Exploring 4IR Technologies as a Solution to Improve the Traffic Flow on the Roads: a Case of the City of Johannesburg

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1 ABSTRACT

Globally, countries are challenged with traffic congestion and many solutions have been done to encounter this challenge. Many developed countries have managed to deal with the challenges of the traffic congestion through the implemented strategies by each country with challenge. This paper is set to study the drivers of the traffic congestion which results to numerous negative impacts and address the environmental and socio-economic challenges created by high usage of private vehicles in the City of Johannesburg, South Africa. Further, the authors consider solutions to reduce traffic congestions through the assistance of the 4IR technologies. The methods selected on this study follow both quantitative and quantitative approach using different graphs for traffic analysis illustrating the traffic data, and the use of ArcGIS software will be deployed to create a map indicating roads with high volumes of traffic. The preliminary results indicated that many private vehicles on the roads have a greater contribution in traffic congestion especially when accidents happen, rotational load shedding in the city, different peak hours of the day which this has a negative impact on the economy as it reduces the productivity of the city. The implications of the study indicate that the usage of private vehicles is more reliable than the use of public transport which results to high traffic congestion volume during different intervals and there are less technological efforts deployed to reduce the ever-rising challenge of traffic. However, the study recommends the adaptive traffic signals, real-time traffic monitoring, smart corridors, and pedestrian tracking systems with advanced V2I technologies. With this, there are possibilities of reducing the traffic congestion in the City of Johannesburg.

Keywords: Traffic congestion, 4IR, City of Johannesburg, private vehicles

2 INTRODUCTION

Globally, countries are challenged with traffic congestion and many solutions have been done to encounter this challenge. Many developed countries have managed to deal with the challenges of the traffic congestion through the implemented strategies by each country with challenge. The Republic of South Africa is a developing country with urbarnazation taking places daily, people moving from rural areas and other countries to cities for better opportunities. The City of Johannesburg Metropolitan Municipality which is located in the Gauteng province (state) contributes a lot to the economy of the country and afford a lot of opportunities to both its citizens and people from other countries. This leads to population growth, the infrastructure to service the city becomes overwelmed and different challenges arise which needs soution at some point. The movement on the roads becomes too much at points leading to traffic congestion and this is a global challenge when a city is too populated. Operations of the city becomes very slow as people spent time in traffic jam resulting to the affect in the economy and other importance services. Therefore, need for viable solutions that are used by the developed cities such as making the City of Johannesburg to be intelligent. An intelligent city uses the information to make their cities more livable, sustainable, and enjoyable compared to traditional towns. While smart cities are the future of urban landscapes, every piece of technology in a network needs to work together flawlessly so that community leaders can implement strategies to accomplish their goals (Giarratana, 2019).With the adoption of the fourth industrial technologies in the city, this could control the traffic jamming and make the city to more effecient, and resulting to a productive economy.

3 LITERATURE REVIEW

3.1 Modes of transportation on the roads

Transportation is the physical movement of passengers and goods from geographical location to another to enhance their utility (Akintayo, 2010). There are different kinds of transportation on roads which entail public and private transportation. These modes includes bus, minibus taxis, motor vehicles and motorbikes. All these modes of transportation use the roads at once and there are no designated times to use the roads. These leads to roads being flooded during the certain peak hours, in the morning, midday and early in the evening. Further, road transportation has average operational flexibility as vehicles can serve several purposes but can rarely operate outside roads. Road transport systems have high maintenance costs, both for the vehicles and infrastructures, which are related to low life spans. They are mainly linked to light industries and freight distribution, where rapid movements of freight in small batches are the norm (Rodrigue, 2020) .

3.2 Road Traffic congestion

Traffic congestion is a worldwild challenge created by many factors including urbanization, avoiding use of urban public transport, many private motor vehicles on the road, not many option of origin to destination roads, multi-functional traffic robots, non-proper manual systems and more technological systems deployed. As different road users form different locations moves towards the city at certain periods or intervals road become congested and the movement becomes very slow. Consequently, Giarratana (2019), states that congested roadways wreck havoc on the economy and culture of urban areas. Traffic causes significant problems for every aspect of a city, from the motorists that travel on public roads the roadways to the organizations that operate within cities to the residents that call them home. Some of the major complications that are directly linked to traffic include accidents, air pollution, noise pollution, reduced emergency assistance and reduced productivity. Accordingly, traffic congestion is a significant problem in many cities around the world. Jakarta, one of the most populous cities, faces this problem. However, there is different approach implemented to reduce the traffic jamming in the city such as strict policies and legislative frameworks on travelling patterns for road users, congestion charging and parking pricing reduce traffic congestion most if they are implemented for car based travel (Ilahi et al., 2020)

3.3 Fourth Industrial Revolution technologies (4IR) deployed for traffic control

The use of technology has ease down the pressure that canno be dealt with manually by people. According to McGinnis (2020), states that the Fourth Industrial Revolution is a way of describing the blurring of boundaries between the physical, digital, and biological worlds. It's a fusion of advances in artificial intelligence (AI), robotics, the Internet of Things (IoT), 3D printing, genetic engineering, quantum computing, and other technologies. It's the collective force behind many products and services that are fast becoming indispensable to modern life. Think GPS systems that suggest the fastest route to a destination, voice-activated virtual assistants such as Apple's Siri, personalized Netflix recommendations, and Facebook's ability to recognize your face and tag you in a friend's photo.

4IR technology has a positive in traffic control. Artificial Intelligence (AI), for example, can improve urban planning by optimising routes for transport operators, reducing commuters' journey times particularly significant move given our urban layout. Municipal governments could utilise traffic data for the planning of roads and the monitoring of traffic patterns. This has already been successfully piloted in cities in the United States as the use of an AI system which detects vehicles in images from traffic cameras, the information is sent to a control centre, where algorithms analyse traffic density. The system detects congestion and direct traffic lights to re-route traffic, based on real-time data (Marwala, 2020).

The 4IR introduces technologies such as smart roads. Smart roads are roads that think, feel, predict the needs of the people and the vehicles that travels on them. Roads that have an environmental conscience help cause positive changes on the vehicles and improve overall safety with the aim of making difference to the world (Emilee, 2016). Consequntly, Adetayo (2017) mentions that smart-roads are also a form of stylized road infrastructures that communicate with vehicles, users, and components of traffic management to enhance safe, reliable, comfort, efficient, affordable, and digitilized means of transportation. The typical smart-road will be more animated than the conventional, it will come with sensors, data capture capabilities, ability to respond to changes in the environment and will be able to communicate with the vehicles.

4 STUDY AREA

The city of Johannesburg is located in the Gauteng province, and it is been regarded as one of the biggest metropolitan areas in South Africa, (The local government handbook, 2014). City of Johannesburg (COJ) covers an extent area of 1.645 square kilometers, (Smith, 2013). In the past decades the administration of the City of Johannesburg Metropolitan Municipality was decentralized initially into 11 regions these new regions were subsequently reduced in number to 7 regions (A-G) in 2006 (Smith, 2013).
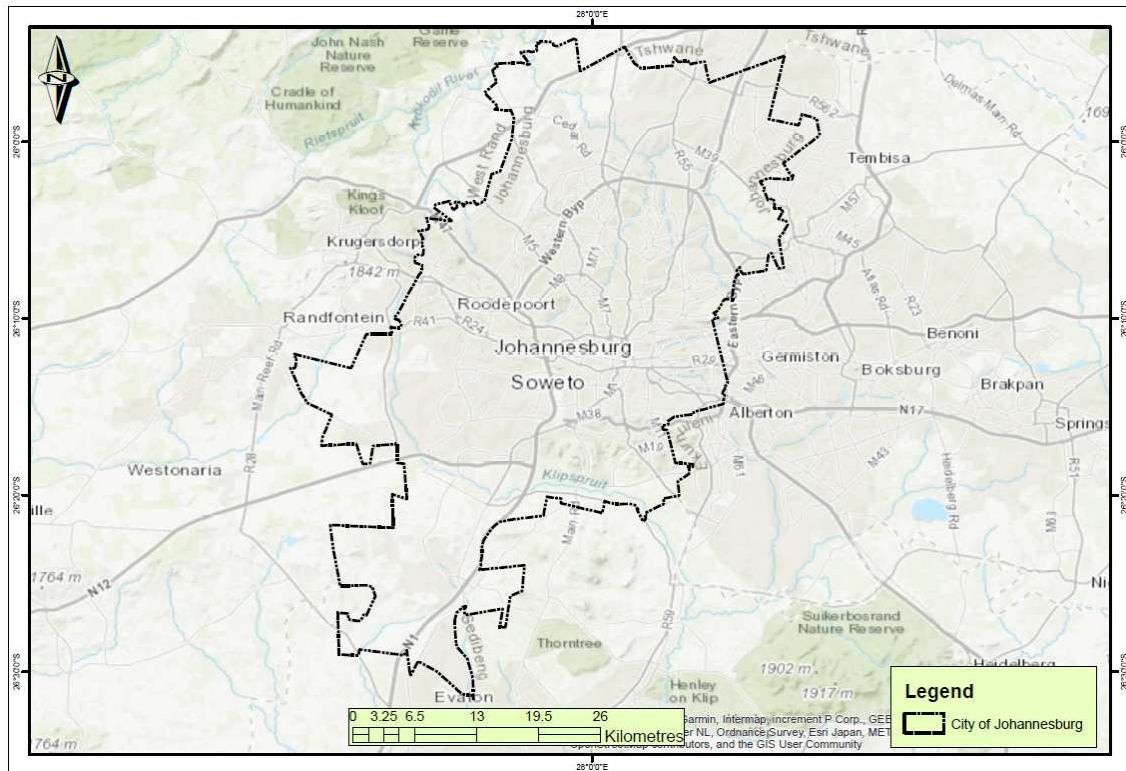

Figure 1: COJ Map [Source: Authors, 2021]

According to (SAIRR, 2014) South Africa's large population lives in urban areas, as an aftermath of urbanization over past years. High economic development in such urban areas has also attracted people to cities looking for better opportunities.

5 METHODOLOGY

A mixed method research design was adopted were quantitative data and spatial data analysis was used. Various research instruments were employed in the study such as Tomtom traffic index which provide accurate traffic information in real-time and statistics of previous information . This assisted to give the inside of the study to identify the traffic flow that happens, daily, monthly and yearly. Accordingly, a survey was conducted were road users were provided with questionnaire to understand the road patterns and what causes traffic congestin mostly. 30 road users who were provided with questionnaire are daily road users as they might have different experiences taking place daily. Purposive sampling was adopted as it is necessary to extract the necessary information of areas and times that are mostly affected by the traffic congestion. ArcGIS assisted with creating the City of Johannesburg map showing most roads that are affected by traffic jamming towards and out of the city. Map creation indicating the most areas affected by traffic, statistics from Tomtom and documented studies were the main sources of data. Comparative analysis was conducted in order to see the changes on traffic when the city was affected by the COVID 19 pandemic especially in 2020 and in 2021 when restrictions were eased down and there was lot of movement on the roads daily, and to identify the fourth industrial technologies deployed in the developed cities managing to control the traffic congestion. Further, content analysis was employed to review previous documented studies. Secondary information used was obtained from larger data base such as Scopus, Science direct, Sage and Google scholar.

6   RESULTS AND ANALYSIS

6.1 Roads affected by traffic congestion in the COJ

The City of Johannesburg (COJ) is one of the busiest areas in the republic which makes the movement on the road busy and mostly leading to high level of traffic congestion. There are several factors that leads to traffic congestion in the COJ such accidents, multi-funtional traffic robots especially when there is load-shedding (no electricity power), traffic officers normal routine of ensuring non-corruption activitties are taking place, the huge population number of people travelling towards the city creates traffic congestion. Which becomes a very huge concerns for all users travelling times to places of interest and affecting the productivity of individuals impacting the economy negativily.
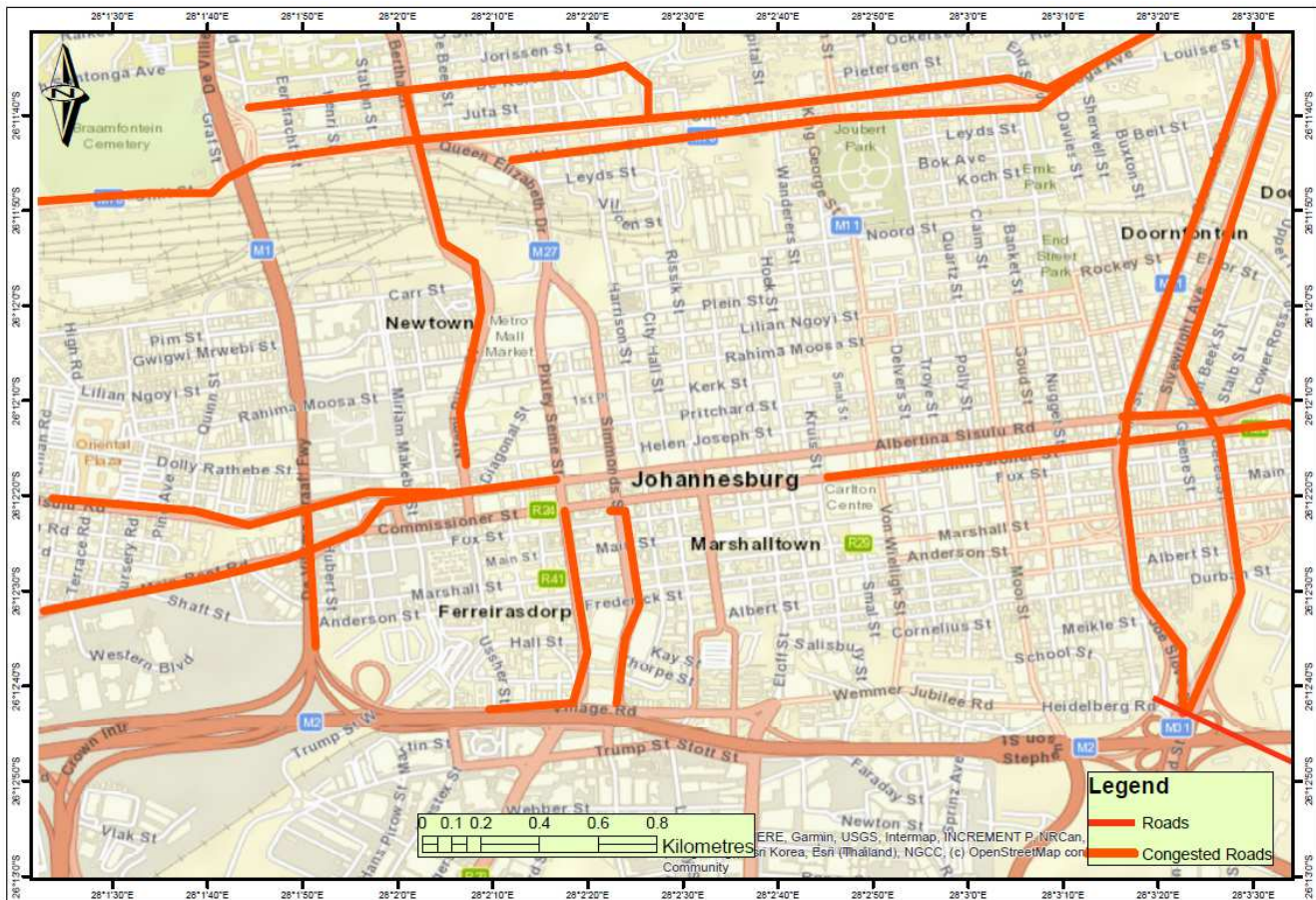

Figure 2: COJ traffic congestion Map [Source: TomTom, 2021]

The above figure 3 indicates the City of Johannesburg road network and the roads that are mostly congested. Roads that that highly congested are represented by the orange colour and mostly used major roads in the city are represented by the red colour. The main reef road and Albertina Sisulu road from the west of the map, mostly during peak hours have a high traffic congestion normally when road users are going to work in the morning and during midday towards the city. Consequently, the same amount of traffic congestion is noticed during later in the day and early evening when road users travel back home from different places of interest. De Korte street and Smith street from the north of map is mostly congested during the midaday as this roads service the Braamfontein area which serves as a CBD providing major economical services and also in the early evening when road users travel back home. Sivewright Avenue and M31, noticable is affected by high level of traffic congestion in the early evening from the Doornfontein area as most road users use the road to connect to the M2 and M31 which are the major roads serving travellers different urban areas of the city of johannesburg metropolitan area.

6.2 Congestion levels in the City of Johannesburg

The level of traffic congestion differ by months which this is sometime caused by different activities that take place daily.
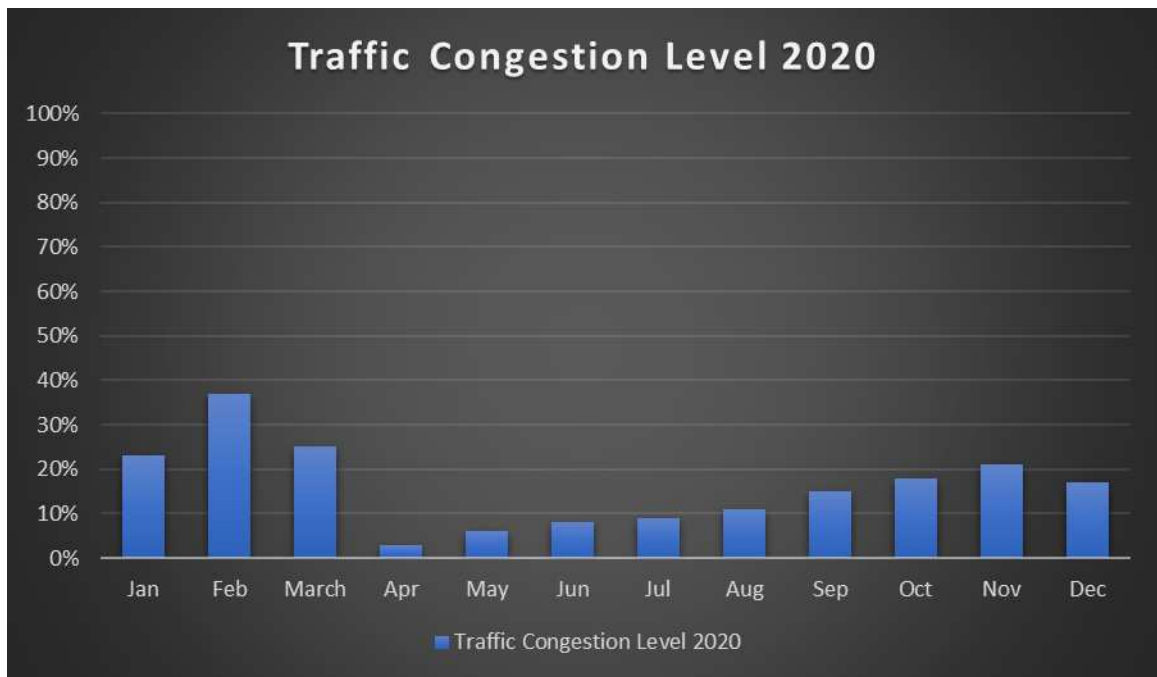
Figure 3: Traffic congestion level 2020 [Source: TomTom, 2021]

In the year 2020 traffic congestion in the early months of the year was high due to the normal state of the cities functionality and in the middle of the year traffic congestion dropped. This was due to the global pandemic that hit the country and the restrictons were put in place as the coutry was shutdown to a lockdown strictly movement was implemented and monitoring. Travelling was not permitted and only allowed due to certain conditions. During the first month of the year, January had average of around 25% percent as some of the workers and users of the road had to start travelling making daily trips. In February, the rest of the firm and institutions re-open, workers and users of the road also had to start travelling making daily trips which made the rate of traffic congestion to go up by 13%. In March, there was a reduction in traffic congestion as the pandemic was in the country, with announcement of awareness for travelling, travelling to certating areas of interest by the road users decreased by 11%. Consequently, in April, the traffic congestion dropped immesely to 3% as in late much the country was shutdown to lock down and only a certain percentage of movement was existing. Further, in the middle to later on year the restrictions were being eased to open some areas of economy from around late May to Novemember which is why the graph is scaling up from May to Novemebr. Further, in December, as it was the festive season, restrictions were lifted to combat the pandemic and the movement was restricted a bit and other operations in the city went on break due to festive, therefore, the traffic congestion reduced by 3%.
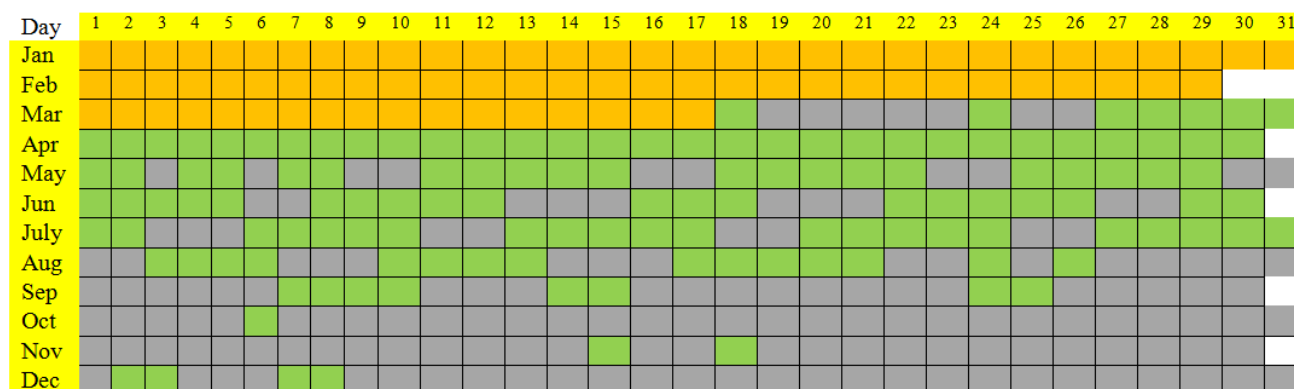

Figure 4: COJ Days with traffic flow [Source: TomTom, 2021]

The above figure 4 indicates the days with and without traffic congestion in the City of Johannesburg from January to December 2020. The Orange colour indicates the day with high level congestion at peak hours of the day. The green colour indicates days wereby there was less traffic congestion and the grey areas indicates the day with average traffic congestion and affected by the pandemic restrictions. As seen on the above table from January to the middle of March the daily traffic congestion was high and later on the month the traffic

eased down due to travelling restrictions introduced to the country. As it can be noted the pandemic had an major effect on travelling in the year 2020 as from April the high level of congestion were eased down.

Figure 5: COJ Traffic congestion level 2021 [Source: TomTom, 2021]

In 2021, the restrictions were eased down due solutions were identify to combat the pandemic and most operations were operating but must converted to take places from home than office and lot of online working was happening. The traffic congestion in 2020 early in the year compared to 2021 was slightly more less the same in January and February but in 2021was a bit lesser. In March and April 2021 traffic congestion was very high as more economic activities were opened and more daily trips by users of the road were taken.
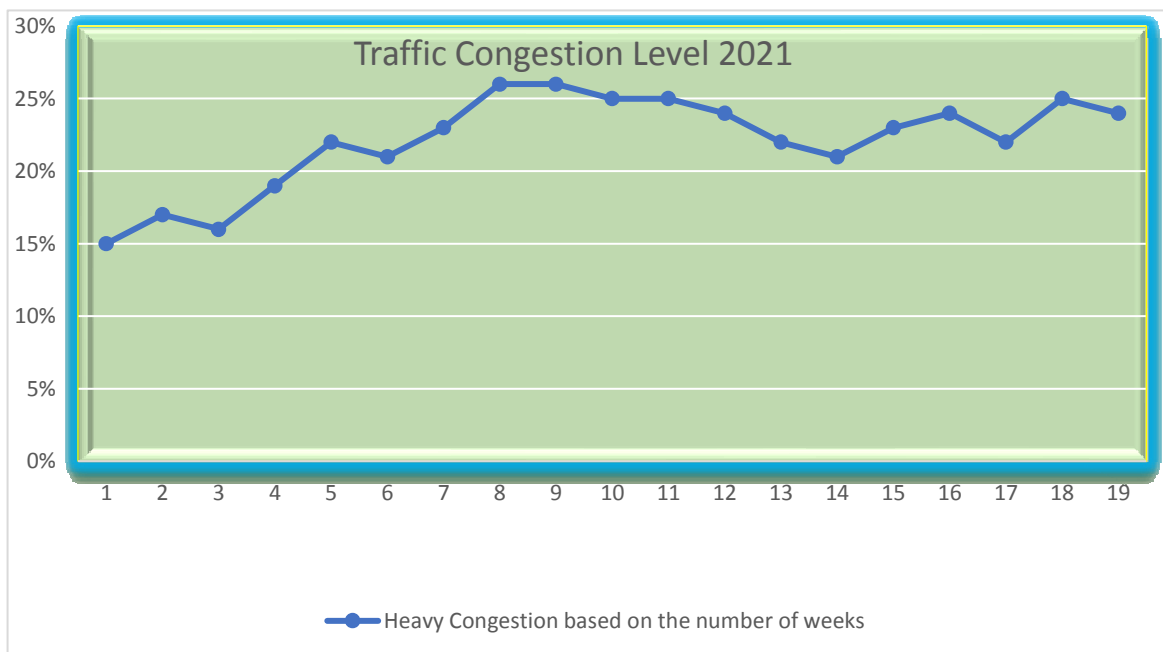

Figure 6: Weekly congestion level 2021 [Source: TomTom, 2021]

The above figure 5 indicates the level of traffic congestion in the City of Johannesburg from the first week of January to the second week of May. The above indicates that traffic congestion level in the first week of January to the fourth week the traffic congestion was between 15% to 20% as some of the operations in the city were still not open and due to working from home. In the first week of February to the last week of

February the level of congestion was going high and in the last week of February had the high level of traffic congestion due to the economy opening up. In the weeks of March and April the level of traffic congestion were declining due to some restriction in the country and holidays inbetween resulting in less travelling. However, the level of travel congestion was high at peak hours of the day.

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
12:00 AM	1%	0%	0%	0%	0%	0%	0%
	0%	0%	0%	0%	0%	0%	0%
2:00 AM	0%	0%	0%	0%	0%	0%	0%
	0%	0%	0%	0%	0%	0%	0%
4:00 AM	0%	0%	0%	0%	0%	0%	0%
	0%	1%	2%	2%	1%	1%	0%
6:00 AM	1%	30%	29%	28%	28%	27%	3%
	3%	48%	45%	45%	43%	42%	6%
8:00 AM	5%	34%	31%	31%	29%	29%	9%
	7%	18%	18%	18%	18%	19%	12%
10:00 AM	8%	15%	16%	16%	16%	18%	15%
	10%	16%	17%	17%	17%	19%	17%
12:00 PM	10%	17%	18%	18%	19%	23%	18%
	8%	18%	18%	19%	19%	26%	17%
14:00 PM	7%	18%	19%	19%	20	28	14%
	7%	23%	24%	24%	24%	34%	11%
16:00 PM	7%	38%	38%	38%	38%	43%	10%
	8%	42%	41%	40%	40%	37%	9%
18:00 PM	8%	22%	21%	21%	22%	24%	10%
	9%	11%	10%	11%	11%	16%	11%
20:00 PM	5%	5%	6%	6%	7%	9%	9%

Figure 7: COJ rush hour [Source: Authors, 2021]

The above figure 7 indicates the rush hour times in the City of Johannesburg wereby traffic congestion take place. As indicated in the above figure, it can be noticed that most days with high trafic congestions are Mondays to Fridays during 6:00 am in the morning to 8:00 am in the morning whereby most of the users are travelling to work and other city operations, and from 16:00pm to 18:00pm when most of the road users are travelling back home. With the introduction of the fourth industrial technologies, it will be workable to bring a solution when knowing when is the traffic congestion challenge is at its highest and how it can be combated.

7 CONCLUSION

Not only can traffic make the most patient people frantic, but traffic can also have a significant drag on the economy. A trip that should take no longer than 20 minutes can turn into several grueling hours, which caused by bumper-to-bumper traffic. Traffic congestion is the result of cities having more drivers than in the past with outdated maintenance, planning, and infrastructure that is not able to handle the needs of public roads (Giarratana 2019). While not often thought of in this way, traffic congestion is becoming a national crisis and needs to be addressed by city planners using advanced technology to help alleviate stress on public road infrastructure. City of Johannesburg must handle millions of drivers on the road at once. The city feels the stress of drivers battling traffic daily. Having a hundred of thousand of drivers stuck in traffic can waste a lot of potential hours and millions of Rands on the economy. Therefore, there is a need to deploy the 4IR technologies to control the traffic congestion and ease down the pressure on the roads daily for swift and smooth movement. Traffic will continue to plague cities as more drivers hit the roads each year, and city

engineers will need to look to cutting-edge technology to help the public have a healthier and happier life. Therefore, urban planners, policy and legislative framework makers need to find the right balance that our public spaces need to build a better future for our growing urban centres. The, city has no some sort of alternatives of controlling traffic congestion, the traffic jamming continues till the traffic flows. The traffic signal robots has proved that they are not enough to control the traffic jamming in the city, however, the situation becomes worse when there is no electricity for the robots to operates. Which this calls for more technological innovations that could assist the traffic officers to keep traffic flowing the roads.

8 RECOMMENDATIONS

Traffic congestion is not a new phenomenon, howerever, there are strategies that are being impleted globally through the use of technology to this challenge. The study recommends the use of adaptive traffic signals which allows cities to gain better insight about traffic, including the flow and the length of time cars idle at lights and The information can then be used to modify the timing of traffic signals so that they coincide with traffic patterns during the day, real-time traffic monitoring as this technology illustrates where public buses, taxis, and other modes of transit are located, it shows where parking spaces are available and so on, and smart corridors which this make sections of roads feature technologies that alert drivers of the upcoming traffic conditions, including any accidents that lie ahead, how long it will take them to reach a particular destination, impending weather events, and other obstacles that could impact driving (Giarratana, 2019). Smart corridors keep motorists "in the know" so that they can plan ahead, which in turn can help to ease traffic.

9 REFERENCES

Adetayo, O. A. (2017). Idea of smart development in the Fourth industrial revolution emphasis on smart road. SciFed Journal, 1 (1): 1-6.
Akintayo, S.B. (2010). Transport economies.S. Asekome and co press Zaria.
Emilee, T. (2016). Smart roads: Bedrock of future Transport.
Giarratana, C. (2019). That dreat ''T'' word. Available from: https://www.trafficsafetystore.com/blog/4-ways-cities-are-using-smart-technology-to-control-traffic-congestion/ (Accessed 15 May 2021).
Ilahi, A., Belgiawan., P. And Axhausen, K.W. (2020). Mapping the travel behavior Genome. Influence of pricing on mode choice decision integrated with latent variable: The case of Jakarta Greater Area. Elsevier. Pg 125-143.
Marwala, T. (2020). Urban Planning in the fourth industrial age. UJ. Available from: https://www.uj.ac.za/newandevents/Pages/Urban-planning-in-the-fourth-industrial-age.aspx (Access 20 May 2021).
McGinnis, D.(2020). What is the Forth Industrial Revolution?.The 360blog. Available from: https://www.salesforce.com/blog/what-is-the-fourth-industrial-revolution-4ir/ (Accessed 20 May 2021).
Rodrigue, J.P. (2020). The Geography of transport system. Rodrigue, J.P. (5thed.) Transportation modes, modal competitition and modal shift. New York: Routledge.
SAIRR. (2014). Power of ideas. Available from:http//irr.org.za/reports-and-publications/South-Africa-survey (Acceseed 24 May 2021).
The local Government handbook, (2014). A complete guide to all municipalities in South Africa. Adopted online from:http//www.municipalities.co.za (Accessed on 24 May 2021).