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Exploring the Interoperability of Public Transport Systems for Sustainable Mobility in Developing Cities: Lessons from Johannesburg Metropolitan City, South Africa

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Abstract: There have been growing concerns with regards to the state public transportation systems, particularly in the cities of developing countries. Chief among these concerns has been the lack of well-coordinated, efficient, and reliable transportation systems. The city of Johannesburg, just like any other fast-growing municipality in developing and emerging economies, has not been spared with regards to incessant public transport challenges. Consequently, there have been collective efforts from both public and private stakeholders to invest immensely in both innovative rail and road transport systems in the past decade. This article sought to achieve twin objectives. First, the work identified the state of connectivity between the rapid rail transportation and rapid bus transit systems based on Geoweb 2.0 data. Second, the work visualized the level of connectivity between these two modes to develop and formulate policy frameworks in integrating public transit systems in cities of the developing world, learning from the metropolitan city of Johannesburg. A mixed-method approach consisting of spatial and quantitative aspects was used to examine the state of connectedness and the promotion of access and mobility between the two modes. The local Moran's I index was used to compute node clusters within the public transport system. Results from the analysis demonstrated that both high-clusters and low-clusters exist in the public transportation network, which have a high degree of centrality. It was revealed that commuters navigate from these nodes/stops with relative ease due to the short walking radius. However, the work revealed that most rail networks and bus routes, as well as the stations and bus stops, are not connected and are not significant in the local Moran's I index, thus, making it difficult for commuters to conveniently move from the Gautrain to the Rea Vaya bus. There are, therefore, gaps with regards to the sharing of infrastructure between the two public transport modes and systems.

Keywords: Geoweb 2.0; public transportation; bus rapid transit system; rapid rail transportation system

1. Introduction

Over the years, public transportation has been seen as a service that should prioritize accessibility in a package of flexible travel modes for various users [1,2]. Contemporarily, there have been growing concerns with regards to the state of public transportation systems, particularly in cities in developing countries [3–5]. Traditional public transportation in developing cities is characterized by most commuters as being unreliable and not spatially integrated, mainly due to hindrances, such as overcrowding and lack of connectivity between the various modes [6,7]. Given the design of the traditional public transportation system of fixed routes, which does not always cover the entire urban area, there is a need to assess the robustness of such systems [8]. Unpacking the existing spatial relationships in such complex networks will inform public transportation operators and urban planners to identify influential nodes and inform the allocation of funds to upgrade such nodes. Navarrete and de Dios Ortúzar [9] have articulated how the identification of influential nodes would lead to improved connectivity in public transportation systems, which, in turn, would lead to a sustainable urban public transportation system.

Poorly connected transportation systems negatively impact commuting trips, as they have longer travel times, which delays the destination arrival. Zhu et al. [10] assessed connections between nodes; their results revealed that measuring the identifying connectivity patterns in public transportation systems had significant policy implications and can inform future infrastructural expansions. Castanho et al. [11] evaluated connectivity in relation to movement between cities. Their results revealed that the identification of important nodes has led to previous locations in the core-periphery to become more accessible. The creation of a sustainable transportation system requires individuals and stakeholders to be socially included in the developmental process [12]. In the Gauteng province, South Africa, the Metro Railway has been the traditional railway line responsible for transportation commuters regionally and nationally. In 2010, a modern train was developed to transport commuters across three metropolitan cities. Since its inception, the Gautrain has been identified as the backbone of the future public transport system in the province [13]. The Gautrain railway tracks have a spatial coverage of 80 km, with top speeds of 160 km/h. Due to an increase in travel speeds from the traditional Metro Railway, which averages 90 km/h, the Gautrain has been coined a rapid transit system, as it is currently the second fastest train in Africa, similar to the Coradia Algiers Oran Express Train in Algeria. Currently, there are 10 operational stations across three metropolitan cities in the Gauteng province. However, the railway network is not currently integrated into other public transportation systems in the province. Mishra et al. [8] have outlined the merits of a multi-modal transportation system over singular networks. The use of a multi-modal transportation system has affected urban development in a positive way and spurred new economic activities along transportation nodes.

In this paper, we hence propose to examine the benefits of developing an integration of services offered by the Gautrain, Gaubus (a rapid bus transportation service offered by the Gautrain) and Rea Vaya (a rapid bus transportation). In theory, this should enhance the commuting experience. The paper is organized as follows. In Section 1, we present the status quo and show how it is related to the addressed problem. In Section 2, we outline the methodology, while in Section 3, we present the findings of the study; in Section 4, we discuss the findings in detail, while at the same time outlining the implications of planning. Lastly, in Section 5, we present recommendations of the study and draw conclusions from the results.

1.1. Related Work

In transportation planning, connectivity-related literature typically focuses on the key themes, such as accessibility, infrastructural development collaboration, and policy initiatives that encourage inter-modality [14]. Despite significant research on intermobility [15–17] and public transportation connectivity [18–20], few studies have focused on connectivity between rapid rail transportation and rapid bus transit systems in developing countries. Literature has shown that the connectivity of people, services, information, places, and infrastructure can contribute to the regeneration and developmental pursuits of urban areas [21–23]. For example, the development of a high-speed railway train station, such as Gautrain in South Africa, has led to an appraisal of the property value of properties surrounding the train stations [24]. This also resonates with a study by Emeric and Newman [22], which reveals that locations within proximity to transportation hubs have a more well-developed space.

Ho et al. [25] have articulated how previous studies of transportation nodes assume that all nodes are distributed homogeneously. In assessing node connectivity, it is essential to take note of the influence of activities in the surrounding environment [26,27]. To examine the importance of connectivity on the distribution of transportation nodes in urban areas, there is a need for innovative means to identify spatial locations that will influence commuting trends. Urban planners and researchers are increasingly developing new models and frameworks to enhance transportation networks with emphasis on the interconnectivity of services [28,29]. Generally, commuters can be referred to as active agents in the mobility system, as they are a potential source for change in shifting transit-share. Furthermore, enhancing connectivity between public transportation services and infrastructure has the potential to lead to the hedonic of place making. Through weighting links between nodes, we can identify influential nodes along a public transportation system. Consequently, a sustainable-oriented mobility system should take an active role in creating a system that allows for the seamless transfer between various public transportation systems.

To assess the level of the connectivity of transportation networks, several scholars have investigated the factors of service quality, such as proximity [21], travel time, waiting time, the number of destinations served, and the number of transfers required to complete trips. The commuter's mode choice is usually influenced by the ability of a mode to connect them between their homes, workplaces, or recreational locations—also known as places of interest. Accordingly, accessibility can then be translated to the distance between commuter points of interest and the location of the public transportation nodes/stops [30]. Given how the spatial network of a multi-modal transportation system has numerous stops, these can also service in the creation of a mobility hub that serves multiple transportation networks.

Previous studies have developed models and indicators to assess the level of connectivity, such as using node measure indicators [31,32]. Centrality measures were initially developed to assess connectivity in social networks [33]. Over the years, applications of centrality have been used to understand other forms of networks. Curado et al. [34] used centrality measures to understand the diversity of relationships that influence tourism trends in urban networks. Findings from the analysis revealed that centrality measures can be used by urban planners to rigorously evaluate the urban spatial networks, as nodes can be ranged by their level of importance in relation to surrounding nodes, such as assessed land value based on the centrality of nodes, and locations with high order nodes would attract higher rental fees and more commuting trips towards them. Whilst centrality with regards to tourism data would mean locations with high order, nodes would attract the most tourists and their accessibility should be prioritized for developmental projects. With the number and diversity of relationships that occur between spaces, information and social processes endow the city with characteristics of a complex system. One way of dealing with the complexity of the city is through networks, since they capture the relationships (edges) between objects. By measuring the closeness and centrality of the system, we can identify influential nodes along a public transportation system and, in turn, inform policies regarding the expansion of the systems. This is in line with national policies, which seek to establish a transport system that is environmentally friendly. There are efforts to achieve integrated intermodal coordinating structures and also promote the provision of seamless intermodal services [35,36].

1.2. GeoWeb 2.0

The growth in Web 2.0 data with geographical information in this paper has led to a rapid growth in research of a social network pattern analysis [37]. Derudder and Taylor [38] undertook a study to determine the comparative connectivity in the world-city network. The study explored the position of an "interlocking network model" in city developments. Their research revealed inter-urban flows that rely on location, social interaction, and economic activities. Drawing from the results, city developments can be understood by representing them "on and off the map" in relation to their specific interlocking with the global economy [37,38]. With regards to public transportation connectivity, a station or stop's connectivity would be influenced by the geolocation of the station or stop, commuter social interactions, and, finally, the land use in the surrounding environment.

Cheng et al. [39] demonstrated how human mobility can be understood using spatial-temporal and social data from location-sharing services. Check-in data was collected from Facebook Places, Foursquare, and Gowalla to investigate factors that influence human mobility. From their findings, through the comparison of population density and income density, we learned that people in the densest areas travel more than people in sparse areas, whilst those located in the sparsest areas travel farther than people in slightly denser areas [39]. A possible explanation for this phenomenon could be the variations in connectivity level within the study area. Connectivity, hence, is related to service accessibility [40].

Hollenstein and Purves [41] also used the Web 2.0 data in their research to delineate the core of a city. The study involved analyzing Flickr data—that is, picture tags that contained the following categories: "Downtown"; "City Centre"; central business district "C.B.D." Analogous to preceding research, Thurstain-Goodwin and Unwin [42] used the kernel density estimation technique to convert the geotagged pictures to spatial points to map out the city core. This technique of using Web 2.0 was consequently adopted in the current study, as geotagged data from social media was used to map and create a continuous spatial density to show connectivity variations in the city. The article, consequently, seeks to unpack how mobility can be improved in the city through visualizing the points of interest of public transport commuters and using these locations as a starting point to promote connectivity in the urban transit system.

The granularity of Web 2.0 data has many merits to unpacking mobility research. The digital footprint left by users allows researchers to quantify the socio-economic groups of users. Common limitations of Web 2.0 include the data internet connectivity issues and the missing geographic coordinates of data. Users may also opt to switch off their mobile data. Furthermore, in developing countries, such as South Africa, mobile data costs are high, hence, limiting the frequency of which commuters utilize social media platforms. Figure 1 reveals the distribution of social media users in South Africa as of January, 2020, by age group and gender. To assess connectivity for a public transportation, we draw from previous studies on the statistics of how communities have embraced the use of social media in their daily lives [39,43–46].

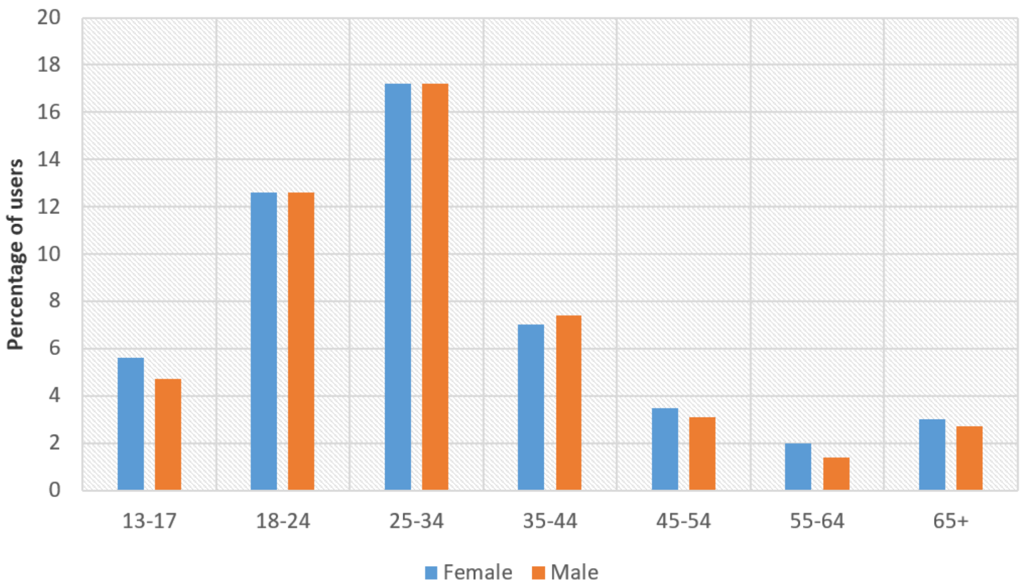

Figure 1. Distribution of social media users in South Africa.

A public transportation system, such as the Gautrain and Rea Vaya, has commuters from all income groups, with a bias to the middle-income group. Given the socio-economic dynamics of the commuters of these two systems [24], Web 2.0 data will capture commuters who are in the 18 to 44 age groups.

2. Materials and Methods

This section presents the step-by-step approach on how the technical architecture of collecting and analyzing GeoWeb 2.0 (see Table 1) and public transportation network data was undertaken. Social media posts from Facebook and Twitter with geolocations were collected for the period of January to June in 2019, with the Gautrain and Gaubus having 6548 posts and the Reva Vaya 2383 posts.

Table 1. GeoWeb 2.0 dataset.

Column ID	Column Name	Unit	Interpretation
1	Lat	Degree	Latitude reference of GeoWeb 2.0
2	Lon	Degree	Longitude reference of GeoWeb 2.0
3	Message		Information conveyed in social media post
4	Location		Suburb or city post was made from
5	Source	T or F	Social media platform Twitter (T) or Facebook (F)
6	Date	YYYYMMDD	The day of the month or year
7	Time	HMS	Time of day

We then performed a geographical analysis and a connectivity analysis. The flowchart summarizes the data analysis process (see Figure 2).

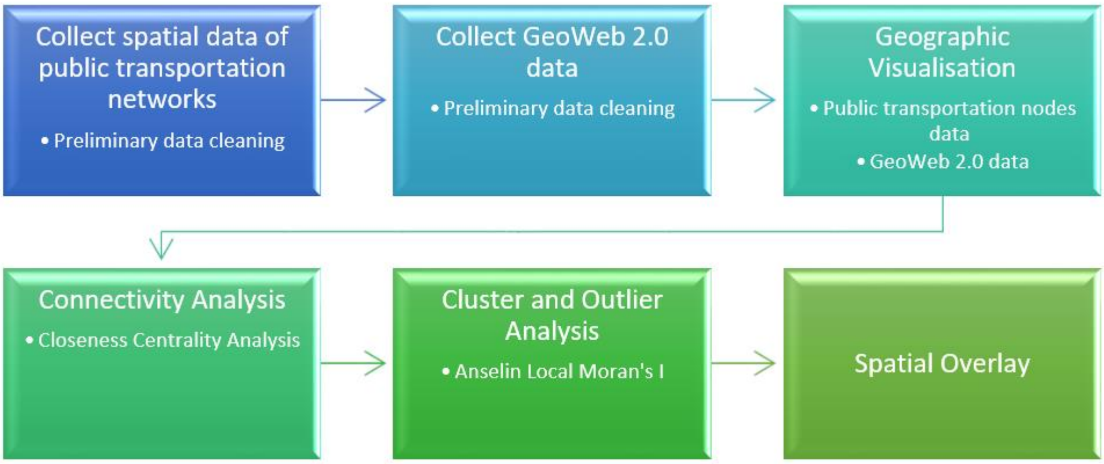

Figure 2. Flowchart of proposed method.

- **Step 1**: Data from public transportation providers were collected in shapefile format (point data for bus stop and train stations and polyline data for route public transportation networks) and a proximity analysis was conducted. All bus stops within a 50-metre radius from each other were regarded as a single node. These data are currently not open source, but available on request from the public transportation providers.
- **Step 2**: GeoWeb 2.0 data were collected and posts were filtered to retain only the posts with the key words “Gaubus”, “Rea Vaya”, and “Gautrain”.
- **Step 3**: Spatial visualization: new public transportation node data and GeoWeb 2.0 data were loaded on ArcGis Pro software.
- **Step 4**: The connectivity analysis was computed using the centrality extension in Matlab.

Defined by $d(i,j)$, the distance between vertices i and j and the closeness of a bus stop i were computed as $C_c(i) = \frac{n-1}{\sum_{j\in\subseteq} d(i,j)}$, with n being the number of bus stops in the public transportation network. In this work, the distance was computed according to the Euclidean distance between bus stops. It should be noted that though it was highly efficient in determining the influential bus stops, the closeness centrality due to the computational complexity involved in the calculations was not easily applicable in large-scale networks [47].

- **Step 5**: A local Moran's I analysis [48] was developed using the centrality indicator and a heatmap was created for the spatial concentration distribution of nodes. Arc GIS Pro was used to calculate the local Moran I index to visualize the distribution of nodes along the public transportation networks. Arc GIS Pro was chosen as it provides a myriad of spatial statistical analysis tools for mapping clusters. To identify the distribution of hot spots along the public transportation networks and rank these hot spots, the degree centrality was used to take into account the network relationship of the bus stops. Consequently, this was used to articulate why some bus stops were hot spots and others were not. When calculating the local Moran's I index, we used a fixed distance band to conceptualize the spatial relationships, ensure all nodes had a neighbor, and ensure a uniform distribution.

$$I_i = \frac{c_i - \overline{C}}{S_i^2}, I \sum_{j=1, j\neq i}^{n} w_{i,j} \left(c_j - \overline{C}\right) \tag{1}$$

where c_i is the closeness centrality of the bus stop at location i, $\overline{X}$ is the mean of the corresponding attribute, and $w_{i,j}$ is the spatial weight, being the travel time between bus stops i and j:

where n equates to the total number of bus stops.

$$S_i^2 = \frac{\sum_{j=1 j\neq i}^{n} \left(c_j - \overline{C}\right)^2}{n-1} \tag{2}$$

- **Step 6:** Spatial overlay: finally, the three public transportation network data were overlaid, and the connectivity of the multi-modal network was visualized.

The metropolitan city of Johannesburg is commonly known as "Jozi" due to the economic activities. The public transportation system in the city is comprised of a mix of motorized and non-motorized modes. Moreover, given how the city has invested in public transportation infrastructure since 2010, the modal share by the rapid rail transportation and rapid bus transit systems has increased immensely. The Gautrain (a rapid rail transportation system) and Gaubus (a rapid bus transit system) have routes that serve the Northern portions of the city (see Figure 3), whilst the Southern portions of the city are served by the Rea Vaya (a rapid bus transit system) whose routes link commuters to various points of interest. Currently, connectivity in the city is limited, with little to no connectivity to the existing public transportation systems. We proposed identifying the connectivity of bus stops (which we refer to in the paper as nodes) and proposed connecting the two public transportation systems to enhance intermodal travel in the city (Figure 3).

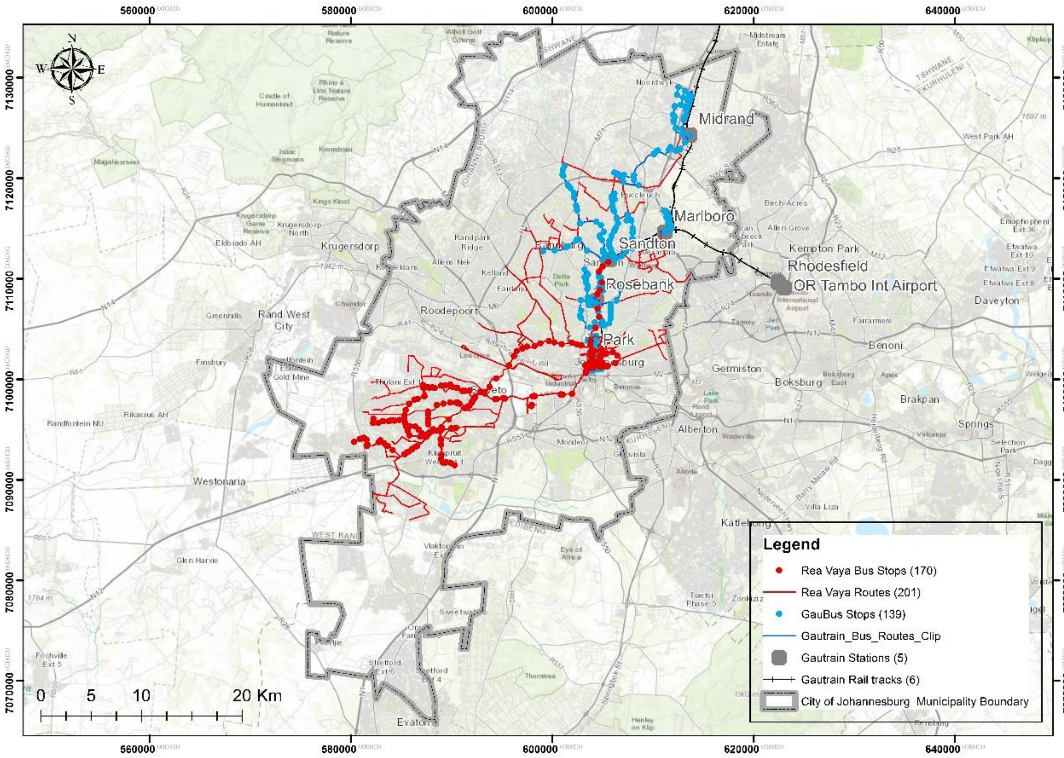

Figure 3. Study Area.

3. Results

Assessing the connectivity of transportation networks is essential in facilitating inter-modality. A societal analysis of the GeoWeb 2.0 data revealed patterns in the social media posts. The social media posts, which mentioned the three modes of public transportation, revealed that commuters associate these modes mainly with three trip typologies (see Figure 4). The month of February had approximately 3700 posts associated with commuting for work purposes, whilst the month of January had 967 posts associated with commuting home. Overall, most of the posts were associated with work trips, with February, June, January, May, April, and March having 3700, 2000, 1999, 1803, 801, and 701 respectively. Leisure trips were mostly in February and June, with approximately 2500 and 1300, respectively.

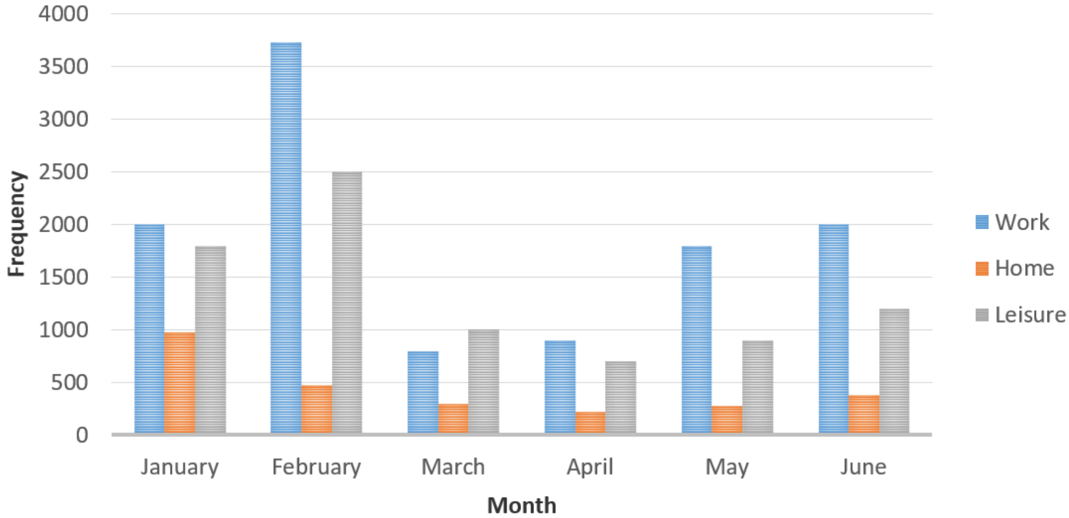

Figure 4. Time series analysis of daily GeoWeb 2.0.

Figure 5 presents the top 17 words mention in the social media posts. The results revealed that in most scenarios, when commuters post about public transportation systems, they link them with a location or point of interest. Soweto had the highest mention of 8002. Soweto is a township to the South of the city that provides housing for a large population of middle to lower income groups in the city. Auckland Park had the second highest mention of 4187. Auckland park houses media companies and tertiary institutions, such as the University of Johannesburg and Rosebank College.

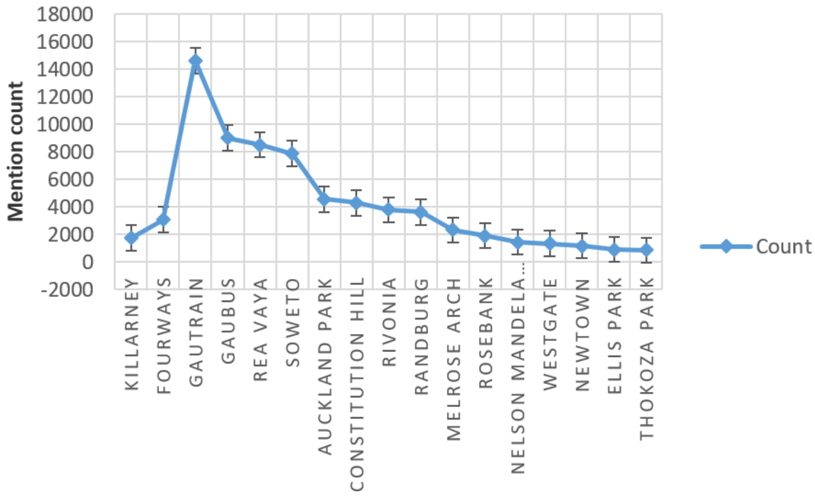

Figure 5. Geographical analysis of GeoWeb 2.0.

Other notable locations are: Fourways (2106), which is the fastest-developing commercial and residential hub; Constitution Hill (4032), which is located in proximity to the city municipal offices; and Randburg (4012), which is well known for its surplus of shopping centers and entertainment areas.

Spatial Connectivity

The growth in intermodal commuting in the city of Johannesburg promises to improve the quality of life of the citizens in the city. In this paper, we assessed the connectivity of two modes of public transportation: the rapid rail transportation system and the rapid bus transit system. Nodes with a high degree centrality index had the uppermost number of associations upon the node. Figure 5 reveals that of the three networks, the Rea Vaya network had the peak number of higher order nodes, followed by the Gaubus. It is notable that the Gaubus and Rea Vaya degree centrality was similar for these nodes and the creation of an augmented public transportation of the two networks would be easy, as their operational dimensions are similar. However, the travel timetable and pricing would need to be adjusted to ensure the seamless interchange of commuters between these two networks to meet the underlying commuting requirement of ease of use.

A spatial statistical analysis of the public transportation nodes revealed hot and cold spots. Overall, the local Moran I classification of the Gautrain–Gaubus network nodes revealed notable high-cluster nodes at Park Station, Rosebank, Sandton, Malboro, and Midrand (see Figure 6). These nodes are located within economic and business nodes in the locations; hence, commuters traverse between these two locations frequently. Given the spatial concentration of economic activities in Rosebank, there was, notably, the highest number of high-cluster nodes present in this location. From Figure 6, there were no existing nodes that linked commuters who resided to the South of the city to the Gautrain network. Consequently, commuters who resided to the South of the city, such as in Soweto, must use another form of mobility mode before they can access the Gautrain system. Accordingly, a partnership seems worthwhile for the Gautrain network and Rea Vaya network, as the Rea Vaya has an existing road network that flows from Soweto past Braamfontein (see Figure 7).

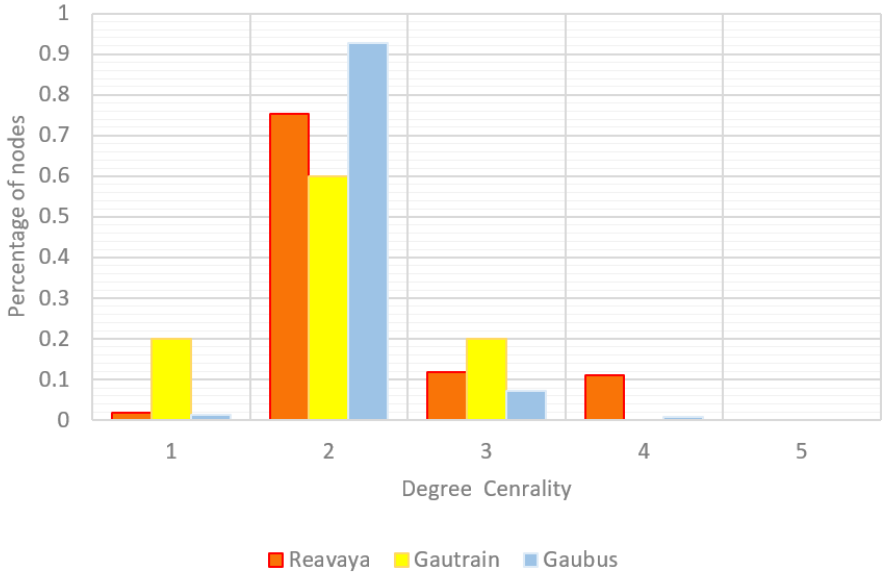

Figure 6. Degree centrality of existing networks.

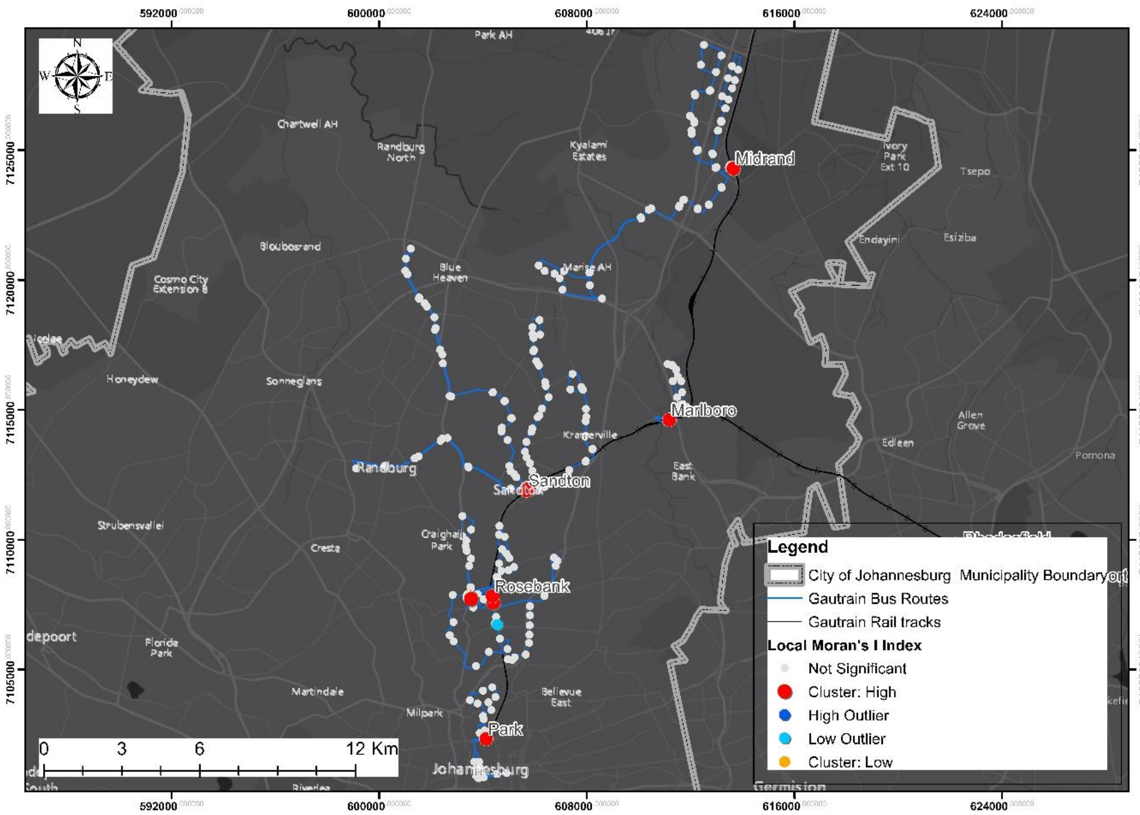

Figure 7. Local Moran's I index of Gaubus and Gautrain Network.

The Moran's I classification for the Rea Vaya network revealed significance levels of higher cluster nodes in the Johannesburg Central Business District (Braamfontein and Marshalltown) and to the South of the city in Soweto (Orlando and Dobsonville). A few notable low outliers were also located within proximity to Braamfontein (see Figure 8). A low cluster was also evident to the South of the city at Protea Glen. Currently, the Rea Vaya is expanding the network to the Northern part of the city. A collaboration between the Rea Vaya and Gaubus would ensure a larger spatial coverage of the rapid bus public transportation system.

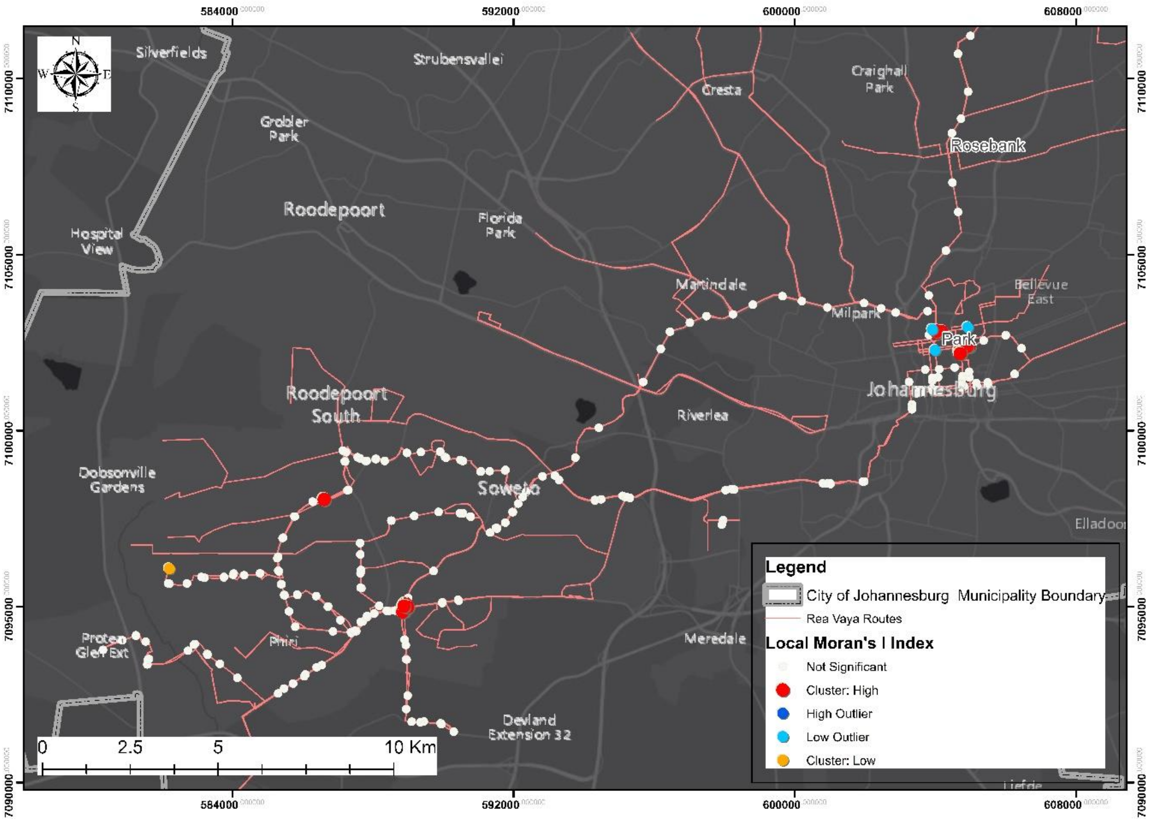

Figure 8. Local Moran's I index for Rea Vaya Network.

We then used the degree centrality to compute the robustness of the connected public transportation system comprising of the Gautrain, Gaubus, and Rea Vaya. Figure 9 reveals there were more high order nodes along the three public transportation systems. The Rea Vaya network had the most higher order nodes with a degree centrality of 4. Another interesting pattern was that the Gautrain had a node with a degree centrality of 4.

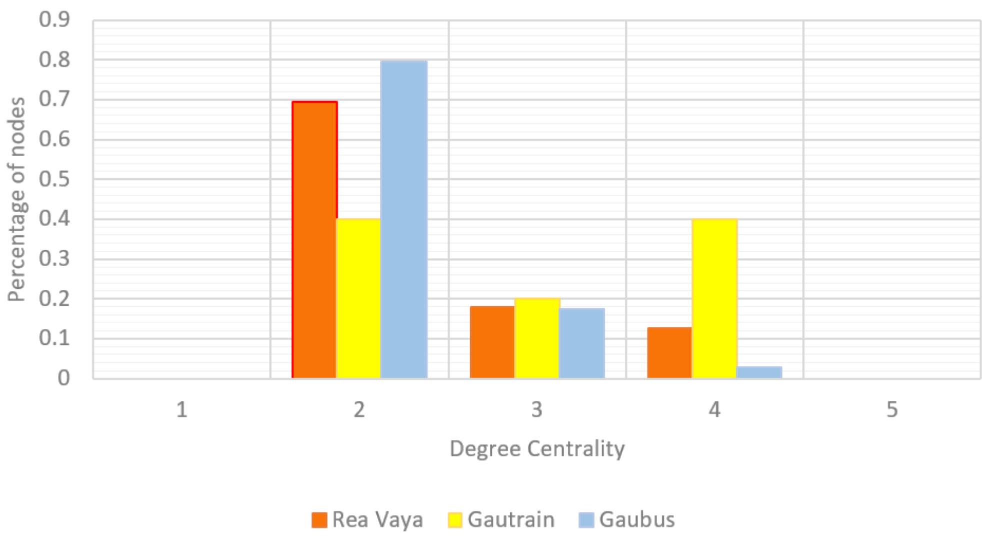

Figure 9. Degree centrality of connected network.

Figure 10 reveals the location of nodes with respect to a cluster and outlier analysis. More high-cluster nodes were prominent in locations such as Midrand, Rosebank, Sandton, Dobsonville, Orlando, Naledi, Phiri, Auckland Park, Protea Glen, and Roodepoort, whilst low-cluster nodes were more prominent in Braamfontein and Marshal town. One notable aspect of the connected public transportation system was the high number of high-cluster nodes.

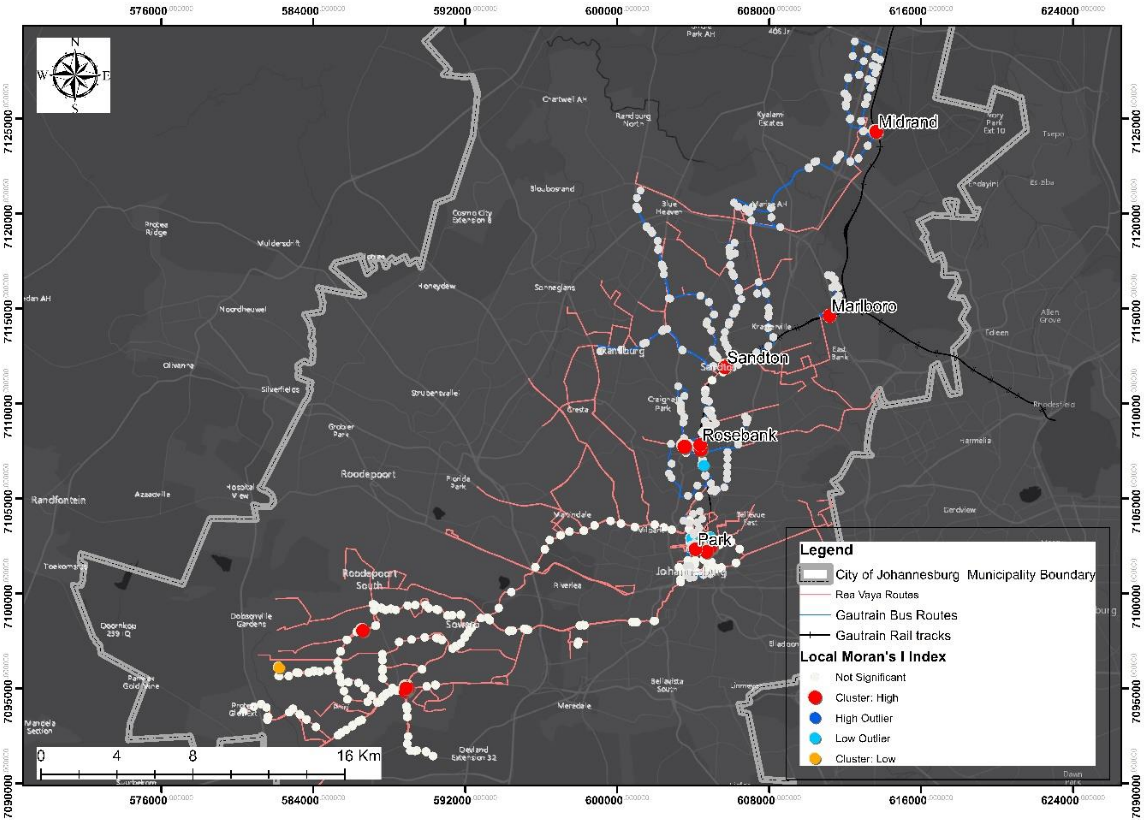

Figure 10. Locan Moran's I index for connected network.

4. Discussion

The development of a sustainable public transportation system is essential for urban development—this being another lacuna that justifies this current study by advocating for improved access to areas of economic and business nodes in the city. The results revealed that the Rea Vaya network has been successful in improving commuter accessibility to economic and business nodes for commuters residing in the Southern parts of the city. Given the foregoing results, the commuter concentration zones of the Gautrain and Rea Vaya were then overlaid to identify which nodes should be used as the initial geolocations to promote multi-mobility within the city (see Figure 11). The results revealed that Park Station has the highest integrated commuter concentration.

With this high commuter convergence, improving commuter transfer, such as with geolocations, would be a good starting point, as there is pre-existing transport infrastructure. 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 that can later be redeemed for a discount. This would build on the existing commuter concentration and attract other commuters to join the system.

The introduction of a multi-modal transport system would be cost effective for the two public transit providers to partner towards promoting multi-mobility within the Johannesburg city region instead of building separate infrastructure (as is the current case with the Gautrain and Metrorail), as the Gautrain would link commuters to economic and business nodes in the Northern parts of Johannesburg (namely, Rosebank, Sandton, Marlboro, and Midrand) and the Rea Vaya would link commuters to areas of economic and business nodes in the Southern part of the city.

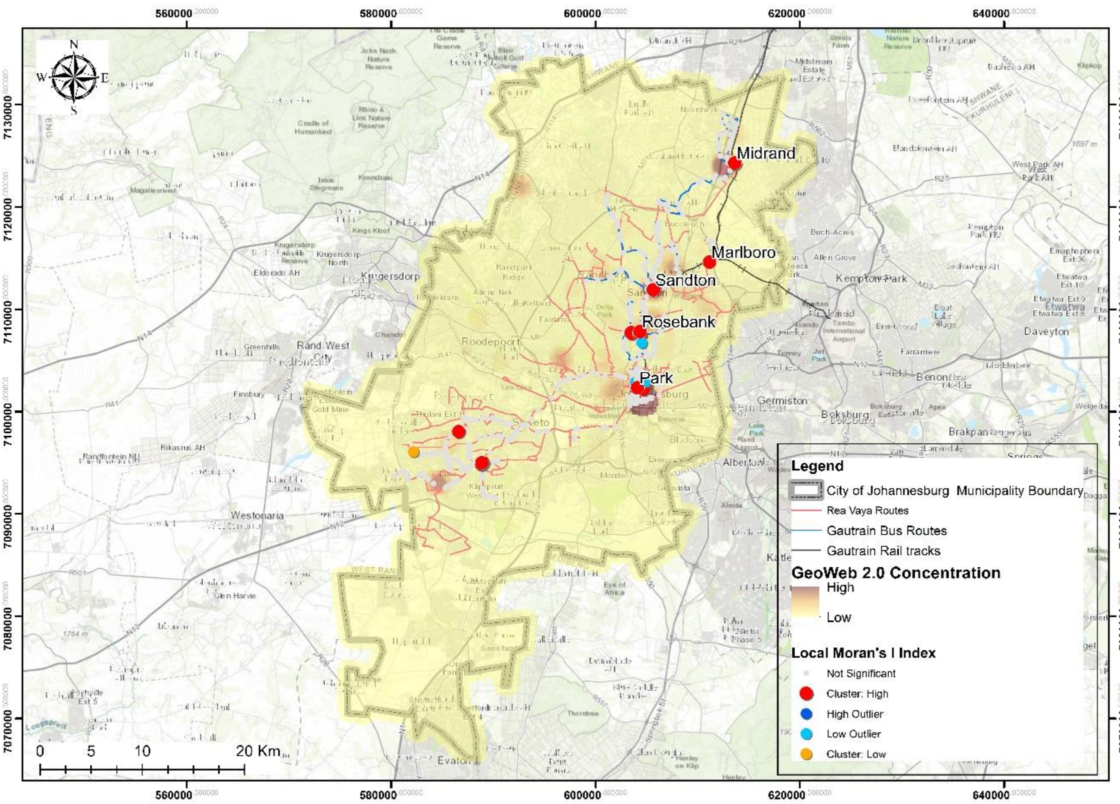

Figure 11. Spatial connection of all nodes.

5. Implications, Reflections, and Generalizability of Findings

This work has several implications with regards to the new knowledge generation for academic purposes and policy formulation and implementation in the local, provincial, and national spheres. The methodology proposed in this paper can be adopted to inform interventions that integrate the network designs of numerous public transportation systems in the country's numerous cities: particularly metropolitan cities. This paper has proposed the integrated network design framework of multiple public transportation systems using a case study of South Africa. We therefore propose a scenario that illustrates the benefits of integrated network designs. Commuters who reside in the South of the city of Johannesburg (for example, in Soweto) but work in Sandton, which is on the North of the city, are currently utilizing more than one mode of transportation to traverse daily from home to work, since there are no direct public transport or routes that service these two locations. The integration of payment systems and the creation of transfer points at influential nodes, which may result from policy recommendations and implementation, may lead to the improved and smooth movement of commuters within and between metropolitan cities.

A close reflection reveals that contemporary public transportation systems in cities of the developing world seek to become highly flexible and demand-responsive [49]. Currently, knowledge gaps exist in transportation policies on how existing public transportation systems can be integrated. Several public transport modes are currently managed and operated separately in South African cities. Moreover, given the lack of integration of the transport modes, the commuters currently cannot plan their trips, as the timetables are not integrated and the payment systems are different. In addition, the fare payment systems are not harmonized, as commuters who utilize mini-bus taxis pay in cash; commuters utilizing the Rea Vaya have the option to utilize an e-ticketing system, and commuters who utilize the Gautrain and Gaubus use smart cards that are linked to both the Gautrain and Gaubus e-ticking system. Given that these numerous payment methods are not interlinked, the ease for a commuter to utilize all three modes is hindered. With regards to the city of Johannesburg, to create a bridge between the different parts of the city, the creation of enabling platforms for commuters to use both the rapid bus transit and the rapid rail transportation systems in an integrated format would lead to the improved use of multi-mobility within the cities. The flexibility in travelling between various places within the city, particularly the Southern and Northern points, will lead to reduced travel times (as the Gautrain and Rea Vaya are currently the fastest modes of public transportation) and, overall, this would lead to a reduced reliance on private vehicle travel.

The results of this study are generalizable and can be replicated in several cities of the developing world. In this paper, two public transportation systems are considered, which are the rapid bus transit system and a rapid railway transportation system. However, these modes are only located in a few locations of the city. The data and methodology can be applied in other metropolitan cities within the Gauteng provinces, such as the cities of Tshwane and Ekurhuleni, to determine ways of integrating the rapid bus transit systems within the cities, and Gautrain, which also serves these two cities. In other metropolitan cities of South Africa and other developing city contexts, researchers can incorporate the mini-bus taxis, which are sometimes referred to as informal public transportation systems, although they are very robust and dominant in several cities of the developing world. Considering that the majority of commuters are already familiar with mini-bus taxis in cities of the global South and that innovative urban public transport systems are being slowly developed in such cities [2], linking the various transportation modes would lead to sustainable transportation systems in these cities. To adopt such urban public transportation network systems, the choice of parameters should be more appropriate to include the flexibility of mini-bus taxis.

This work has brought several findings to attention; consequently, there are several lessons and points to consider. Firstly, integrated urban public transportation systems have the potential to enhance the overall commuting experiences, as they allow for more multi-modal trips. Secondly, influential nodes exist within a public transportation network; as a result, the properties surrounding these nodes should be used to enhance commuting experiences, as they offer gateways to surrounding communities. Thirdly, to ensure the ease of transfer between various modes of public transportation, the introduction of e-ticketing systems is essential, as public transportation systems without harmonized fare systems lead to delayed travel times, as commuters change their payment methods at each boarding point.

6. Conclusions

Although the improvement and efficient development of public transportation is an effective means of ensuring sustainable mobility within urban areas, the majority of travelers in the city still favor the use of their private automobiles. An understanding of commuter points of interest would lead to the better understanding of commuters' travel patterns. Contemporarily, there still exists a knowledge gap regarding the planning and implementation of sustainable intermodal public transportation systems. The Green Transportation Strategy for South Africa (2018–2050) seeks to address the current and future transport demands [35]. The identification of hot spots along public transportation networks will inform investment decisions on which nodes require infrastructural upgrades to meet the transportation demands. With regards to the article, the identification of hot spots is premised on creating an integrated transportation system. The use of Geoweb 2.0 data in this article is one step towards understanding commuter travel patterns, as citizens have grown accustomed to using social media in their daily lives. Hence, linking GeoWeb 2.0 data and the public transit system would lead to a bridge toward improving commuter access to their point of interest, such as economic and business nodes.

As the findings are funneled by the need for innovative means to inform multi-mobility planning, a statistical analysis approach was adopted to predict the sphere of influence of the Gautrain and Rea Vaya based on GeoWeb 2.0 data. To this end, the Rea Vaya, which has an extensive network in the Southern parts of the city, can improve the accessibility to economic and business nodes in the South, while the Gautrain, which is a rapid rail transportation system, has an existing network system between Park Station and Midrand that provides access to the Northern parts of the city.

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