

# Exploring the Applicability of Location Based Services to Determine the State Routes Transport Networks Integratedness in the City of Johannesburg

*Brightnes Risimati, Trynos Gumbo*

(Brightnes Risimati, Masters scholar, University of Johannesburg, Department of Operations Management, P.O Box 17011, Doornfontein, 2028, brightnesrisimati@gmail.com)

(Dr Trynos Gumbo, Senior Lecturer and Head of Department, University of Johannesburg, Department of Town and Regional Planning, P.O Box 17011, Doornfontein, 2028, tgumbo@uj.ac.za)

## 1 ABSTRACT

In cities of the developing countries, particularly in African, Asian and Latin American continents; there have been growing concerns in terms of the state of public transportation systems. One of the main among the concerns have been lack of well-integrated, reliable and efficient public transport systems. This is particularly so in urban centres, due to rapid growth of the urban population coincided with the end of colonialism, giving rise to large scale economic, spatial and structural transformation of urban landscapes. The consciousness of the need for well-functioning innovative public transport systems by all spheres of governments and the private sector institutions has prompted precipitate action in the past decades to invest in innovative transport systems. Conversely, just like any other rapid growing metropolitan municipalities in developing and emerging economies, the city of Johannesburg has not been released with regards continuous public transport challenges. In the past decade, the City of Johannesburg has actively participated in the development of the first fast train system; the Gautrain in conjunction with two other metropolitan cities within the province. To support the innovative train system, the city also invested in and developed the Rea Vaya; a rapid bus system. However, the state of connectedness of the rail and road route networks within the city have not been well documented. Therefore, this study aims to delineate the extent routes network integration among Gautrain and Rea Vaya within the Johannesburg urban public transport system and how working relationships could be improved. The study adopted a phenomenological case study survey design that applied mixed-method approaches to gather spatial, qualitative and quantitative data. The exploratory approach was used to formulate the research problem for precise investigation whilst the descriptive approach was used to gather complete and accurate information. Research techniques such as crowdsourcing, interviews, social media was used to collected data. Whilst data analysis and interpretations were conducted with techniques such as main content analysis, Geographic Information Technologies and Echo-Echo. Research findings; indicate that there are limited areas where the route networks between the public transport systems are connected. The large sections of the networks are disintegrated. The work recommends conscious efforts in planning and developing both rail and road route networks that are integrated to promote efficiency of public transport systems.

Keywords: integration, route networks, urban public transport, multimodal integrated system, rail-networks, City of Johannesburg.

## 2 INTRODUCTION

In cities of the developing countries, particularly in African, Asian and Latin American continents; there have been growing concerns in terms of the state of public transportation systems. One of the main among the concerns have been lack of well-integrated, reliable and efficient public transport systems. This is particularly so in urban centres, due to rapid growth of the urban population coincided with the end of colonialism, giving rise to large scale economic, spatial and structural transformation of urban landscapes. The consciousness of the need for well-functioning innovative public transport systems by all spheres of governments and the private sector institutions has prompted precipitate action in the past decades to invest in innovative transport systems.

On the other hand, mobility in urban context is continuously adapting and transforming to quotidian challenges, as can be perceived with the global shift towards smart city planning. This shift towards encourage communities to utilising multi-mobility modes and public transport in their everyday commute has led to a lessening in the negative impacts of private-car-dependence (such as congestion which has become a norm in major roads in urban areas) in the developed cities (Miranda and Rodrigues da Silva, 2012). Typically, sustainable urban mobility describe movement patterns or city transport networks, which are utilizing active travel modes, energy efficient renewable forms of energy, or shared vehicles wherever

possible, resulting in low carbon output per commuter journey (Banister, 2005). Integrated multimodal networked public transport have emerged as a mobility paradigm, utilizing transfer potential to provide maximal service for a reasonable and efficient operating budget, providing a genuinely feasible alternative to the automobile travel for many trips within urban areas (Goodwin et al., 1991).

Conversely, just like any other rapid growing metropolitan municipalities in developing and emerging economies, the city of Johannesburg has not been released with regards continuous public transport challenges. In the past decade, the City of Johannesburg has actively participated in the development of the first fast train system; the Gautrain in conjunction with two other metropolitan cities within the province. To support the innovative train system, the city also invested in and developed the Rea Vaya; a rapid bus system. Conversely, the state of connectedness of the rail and road route networks within the city have not been well documented. Therefore, the aim of this paper is to delineate the extent network integration among Gautrain and Rea Vaya within the Johannesburg urban public transport system and how working relationships could be improved.

### **3 CONCEPTUAL FRAMEWORK: INTEGRATION IN URBAN PUBLIC TRANSPORT PROVISION**

Literature on commuters need for integrated urban public transport has been well documented (Jackiva et al., 2015; Nunes et al, 2014, Musakwa and Moyo, 2016; Filippi et al., 2013), henceforth contemporary there has been a global growth in research on how to achieve integrated public transport operations in cities around the world. According to Reggiani (2001), “the term transport intergration denominates concepts such as technical, economic, organizational, information and policy-based concepts; and solutions that pledge the continuity of travels from door to door. Nevertheless, transport integration is mainly focused on connecting various transportation modes operating in certain transport system, providing solutions to facilitate commuters between the modes and assuring efficient, smooth and afe flow of commuters from their origins to their destinations (Ibrahim, 2003).

Integration of an urban public transportation is defined as an organizational process by which components of the commuter public transportation system (Network and infrastructure, information and marketing components, fares and ticketing systems) and a variety of carriers, (Kourtit and Nijkamp, 2012) who serve different transportation modes, interact more closely and efficiently, to generate an overall improvement in service quality level and enhanced performance of the combined public and individual transportation. In particular, the implementation of various transport integration solutions may results in the benefits such as reduction of travel times, transportation costs, environmental pollution and traffic congestion (Paulley and Webster, 2017). Transport integrating solutions may improve the urban public transport system accessibility and overall competitiveness as well as assure better utilization of different transportation means and infrastructure.

Moreover, integration of urban public transportation is mostly determined by the pattern of land use, the nature of the transportation systems, and the characteristics of the traveller (Hidalgo and King, 2014). Travel cost, time, distance, and the choice of travel mode are all important. The closer the origin and destination to the main transportation system the higher the level of connectivity (De Abreu Freire & Painho, 2014). The wider the variety of modes for travelling between a given origin and a particular destination the greater the connectivity. In addition, the less time and money spent in travel the more places that can be reached within a certain budget and the greater the connectivity (Datta, 2015). In order for the concept of connectivity to be useful for evaluation of the need for and effectiveness of transportation and land use planning policies it needs to be translated into measures of connectivity.

There are different types and forms of transport integration in the urban areas. These include integration of different modes of public transportation; integration of public and individual transportation; integration of transportation policy with other policies concerning spatial planning and city management; spatial integration based on the application of efficient land use strategies (such as multimodal terminals and interchange platforms, shared lanes for means of public transportation) (Paulley and Webster, 2017). Moreover, infrastructural integration based on development of various technical solutions in transportation infrastructure (for instance passageways connecting public transportation stops, overpasses, underpasses, shared stops for public transportation); organizational integration (for instance metropolitan tickets various

transportation modes and coordinated timetables); economic integration focused on introduction of various measures supporting sustainability and efficiency of the public transportation systems (for example integrated tariffs). Informational integration (passengers' information systems; web pages; electronic travel planners) (Kourtit and Nijkamp, 2012).

#### 4 STUDY AREA

The Johannesburg Metropolitan City is well-developed economic hub and the ever fast growing city in terms of the population, economy and development in South Africa. The city is located in the Gauteng Province, and covers an area of approximately 1, 645 km<sup>2</sup> (City of Johannesburg, 2013). It is divided into seven regions, namely Region A, B, C, D, E, F and G. Besides, Johannesburg being the over populated and economic hub of South Africa, the Johannesburg metropolitan City as well as its neighbouring metropolitan cities (City of Tshwane and City of Ekurhuleni) share the most innovative transportation mode, the Gautrain in Gauteng connecting these three functional cities into one capital and economic region (see figure 1). Subsequently, routes of urban public transport systems, commuters movement patterns and accessibility become central issues within the Johannesburg Metropolitan City perpetuated by demand.

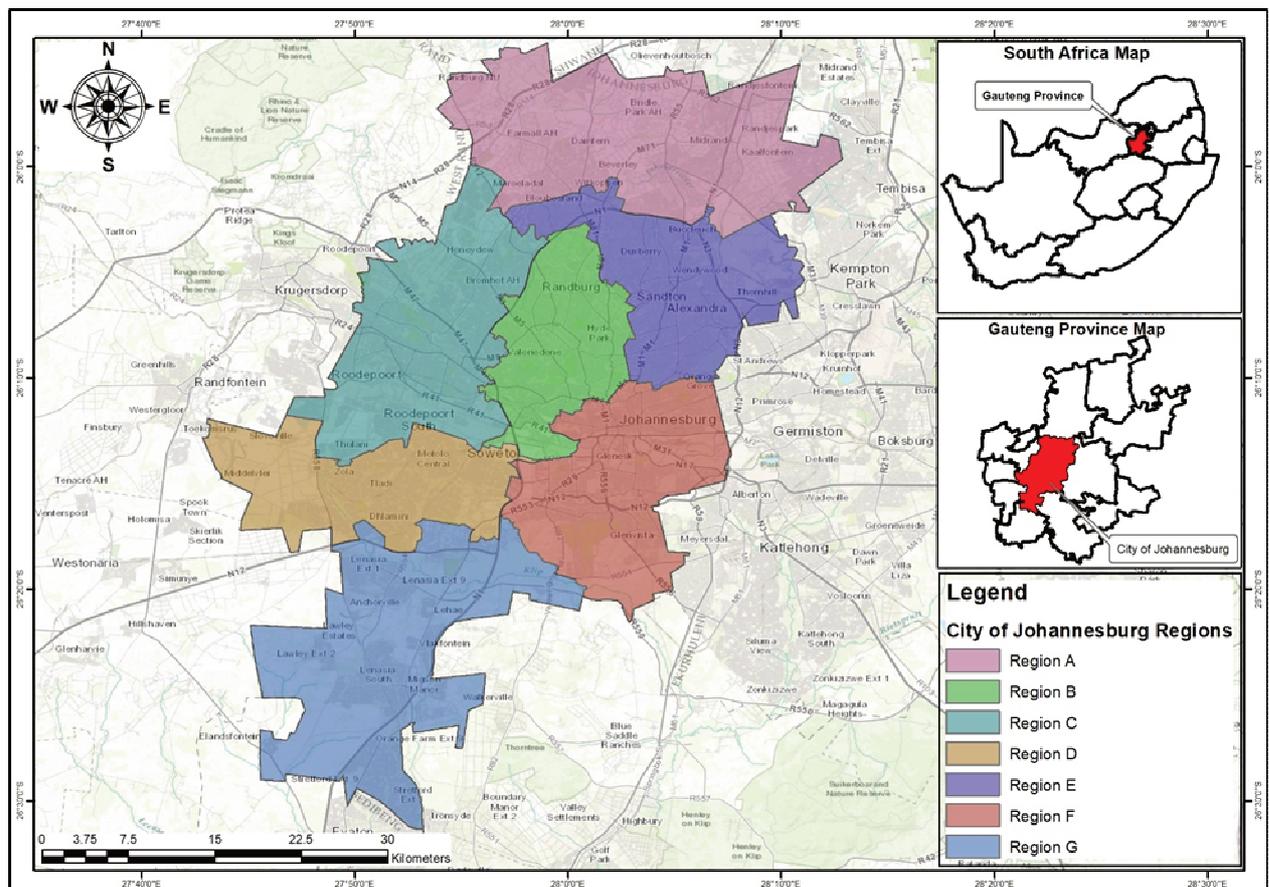


Figure 1: City of Johannesburg Map (Source: Author, 2017)

The city of Johannesburg has been defined as a world class African city. This definition entails that the city will strive to become a smarter city, but what is it to be 'smart', does it only involve decision-making or the use of advanced technology? Scholars have over the years articulated that at the core of development of smart cities is the need for developments which improves the quality of life of the citizens (Kummitha & Crutzen, 2017; Bakici et al., 2013; Ferreira et al., 2017). Currently the city of Johannesburg is promoting transit oriented developments (TOD) in previously marginalised areas by focusing on development on economic and business nodes (see figure 1). However the existing urban public transportation network is spatial segregated and there is little to no clear collaboration between the various public transit providers (namely the Reya Vaya; Gautrain/bus; Metro Bus/rail; Meter-taxis; Mini-bus taxi; and Uber), as they are developed and operated separately. Hence this presents a knowledge gap of how to connect commuters and these places of economic and business activities.

Urban public transport is at the heart of the City of Johannesburg's development agenda. There has been making efforts in the city to create Transit Oriented Development (TOD) Urban renewal as a way of building 'corridor of freedom' (Gauteng Department of Roads and Transport, 2013; Steer, 2012). Johannesburg Metropolitan Municipality caters for both non-motorized and motorized urban public transportation. These include Gautrain, Rea Vaya BRT, Metrobus, Metrorail, Putco, Minibus Taxis, Uber and dedicated bicycle lanes for private cycle lanes for private bicycle cyclists. Public transportation in Johannesburg Metropolitan City is used by the youth to commute to school, to get to service centres and recreational areas; adults to commute to work and recreational areas and by old aged citizens to commute for leisure and to get to basic services. Conversely, for the purpose of this study two urban public transport modes are explored on state of routes integratedness.

The Rea Vaya BRT and Gautrain are located in City of Johannesburg of Gauteng province, Republic of South Africa. The Rea Vaya operates only under the jurisdiction of the City of Johannesburg in southern part. Whilst Gautrain operates within the three metropolitan cities in Gauteng province which include City of Tshwane, City of Johannesburg and City of Ekurhuleni in the East Rand of Gauteng Province. The three metros, as mentioned earlier they form the region which is the economic hub of the Republic of South Africa and are only cities in the entire African continent that has a rapid transit train. These two public transport modes started operating during the 2010 FIFA World Cup which was hosted by South Africa. They also operate along mixed land used as well as major economic, institutional and social nodes such as the Johannesburg Park Station, OR Tambo International Airport, FNB Stadium, Emirates Airline Park Stadium, Sandton and so on.

## 5 METHODOLOGY

The study adopted a phenomenological case study survey design that applied mixed-method approaches to gather spatial, qualitative and quantitative data. The study examined the applicability of location based services to define the state of public transport routes integratedness and movement patterns of commuters within Johannesburg Metropolitan City. The exploratory approach was used to formulate the research problem for precise investigation whilst the descriptive approach was used to gather complete and accurate information. Key informant interviews were also conducted with key informant personnel from Johannesburg Roads Agency (JRA), Gautrain Management Agency (GMA) and Gauteng Department of Roads and Transport to give complete and accurate information on Gautrain and Rea Vaya Routes Integratedness in Johannesburg Metropolitan City.

Data from Echo-Echo was used to gather social media comments on the urban public transport modes and locations co-ordinates of where the comments were made. The co-ordinates were converted into shape files, which in turn were used to create the krigging maps. Conversely, these maps display High Commuter Concentration zones and Low Commuter Concentration Zones and help to track the movement patterns of commuters using urban public transport and survey questions about origin and destination were included to validate locations and create maps with possible routes emanating from various locations to major nodes of the City of Johannesburg. The data in this study were analysed and interpreted thematically, semantically and spatially through techniques such as content analysis and Geographic Information Technologies. The study period is from January to August 2017, and the spatial, qualitative and quantitative analysis were triangulated to yield viable results.

## 6 MODES OF PUBLIC TRANSPORT AND THEIR ROUTES INTEGRATEDNESS WITHIN THE JOHANNESBURG METROPOLITAN CITY

### 6.1 Moving with Gautrain

Gautrain is one of several strategically integrated Gauteng Provincial Government projects to meet future transport demands anticipated because of economic and population growth (Ruwanpathirana and Perera, 2015). It is also referred to as a mega-engineering project. It is a state-of-art rapid rail connection between City of Johannesburg (Africa's business capital), City of Tshwane, and City of Ekurhuleni (Moosajaa, 2015). The Gautrain has been identified as the backbone for public transit provision in the Gauteng province, since according to Gauteng City Region (GCR) can best be described as a cohesive cluster of cities, towns and urban nodes which collectively make up the economic hub of South Africa, generating more than 36% of the

country's Gross Domestic Product (GDP), whilst covering less than 2% of the South Africa's total surface area. Figure 2 illustrate Gautrain routes and stations map.

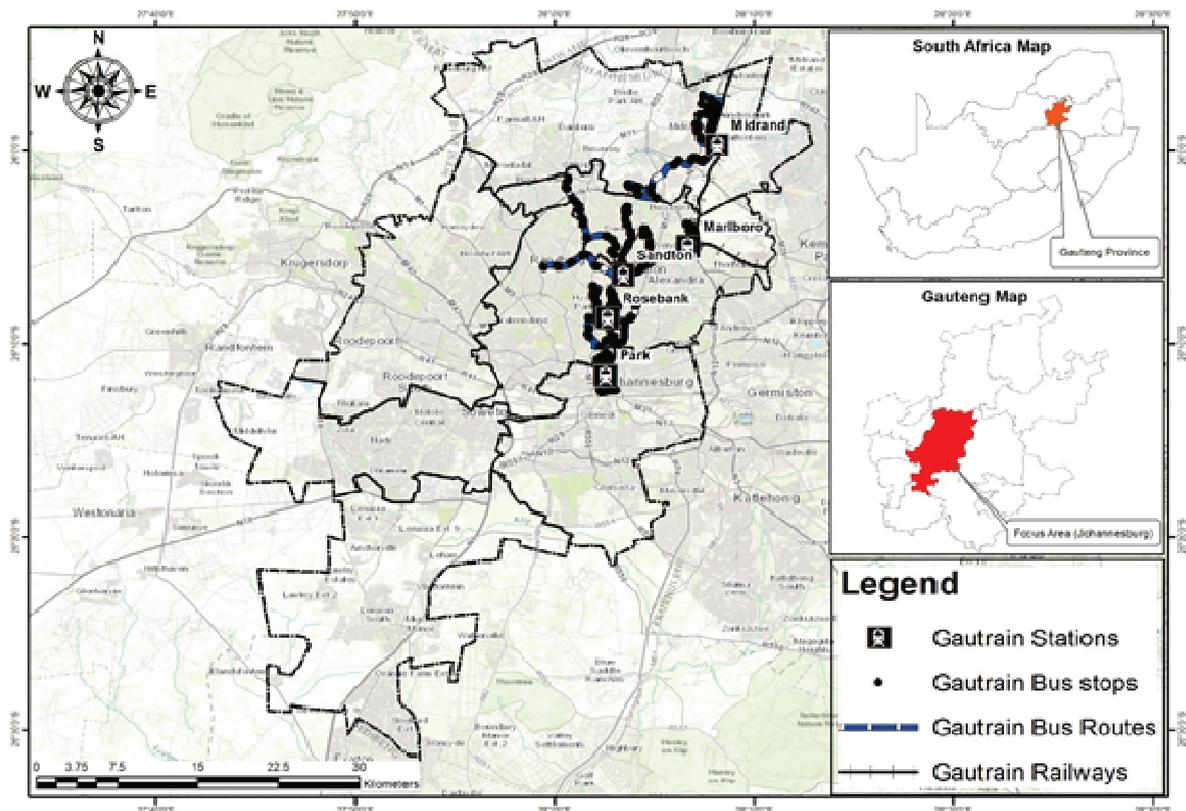


Figure 2: Gautrain routes and stations map (Source: Author, 2017)

In terms of routes network, the Gautrain alone operates in three metropolitan cities in Gauteng province namely City of Johannesburg, City of Pretoria and Ekurhuleni Metropolitan municipality. It has only 10 functional train stations, namely Park, Rosebank, Sandton, Marlboro, Midrand, Centurion, Pretoria, Hatfield, OR Tambo and Rhodesfield. However, the Gautrain within jurisdiction of City of Johannesburg operates in the upper spaces such as Rosebank, Sandton, Randburg and Fourways. Gautrain does not operate in the southern spaces of the Johannesburg, and conversely there are potential clients and need for expansion and integration with Rea Vaya that is currently operating in that area (See figure 2).

## 6.2 Relying on Rea-Vaya

The Rea Vaya Bus Rapid Transit (BRT) is a fairly new bus system in the city of Johannesburg. Its launch in 2009 was met with much uncertainty, but great hope as a new public transport initiative for the city. The system can be found in many different areas across the greater urban fabric of Johannesburg, connecting the south to the north and the east to the west. It covers a route of 325 km to date and continues to be in the process of expanding (COJ, 2015). The system is made up of trunk routes that keep to the designated lanes and are connected by the stations along the route. The T1 route runs from Thokoza Park in Rockville, Soweto and ends in Ellis Park. There are more than 15 bus stations across this route that facilitates access onto the buses. The main trunk routes are supported by complimentary and feeder routes that navigate other parts of the city. These feeder buses use the main routes of the road network like other vehicles and public transport systems. Figure illustrate Rea Vaya Bus Stations and Bus Route. Figure 3 illustrate Rea Vaya Bus Stations and Bus Routes.

In terms of routes network, Rea Vaya Operates in Region A to F within the Johannesburg Metropolitan City. It operates in different phases and has systematic hierarchical routes that connect micro city centers in the metropolitan city of Johannesburg. It has completed the construction of Phase 1A and 1B and currently developing Phase 1C. Rea Vaya's Phase 1A has a trunk route operating between Ellis Park in Doornfontein and Thokoza Park in Soweto, linking with several feeder routes Soweto (Rea Vaya, 2016). Feeder buses run from Protea Glen to Thokoza Park and from Eldorado Park to Lakeview (Rea Vaya, 2016). The route covers

325 km of special lanes and intersections while feeder and complementary buses carry passengers to the trunk route stations.

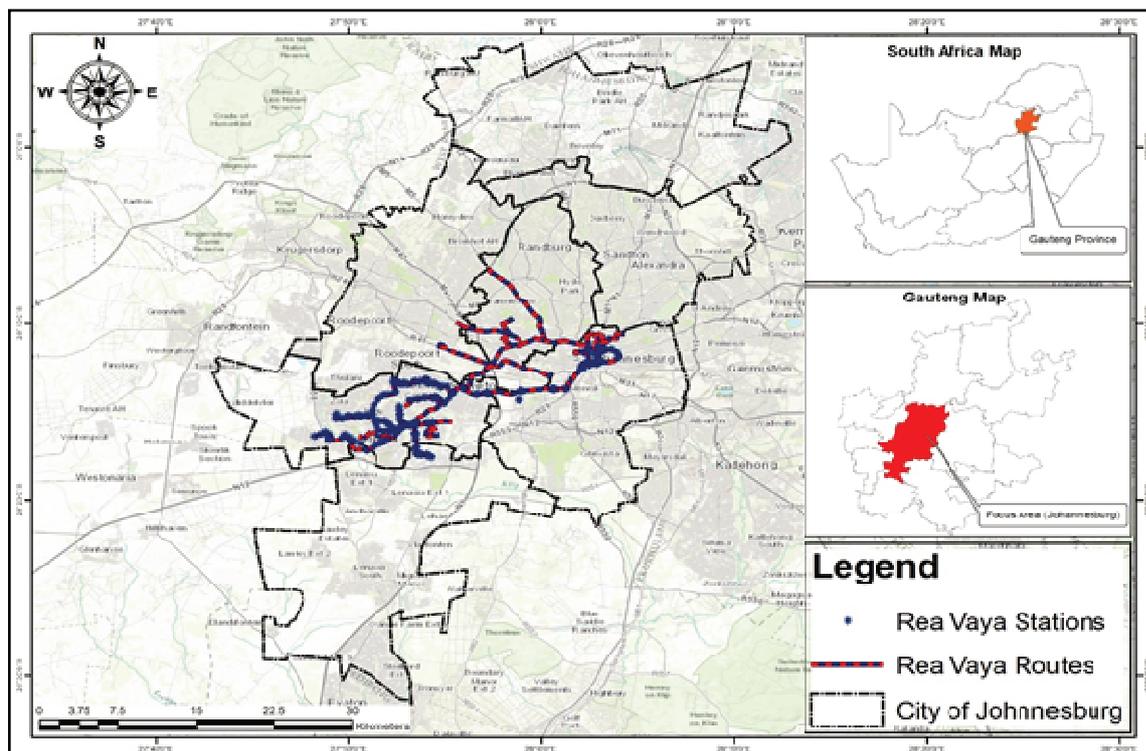


Figure 3: Rea Vaya routes and stations map (Source: Author, 2017)

The inner city circular route travels around the Central Business District from Hillbrow and Braamfontein, to Ellis Park in the east and Chancellor House on the western edge of the city (Rea Vaya, 2015). The Phase 1B has routes that operate through Cresta, Windsor West, Parktown, Yeoville. In addition, routes that operate to and from University of Johannesburg Soweto Campus are being added. The route starts in Noordgesig in Soweto and travels through Pennyville, New Canada, Highgate, Auckland Park and Braamfontein to Parktown, Metro centre and Rissik Street in the CBD.

The route has made it possible for commuters to easily reach key public healthcare centres such as the Rahima Moosa, Helen Joseph and Charlotte Maxeke hospitals as well as educational institutions such as University of Johannesburg, Wits University, Milpark College, Parktown Boy's High School and Barnato Park High School. Feeders run to and from Leaglen, Stormhill, Florida, Cresta, Yeoville and Parktown. There are also additional feeders in Soweto from Pemville and Mapetle. These routes are now linked to the Metro Centre Rea Vaya loop, which travels to the inner city through Braamfontein.

Rea Vaya's current focus is the development of Phase 1C following the completion of Phase 1B. Phase 1C will run from: Parktown to Alexandra; then Alexandra to Sandton, with complementary services between the CBD and Ivory Park; and from the CBD to Sunninghill on Oxfords and Revonia. Future plans also include extending the Phase 1C route from Sandton to Randburg by 2018, and possibly extending the Phase the trunk route from Soweto Highway to Dobsonville, enabling feeders to services areas such as Braamfisherville. Construction for the routes and stations has already started in the Sandton area. The Rea Vaya trunk routes from the CBD to Sunninghill through Oxford Road and Ivory Park to Sunninghill will be prioritized after 2018. The three interchanges will be at Sandton, Alexandra and Westgate, where a number of station modules will be clustered and there will be integration with other modes of transport, including walking and cycling.

With its intention to be one of the most sustainable forms of public transport in the city, the Rea-Vaya is noted as cost effective, safe and relatively reliable. It is considered as an inherent component of the city's future urban form as it is one of the main elements of the corridors of freedom initiative. Finally, the Rea-Vaya is referred to as one of the most determined initiatives by the city, being spread headed by a woman and having a completion goal of three years from ground breaking to implementation and operation (Moosajee, 2015).

### 6.3 Analysis of Gautrain and Rea Vaya Routes Integratedness

The findings of this study indicate that there are limited areas where the route networks between the public transport systems are connected (see figure 4). Currently, the Gautrain operates in the upper spaces of Johannesburg, such as Rosebank, Midrand, Sandton, Randburg and Fourways. Whilst the Rea Vaya does not have existing networks in these locations. Rea Vaya's Phase 1A has a trunk route operating between Ellis Park in Doornfontein and Thokoza Park in Soweto, linking with several feeder routes Soweto. Feeder buses run from Protea Glen to Thokoza Park and from Eldorado Park to Lakeview. The Rea Vaya has proven successfully in improving accessibility to economic opportunities for locations which were once spatially segregated in Johannesburg. As can be seen with the network flowing from Soweto moving upwards to the inner CBD in Braamfontein. Most of the Rea Vaya stations seem to be well located as they are within the high commuter concentration zone (see figure 4).

The existing urban public transport network is spatially segregated, and there is little to no clear collaboration between the Gautrain and Rea Vaya, as they are developed and operate separately. Hence this presents a knowledge gap of how to connect commuters to places of economic and business activities. Conversely, from the works of modern day scholars (Filippi et al., 2013; Nune et al., 2014), the network integration of the public transport systems will lead to improved service delivery, inter-connectivity of places of economic activity and improve quality of life. Therefore, for City of Johannesburg to promote smart mobility, there is need for development of planning support systems which will guide the growth and integration of the existing and future public transport systems.

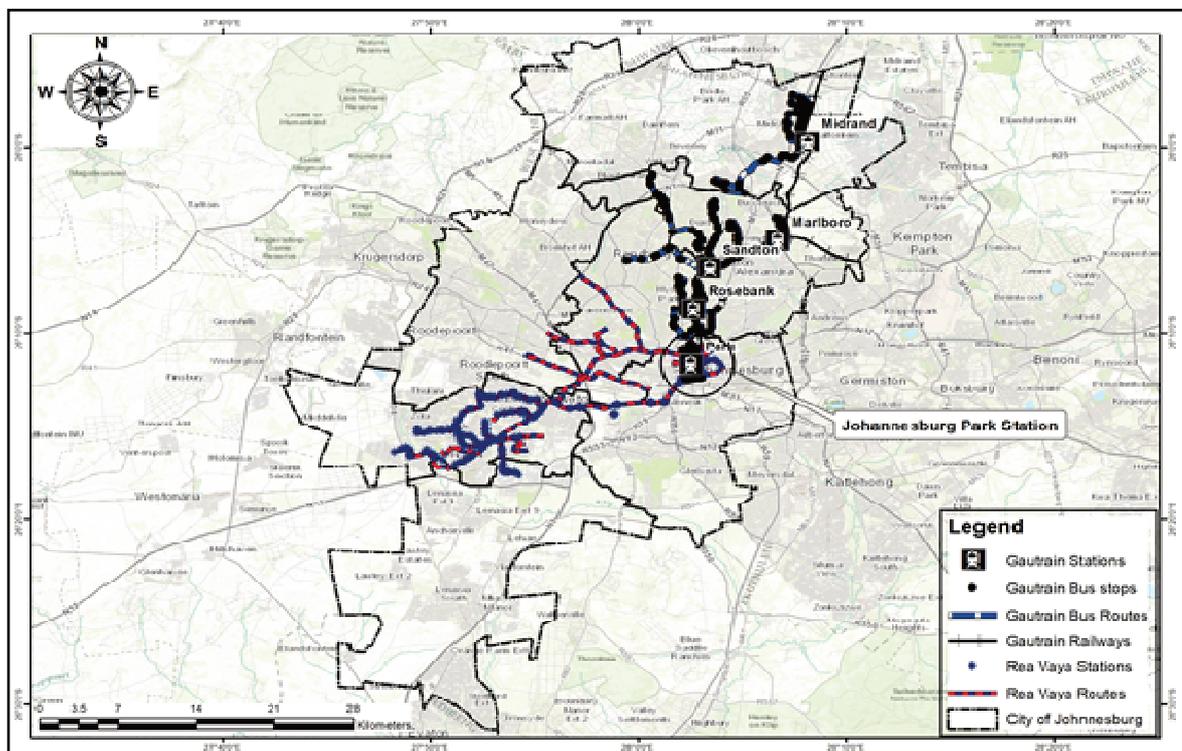


Figure 4: Public transport routes integratedness within (Source: Author, 2017)

On the other hand, the Johannesburg Park Station hub functions as a vibrant intermodal transport node (see figure 4). It is a major public transport interchange where the public transport network integrates, and commuters from all over Johannesburg, South Africa, Africa transfer from trains and buses to minibuses and more. Gautrain and Rea Vaya services at Park Station provide for inter-city transport as well as intra-city and regional transport services. Given that Johannesburg Park Station is a prominent transport terminal in Johannesburg, Gauteng, South Africa, and Africa, distribution terminals in the form of bus stations, rail stations, and taxi ranks are located in the close proximity to the Park Station precinct. The Gautrain Park Station, bus routes, as well as the Rea Vaya Bus Rapid Transit routes should also be noted as essential feeder and distributor routes in the area.

#### 6.4 Gautrain and Rea Vaya Social Media Commuter Concentration

Accordingly, from the findings, the majority of the commuters are located near the stations, this is due to the current stations are located in melting points of commuters, such as the Park Station, which is located in the Johannesburg CBD and acts as main interchange hubs of Johannesburg and an entry point for most regional and local commuters, also it is at the close proximity to MTN Taxi rank and Bree Taxi Rank located only 10 minutes away. This hub has a high connectivity of public transportation level. Notable areas which are currently not serviced by the Gautrain and Rea Vaya, include Roodepoort; Randburg; Woodmead; Magaliessig; Honeydew; Fourways; Lenasia; Glenvista; and Lawley. The commuter concentration zones of the Gautrain and Rea Vaya were then overlaid on a ratio of 50:50, to ascertain which stations should as the initial geolocations to promote multi-mobility. Park Station had the highest integrated commuter concentration as shown in figure 5.

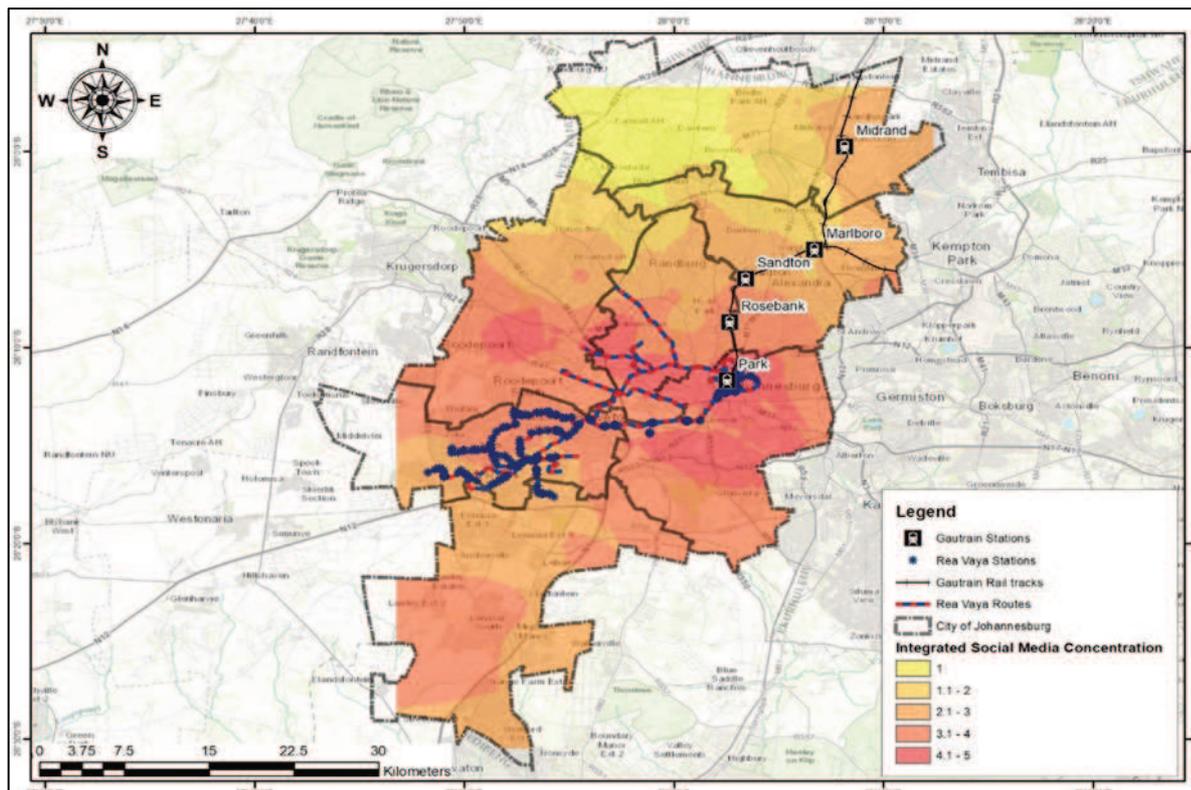


Figure 5: Routes Network Integratedness (Source: Author, 2017)

With this high commuter integrated, improving commuter transfer in the geolocation would be a virtuous starting point, since the infrastructure and commuter number are already pre-existing. While variations in income levels may be a factor to prevent inter-transfer between the two modes commuters should be given an incentive for using both modes of transit in one trip, such as a discount in commuter fares or points which can be later redeemed for a discount. This would build on the existing commuter concentration, and further attract other commuters to join the system. Moreover, as it would be cost effective for the two public transit provides to partner towards promoting multi-mobility within City of Johannesburg, then building separate infrastrure, as the Gautrain would link commuters to economic and business hubs in the northeren zones of Johannesburg, Namely: Sandton, Rosebank, Marlboro and Midrand; and the Rea Vaya would integrate commuters to areas of economic and business nodes in the southern zones of the city.

#### 6.5 Gautrain and Rea Vaya Commuters Movement within the City of Johannesburg

The movement of commuters within the city changes with time (Mitchell and Casalogno, 2005), as a result of developing transportation systems in addition to innovations within the Information and Communication Technologies Sector. While exploring the state of public transport networks integratedness within City of Johannesburg in this endeavour, it is essentially to understand the commuters movement within various areas of the city (Ambrosino et al., 2014).

Conversely, figure 6 and 7 illustrate the possible origin and destination areas of Gautrain and Rea Vaya commuters who form part of the study. From the results it can be deduced that from each location, commuters has two or three possible routes that they can take when travelling from their origin to destinations. For instance a commuter has two or three possible routes that he/she can take when travelling between Johannesburg Park Station and Sandton.

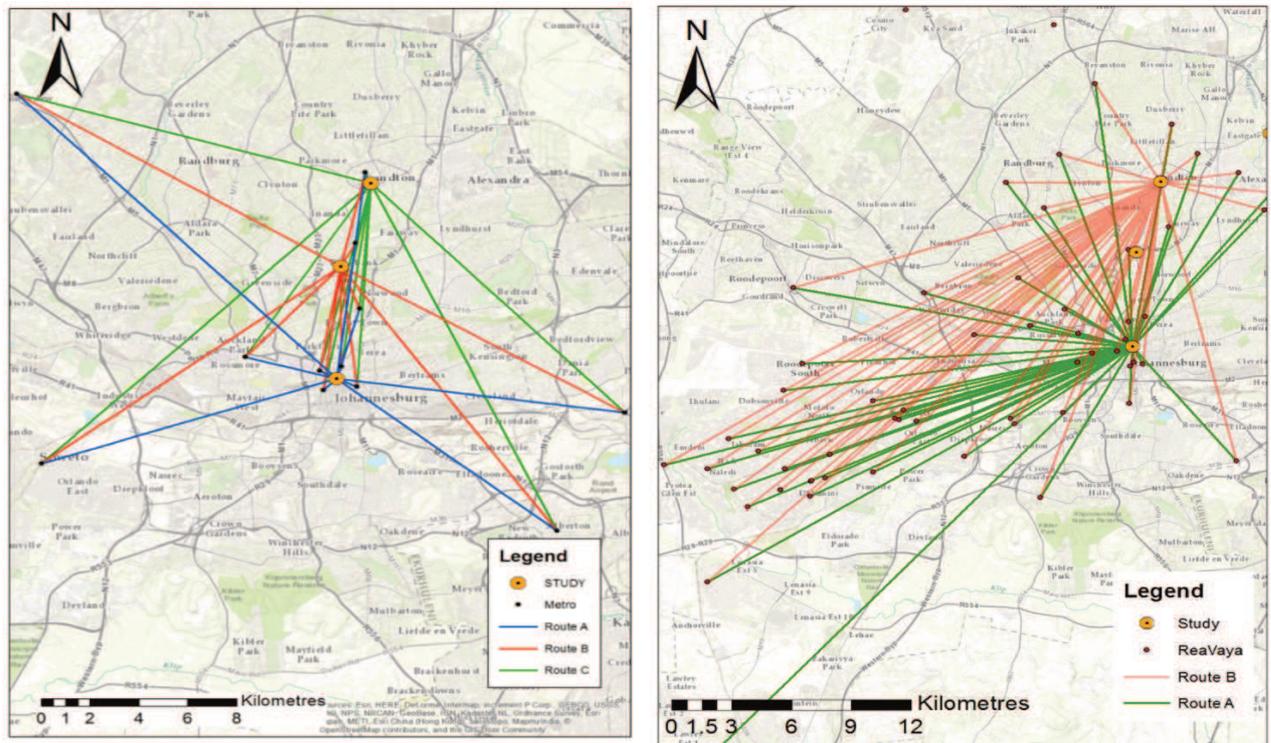


Figure 6: Gautrain Movement of commuters (Source: Author, 2017), Figure 7: Rea Vaya Movement of commuters (Source: Author, 2017)

These routes may be direct links from their origin to their destinations or may be interconnected through other stations as alternative routes to reach their destinations conveniently. The two modes of public transport in Johannesburg metropolitan city constantly need to track the movement of their commuters because of change in origin and destinations over time, thus the idea of location based services is applicable in tracking commuter movement patterns through geo-locational patterns that display commuter concentration zones. Therefore, the idea is for the service provider to reach out to commuters in the form of expanding services or contracting emergency and temporary urban public transport in times when required most, such as traffic congestions and tracking social media feeds using location based services analysis software such as Echo-Echo to manage their social media platforms effectively which in turn renders real-time and effective service to many of its commuters and the public at large.

## 7 CONCLUSION

To conclude mobility is continuously adapting and transforming to quotidian challenges, and be perceived with the global shift towards smart city planning. The shift towards encourages commuters to utilize multi-mobility modes and public transport in their everyday commute, to promote the reduction in the negative impacts of private-car-dependence in the urban contexts. This study delineated the extent routes network integration among Gautrain and Rea Vaya within the Johannesburg urban public transport system. The study findings indicated that there are limited areas where the route networks between the public transport systems are connected. The large sections of the networks are disintegrated.

However, it is recommended that conscious efforts in planning and developing both rail and routes networks that are integrated to promote efficiency of public transport systems. The network integration of the public transport systems will lead to improved service delivery, inter-connectivity of places of economic activity and improve quality of life. Therefore, for City of Johannesburg to promote smart mobility, there is need for development of planning support systems which will guide the growth and integration of the existing and

future public transport systems. Typically, sustainable urban mobility describe movement patterns or city transport networks, which are utilizing active travel modes, energy efficient renewable forms of energy, or shared vehicles wherever possible, resulting in low carbon output per commuter journey. Integrated multimodal networked public transport have emerged as a mobility paradigm, utilizing transfer potential to provide maximal service for a reasonable and efficient operating budget, providing a genuinely feasible alternative to the automobile travel for many trips within urban areas.

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