into the existing public transportation system.

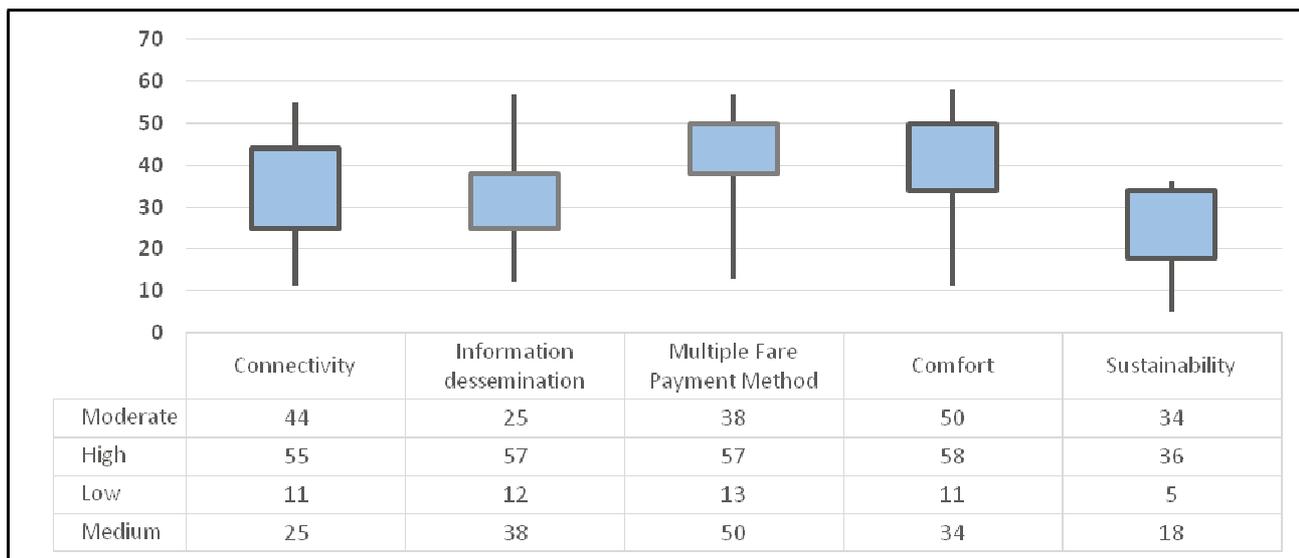


Figure 7: Rea Vaya

In the city of Johannesburg, the Rea Vaya (bus rapid transportation) connects commuters from the south of the city to places of economic interest, namely the Central business district in Braamfoentin, Rosebank and parts of Sandton. The route network connects commuters from Soweto (which has a population of over 1,2 million) to their work places. With such a high demand, this has led to the municipality investing on infrastructural upgrades to support the system. Commuters can either use cash or bank cards to load money on a smart card, which allows them to pay for commuting trips and tag-in and out of the bus stations (see figure 7). Regarding comfort and sustainability, commuters have highlighted concerns with the payment system as the online payment network is unreliable which has led to commuters seeking alternative commuting modes. However given the high demand for connecting from Soweto to the CBD, the continued investment into the Rea Vaya would greatly improving the commuting experience in the region.

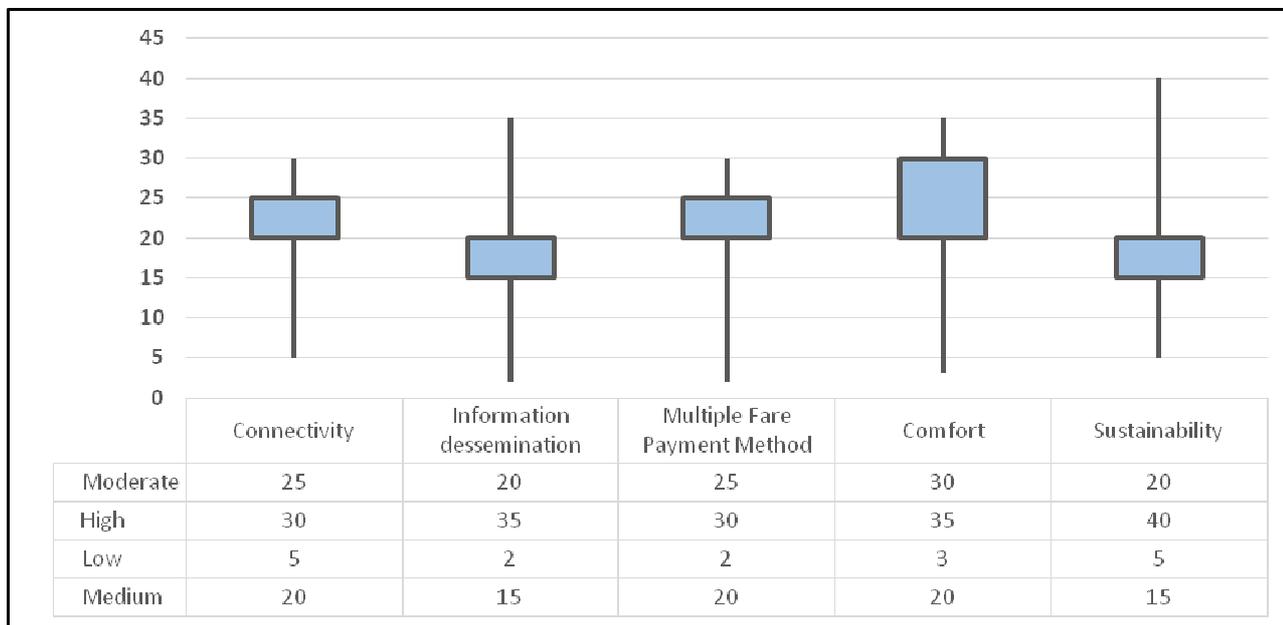


Figure 8: A Re yeng

In Pretoria the A Re yeng was recently introduced to improve mobility within the city’s CBD. The bus rapid transportation, is within close proximity to traditional public transportation networks, however more A Re yeng bus routes are still required (figure 8). Information dissemination is currently based on traditional means, namely signage at bus stops and little socia media usage. Fares can be made at disgnated stations, however commuters cannot tag-in with other means. There is still a need to expand the route network to ensure sustainability of the system.

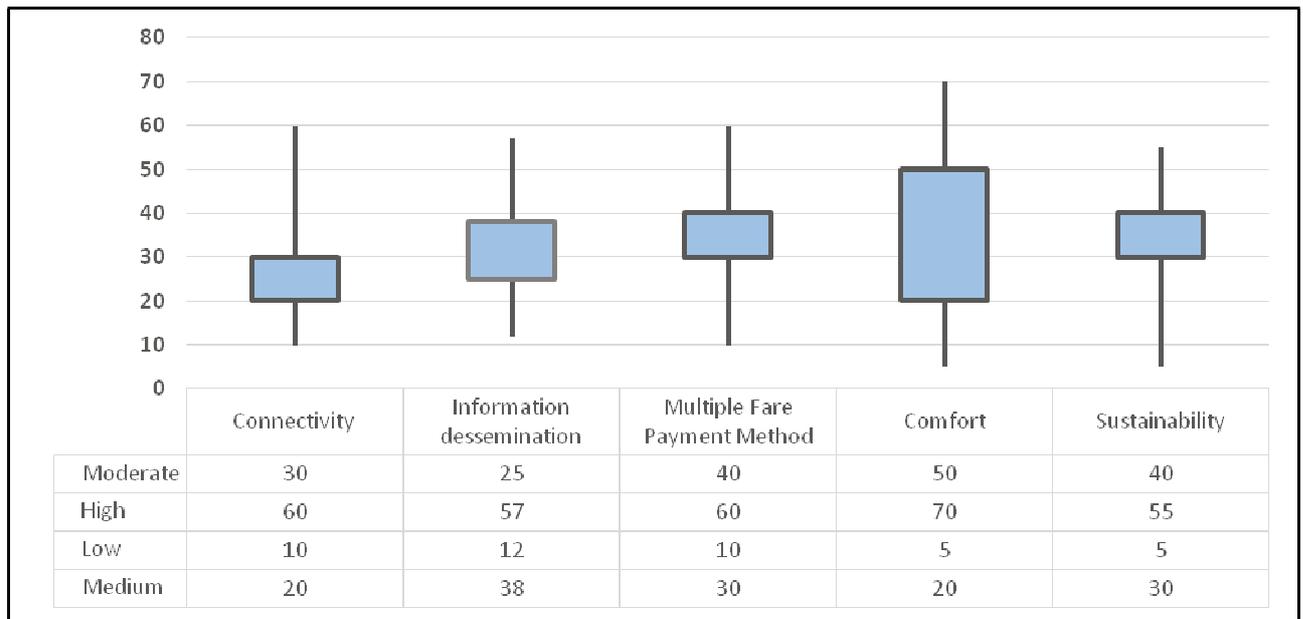


Figure 9: MyCiti

Technology utilization in current public transportation systems, promises to increase commuter ridership. In the city of Cape Town, MyCiti (bus rapid transportation) is a notable example of innovative public transportation. The route network is well connected to other existing public transportation systems, namely train, ships and road based public transportation systems (figure 9). The smart card used for boarding the bus can be utilised to make purchases at select shopping centres. Regarding comfort and sustainability, commuters have outlined the seats are functional and comfortable. The smart-card has over the years been praised for the multi-useability, this which has lead to an increase in commuting trips undertaken using MyCiti.

## 7 CONCLUSION

In this paper from a spatial perspective, we observe that transportation routes are along commuter points of interest which as some advantages but is not always the best solution to ensure decentralisation of development. Moreover, the preferred solution for one operator does not necessarily coincides with the national public transportation system’s best solution. In conclusion the innovative public transportation systems have improved mobility in the city, however, currently interchange zones between these modes are still limited which has adversely affected the rate of multi-modal commuting. Also economic opportunities over time for citizens have increased in location within close proximity to routes of these innovative mobility systems.

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