

The Effectiveness of Smart Transportation Systems in Emerging Economies: A Case of South Africa

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Abstract

The global population is estimated to increase by 2.6 billion by 2050, in which 70% of the world's population will be staying in the cities. Countries will have to introduce solutions to traffic congestion, pollution, and security. South Africa is not immune to the global challenges and the rise in population. The purpose of this study is to evaluate the effectiveness of Smart Transport Systems in developing countries. The study used a qualitative approach, and scoping research methodology technology to review the papers published between 2015-2021, which were specifically concentrated on South African smart cities and transport. Articles relating to smart cities and transport in South Africa were intensively reviewed and 250 papers were selected. It was found that despite the challenges which South Africa as a country is facing, relating to the socio-economic, its initiatives are gradually developing especially in different metropolitan municipalities which are leading to very successful projects in both the public and the private sector. South Africa does have smart transport infrastructure in place which gives a good kick start and development of smart transport. However, good monitoring, evaluation, and planning of the current infrastructure are of great importance.

Keywords:

Smart Transport, Smart Cities, Intelligent Transport Systems, and South Africa

Introduction

As the global population grows, the social and economic challenges grow too. It is estimated that the world's population will grow by 2.6 billion by 2050. It is estimated that about 70% of the world's population

will be staying in the cities by the year 2050 (Bélissent 2010, Mangiaracina et al. 2017; Jordaan et al. 2019). Similarly, in South Africa, it is estimated that 71% of the population will be staying in cities by 2030 (Jordaan 2019), as of now, 63% of the population is residing in urban cities which is one of the highest around the globe (Matubatuba 2020). This means that cities will have to be smart to be able to respond to the challenges faced by people such as: improving the standard of living of people, minimise expenses, and increasing effectiveness and efficiency (Das and Emuze 2014, Jordaan et al. 2019); climate change and global warming by introducing renewable energy sources and the green initiatives (Hoe 2016); and subsequently deal with the climate changes, more especially in the transportation and health sector (Jordaan et al. 2019). However, in South Africa, public transportation systems have not kept pace with the rapid growth of urbanisation, resulting in increased demand for transportation, increased traffic congestion, and straining road infrastructure, necessitating alternate modes of transportation, such as the Rea Vaya (BRT - Bus Rapid Transit) systems (Matubatuba 2020).

The common strategy to introduce smart transport is to introduce smart technologies which will manage better smart transport in cities (Debnath et al. 2014). The research and development of smart transportation have shown great importance worldwide, mainly regarding the issues around congestion and urbanisation (Wibowo and Grandhi 2015). The government of South Africa is planning to build three smart cities in the next 25 years (BusinessTech 2017). According to Maswaku and Mokoena (2017), the question remains, do developing countries such as South Africa need smart technologies, as opposed to the poverty and equality which the majority of South Africans are currently facing? The developments in the transport industry mean the promotion of economic growth and social upliftment through an increase in mobility and accessibility improvements to people, markets, and resources. It is worth noting that the urban territories in South Africa are shaped by the historical spatial planning policies which reflect the public transport systems of the most current South Africa (Ferro et al. 2013). Therefore, this study is looking at the feasibility of adopting smart transport systems in the country under study, despite the current well-known socio-economic challenges caused by the historical spatial planning policies and other socio-economic challenges. However, it should be noted that there is development taking place in the country.

In South Africa, a smart agenda is needed to respond to local challenges such as poverty, inequality, service technology, and poor technology (Wilson and Guya 2020). Countries adopting smart agendas are considered "smart countries" as the technologies are used to respond to local socio-economic challenges (Wilson and Guya 2020). Several international studies indicated that benefits such as road safety improvements, reduction of congestion and fuel consumption, and reliable public transport improvements are the results of the implementation of Intelligent Transport Systems (ITS) (Vanderschuren 2006). Through the legacy of apartheid, the current government is also locating low-cost housing far from the industrial cities resulting in long-distance travel (Vanderschuren 2006). The current Smart Transport System such as the BRT system of Rea Vaya is one of the government's initiatives to come up with solutions for unreliable and non-regulated South African transport systems such as the private individual transport services or the minibus (Asimeng and Heinrichs 2021). While (Matubatuba 2020) considers the South African public transport system inadequate due to it being costly, unsafe, unreliable, and inaccessible which is of great concern to the government. This study is evaluating the effectiveness of the implemented smart transport systems to date in South Africa.

Research Question

As has already been mentioned that South Africa plans to build smart cities in the next 25 years (BusinessTech 2021). What is the state of smart transport in South Africa?

Objectives

- ✓ To evaluate the effectiveness of smart transportation systems in South Africa.
- ✓ To analyse the state of smart transportation in South Africa.

- ✓ To identify the current infrastructure in South Africa.

Literature Review

Smart Cities

Many countries all over the world have started introducing the concept of building smart cities (Hoe 2016; Suresh et al. 2020). The term smart cities was first coined in 1980 where it referred to a city that is entrepreneurially driven and competitive. In the 2000s technology was introduced to smart cities. The idea was to respond to global warming and climate change. Smart cities or cities that are technologically led are attractive to investments (Hoe 2016). The products and interventions of smart cities enhance the quality of life and sustainability through the use of innovation (Chen and Silva 2021). Some smart cities are being built from scratch while others are a refurbishment of existing cities. A smart city is defined as: *"a city that functions sustainably and intelligently, by integrating all of its infrastructures and services in a cohesive way using intelligent devices for monitoring and control, to ensure efficiency and better quality of life for its citizens"* (Suresh et al. 2020). A smart city's idea and operations are incomplete without a smart transportation system, throughout decades, technological advancements have pervaded this industry, allowing smart transportation to become a top focus in smart city development (Chen and Silva 2021). The idea of a smart city combines information and communication technology (ICT) and the Internet of Things (IoT) to improve the quality of city services and link them to people, allowing officials and citizens to communicate, as well as city infrastructure to track cities for various purposes (Derawi et al. 2020). South Africa is not immune to preparing cities for advanced technologies that are integrated into each other to solve problems.

The Department of Transport states that the goal of smart cities and urban transportation is to ensure that public transportation is used to provide reliable access to employment, opportunities, education, and social services. The country is currently building three smart cities that are based in Gauteng and Kwa-Zulu Natal. In Gauteng, the cities are Lanseria in Johannesburg and Mooikloof mega-city in Tshwane which is mostly known as Pretoria. While in Kwa-Zulu Natal, the smart city will be based at Durban Aerotropolis. These three cities are estimated to create many jobs and attract investments in those areas (BusinessTech 2021). As it is known that smart cities go hand in hand with smart transport, the above-mentioned proposed three smart cities will embrace the use of smart transport and intelligent transport systems.

The state of transportation in South Africa

This study reviewed the literature on the state of intelligent transport from the global and local context (South Africa). The challenges faced in the transport sector are reviewed and the landscape of the South African intelligent transport infrastructure is reviewed.

Smart Public Transport

With the advent of smart sensors, smart cars, and vehicular communication, the smart transportation system, also known as the intelligent transportation system (ITS) or transportation-based cyber-physical system (CPS), has been quickly evolving (Xu et al. 2017). The Smart Transport System can connect smart vehicles and roadside units mostly through vehicle-to-vehicle and vehicle-to-infrastructure communications, as well as integration of information, data processing, communication, and control technologies to enable the sharing of real-time traffic data and road information with users, as well as providing efficient and reliable services to alleviate congestion quality and security in the transport system (Xu et al. 2017). Not only does the Smart-city phenomenon of transportation include telematics for personal transportation, as well as intelligent and complex traffic flow control on roads and parking management, but it also requires a public transportation plan (Janoš and Kříž 2018). Public transportation is a core aspect of smart cities, and they should have an intelligent public transportation system (Vakula and Raviteja 2017). Global South public transportation is mostly operated by paratransit operators who self-regulate their services due to a lack of properly organized transportation supply and a limited or non-existent regulatory mechanism and regulation (Asimeng and Heinrichs 2021).

Since 1970, the mini-bus has overtaken all the other types of transport such as rail and bus services, and it is currently the main means of transport (Ferro et al. 2013; Vanderschuren 2006). However, the South African government is continually improving the situation through solving the land-use density and implementation of corridor approaches (Vanderschuren 2006). The corridor city aims to escape the detrimental effects of the edge city, development comes from the central business district, and existing radial links (public transportation) are upgraded, making it a sustainable

city (Vanderschuren 2006). The ITS concept has long been accepted in South Africa and several ITS projects such as electronic e-tolls, electronic fare payment, and traffic control and security CCTV (Thomas 2005). There are currently few smart transports that are currently operating in metro cities such as the City of Johannesburg (CoJ) and Pretoria. The Rea Vaya BRT system is an implemented Intelligent Transport System, operational in CoJ (The World Bank 2020). This BRT system was introduced by the South African government to regulate and ensure efficiency (Asimeng and Heinrichs 2021). The Gautrain project, one of South Africa's and Africa's largest and most ambitious transportation ventures, is playing a key role in boosting economic development and job creation in Gauteng, as well as reducing traffic congestion, promoting public transportation, tourism, and public-private partnerships, and changing the culture of the province (Vanderschuren 2006). The public transportation blueprint in South Africa, and especially in Johannesburg, reflects apartheid spatial planning, with two-thirds of people living on the outskirts of the city and traveling long distances to work in the city (Matubatuba 2020). One of the routes of the Rea Vaya System is currently operating from Soweto Township to several industrialized areas.

Smart Transport System/Intelligent Transport System in South Africa

Intelligent transportation systems (ITS) are technologies, software, and systems that provide accident warnings, reduce driving effort, prevent traffic congestion, and manage traffic (Giannoutakis and Li 2012). Mangiaracina et al. (2017) additionally state that ITS can offer road users real-time traffic and weather information and forecasts. Chen et al. (2020) argue that smart transport systems not only benefit travelers, but they make the smart city to be more productive and attractive. *“Smart transport systems are innovative technology used for cars, facilities, and operating systems that make cars smart”*. The Intelligent Transport System (ITS) is the product of a synergy between many existing technical components that are carefully incorporated into a process to solve general transportation control and provision of transportation information services (Drilo et al. 2009). ITS is a continual process that started in the 1960s embedding technological aspects into the surface of transportation management with microprocessors and integrated circuits advent (Thomas 2005).

The aim of the Department of Transport in terms of ITS is *to provide Intelligent Transport Systems that will detect, connect, and collect information and data for the benefit of transport users and members of the public, and assist in the reduction of discomforts on the road network and to facilitate the movement of goods and people and reduced costs to the state and users* (DoT 2008). In the 1990s the ITS was introduced in Johannesburg, South Africa, by the installation of electronic collection tools systems on Johannesburg roads (Abduljabbar et al. 2019). Advanced traffic control systems are used in larger South African cities to boost road traffic system capacity, at (major) traffic lights, the arrival of vehicles is assessed, and this knowledge about traffic demand is sent to a central computer, which optimizes green times (Vanderschuren 2006).

In South Africa, ITS is being investigated concerning the highway network in eThekweni (Durban) and the Huguenot tunnel, variable message signs (VMS) are available to notify road users (near Cape Town), In addition, a large-scale incident management pilot is planned for the Ben Schoeman Highway (BSH) (Vanderschuren 2006). The Department of Transportation should continue to push for, promote, and finance an integrated public transport ticketing system that consists of a single mechanism with cross-mode interoperability, allowing all banks and cardholders, including those that are unbanked, to participate (DoT 2017).

The South African Society for Intelligent Transport Systems (SASITS) was established on March 20, 2001, in response to a growing interest in Intelligent Transportation Systems. Members of the public and private sectors, as well as the education sector, are members of SASITS (Vanderschuren 2006).

The University of Kwa-Zulu Natal is working on smart transportation initiatives. The initiative is run by the Department of Mechanical Engineering student and academic staff. Their initiative will help with reducing congested traffic. In Durban, they have introduced several smart transport initiatives that assist passengers and motorists (Desai 2016). The City of Johannesburg has partnered with the University of Johannesburg to implement the Maru A Jozi application which aims to provide smart services for the residents of Johannesburg at a fingertip 24 hours a day 7 days a week 365 days a year. The project installed free Wifi at the bus stations so that passengers can enjoy using the Maru A Jozi application. The Maru A Jozi portal application is zero-rated. The application has features such as e-health services, mapping services, education, opportunities, emergency, city services, and transportation information (Rea Vaya - Bus Rapid Transit). For the effectiveness of the use of this project, they introduced and equipped 1800 Digital Ambassadors who trained 400 000 residents on how to use the Maru A Jozi portal (Jozi Digital Ambassadors 2016).

In Cape Town, they are using big data to enhance the commuter's experience and guide them on modes that are less congested. They use big data tools to enhance the quality and efficiency of intelligence. Below are the driving technologies of smart transport and intelligent systems.

Smart transport challenges in South Africa

Smart transportation growth should be aided by modern technology and effective governance, and transportation governance can have an impact on the development of smart transportation (Chen and Silva 2021). The adoption of IoT has been gradual and mainly confined to silos due to a range of reasons, including the difficulty in delivering a safe solution and the difficulty in selecting the "best" middleware (Coetzee et al. 2018) (e.g. the market is flooded with a variety of middleware platforms, each providing its approach and ensuring appropriate end-to-end network connectivity). Smart transportation governance in smart cities consists of a variety of plans, policies, projects, and actions, which may include integrated ticketing, electric vehicles, automated vehicles, and clean transportation policies (Chen and Silva 2021).

Long-term consequences of previous spatial segregation policies, as well as urban planning decisions that largely served the interests of local politicians and private property developers, have resulted in a huge urban sprawl problem (McKay 2020). When the urban density is lower, more energy for electricity and transportation is consumed, as it is proven that the higher the urban areas density CO2 emissions per capita drop (Albino et al. 2015). South Africa currently has a large proportion of its income spent on transport, due to urban areas' poor transport policies and planning caused by the historically weak urban planning decision which were influenced by the former unlawful government of race spatial segregation (McKay 2020).

Material and Methods

The study is following a qualitative approach of scoping research methodology technology, intending to evaluate, analyse, and determine South Africa's effectiveness, state, and relevant infrastructure required for a smart transportation system. This study followed an in-depth analysis. The following steps were followed to review the literature in line with (Mangiaracina et al. 2017; Hill et al. 2017)

Step 1: The evidence sources were identified - The study searched for both academic articles and industry research and government reports relating to smart transport and cities in South Africa. All in all, the study reviewed 250 academic journals. The academic papers reviewed are 225 globally and the ones which are South African-based experiences are only 10 academic articles.

Step 2: A high-level literature review – This was done to back up the argument of the paper of showing the importance of smart transport within South African cities, 225 articles were selected from the following journals, Springer, JSTOR, Emeralds, Science Direct, Taylor and Francis, IEEE, Cambridge University Press, SAGE Journals Online and Scopus. Then through reading the abstracts 97 articles were selected and the ones found more relevant, and out of those papers, 55 papers were most relevant and cited in this study which aided with the importance of meeting the objective of the study and the relevance of the argument of the study.

The number of articles that were searched was from 2015 to 2021. Unfortunately, Cambridge University Press database had problems with limiting the articles from 2015 to 2021. It showed all articles which made it challenging to only select the total number of articles that were published in 2015. However, when reviewing articles from the Cambridge University Press, authors were only focused on articles that were published in 2015. Taylor and Francis do not show a breakdown of the publication. However, the authors focused on articles from this database. Scopus databases do not show a breakdown of different publications. Only the most cited relevant articles from Scopus have been reviewed.

Step 3: The key literature pieces prioritization and identification - The main priority in this study is all articles which are focusing on the South African experiences in terms of smart transportation to meet the main objectives of this study which are evaluating, analysing, and determining South Africa's effectiveness, state and relevant infrastructure required for a smart transportation system. The 10 academic papers were identified through google scholar and Scopus engine searches with the following keywords:

- South African Smart Transport
- Smart Cities and Transport in South Africa
- Intelligent transport system in South Africa
- South African cities with intelligent smart transport
- The smart transportation system in South Africa
- South African smart transportation system

The aim was to find out the state of the cities in terms of smart transport, while concurrently analysing and determining the effectiveness of the current smart transport implemented projects and lastly relevant infrastructure which is still needed by the South African cities. The study was conducted by reviewing all relevant research articles, these are journals, and conference papers, with the following titles: smart cities, smart transport, and smart transport/cities. Intelligent transportation system/intelligent transport management, internet of things, and smart transport or transportation management.

The study specifically exhausted all the research articles and papers relating to South African transport. The table list below shows all the research articles from 2005 to 2021 which are published concerning smart transport in South Africa.

Step 4: The key literature sources in-depth analysis - The study is systematically reviewing the state of smart transport in South Africa, all papers which are reviewed so far, mainly those that are generic are more than 15 years old, these are the two papers Thomas, D., 2005 and Vanderschuren, M.J.W.A. 2006. Besides the fact that technology changes repeatedly, there are so many technological implementations related to transport that took place in South Africa in the last 5 years. Both papers have covered the most of smart transport-related elements in South Africa which gives this research solid background of what was implemented more than a decade ago.

In a complex environment, Information and Communication Technologies (ICTs) can help improve transportation sustainability by more efficiently controlling systems, facilitating behavioral changes, and lowering energy consumption, ITS is the most common acronym for the integrated application of ICTs to transportation (Mangiaracina, Perego et al. 2017). ITS applies to all forms of transportation, including air, ship, rail, and road, as well as every component of a transportation system, including the vehicle, infrastructure, and driver or user, all of which interact dynamically. The most recent paper by Abejide et al. (2018), is looking at the intelligent transport system and public transport in South Africa. The paper is only concentrating on the state of public transport and ITS implementation in South Africa, which is not the inclusion of all elements of smart transport, as per this study. This paper concentrates on all the 4IR technologies such as big data, AI, the Internet of things, and the machine learning algorithm. Abejide et al. (2018), are investigating the challenges faced by South Africa in terms of the lack of an Intelligent transport system, specifically an intelligent communication system that may aid road users, with current problems such as congestion, accidents, and road delays.

Abejide et al. (2018) also related more to the paper authored by Olayode et al. (2020), the paper is specifically concentrating, and its unsignalized road intersections and traffic congestion in Johannesburg South Africa. Abejide et al. (2018) study used survey questionnaires in the Free State province of South Africa, while Olayode et al. (2020) is a holistic critical research review, specifically focusing on Highways unsignalized road intersections as a suggestion for the implementation of signalized road intersection on a highway's roads. Both papers differ from this study in both the direction of their study as well as the research methodology, even though the papers are concentrating on the South African transport sector relating to smart transport, but with this paper study is covering all the provinces, reviewing government publications relating to generic smart transport and is also inclusive of all kinds of 4IR technologies implemented so far relating to smart cities.

(Madihlaba G.L. 2019) is one of the papers recently related to this study. Madihlaba's study is more directed at the secondary cities of South Africa, "*The secondary cities are defined as a group of cities that sits somewhere below the group at the very apex of an urban hierarchy - an apex occupied by 'primary cities' or 'primate cities'*". (Madihlaba, G.L., 2019)'s research project aims to find out what the options are for using ITS to solve the transportation issues in Port Shepstone's secondary area, as well as what proposals can be made for the implementation of ITS in Port Shepstone. It is a small town situated in the Mzimkhulu River which is known as the largest river on Kwa-Zulu Natal south coast. The study is also not generic as it concentrates on one area which is not even overpopulated as most primary cities are covered in this study.

Systematic review. the other related study which is also a master's thesis on Intelligent transport by (Matubatuba 2020) concentrates more on the South African BRT system, specifically the one operating in the CoJ known as Rea Vaya, the aspect of ITS as only-sided into BRT transport system.

(Hommes and Holmner 2013) the study is looking into the implications of ethical standards in implementing Intelligent transport systems. The study is specifically relating its problem statement to an initiative made by South African National Road Agency Limited (SAMRAL), three initiatives that took place between 2007 and 2012, under the Gauteng Freeway Improvement Project. (Hommes and Holmner 2013) the study is very crucial for policymakers to consider the ethical standard of every technology implementation, to avoid life-threatening issues which may result from personal information collected through such technological initiatives. The study used qualitative research, with a case study tool. Information regarding ITS implemented in the Gauteng Freeway Improvement Project was collected from both academic papers, SANRAL, and other government reports. This study is the same as (Matubatuba 2020; Olayode et al. 2020; Abejide et al. 2018), the studies are concentrating on specific aspects of ITS or smart transport, which limit the study to review every South African government report and academic articles, which clearly outline the difference between these articles relating to ITS and Smart cities/transport in South Africa with this study. It is found in this study, smart cities are inseparable from smart transport, and hence the following papers are based on South African smart cities (Dlodlo et al. 2018). Most of these papers are very specific with a certain element or technology of the intelligent transport system, and all link back to the smart cities/transport. Specifically, this study was looking at the overall initiatives from both the public and transport sectors regarding smart transport/cities. In this study, it is also learned that smart cities and transport are also two inseparable concepts, as one cannot discuss the other term without the involvement of the other.

Table 1. Local Academic Articles on Smart Transport and Cities

No.	Author	Paper title	Year	Findings
1.	Coetzee et al,	European Union and South African smart city contextual dimensions.	2015	Europe has been working on smart cities, while South Africa has recently started.
2.	Abejide, O., Adedeji, J. and Mostafa Hassan, M.	Intelligent transportation system as an effective remedy to improve public transportation in South Africa.	2018	South African transportation is uncoordinated and has pitfalls.
3.	Aropet, R.	Southern African solutions to public transport challenges.	2017	Transport systems in South Africa are disconnected and affect all users.
4.	Hommes, E. and Holmner, M.	Intelligent Transport Systems: privacy, security, and societal considerations within the Gauteng case study.	2013	The technology that is used by ITS is against the protection of personal information.
5.	Madihlaba, G.L.,	Adoption of intelligent transport systems for sustainable transportation in secondary cities of South Africa: a case of Port Shepstone.	2019	Secondary cities ignore the use of technological infrastructure for transportation.
6.	Matubatuba, R.	Determinants of consumer adoption of the Rea Vaya (BRT) system in Johannesburg.	2020	Public transport plays a huge role in achieving efficiency, sustainability, and high-quality living.
7.	Olayode, I.O., Tartibu, L.K., Okwu, M.O. and	Intelligent transportation systems, unsignalized road intersections and traffic	2020	Traffic congestions are a major problem in developing and

	Uchechi, U.F.,	congestion in Johannesburg: a systematic review.		developed countries.
8.	Thomas, D.,	Smart transport. <i>SATC 2005</i> .	2005	The transport industry in South Africa is not ready for advanced technologies.
9.	Vanderschuren, M.J.W.A.	Intelligent transport systems for South Africa: impact assessment through microscopic simulation in the South African context.	2006	Transportation improvements promote economic growth.
10.	Adewumi, E. and Allopi, D.	Rea Vaya: South Africa's first bus rapid transit system. South African.	2013	Public transport should be made user-friendly and attractive.

Table 1 above highlights local academic papers on smart transport and cities. In this table, ten articles are highlighted with the oldest article published in 2005 and authored by Thomas focused on smart transportation. This paper purported that the transport industry in the country under study was not ready for advanced technologies. The paper proceeding that was in 2006 by Vanderschuren, alluded that improving transportation systems by including intelligent systems promotes economic growth. All the other articles following that were post-2013. One article published in 2013 by Hommes and Holmner, stated that the technology that is used by intelligent transport systems violated the personal protection of personal information. Another article published in 2013 by Adewumi and Allopi, mentioned that public transport must be made user-friendly and attractive. The remainder of the articles looked at how beneficial intelligent transport systems will be to the transport industry in the country under study while others look at how behind the industry is. The challenges are looked into and some cities do not embrace the technologies.

4. Findings and Discussions

4.1. Smart transport infrastructure in South Africa

The City of Johannesburg metropolitan municipality in Johannesburg has a Maru A Jozi portal. This portal was launched in 2016. The portal is intended to be a one-stop service directory for the residents of Johannesburg. On the portal, residents of the City of Johannesburg can also check transport services (Rea Vaya Bus, which is the Bus Rapid Transit). The city has made free WiFi available at the BRT stations. This makes it easier for commuters to access the internet and be updated about the services rendered by the city.

Bus Rapid Transit (BRT) - Rea Vaya Bus station. The bus stations are fitted with smart technologies that commuters can use to purchase tickets, and load money so that can be able to board the bus and gain access to the station by tapping their access cards. The access cards are linked to one of the country's banks. Commuters can reload their cards at the bank's automated teller machines (ATM) that are cash-accepting. In the station there is a real-time bus tracking that displays the time that the next busses will be arriving at what time and which bus will be going to which destination. All that displays on a screen. Whenever there will be a delay on a specific bus it updates and changes the time for arrival. Rea Vaya is specifically for the City of Johannesburg, and it transports 30 000 commuters daily who are going to work, and it exceeds its target of 80 000 commuters daily. This operates for 18 hours (05:00 to 23:00) from Soweto to the inner city of Johannesburg. The BRT project was approved by parliament in the year 2007. In the City of Tshwane, Tshwane Rapid Transit was introduced in 2014 which is the same as Rea Vaya however, it is meant for the City of Tshwane, and it is called A Re Yeng. There are other advanced transport networks in other cities and metropolitans such as eThekweni, Rustenburg, Mbombela, George, Ekurhuleni, Mangaung, Msunduzi, and Polokwane (Department of Transport 2021). However, those who reside next to the BRT station when they strike residents sometimes vandalise the station and sometimes leading to the temporal closure of the station. This has dire consequences for those who use the bus in the area, the BRT service, and subsequently to the economy.

E-toll services in Gauteng province. E-toll is a product of SANRAL and was launched in 2013. It bills road users whenever they use the roads that have this service. Whenever road users drive past where there is an e-toll technology

their cars are captured automatically by the cameras. At the end of the month, they receive a statement of how much they owe with guidelines on how they can pay. Gauteng drivers are encouraged to register for e-toll services. However, any car that passes the e-toll technology is automatically captured if it has a registration. The statement is then sent to the car owner's address. This e-toll is linked with other nationwide tollgate services. A car that is registered for e-toll services has a demarcated lane that is quicker and has no traffic as it is linked to the tollgate. The demarcated lane is called Shesha lane, which is a Zulu word for fast. This implies that the lane is faster. The driver does not have to queue but drives straight to the demarcated line and will automatically be billed as the tag embedded in the car will read and the car will automatically be billed. However, car owners will have to load the money at the e-toll offices that you can find across the province.

National Traffic Information System (NaTIS) is a product of the Road Traffic Management Corporation. It was launched to the public in the year 2007. South Africa has introduced an electronic system that the public can use to book for writing learners' licenses, driving testing, vehicle testing, renewing licenses, and reporting an accident. On the online system clients can see their bookings and in some cases when needed can cancel their bookings. This system is widely used in the Gauteng province as compared to other provinces. In Limpopo for example, clients go to the traffic department and book an appointment and return to get the service. This is not the case in Gauteng. Clients make an appointment online using the NaTIS system (portal), then go on the given date as per the available slot.

4.2. Recommendation

The infrastructure available needs to be improved so that it can be more effective and implemented in other parts of the country instead of very limited parts of the country. The government needs to educate the residents that whenever they protest, they should not vandalise the station as this has dire consequences for those who use the transport to and from work and school. Acts of vandalism affect the quality of the service and sometimes lead to suspension of the service. Maru A Jozi portal must have the latest information regarding services provided by the city and most importantly, commuters should also check in real time what time the bus will arrive at which station so that those who may be using the portal from home can also work according to the information on the portal. E-toll infrastructure should not only be used for billing clients but should also be used for fighting crime using detecting stolen cars that pass there and being linked to the South African Police Services so that the police force can quickly work on such cases. The NaTIS online portal should also be used in all provinces to help with all the online services including securing appointments. The Department should also consider having virtual consultations and offer some services both online and in the Department to accommodate those who may be good with technology. Furthermore, the integration of all these services will be beneficial as all services will be done on one platform. The Department of Transport should consider a one-stop platform for all the above-mentioned services.

5. Conclusions

The building of smart cities in South Africa will open doors for many opportunities for smart transportation. It should not be undermined that smart transportation plays a crucial role in minimising congestion in the cities, it makes transportation reliable, affordable, and safe. In this study, the main question was: "What is the state of smart transport in South Africa?" The following objectives were outlined and addressed in this study:

- ✓ To evaluate the effectiveness of smart transportation systems in South Africa.
- ✓ To analyse the state of smart transportation in South Africa.
- ✓ To identify the current infrastructure in South Africa.

From the literature, the country has some form of smart transport system. Although they are not as advanced as in developed countries, they can get to that level if the infrastructure is improved, and well taken care of, and involving other interested parties to work within the quest of turning South African transportation into a smart one. The objectives of the study were achieved, and recommendations were made. From the work done in this study, smart transport will require different stakeholders and may take a bit of time to get everything done. However, it will be very beneficial to the country if the smart transport project in South Africa becomes a success. Future studies should look at the roadmap for creating a mutual partnership for creating smart technologies.

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Biography

Lawrance Seseni is an Entrepreneurship Lecturer who teaches undergraduates and supervises honours and master's students at the University of Johannesburg. As part of his work in disadvantaged communities, he has initiated several developmental projects, such as conducting career exhibitions in those communities. He currently serves as the Primary Faculty Advisor of the Enactus University of Johannesburg, an international student organisation dedicated to solving societal problems through social entrepreneurship. In addition, he launched the Business Clinic at the University, as he believes that teaching students to take part in community service projects will create citizens of value. This initiative aims to help struggling SMEs in and around Johannesburg. Furthermore, he is the editor of the department's newsletter and a houseparent in a mixed residence on campus. Among his commitments, he is the lab manager for the European Union's and Erasmus+'s Common Good First Digital Storytelling project. Participants in the Digital Storytelling Project are universities from Iceland, Norway, Denmark, Scotland, Spain, and South Africa. A major goal of this project is to showcase community-generated innovative content. As a researcher, he has had a number of his articles published in international conferences that are indexed by Scopus. His recent experience includes serving as a Session Chair at international conferences, reviewing conference papers, and serving as a Track Chair as well as presenting as a distinguished speaker at conferences. A Golden Key member, Lawrance Seseni is in the process of achieving his Ph.D. in Operations Management.

Sebonkile Thaba is currently a lecturer at the University of Johannesburg. She is a cited author in google scholar and Scopus. As the best paper award winner, she published more than 30 academic articles presented locally and internationally. Some of her duties in the University is to serve in Teaching and Learning, Community Engagement and Decolonization committees. She serves these committees with pride because she is passionate about contributing in enhancing the quality of tertiary education in South Africa. Her teaching and learning philosophy informs her curriculum to include decolonization, 4IR and community engagement. Her students participate in socio-economic driven community projects. Their involvement resulted in more than 500 students being awarded 100 hours community services certificates from Enactus University of Johannesburg. During her spare time she mentors young people who

aspires to be academics of which some of them are now lecturers and cited authors. With regard to her contribution of body of knowledge internationally; she serves as a track and session chair, reviewer, distinguish speaker in supply chain and served as panelist in inclusion and diversity in academia. Sebonkile Thaba is awarded Academic Doctorate Advancement Project towards Transformation (ADAPTT) Scholarship, which is a collaboration of University of Florida (USA) and South African Higher Education (SA-HE) Network (UJ) and is currently finalizing her doctoral studies.

Professor Charles Mbohwa is the former Pro-Vice-Chancellor for the University of Zimbabwe. As an established researcher and professor in the field of sustainability engineering and energy, his specializations include sustainable engineering, energy systems, life cycle assessment, and bioenergy/fuel feasibility and sustainability, with general research interests in renewable energies and sustainability issues. Professor Mbohwa has presented at numerous conferences and published more than 150 papers in peer-reviewed journals and conferences, six book chapters, and one book. Upon graduating with his B.Sc. Honors in Mechanical Engineering from the University of Zimbabwe in 1986, he was employed as a mechanical engineer by the National Railways of Zimbabwe. He holds a Master's degree in Operations Management and Manufacturing Systems from the University of Nottingham and completed his doctoral studies at the Tokyo Metropolitan Institute of Technology in Japan. Prof. Mbohwa was a Fulbright Scholar visiting the Supply Chain and Logistics Institute at the School of Industrial and Systems Engineering, Georgia Institute of Technology; is a fellow of the Zimbabwean Institution of Engineers; and is a registered mechanical engineer with the Engineering Council of Zimbabwe. He has been a contributor to the United Nations Environment Programme and Visiting Exchange Professor at Universidade Tecnológica Federal do Paraná. He has also visited many countries on research and training engagements, including the United Kingdom, Japan, Germany, France, the USA, Brazil, Sweden, Ghana, Nigeria, Kenya, Tanzania, Malawi, Mauritius, Austria, the Netherlands, Uganda, Namibia, and Australia.

Dr Nelson Sizwe Madonsela (ND: IT, BTech, MTech, Ph.D). Business Intelligence Analyst, Senior Lecturer, and Acting Head: Department of Quality and Operations Management, University of Johannesburg (UJ). He holds a doctoral degree (Ph.D. in Engineering Management) from UJ and obtained his Master of Technology degree in Operations Management from UJ. He received a Bachelor of Technology degree in Quality from the University of South Africa (UNISA) and a National Diploma in Information Technology (Software Development) from Tshwane University of Technology (TUT). His research focuses on Business Artificial Intelligence and operation management, focusing on operational excellence. He also focuses on areas such as quality management systems, digital transformation, and project management. He has presented at local and international conferences and authored book chapters. Dr. Madonsela has helped provide high-level strategic and technical guidance in quality management and advanced project management to upskill the workforce among industries within South Africa. Additionally, he serves as a National Advisor on curriculum development, teaching and learning methods, and best practices in quality and operations management in several South African universities.