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Identifying Locations Suitable for Innovative Urban Public Transport Integration in Gauteng Province

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1 ABSTRACT

Globally, integrated urban public transport systems have been used as a solution to improve public transport services and reduce reliance on private cars which assists in reducing traffic congestion on the roads. In South Africa, Gauteng province is challenged daily with traffic congestion on the roads during certain peak hours. Therefore, the government of Gauteng province has developed innovative urban public transport systems - the BRT system and the Gautrain system - to improve the state of reliability and movement frequency of urban public transport. However, there is still a lack of reliability and of seamless travelling. This paper aims to explore locations where innovative urban public transport systems (BRT system and Gautrain system) can be further integrated in the province. The study adopted a qualitative research design that facilitated the gathering and analysis of spatial data and qualitative data from the innovative urban public transport officials, commuters and GIS data (BRT and Gautrain shapefiles). Results reveal that there are numerous locations that can be integrated where commuters can switch from one urban public transport system to another to improve travelling by public transport. The study concludes that this level of integration can create seamless travelling in the province and easy access to different modes of public transport. The study recommends that the identified locations need to receive attention as most commuters of these innovative UPT systems are located around these areas and to use the created model of the study to this effect.

Keywords: Urban Public Transport; Spatial Integration; GIS data; Reliability; Seamless travelling.

2 INTRODUCTION

Urban Public Transport (UPT) has become an increasing need to transport people from origin to destination. UPT is designed to reduce the various negative impacts on the roads. In developed countries UPT functions well with periodic improvements. In developing countries such as South Africa, UPT is not functioning at its best potential as planned, thus it struggles with attracting most of the private vehicle owners on the roads. Although Gauteng province has developed innovative UPT systems it still lacks public transport network connectivity within these systems. The objective of the study is to identify a way to attract more UPT users. Therefore, it aims to explore locations where more innovative urban public transport systems (BRT system and Gautrain system) can be integrated in the province. This is expected to improve the Gauteng province UPT network and hopefully attract many new UPT users.

3 LITERATURE REVIEW

Burt (2014), defines transportation planning as a cooperative process designed to foster involvement by all users of the system, such as the business community, community groups, environmental organisations, the traveling public, freight operators, and the general public, through a proactive public participation process conducted by the Metropolitan Planning Organisation (MPO), state Department of Transportation (state DOT), and transit operators. Transportation planning and design choices have a direct influence on development patterns, travel mode choices, infrastructure costs, redevelopment potential, the health of natural resources, and other community concerns. Transport planning/evolution and demand usually respond to how communities' function spatially (Redman et al., 2013) and, in some cases, transport planning can be used to force spatial change (Browning 2013). Further, transportation helps shape an area's economic health and quality of life. Not only does the transportation system provide for the mobility of people and goods, it also influences patterns of growth and economic activity by opening access to land. Transportation planning is more than listing highway and transit projects. It requires developing strategies for operating, managing, maintaining, and financing the area's transportation system to achieve the community's long-term transportation goals (Burt 2014).

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According to Hidalgo (2009), the public transport planning phase is critical as part of an overall planning system, while the design element is tied to a management plan as it will involve planning of routes and stops integrated with location and frequency of use. What needs to be considered at the strategic level of planning the public transport system is long-term stability of a high service quality for the public transport system to influence urban development and create more sustainable transport patterns (Moyo et al., 2018). Consequently, Mbatha and Gumbo (2019), state that planning a public transportation system is a multi-objective problem that includes among others line planning, timetabling, and vehicle scheduling. For each of these planning stages, there are known models and advanced solution techniques. Some of the models focus on spatial integration, others on commuter convenience. Devising a transportation system is usually done by optimising each of these stages sequentially.

In some instances, the challenge is physical connectivity, as some transport modes are not entering certain locations and, in some cases, the problem lies in the planning phases. For urban public transport to function well, there are certain elements that need to be considered. In the planning process, there is a need to find the current demand and the relationship of movement between different public transport modes and environmental demands. There is a need to formulate a plan which predicts future travel demand and makes recommendations on how to deal with challenges that might occur. The plan needs to assess whether the proposal will meet demand and provide maximum benefit to the community. This includes monitoring existing conditions, such as future population forecast and employment growth; assessing projected land uses in the region and identifying major growth corridors; identifying current and projected future transportation problems and needs; together with detailed planning studies to analyse various transportation improvement strategies to address those needs. Urban public transportation planning in South Africa has been improving over the years as more strategies from around the world are adopted by the Republic. Several transport modes have been implemented in order to improve the state of public transport in the country. Bus Rapid Transit & Speed train are implemented in order to boost quality, efficiency, effectiveness and reliability of the public transport network. Existence of these modes can be found in Gauteng province.

3.1 Integrated Transportation Approach

Transport systems are complex and multi-dimensional with many parts that compose the whole. The objective of integrated transport planning is to find a balance among these dimensions so that planning and investment decisions contribute optimally to the economic, social, cultural and physical potential of the transport system and society in general. Integration is a concern with the whole, with common objectives and agreed desired outcomes. The different options, goals and points of view must be integrated to identify realistic solutions to community problems. Integrated transport planning is more than coordinated transport planning. It integrates multiple and sometimes-conflicting objectives to reach more sustainable transport outcomes that contribute to community, industry and government priorities. Further, it is significant that the transportation network is well established from the beginning of the development, thus designs need to incorporate links between roads to link and foresee enough space for future vehicle movement and potential smart transportation development. In South Africa, Gauteng implemented smart UPT, such as the BRT system in the City of Tshwane (A Re Yeng bus), Ekurhuleni (Harambee bus) and City of Johannesburg (Rea Vaya bus). The development of these concepts played a positive role as it brought more alternatives to UPT; however, it reduced the width of the road used by other vehicles - both public and private transport- leading to traffic congestion at certain peak hours. Hence, environmental challenges and high human health risk are arising due to time spent on the roads where cars release noxious gases (Mbatha and Gumbo 2019).

3.2 Physical and Network Integration

Proximity to, and ease of access at mode interchanges are greatly enhancing public transport services. Hence, walkways must be carefully designed for passengers to change mode. Passengers must be within a short walking distance from their residences to a transit stop. Cities like Hong Kong and Singapore have been able to build mass transit stops in the heart of neighbourhoods, thereby providing proximity to residences, offices and retail outlets. Bus and rail systems should be an integrated network whereby these separate networks are complementing one another. Feeder services using buses, trams or light rail should be designed to maximise the patronage of the trunk routes (Liu and Ceder 2017). Network integration is closely linked to physical integration and both contribute towards the integration of infrastructure. For instance, it is relatively easy to change between different lines on the London Underground (tube) network as tube stations have been

designed with several interchange points between tube lines (Moyo and Musakwa 2016). Cities such as Hong Kong, Singapore and Kuala Lumpur have been able to redesign bus routes so that they feed into and support the mass transit/metro lines (Luk and Olszewski 2003). Similarly, London's underground and buses connect with the overground heavy rail network to take passengers to their final destinations. An essential part of network integration involves timetabling services so that intra-modal and inter-modal services connect efficiently and effectively.

3. STUDY AREA

The study area is Gauteng province which provides many economic opportunities in the Republic with a land cover area of 18 176 m2/ The province is the heart of economic activity.

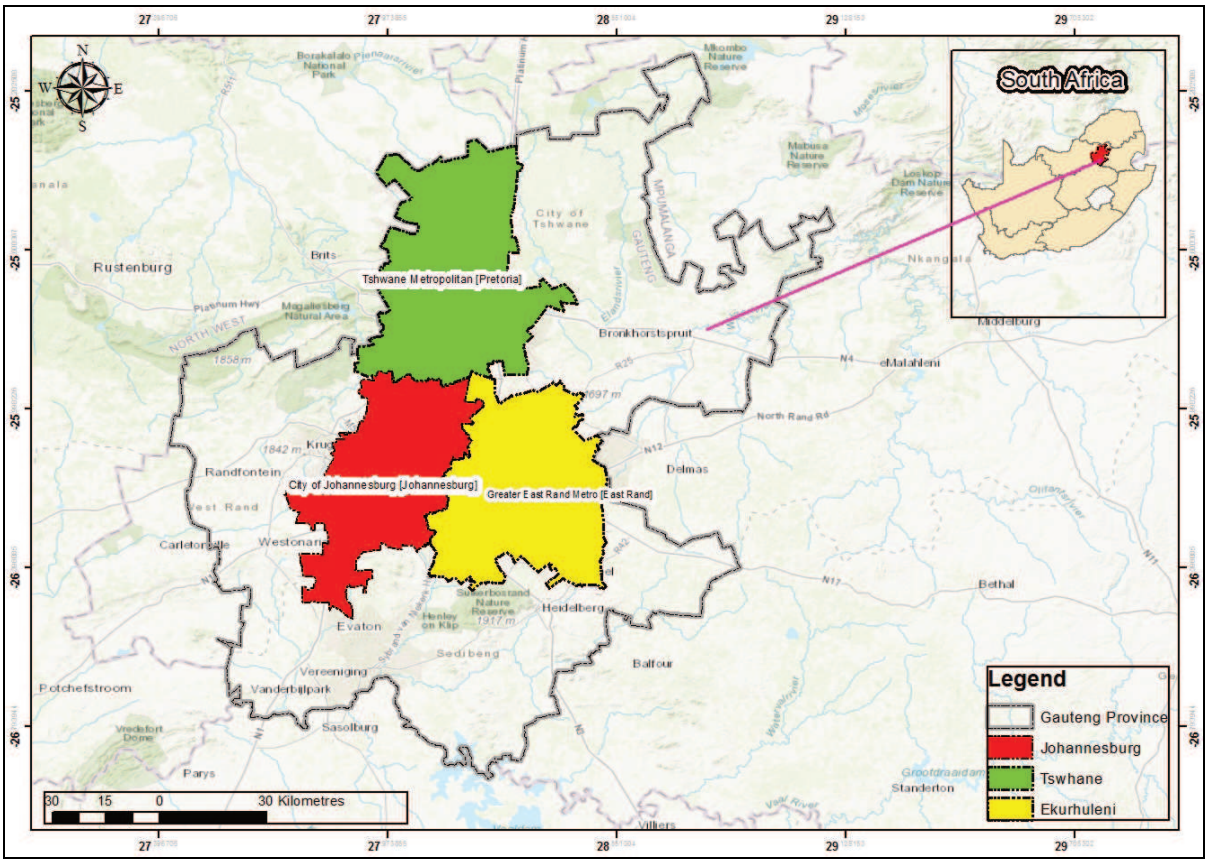

Figure1: Gauteng Province [Source: Author, 2020]

The depicted map (Fig 1) indicates the study area. According to Stats SA (2011), the population of Gauteng Province is 12,27 million. The study focuses on the formal urban public transportation system in the province, specifically Bus Rapid Transit (BRT) system and Gautrain system. The Gautrain system operates in selected locations in the province; however, it services all three metropolitan cities in the province which include the City of Johannesburg indicated in red, the City of Tshwane indicated in green and Ekurhuleni indicated in yellow. The BRT systems established in the province differ in names and work in the designated cities, and designated locations. In the City of Tshwane there is A Re Yeng bus, in the City of Johannesburg there is Rea Vaya bus and in Ekurhuleni there is the Harambee bus.

4 METHODOLOGY

A mixed method research design was adopted where qualitative data and spatial data analysis was used. Various research instruments were employed in the study. Ten interviews were carried out with officials from different departments, including the Johannesburg Road Agency, Department of Transport, Gautrain and BRT officials and Metropolitan Municipalities transport planners/ They assisted in providing insights for the study about the possibility of integrating the different public transport modes (bus and train) in general, and how to integrate the different entities of UPTs in the province. Accordingly, commuters were also interviewed to understand the commuter patterns and if there are any commuters who commute to and from one metropolitan city to another. 20 different daily commuters were interviewed who may have

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different experiences taking place daily. Purposive sampling was adopted as it was necessary to conduct interviews with informed officials and commuters. ArcGIS assisted with creating Gautrain rail tracks; BRT route maps were showing locations serviced, together with physical integration of the FUPT modes. BRT data (shapefiles), Gautrain data (shapefiles), interviews and documented studies relating to this study were the sources of data. Experimental analysis was conducted in order to develop a model through kriging interpolation that explains strategies of identifying suitable locations for integrating innovative Urban Public Transport in the province. Further, content analysis was employed to review previous documented studies. Secondary data used was obtained from larger data base such as Scopus, Science direct, Sage and Google scholar.

5 FINDINGS

The results obtained for this study were from both interviews and kriging interpolation. Interviews is one of the most important technique to collect data as researchers can gather views of some of the important role players involved. Interviews conducted with the officials in Gauteng province, indicated that there are various alternatives of urban public transport modes which include both informal and formal urban public transport. The use of taxis, bus and train services are in operation. Commuters using the City/Municipality bus services are currently subsidised, based on multi-journey ticket sales, by Gautrans in terms of an interim contracts. The subsidy funds originate from the budget of the National Department of Transport (NDoT) (Department of Transport 2007). The City of Johannesburg and the City of Tshwane have implemented the BRT system to improve the state of formal urban public transportation in the province for some time while Ekurhuleni BRT is still new. Further, there are also trains which include types such as Metrorail and Gautrain. Metrorail has schedules which are slow but very cheap. On the other hand, Gautrain is very quick in terms of operating schedules but expensive to use. Implementation of the Gautrain system was both to improve the state of urban public transport and to connect the three metropolitan municipalities in the province.

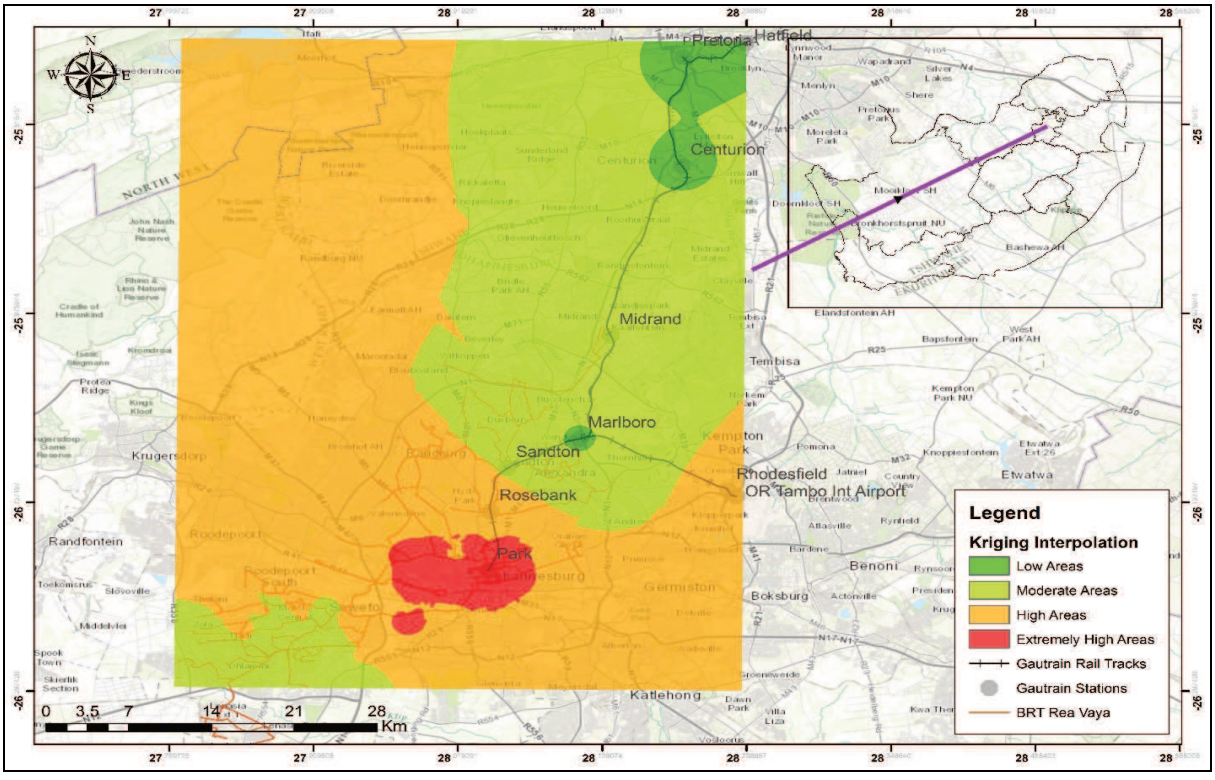

Figure 2: Gautrain and Rea Vaya Kriging Interpolation [Source: Author, 2020]

Officials highlighted that when these systems were developed plans put in place located these innovative UPT systems not far from one another. Gautrain was operating through all three metropolitan cities to act as a spine and connect with BRT systems in the three cities. It was found that the routes serviced by the BRT busses were mostly the busier routes. They were chosen for that purpose and could become potential route extensions planned to increase the BRT services to other locations in the province. Accordingly, this strategy

could lead to the physical integration of numerous routes in the province. Commuters indicated that there was also a need of spatial integration between the two systems as some of them travel between and within these three metropolitan cities and therefore an integrated system would be a positive asset for the overall UPT network of the province. Such integration would lead to seamless travelling which would less stressful for individuals who are travelling within the province.

5.1 Kriging Interpolation

When performing the analysis of UPT integration, this technique assists with creating a model that identifies the locations suitable for BRT and Gautrain integration in Gauteng province. This tool is important to identify hot spots and cold spots of locations concentration.

The map (Fig 2) indicates the suitable locations for physical integration in the City of Johannesburg between BRT Rea Vaya and Gautrain toward innovative UPT. In the index different colours are used to show different concentrations. All the areas overlaid by the location concentration indicate where there is a possibility for physical integration and/or a possibility for future expansions of these innovative UPT modes to develop an integrated UTP for Gauteng province.

Physically suitable integration locations	Percentage of suitable locations for integration%	Location Concentration
Red	15	Extremely high Concentration
Orange	40	High Concentration
Lime Green	30	Moderate Concentration
Green	15	Low Concentration

Table 1: Suitable locations for integration in COJ [Source: Author, 2020]

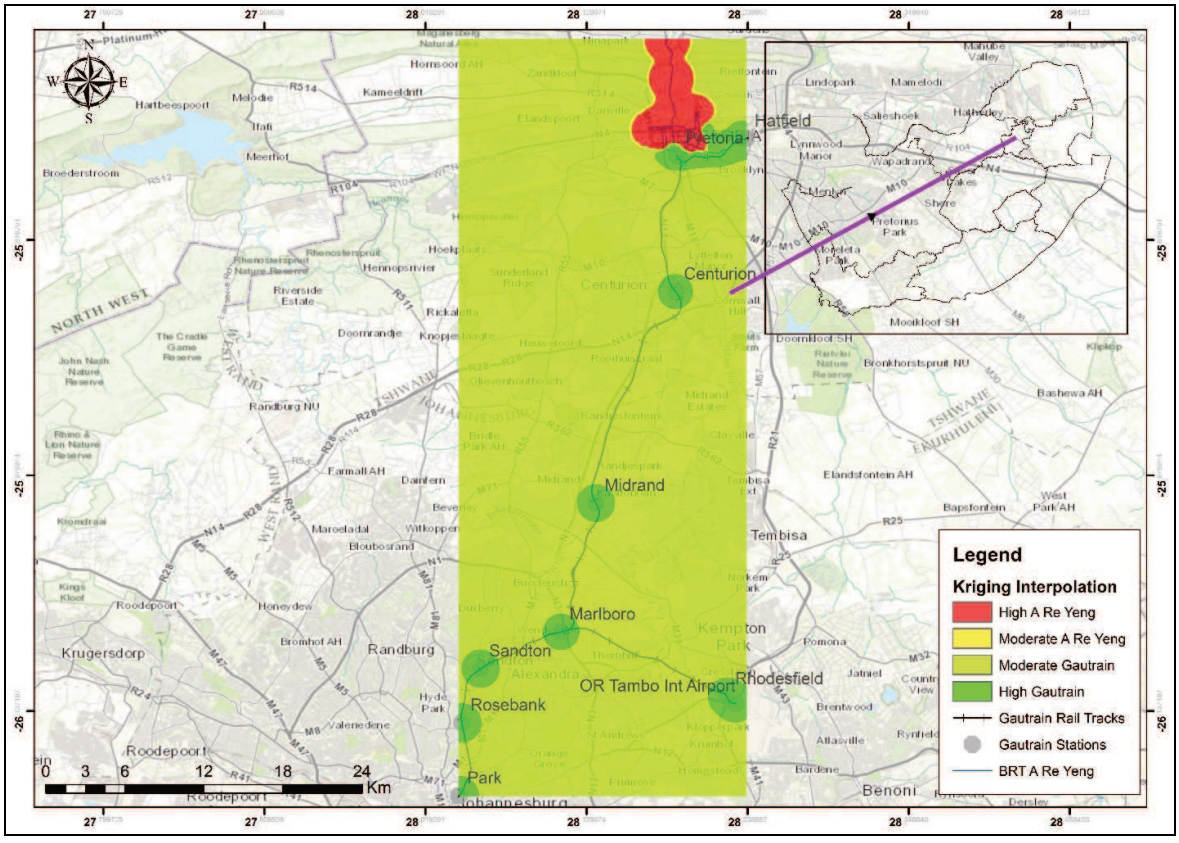

Figure 3: Gautrain and A Re Yeng Kriging Interpolation [Source: Author, 2020]

In the City of Johannesburg, Park station and its surrounding areas show extremely high concentration which is indicated in red. These locations indicated in red shows that it is suitable for physical integration in the city between Rea Vaya and Gautrain so that commuters can switch smoothly from bus to train. However, areas of 'extremely high concentration' in the city are very low in percentages and only identified in Park station and surrounding areas. 'High concentration areas' have a higher concentration percentage which is identified in

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many locations in Gauteng province, moving towards Roodepoort where future Gautrain stations are proposed. Moving towards Ekurhuleni close to Boksburg there are also opportunities for future expansion of the Gautrain station. Rea Vaya services occupy some other locations in Roodepoort. This indicates that when the Gautrain station is being developed in Roodepoort, this presents the possibility of future physical integration between Gautrain and Rea Vaya. Consequently, 'moderate concentrated areas' show a slightly possibility of integration as there is transport network of either Gautrain or Rea Vaya. This indicate that there is a possibility of whereby future stations of these innovate UPT systems could be developed. Further, low concentrated locations indicate that possibilities for physical integration of Rea Vaya and Gautrain are unlikely to happen. Below it is the map indicating suitable locations for physical locations in the City of Tshwane.

The map (Fig 3) shows Gautrain and A Re Yeng kriging interpolation. This analysis was conducted to identify locations that are suitable for physical integration in the City of Tshwane between A Re Yeng and Gautrain. Gautrain rail track, Gautrain stations and BRT A Re Yeng routes were all added to make sense of the suitable location areas for physical integration.

Physically suitable integration locations	**Percentage of suitable locationsfor integration%**	**Location Concentration**
Green	20	High Gautrain Concentration
Yellow	5	Moderate A Re Yeng Concentration
Red	20	High A Re Yeng Concentration
Lime green	55	Moderate Gautrain Concentration

Table 2: Suitable locations for integration in COT [Source: Author, 2020]

The above index of location concentration highlights that most of the areas that are concentrated are close to the Gautrain rail track, Gautrain stations, A Re Yeng bus routes and A Re Yeng bus stations. All the areas far from this have 0% of concentration where there could be a possibility of innovative UPT integration. However, if in the locations where there is concentration expansion of rail track, roads and stations could take place, there could be more concentration throughout Gauteng province and more areas could be identified for suitable physical integration. In the City of Tshwane, both a high A Re Yeng concentration area and high Gautrain concentration area are identified. Where these two-high innovative UPT concentrations connect indicates the suitable areas for physical integration in the City of Tshwane. Most of the locations with high concentration which include Gautrain stations and A Re Yeng station refer to the possibility of integration, as there are existing stations around those locations. Moderate Gautrain concentration also indicate a possibility of where more stations can be developed in the province and a possibility of physical integration could take place. The map (Figure 5) shows the integrated network for innovative UPT in the Gauteng province.

The map (Fig 4) indicates the integrated innovative UPT network of A Re Yeng bus in the City of Tshwane, Rea Vaya bus in the City of Johannesburg and Gautrain moving around all three metropolitan municipalities. As mentioned earlier, there is a possibility of integrating innovative UPT in Gauteng province as there is spatial integration on some locations in the province. This would lead to seamless travelling in Gauteng province. Rea Vaya bus in the City of Johannesburg connects physically with numerous Gautrain stations, A Re Yeng bus in the City of Tshwane physically connects with two Gautrain stations while the Harambee bus is still new and only connects physically with one station in Ekurhuleni. Integrating the BRT system with the Gautrain system will create reliability in UPT and easy access to different locations in the province. There are people travelling daily around the three metropolitan cities for different reasons, mostly work and school. Commuters travelling from the City of Tshwane to the City of Johannesburg can use the A Re Yeng bus from origin (home) and switch modes at a Gautrain station (Hatfield or Pretoria central) to a Gautrain to travel to the City of Johannesburg. Consequently, when commuters get to the City of Johannesburg, they can use Rea Vaya from the integrated areas between BRT and Gautrain to travel to their destination (work, school or place of interest). Further, Rea Vaya services a larger area in the City of Johannesburg including South Western Township (SOWETO), Tembisa, Rosebank etc. Therefore, there are commuters from other locations in SOWETO who travel to Ekurhuleni and the City of Tshwane. Commuters from Soweto, Tembisa can use Reya Vaya to travel to the City of Tshwane and Ekurhuleni by switching in between at Park station to a Gautrain and travel to Ekurhuleni and the City of Tshwane. When commuters reach the City of

Tswane they can switch to an A Re Yeng bus to their destination (work, school, home or place of interest) and on the other hand when commuters reach Ekurhuleni, they can switch to a Harambee bus to their destination.

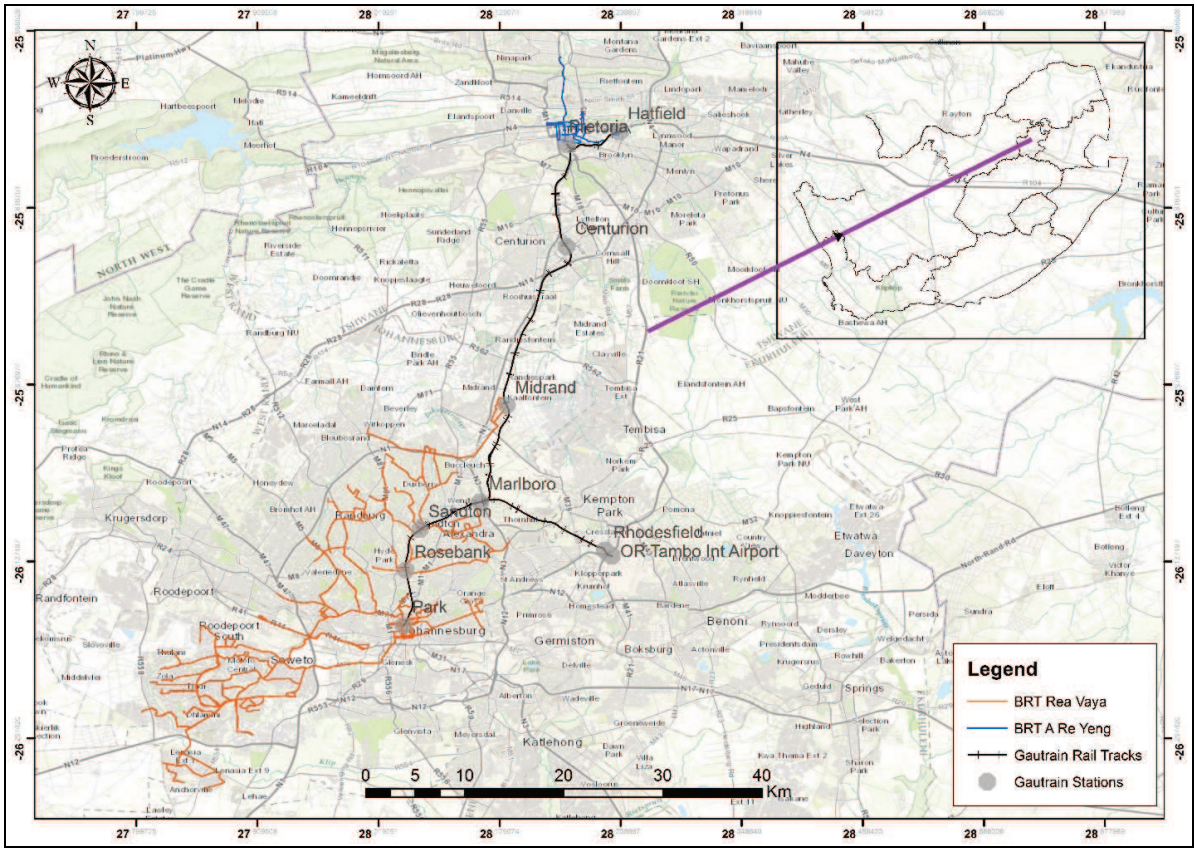

Figure 4: Integrated BRT and Gautrain Network [Source: Author, 2020]

6 CONCLUSION

South Africa is a developing country with good functioning UPT modes. Gauteng province has developed two of the world class UPT systems which are the BRT system and the Gauteng System. However, the study has indicated that these systems are currently not integrated which leaves a huge gap to commuters who use both UPT systems to reach desired destination. Therefore, an experimental analysis using kriging interpolation was performed to identify locations that can be suitable for physical integration in the Gauteng province. In the City of Tshwane, the results have shown a possibility for physical integration between A Re Yeng and Gautrain in Pretoria Central and Hatfield station. In Johannesburg the results have also shown a possibility for physical integration in Park station and other areas close by, and in Ekurhuleni Harambee is still small but over time it will increase and it will assist to connect Ekurhuleni metropolitan with the two metropolitan cities (COT and COJ). This shows that there is a possibility of bringing these services together and create one integrated transport network that will function across the province. Furthermore, the analysis also indicated areas which are possible for future expansion for implementation of stations to expand the transport network.

7 URBAN PUBLIC TRANSPORT INTEGRATION MODEL

Figure 5 explains the model regarding how to identify suitable locations for integration between the BRT system and the Gautrain system. Kriging interpolation was performed to designate suitable locations and help to identify current cold and hot spots of locations that need formal urban public transport services. When kriging interpolation was performed, first, Gautrain shapefiles and Rea Vaya shapefiles were combined to produce desired locations for integration in the City of Johannesburg. Second, Gautrain shapefiles and A Re Yeng shapefiles were combined also to produce desired locations for integration in the City of Tshwane. Kriging interpolation analysis was performed with an ARCGIS software. Lastly, the analysis also revealed locations that need services for the expansion of this UPT network. Accordingly, an

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integrated network map was designed to show the integration of BRT with Gautrain from the City of Johannesburg to the City of Tshwane in Figure 4.

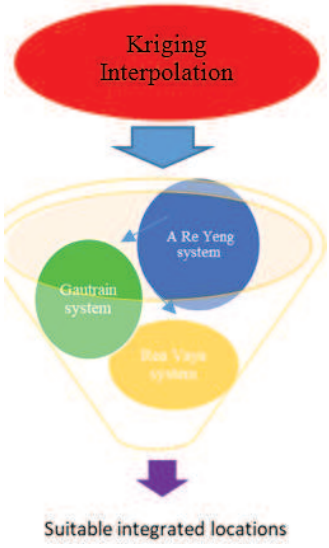

Figure 5: Spatial integration UPT model [Source: Author, 2020]

8 RECOMMENDATIONS

Adoption of integrated UPT network across the province is significant to attract more ridership of UPT and reduce private vehicle ownership and use on the roads resulting in less car accidents, less GHG emissions and producing smooth travelling from one city to the next. This is important, as in South Africa private car ownership increases regularly every year. The model used for the study can be adopted in order to identify suitable locations for UPT integration.

9 FUTURE STUDIES

Integrated UPT system allow for reliable, effective, convenient, safe, efficient and smart public transport in a certain place. The study focused on integrating spatially innovative UPT services in Gauteng province with the primary focus on both the BRT system and the Gautrain system. If there is a possibility of integrating these systems, the above-mentioned factors will take place. Therefore, there will be a need for such innovative UPT networks to connect all nine provinces in the country to create seamless travelling with well-functioning spatial integration. Future work will look at integrating UPT networks throughout South Africa.

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