ISSN No:-2456-2165

An Analysis of Public Transportation for Bus-Based Commuting in India

Aryan Randeriya
Department of Computer Engineering,
Tapi Diploma Engineering College,
Surat, India

Neel Dedkawala
Department of Computer Engineering,
Tapi Diploma Engineering College,
Surat, India

Himanshi Borad
Department of Computer Engineering,
Tapi Diploma Engineering College,
Surat, India

Abstract:- This review paper provides an in-depth analysis of public transportation for bus-based commuting in India. The paper covers various aspects of public transportation such as congestion, emission, and commuters, providing a comprehensive understanding of the current state of public transportation in India. The paper also looks at the trends in public transportation in Indian cities, highlighting the growing popularity of bus-based commuting. The paper explores the merits of prioritising buses as a means of public transportation, highlighting their environmental and economic benefits. Additionally, the paper envisions a "smart" future for bus-based public transportation, exploring the potential of advanced technologies to improve the efficiency and convenience of bus-based commuting. Finally, the paper sheds light on the limitations of public transportation, including the dark side of public transit and the obstacles that need to be addressed. The paper concludes by discussing the electric revolution and its potential to revolutionise public transportation in India.

Keywords:- *Public Transportation, Buses, India, Public Transport, Transit, Traffic Congestion, GHG's (Greenhouse Gases), EV (Electric Vehicles), Emissions, Sustainability.*

I. INTRODUCTION

The purpose of this review paper is to survey and provide an analysis of public transportation specifically in regards to bus-based commuting in India. The issues of congestion, emission, and the increasing number of commuters in Indian cities will be examined. Additionlly, the paper will also explore the trends in transportation in major cities and the merits of switching from private transport. Furthermore, this paper will examine the smart technological advancements in bus commuting and the potential of the electric revolution to improve the public transportation system in India. The paper will also explore the limitations, and obstacles faced by bus-based commuting and how to overcome such limitations.

II. ANALYSIS OF CONGESTION, EMISSION AND COMMUTERS

One of the major reasons why private transport is harmful to the environment and should be frowned upon is the number of toxic emissions that are released. Vehicles emit various harmful fumes such as CO2 (Carbon Dioxide) & CO (Carbon Monoxide) from their exhaust leading to a negative impact on the environment and a cause for public health concerns.

The IARC (International Agency for Research on Cancer) classifies vehicle engine exhaust as "carcinogenic" i.e cancer causing according to evidence-based findings. Continuously inhaling vehicular fumes over a long period of time could possibly even lead to lung cancer.

According to the Global Burden of Disease 2010 (GBD) study, outdoor air pollution is among the top 10 risks worldwide and the top six risks in developing countries of Asia. In 2019 more than 1.4 million people lost their lives due to air pollution.

ISSN No:-2456-2165

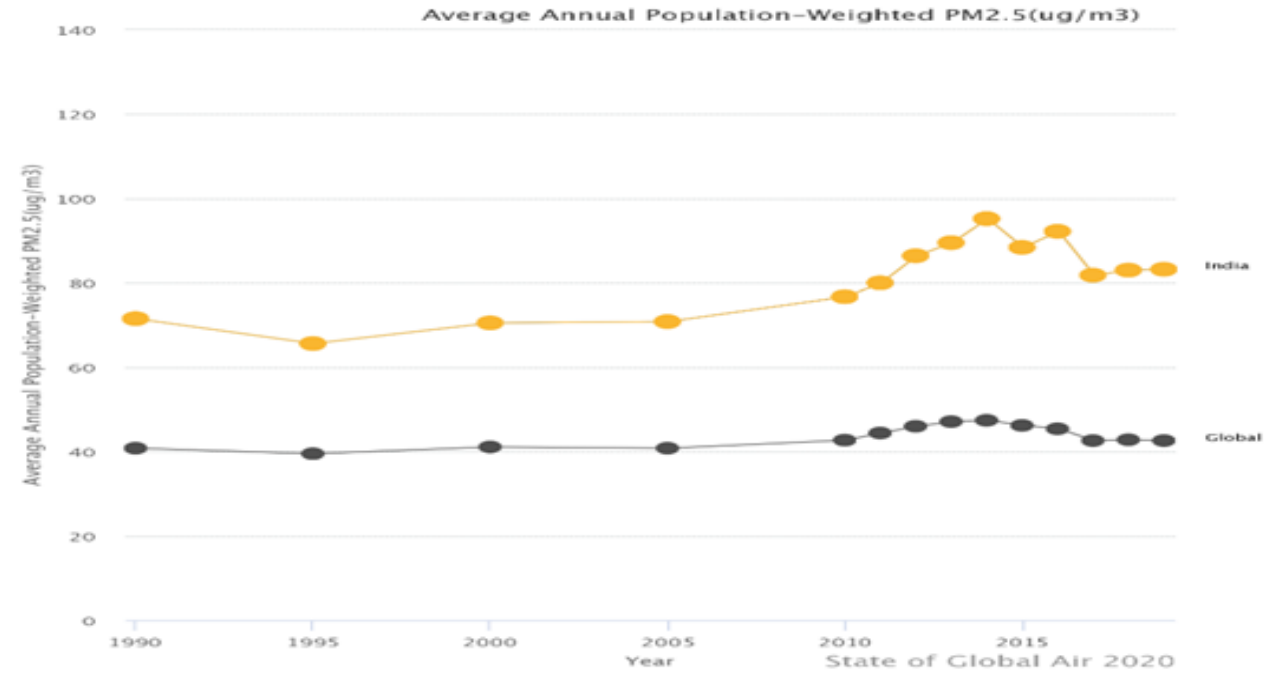

Fig 1 Average Annual Population-Weighted PM2.5 (Fine Particulate Matter) India vs Global Average [1]

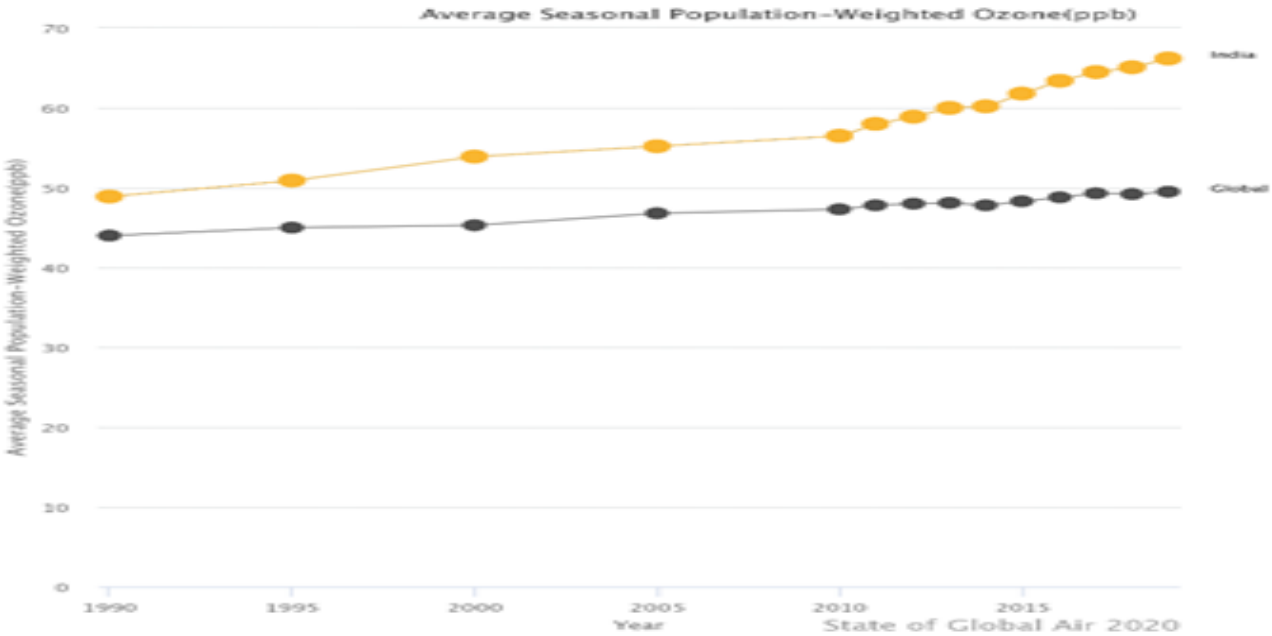

Fig 2 Average Seasonal Population-Weighted Ozone Pollution. India vs Global Average [2]

Additionally, one of the major challenges facing public transportation for bus-based commuting in India is traffic congestion on the roads. This is primarily caused by the growing population of one of the largest populated countries in the world, thereby substantially increasing the number of private vehicles on the roads, which leads to traffic jams, longer travel times, and frustration due to the excruciatingly long waits. Traffic congestion is often overlooked but is directly linked to and contributes to air pollution, carbon footprint and ultimately global warming. Congestion also leads to a significant risk of road accidents.

According to the Ministry of Road Transport & Highways - Annual report 'Road accidents in India — 2021', there were 4,12,432 road accidents over the country and claimed 1,53,972 lives in the year 2021 alone. It is estimated that the economy lost around 3% of GDP (1999-2000) due to road mishap. (Source: Road Accidents in India – Ministry of Road Transport & Highway, Government of India).

Fatalities, on account of road accidents, increased by 1.9 percent in 2021 corresponding to the same period in 2019. [3] Among the top 10 most congested cities around the world, 3 are major metropolitan Indian cities - Delhi, Kolkata & Mumbai.

ISSN No:-2456-2165

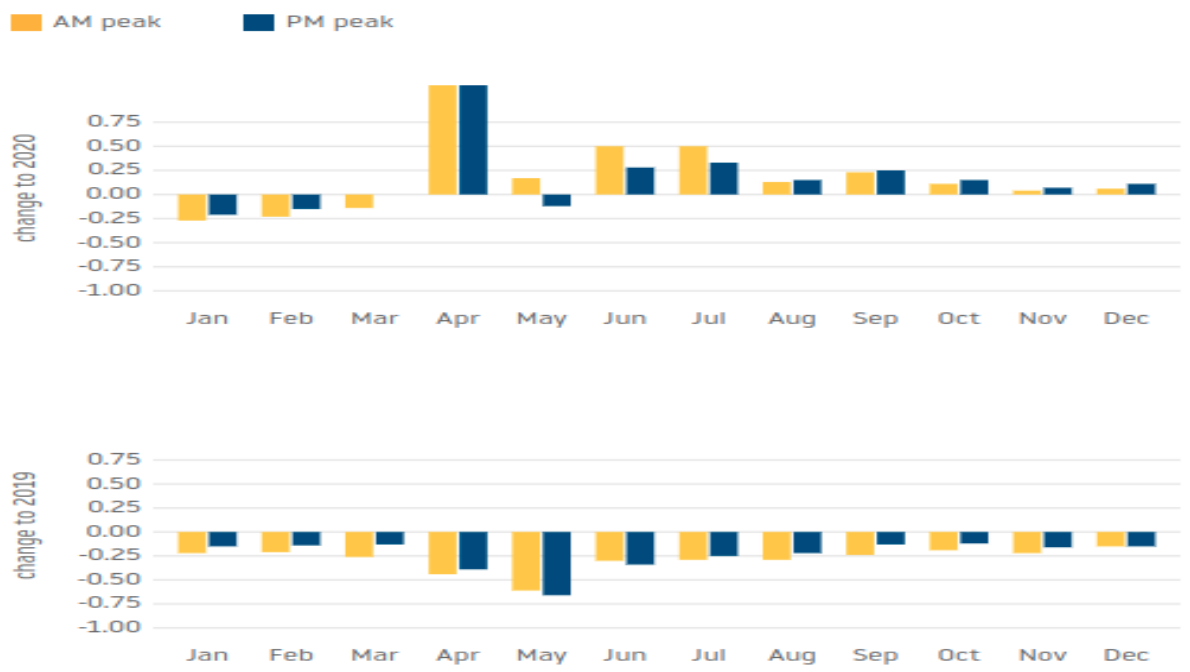

Fig 3 Congestion in India During Rush Hour Throughout 2021 in Comparison to 2020 and 2019 [4]

Table 1 Cities Among the Global Top 10 Belong to India - Global Traffic Index 2023 [5]

Global Rank	City	Traffic Index
1	Lagos, Nigeria	348.7
2	Los Angeles, CA, United States	343.4
3	San Jose, Costa Rica	331.1
4	Colombo, Sri Lanka	305.1
5	Dhaka, Bangladesh	287.4
6	Delhi, India	284.3
7	Sharjah, UAE	283.4
8	Kolkata, India	270.9
9	Guatemala City, Guatemala	259.6
10	Mumbai, India	257.7

Private commuters face a number of challenges such as parking difficulty, overall cost, impact on health, stress, environmental impact, and are more susceptible to road accidents. On the other hand commuters using public transportation overcome all these challenges with ease such as there is no difficulty for finding a parking spot, significantly reduced price for purchasing tickets and travelling, additionally the environmental impact and carbon footprint emitted by public transport is remarkably reduced in comparison.

The amount of passengers accommodated and the benefits offered by public transportation such as buses is far more compared to private transit, but unfortunately public transportation is not widely favoured over cars and bikes.

ISSN No:-2456-2165

III. TRENDS IN PUBLIC TRANSPORTATION IN INDIAN CITIES

In India, there has been a growing trend towards improving public transportation infrastructure, with a focus on creating safer, more efficient, and environmentally friendly systems [6]. This includes the development of metro rail systems in cities like Delhi, Mumbai, Bangalore, and Kolkata, as well as the expansion of bus rapid transit (BRT) systems in cities like Ahmedabad and Jaipur. The Indian government has also launched initiatives like the Smart Cities Mission, aimed at modernising and upgrading urban transportation networks.

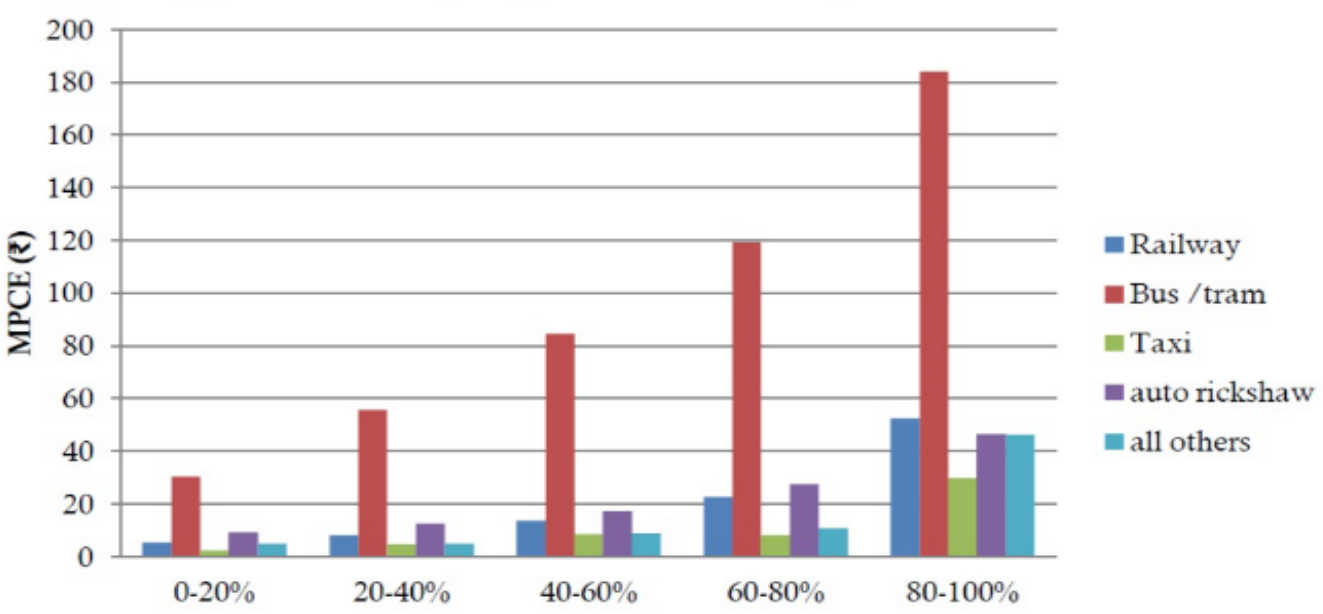

Fig 4 India's 5 Most Popular Means of Transport [7]

- *In India, Public Transportation has Undergone Significant Changes in Recent Years. Some of the Current Trends in the Sector are:*

Increased use of technology: There has been an increase in the use of technology in public transportation, with the introduction of GPS-enabled bus tracking, digital ticketing systems, and smartphone apps for booking tickets.

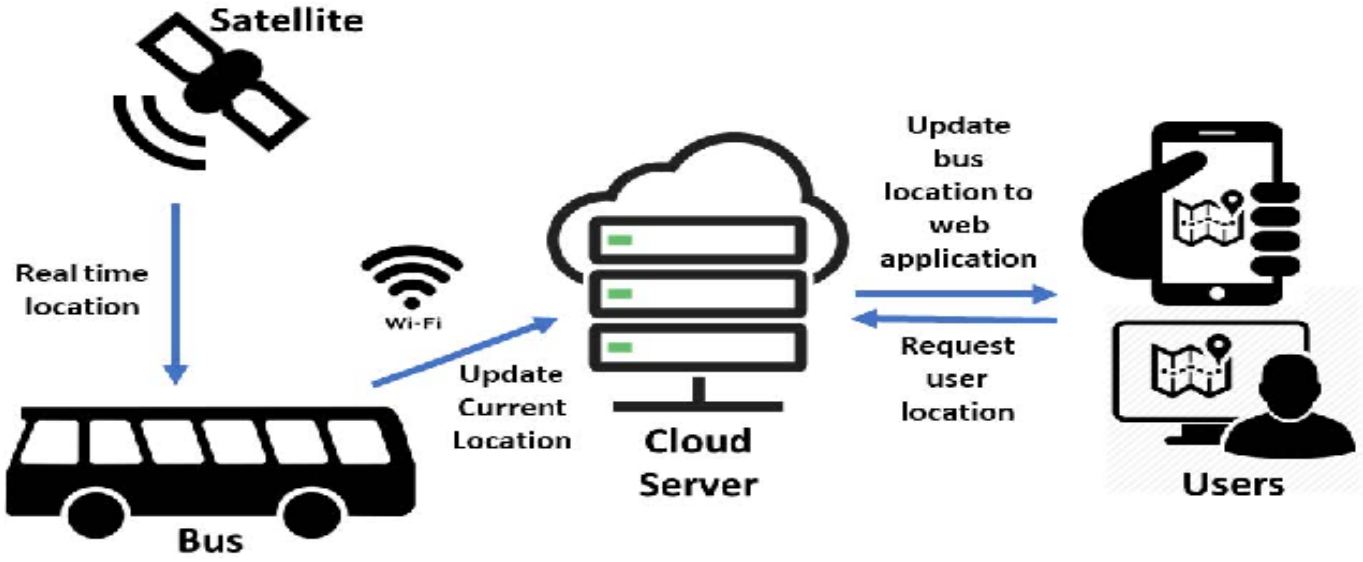

Fig 6 Emerging Trends in Digitisation in Public Transport [8]

Focus on sustainable transportation: The Indian government is focusing on promoting sustainable transportation options, such as electric buses and the development of mass rapid transit systems.

ISSN No:-2456-2165

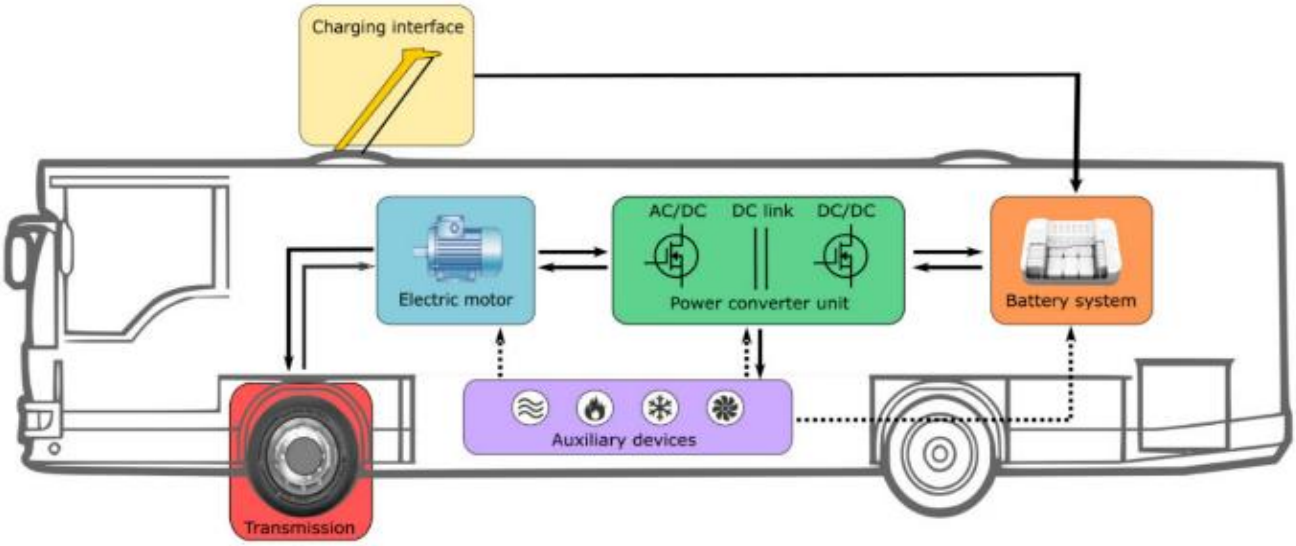

Fig 7 Sustainable Transportation [9]

Expansion of metro systems: There is a push to expand the metro rail system in major cities, to alleviate traffic congestion and provide an efficient mode of transportation.

Privatisation of bus services: Private operators are being encouraged to participate in the provision of public transportation services, leading to the growth of private bus operators and the modernization of the fleet.

Integration of transportation systems: There is a move towards integrating different modes of transportation, such as suburban trains, metro trains, and buses, to provide seamless connectivity for passengers.

IV. MERITS OF PRIORITISING BUS AS MEANS OF PUBLIC TRANSPORTATION

Bus as a means of Public transportation is a far superior and efficient mode of travelling in comparison to other systems. Buses are typically less expensive than other forms of public transportation, such as trains, subways, flights so they're a more accessible and ideal option for people with lower incomes. They emit substantially less greenhouse gases per passenger than bikes, cars, and help mitigate the effects of climate change and ultimately reduce global warming. Buses are very accessible to the general public and are available for use with ease.

They're a good option for the mass populace who aren't economically well off and live in rural areas where trains and subways are not a feasible option in terms of flexibility and usability. Buses are very convenient and flexible in comparison due to their flexible routes with multiple stops, they can run more frequently and can reach areas through their routes that would generally not be accessible by trains or subways. Additionally, promoting the use of bus transportation, implementing and operating a large-scale extensive bus system can also create vast employment / job opportunities in various public sectors. Bus Transportation can also help improve the following:

Fuel Efficiency: Public transportation is the ability to outfit buses and other public transit vehicles with alternative fuel sources. Some systems are completely electric or utilise renewable resources for fuel. Even compared to other gas-powered vehicles, public transportation is better in terms of fuel efficiency.

Reduced Air Pollution: Less fuel burned means better air quality for cities that integrate public transit. Approximately 85% of the greenhouse gas emissions that come from transportation are due to day-to-day commutes. By leaving the car at home, a person can save up to 20 pounds of carbon dioxide emissions every day.

Road Congestion: No one likes to be stuck in traffic, but rising populations demand improvements in road infrastructure that can be costly and take a lot of time. However, road construction can often make the situation more challenging before it gets better. Another benefit of public transportation is that more people riding on buses, trains, and other public systems means there are fewer vehicles on the road to cause traffic.

V. ENVISIONING A "SMART" FUTURE FOR BUS BASED PUBLIC TRANSPORT

From the past few years, newer discoveries and development in technology has led to the advancement of existing transportation facilities. Governments have started to implement various functionality to ameliorate the way society as a whole travels from one place to another by means of buses.

Buses can be systematically integrated with other modes of transportation such as metro trains, trams, and cycle lanes, ultimately creating a comprehensive transportation system. They can be used as feeder services to connect remote areas to other means of transportation that are inaccessible to metro stations, tram stops, airports etc. Bus stations can be developed into interchange hubs or transfer stations so that the passengers can seamlessly

switch over to other modes of transport depending on their travel needs. Convergence zones can be created where supplementary means of mass transit intersect and create a network. A unified fare system can also be developed and implemented so that it is easy for passengers to use multiple modes of transportation with ease and without the need of purchasing separate tickets. Real-time information regarding bus schedules, route information, ticket status and booking, trip information, accessibility information can be made available through a centralised system, such as a mobile app or website, providing passengers with in-depth and useful information. A smart public transportation system would prioritise the needs of the user, promote ease of use and could include GPS tracking of transportation vehicles to monitor real time location, speed, and ETA. Additionally, the system can be integrated with transportation management systems to give real-time updates on schedules, delays, and cancellations. With real-time factual information, passengers will be able to make informed decisions and plan their journeys more effectively, significantly reducing travel time, confusion and improving overall convenience of the travellers. The app can provide eye to eye support and assistance to passengers through a built-in customer support system so they can convey their problems and any issues they may be facing to the appropriate administration personnel. Overall, the aim of an effective bus based public transportation system is to provide affordable, accessible, feature intensive and environmentally friendly transportation for the general public to reduce congestion, improve air quality, reduce our carbon footprint and support sustainable urban development in Indian cities.

VI. THE DARK SIDE OF PUBLIC TRANSPORT: UNCOVERING ITS LIMITATIONS

The hazards of the usage of public transport is the major inconvenience for the passengers. For instance, there are usually too many people on the same bus travelling the same route during rush hour. And this problem is even more severe. It's possible that thieves may be on the bus. People need to observe the bus timetable and schedule in order to catch the bus on time.. Furthermore, sometimes, the bus may no longer tour suburbs or deep inside towns or villages, so people should stroll for a long time to reach the near vicinity of a bus stop. With increased congestion on roads in India's major cities, there has to be a relook at India's policy on promoting buses, a key means of public transport [12].

- *Let's Analyse the Limitations of Public Transportation:*

Number of buses - Indian cities need to add several thousand buses more, and not just spend heavily on establishing Metro rail [12]. There are over 1.7 million buses in India, about 10% of them operated by governments. Individual cities do not have enough of them to provide a good service, and the gap is filled mostly by unregulated intermediates, such as vans, rickshaws etc.

Comfort - The buses operated by governments are not properly designed, are uncomfortable and badly maintained. This leads passengers riding the bus to remain dissatisfied with the experience and be tired after a long excruciating journey.

Use - Buses have an image problem in Indian society hence they may be frowned upon. There lies an aspiration among people to progress from a bicycle to a scooter, then to a four-wheeler.

Information - One of the key barriers to taking a bus is not getting information about the service. Bus corporations deprive themselves too, of revenue, by failing to act on this.

Cities such as London and Singapore have systems in place to inform passengers where the next bus is on a route and predict its arrival at a stop in real time.

Such a system is not available for even the largest metro cities in India, something the Smart City mission should have addressed.

VII. NAVIGATING THE OBSTACLES OF PUBLIC TRANSIT: ADDRESSING ITS LIMITATIONS

The merits of a bus system are to a great extent but it still has far too many limitations. So how can the government or various institutions improve existing systems? They can implement the following methodology to substantially enhance transportation:

Improve bus frequency: First and foremost, passengers want buses to arrive more frequently. A full 80% of respondents to a 2020 Hamburg survey state that bus frequency is a top priority. The time spent waiting for the bus (sometimes in the rain) is a major part of their total transit time. Increasing the number of buses traversing the route would lead to less congestion and far less wait times.

Improve bus ticketing systems: Streamlined ticketing systems are essential for transportation efficiency. People don't like to wait in slow, crowded ticket lines, and touchless ticketing is critical for a virus-sensitive public due to the recent pandemic, COVID-19. Mobile phone-based ticketing, which allows passengers to use their phone as both ticket machine and ticket would help passengers to travel with ease. The increased demand in the public transportation sector means transit operators must move faster to incorporate touchless, fully digitised payment systems.

Increase passenger comfort and safety: Safety and comfort have always been a concern for transit riders. Travellers wish to have a comfortable experience of travelling from one place to another. As of current times, buses fail to fully accommodate every passenger so many of the passengers are obliged to travel the bus while standing, which is also a safety risk. Every bus should implement air conditioning and ventilation systems to regulate the temperature and ameliorate passengers suffocation while riding.

ISSN No:-2456-2165

Reduce bus emissions and GHGs: The public is very aware of sustainability in public transport, and while any transit option is better for the environment than a private car, the public has a strong perception of the negative impacts of diesel buses on local air quality and climate change overall. To completely eliminate the drawback of GHG emissions, the government can impose strict rules regarding the prioritisation of electric public transport hence eliminating the need for fossil fuels in buses. [13].

London, for instance, is a city with an iconic bus system that integrates famously with its equally popular 'tube' system (as the Metro is known there).

In India, buses need an image makeover and cities need several thousand more buses, of good design and build quality. They need to use contactless fare payments using suitable cards, since buying tickets is also a barrier. Buses also need support to move faster through city traffic, using policy tools such as congestion pricing for cars.

E.g., London discourages the use of cars through a congestion charge within a defined area. The London congestion charge immediately cut traffic in the demarcated area by 20%, helped speed up buses and improved revenues.

The biggest reform that the U.K. experience teaches is integration. Bringing traffic authorities, road engineers and transport operators under the same umbrella helped eliminate planning and operational problems.

Indian cities have unified Metropolitan Transport Authorities to do that; they must be brought to life and given mandatory targets. The goal should be a stipulated higher share of travel by public transport, walking and cycling. Importantly, this should be evaluated through periodic surveys of customer satisfaction of the public [12].

VIII. THE ELECTRIC REVOLUTION

The electric revolution in public transportation systems is a major shift towards the use of electric vehicles as a means of reducing carbon emissions and improving sustainability. It is driven by a growing demand for clean and efficient modes of transportation. The transition to electric buses offers numerous benefits, including reduced dependence on fossil fuels, lower costs of operation, and improved air quality. The widespread adoption of electric buses has the potential to transform the world and the way people travel.

The growing need to reduce the dependence on imported oil, and the growing concerns over climate change have been the key drivers to the growth of electric vehicles (EVs) throughout the world. To keep pace with the global economy, various policy initiatives have been introduced by the Indian government since 2007 to give an impetus to the high-potential EV industry. Further, the government's goal to achieve net-zero emissions by 2070 as committed during the recently held COP26 summit, further presses the need to focus on EVs as the 'future of mobility' [14].

India's adoption of EV technology has gained increased momentum recently. The Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme launched in 2015 shows results hinting India is on the brink of an EV revolution [15].

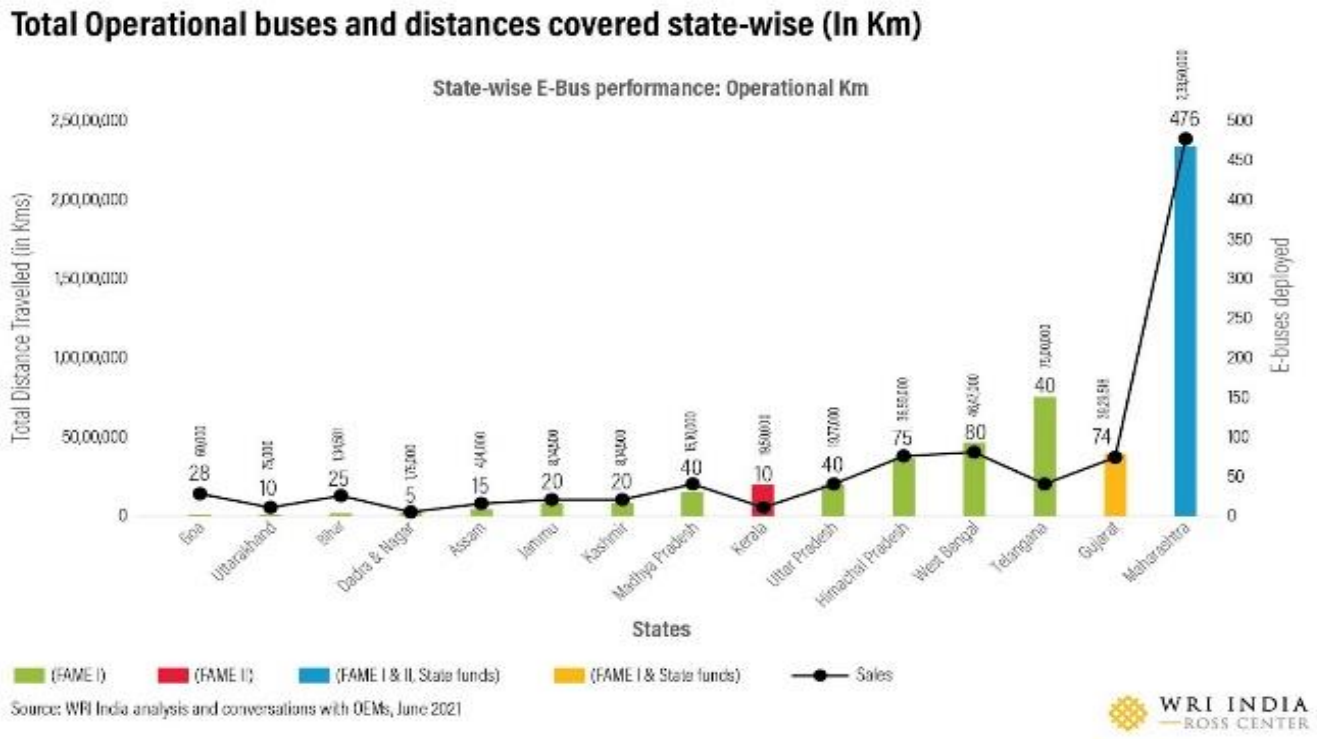

Fig 8 State- Wise Total Operational Buses and Distances covered (in Km). [16]

ISSN No:-2456-2165

IX. CONCLUSION

In conclusion, this paper focuses on the problems of widespread transportation systems and how public transportation effectively resolves such issues. The disadvantages of private transport are backed by metrics and graph based proof in order to favour public transit. The trends in public transportation are analysed alongside the merits and demerits of bus-based commuting. A smart future for bus based public transport is examined on the basis of how technological advancements could lead to improvements in the current systems set in place. The “dark side” of public transport is explored and the limitations and disadvantages are uncovered. These limitations and obstacles faced by buses are addressed and solutions are provided that would alleviate and eliminate undergoing problems. The paper ends with “the electric revolution” which is the uprising and transformation from fossil fuels to electricity. We review how the Indian government has been pushing towards clean energy and adoption of electric vehicles alongside the necessity of widespread adoption of electric vehicles. The government and institutions set in place may examine such methodology and implement them accordingly. Additionally, surveys and reviews should be conducted in order to analyse solutions and effectively implement processes that would benefit the public and mitigate the travelling procedure and administration/management of the systems that are set in place.

REFERENCES

[1] State of Global Air 2020. <https://www. state ofglobalair.org/ >
[2] State of Global Air 2020. <https://www.state ofglobalair.org/ >
[3] Ministry of Road Transport & Highways -Annual report ‘Road accidents in India — 2021’ <https://www.pib.gov.in /Press ReleasePage .aspx? PRID=1887097>
[4] India Traffic Index Ranking <https://www.tomtom .com/traffic-index/india-country-traffic/>
[5] Traffic Index by City 2023 <numbeo.com /traffic /rankings.jsp>
[6] Urban Transport News <https://urbantransportnews .com/article/current-trends-that-will-shape-the-future-of-transport-and-mobility-in-india>
[7] Doubling the use of buses and coaches <http://www.busandcoach .travel/en/latest _news /buses---indias-most-popular-means-of-transport.htm>
[8] Emerging Trends in Digitisation in Public Transport <https://www.semanticscholar.org/paper/Real-time on-campus-public-transportation-system-Saad-Hisham/9f65581c77e6e69ac33c1bc2d2d3b13a40bc9703/figure/0>
[9] Here’s Why India Needs a Comprehensive 2030 Electric Bus Rollout Plan <https://www.mdpi.com /2071-1050/13/21/12189>
[10] Benefits of Public Transportation <https://www. remix.com/blog/8-benefits-of-public-transportation>
[11] Limitations of Public Transport <https://www. javatpoint.com/advantages-and-disadvantages-of-public-transport>
[12] Revamping city buses <https://www. techsci research.com/blog/modern-technologies-for-bus-operations-in-autonomous-world/298.html>Ways to Improve Public Transport <https://blog. ballard . com/4-ways-to-improve-public-transport>
[13] Future of public transport in India – Electric Buses <https://www.financialexpress.com/auto/electric-vehicles/future-of-public-transport-in-india-electric-buses/2421366/>
[14] How can EVs revolutionise green public transport in India <https://timesofindia .indiatimes.com /blogs/ voices/how-can-evs-revolutionise-green-public-transport-in-india/>
[15] More than Half of all E-Buses in India Found on Maharashtra Roads
[16] <https://wri-india.org/blog/more-half-all-e-buses-india-found-maharashtra-roads>