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A study on: Assessing carbon emissions and sustainable alternatives for auto rickshaws

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Abstract

Auto Rickshaws are one of the widely used transportation in India. In the context of Carbon Emissions, Auto Rickshaws also create a negative impact on the environment. The Auto Rickshaws which were introduced in India during the mid-20th century emit high levels of carbon monoxide due to outdated engine technology. Efforts to mitigate emissions include promoting fuels and adopting electric or hybrid models, but challenges persist in widespread adoption. These outdated auto rickshaws typically run on gasoline or diesel engines that lack modern emission control systems. The emissions from these outdated auto rickshaws contribute significantly to air pollution in Indian cities, which already face severe air quality challenges. The pollutants emitted by these vehicles have adverse effects on public health, leading to respiratory diseases, cardiovascular problems, and other health issues, especially among vulnerable populations such as children, the elderly, and individuals with pre-existing health conditions. To address this issue, CNG and LPG auto rickshaws are popular alternatives to traditional gasoline or diesel vehicles in many Indian cities due to their lower emissions. They use cleaner-burning fuels, such as compressed natural gas (CNG) or liquefied petroleum gas (LPG), reducing pollutants and improving urban air quality. Both options contribute to India's efforts to promote sustainable transportation and reduce environmental impact.

Additionally, there are efforts to promote the adoption of electric and hybrid auto rickshaws as environmentally friendly alternatives. Electric auto-rickshaws produce zero tailpipe emissions and can significantly reduce the carbon footprint of urban transportation systems. However, challenges such as high initial costs, limited charging infrastructure, and range limitations have slowed down their widespread adoption.

Despite these challenges, regulatory measures, government subsidies, and public awareness campaigns are gradually driving the transition towards cleaner and more sustainable auto-rickshaw fleets in India.

Keywords: Carbon emissions, auto rickshaws, sustainable alternatives, pollution for the environment

Introduction

Auto rickshaws, often simply called "autos," are an integral and ubiquitous part of Bangalore's urban landscape. These three-wheeled vehicles serve as a popular and convenient mode of transportation for both residents and visitors in the bustling city. As an essential component of the city's public transport system, auto rickshaws can be spotted on virtually every street corner, offering passengers a flexible and relatively affordable way to navigate Bangalore's busy roads. Whether you're looking for a short hop within the city or a more extended journey to explore its diverse neighbourhoods and attractions, auto rickshaws play a crucial role in ensuring connectivity and mobility in the vibrant metropolis of Bangalore.

Auto rickshaws play a pivotal role in urban transportation systems, particularly in densely populated cities of developing countries.

These compact three-wheeled vehicles serve as a vital component of the urban mobility ecosystem, offering several key advantages. Firstly, auto rickshaws provide indispensable last-mile connectivity, bridging the gap between public transit hubs and final destinations. Their ability to navigate through congested and narrow urban streets makes them invaluable for reaching places that larger vehicles may struggle to access. Secondly, auto rickshaws are known for their affordability, making them accessible to a wide range of commuters, including those who cannot afford private cars or find other transportation options financially burdensome.

This affordability extends the reach of public transportation networks, ensuring that urban residents have access to convenient and reasonably priced mobility solutions.

Moreover, the flexibility of auto rickshaws is a significant asset. Unlike fixed-route buses or trains, they can adapt to passenger requests, offering a personalized, door-to-door service. This adaptability caters to the diverse needs of urban commuters, enhancing the overall convenience of urban transportation. Furthermore, auto rickshaws contribute to reducing overall congestion in cities. While they do occupy road space, they are smaller and produce fewer emissions than larger vehicles. In congested urban areas, these nimble vehicles can help ease traffic gridlock. Additionally, auto rickshaws generate employment opportunities for a substantial number of drivers, supporting local economies and providing livelihoods for many individuals and their families. This economic contribution is a vital aspect of their role in urban transportation.

In summary, auto rickshaws serve as an integral part of urban transportation systems, providing last-mile connectivity, affordability, flexibility, and employment opportunities while also aiding in reducing congestion. Their role in urban mobility extends beyond mere transportation, contributing to the accessibility, economic well-being, and overall efficiency of cities.

Auto rickshaws, though smaller and generally more fuel-efficient than many other forms of motorized transport, still make a notable contribution to carbon emissions in urban areas. These emissions primarily stem from two key factors. Firstly, many auto rickshaws are powered by internal combustion engines that run on gasoline or diesel, which release carbon dioxide (CO₂), a significant greenhouse gas, when burned. Despite efforts to promote cleaner fuels like compressed natural gas (CNG) in some regions, a substantial number of auto rickshaws continue to rely on fossil fuels, contributing to air pollution and climate change. Secondly, auto rickshaws often operate in densely populated urban areas with heavy traffic congestion.

Prolonged idling and frequent stop-and-go driving, which are common in congested traffic, can result in higher emissions per kilometre travelled. Additionally, emissions of other pollutants, such as nitrogen oxides (NO_x) and particulate matter (PM), can have adverse effects on air quality and public health. While the carbon emissions from an individual auto rickshaw are relatively small compared to larger vehicles, the cumulative impact of numerous auto rickshaws operating in densely populated cities can be significant.

Efforts to reduce the carbon footprint of auto rickshaws include promoting the adoption of cleaner fuels, improving fuel efficiency, and incentivizing the use of electric or hybrid models. Transitioning to more sustainable and eco-friendly technologies is crucial to mitigating the carbon emissions associated with these ubiquitous urban vehicles.

Objectives

The study aims to understand the following:

- To study the sustainability of e-rickshaws in Indian transport system
- To study the advantages and disadvantages of e-rickshaws.
- To study the policy implications of e-rickshaws.
- To study how e-rickshaws compare to other forms of three-wheeled public transportation vehicles.

Literature Review

Carbon Emissions

(Brief, 2018) A study by The Energy and Resources Institute (TERI) revealed that auto rickshaws in Bengaluru are responsible for significant carbon emissions, NO_x, and PM₁₀ pollutants. Transitioning to electric autos could reduce carbon emissions by 0.11 million tonnes per year, PM₁₀ by 114.5 million tonnes per year, and NO_x by 37.6 million tonnes per year.

(Reddy, Aravindhan, & Mallick, 2017) ^[5] Research has resulted in the development of a solar-powered electric auto-rickshaw (SPEA) designed for Indian conditions. The SPEA demonstrated effective battery charging and discharging capabilities, with the potential to mitigate CO₂ emissions over 25 years compared to conventional engines.

A mere ban on two-stroke autorickshaws won't significantly reduce pollution, but transitioning to electric autorickshaws could lead to a substantial reduction in carbon dioxide emissions, potentially mitigating over 4.4 lakh tonnes of CO₂ annually.

(Chandrashekar, Chatterjee, & Pawar, 2022) ^[2] A study in Sangareddy district, India, quantified CO₂ and CO emission factors for diesel auto-rickshaws under real-world driving conditions. Emission rates were influenced by road type, speed, and acceleration, with urban roads showing higher emissions compared to rural roads. After a real-world driving test in state of Telengana, it was observed that the CO₂ and CO emission rates were higher at a speed range of 35-45 kmph, compared to a speed range of 5-10 kmph and 15-30 kmph.

(Bagul, Kumar, & Kumar, 2021) ^[22] It can be noted that auto rickshaws in India emit several tonnes of pollutants and that the current rate of adoption of electric auto-rickshaws is not enough to reduce emissions. It is recommended that the government introduces policies in order to curb emissions from auto rickshaws in India.

Auto Rickshaws

A typical auto rickshaw is designed to hold one person, the driver in the front, with the back seat typically holding 2-3 people. Larger auto rickshaws can have double rows seating the back, holding up to 6-7 people in these cases. According to (Rao, Maiti, and Mulukutla) in areas underserved by public transport, autorickshaws play a key role in providing connectivity to many passengers and account for 10-20% of total daily trips in Indian cities. (Kumar & Sinha, 2014) ^[1] For reference, there are about 25000 auto rickshaws operating on the road almost a decade in the city of Patna, which composed to about 20% of traffic congestion. (Chandrashekar, Chatterjee, & Pawar, 2022) ^[2] Auto rickshaws are responsible for high levels of CO₂ emissions ranging from 1.69 to 1.89 times higher emissions on urban roads than on rural and hence can be highly unsafe for health. As indicated by (Bose, Sperling, Delucchi, Nesamani, Redmond, Schipper, & Tiwari, 2001) ^[3] India's capital, New Delhi is facing several issues, but one of the more serious one relates to a high GHG (greenhouse gas) emission rate leading to an increase in global warming and heat waves throughout the city. The transition from 2-stroke to 4-stroke auto rickshaws has played a significant role in increase fuel efficiency and reducing emissions due to the higher efficiency in the latter, as stated by (Leighton, Sam & Ahern, 2003) ^[4].

Sustainable Alternatives

(Majumdar, & Jash, 2015) ^[16] Studies show that e-rickshaws are more energy-efficient than other types of motorized public road transport vehicles. If e-rickshaws are properly implemented, they could help address the issue of environmental pollution caused by transportation.

(Reddy, Aravindhan, & Mallick, 2017) ^[5] There are some major challenges that need to be addressed before e-rickshaws can be properly implemented. Another alternative that isn't as popular as electric rickshaws is solar powered rickshaws. It involves placing solar panels on the roof of the rickshaw in order to continuously charge it during the day and yield enough battery power to run through the day. Research says that a sunny day provided a maximum of 250W of charging power and 2kWh of battery.

Electric auto-rickshaws, or e-rickshaws, are becoming increasingly popular, and are changing the conventional auto-rickshaw sector in a significant way. The switch to electric auto-rickshaws has the potential to have a big impact on regional economies. It can open up new job opportunities in the manufacturing, maintenance, and charging of e-rickshaws. It can also enable innovative business models, such as e-rickshaw sharing services.

(Mishra, Dr. Rout & Kumar, 2022) ^[6] Electric rickshaws have the potential to alleviate the challenges of environmental and noise pollution caused by transportation. (Biswas, Das, Sourov, Islam, Kibria, Hasan, 2019) ^[7] However, there are some challenges that need to be addressed before they can be widely deployed, such as: public charging facilities, improved battery efficiency and technology, state subsidies, etc. In Bangladesh, e-rickshaws are significantly gaining popularity. Investing in e-rickshaws is highly profitable not only to manufacturers but also to drivers, with a profit investment ratio of 1.96.

(Singh, 2014) ^[10] E-rickshaw battery efficiency decreases rapidly with age. Better battery technology and solar battery hybrids could be game changers for e-rickshaws. This could lead to an almost-endless driving experience saving costs and increasing efficiency. Additionally, customers felt unsafe riding in e-rickshaws over CNG operated rickshaws due to the build quality being worse. This poses a challenge on manufacturers to invest heavily on safety parameters to increase sales.

Pollution for the environment

(Gupta, & Elumalai, 2019) ^[11] The exposure of drivers within vehicular systems constitutes a significant portion of daily air pollutant exposure. This research focused on analyzing particulate matter (PM) concentrations in different microenvironments, including within vehicles (Specifically auto-rickshaws), outdoor spaces, and indoor settings.

(Reynolds, Kandlikar, & Badami, 2011) ^[12] In New Delhi, after thorough research, it was seen that about 90% of auto-rickshaws that were powered by CNG were equipped with 4-stroke engines, demonstrating a reduction in emissions per vehicle from the decade earlier.

(Khanna, Khan, Chahal & Goyal, 2018) ^[13] According to this research article, the results revealed auto-rickshaws featuring 2-stroke engines were significantly more prone to being high-PM emitters. To add on, electric rickshaws have consistently applauded to be environmentally preferable due to their reduction in noise and air pollution. This research was based off 220 rickshaw drivers.

(Wang, Zhang, Jin, Zhang, & Feng, 2021) ^[14] According to a research that took place in Delhi, analysis revealed that auto drivers were at a significantly elevated risk of developing respiratory, ophthalmic and dermatological health related diseases due to high concentrations of particulate matter (PM1, PM2.5, and PM10). This could not only lead to several heart related diseases but also early deaths.

Research Methodology

Sample and Data collection

With the help of research papers and articles, we gathered information about different sustainable alternatives available in the market which included the likes of solar powered and battery powered rickshaws that led to lower emission rates, causing less harm to the environment. All of this was done through the help of published research papers on Google Scholar.

We also created a structured questionnaire to gain first-hand knowledge about suitable alternatives to auto rickshaws.

Measures

We were able to identify the benefits of the implementation of electric rickshaws in the market with the help of the questionnaire answers and quantitative and qualitative data collected from research articles. Further, we combined both our primary and secondary data to analyse the viability of the information gathered.

Sample characteristic

Our questionnaire named, "Assessing Carbon Emissions and Sustainable Alternatives for Auto Rickshaws" received a total of 102 responses from the age group of 18-30, which shows a concern for the global concern for high pollutants from 3-wheeler vehicles. These respondents included young aspiring students from various colleges and working class people throughout the city of Bangalore.

Findings

Auto Rickshaws have been proven to have a high impact on the rate of carbon emissions in India. Hence, a questionnaire was prepared in order to analyze the role auto rickshaws play in contributing to carbon emissions and e-rickshaws as a future of the industry in order to mitigate the high amounts of pollution caused by auto rickshaws. The questionnaire yielded a total of 102 responses where 69.3% of responses said that primary contributor for carbon emissions is fuel. To add on, 73.5% said that the speed of the vehicle is a major determinant for how much emission is produced by the auto rickshaw. To overcome this issue of high emissions, 80% of respondents said that regular maintenance of the vehicle is a must in order to mitigate emissions.

To a surprise, only 66% of people think that the switch to electric would be a sound choice for the future against other options including biodiesel and natural gas. Almost 4/5th of the participants think that the government should employ emission standards in order to reduce pollution and improve air quality throughout the country. Auto rickshaws have been known to emit more harmful pollutants, and this is mainly due to drivers not changing oil filters on a regular basis.

The policy implications of implementing e-rickshaws in the Indian landscape include several factors such as:

Transportation, Financial, Employment, and Safety. Transportation policies involve the transition to e-rickshaws from traditional auto rickshaws. This includes factors like licensing and fare regulation. Financial policies are the most important due to the high initial costs of adopting e-rickshaws. Hence, government should look into providing subsidies and micro financing options for drivers. Adoption of e-rickshaws could also lead to an increase in employment opportunities, and hence policies should help regulate fair wages. Lastly, the government should introduce safety standards for vehicle design to increase safety for the driver and passenger.

According to (Kokate, Bankar, Vispi, & Karandikar, 2018)

[21], a switch to electric is the best option for the present and the future and has already made its mark in the Indian transport system. There are a few positives to note such as no air and noise pollution and reduced cost of travel. However, one of the main drawbacks include smaller seating capacity due to the big battery size.

Well known research institutions such as The Energy and Resources Institute (TERI) have thoroughly researched on this matter have said concluded that a switch to e-rickshaws would lead to a reduction of 0.11 million tonnes of carbon emissions annually, 114.5 million tonnes of PM10 and 37.6 million tonnes of NOx.

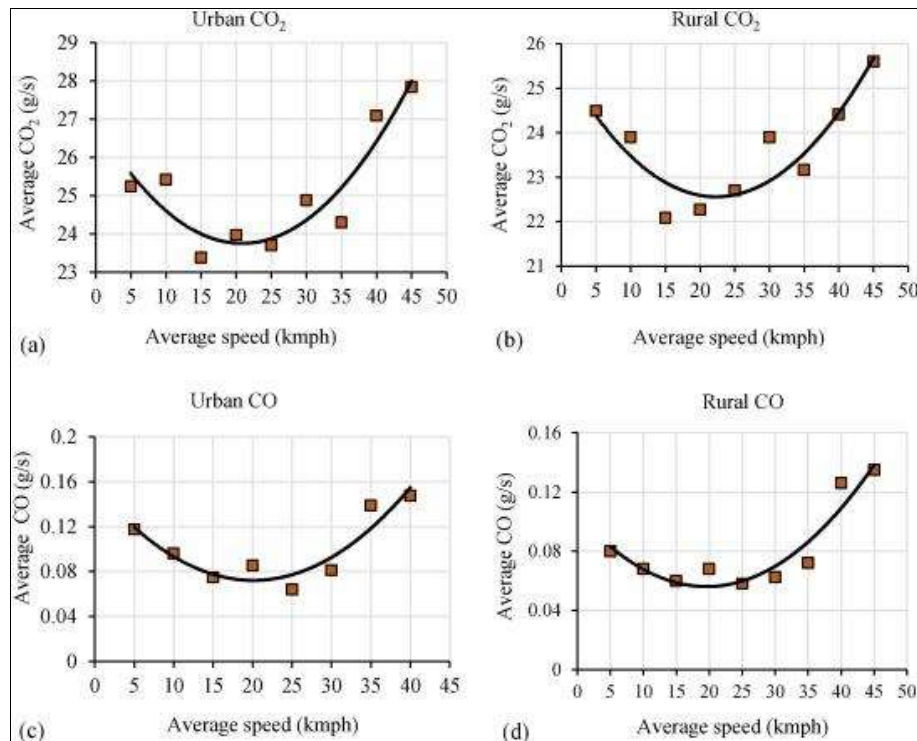


Fig 1: Urban and rural CO₂

Another study conducted by (Chandrashekar, Chatterjee, & Pawar, 2022) [2] in Sangareddy district, India, systematically quantified CO₂ and CO emission factors for diesel auto-rickshaws under real-world driving conditions. Emission rates were found to be influenced by road type, speed, and acceleration, with urban roads exhibiting higher emissions compared to their rural counterparts.

Conclusion

In conclusion, the transition to electric rickshaws presents a promising avenue towards achieving sustainability and reducing environmental impact in the transportation sector, particularly in comparison to CNG rickshaws. Electric rickshaws offer several advantages, including zero tailpipe emissions, lower operating costs, and reduced dependence on fossil fuels. Furthermore, advancements in battery technology and charging infrastructure are making electric rickshaws increasingly practical and viable for widespread adoption. By embracing electric rickshaws as a sustainable alternative, India can significantly contribute to mitigating air pollution, combating climate change, and improving the overall quality of urban life. However, successful implementation will require collaborative efforts from

policymakers, industry stakeholders, and the broader community to address challenges related to infrastructure, regulation, and affordability. Ultimately, electric rickshaws have the potential to play a pivotal role in shaping a cleaner, greener, and more sustainable future for urban transportation in India.

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