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Study of Transport Indicators for Urban Mobility and Environmental Sustainability in Mumbai

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Abstract

Urban mobility plays a critical role in economic productivity and environmental sustainability in rapidly growing metropolitan regions. One of the most densely populated cities in the world, Mumbai, is facing more mobility issues as a result of increased environmental concerns, a lack of adequate road infrastructure, and an increase in vehicle ownership. This study examines key transport indicators influencing urban mobility and environmental sustainability in Mumbai. The study uses indicator-based analysis to see whether a transport system is effective or not using secondary data on vehicle population, emissions, public transport utilization, and transport infrastructure. A spider (radar) diagram is used to assess mobility dimensions including accessibility, efficiency, sustainability, affordability, safety, and technological integration. Additionally, a conceptual regression framework is proposed to analyses the relationship between transport indicators and urban sustainability outcomes. The findings reveal that although Mumbai demonstrates strong public transport accessibility and affordability, rising private vehicle ownership and limited road expansion contribute to congestion and environmental pressures. The study highlights the need for integrated transport planning, metro network expansion, smart mobility technologies, and sustainable transport policies to improve urban mobility and environmental outcomes.

Keywords: Urban Mobility, Sustainable Transport, Transport Indicators, Smart Mobility, Environmental Sustainability, Mumbai Transport System.

Introduction

Urban mobility is an essential element of economic development and social integration in modern cities. Efficient transportation systems facilitate the movement of people and goods, support economic productivity, and enhance the quality of life. However, rapid urbanization and population growth have placed immense pressure on transport infrastructure in many developing cities. Mumbai represents one of the most densely populated metropolitan regions in the world. The city experiences intense mobility demand because there is high population density, multiple economic activity, and spatial concentration of employment. Although public transport systems like suburban railways and buses are widely used, the surge in private vehicle ownership has led to increased traffic congestion, longer travel times, and higher levels of environmental pollution (Government of Maharashtra, 2023; MoHUA, 2022)..Urban transport systems significantly influence environmental sustainability. Air pollution, energy use, and greenhouse gas emissions are all significantly impacted by road transport. This leads to increasing urban mobility while reducing environmental effects has emerged as a significant policy challenge. In recent eras, various cities all over the world have adopted **smart transport and sustainable mobility strategies**, including intelligent traffic management systems, metro expansion, electric buses, and digital mobility

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platforms. Mumbai has also begun implementing such initiatives to improve mobility efficiency and environmental sustainability. This study examines key transport indicators related to infrastructure, vehicle density, public transport usage, and emissions in Mumbai. The study aims to understand current mobility challenges and identify solutions for sustainable urban transport development through the analysis of these variables.

1. Importance of the Study

- **Urban mobility challenges:** Mumbai faces severe congestion due to high vehicle density and limited road infrastructure.
- **Environmental sustainability:** Road transport is a major contributor to the city's air pollution and greenhouse gas emissions.
- **Policy relevance:** Policymakers and urban planners can use the research's findings to create sustainable transport policies.
- **Smart mobility development:** The study highlights the role of smart transport technologies such as metro systems, intelligent traffic management, and electric mobility.
- **Academic contribution:** It contributes to the literature linking **urban transport indicators with sustainability and economic productivity**.

2. Objectives of the Study

- **To analyse key** transport indicators influencing urban mobility in Mumbai.
- **To examine the relationship between** transport infrastructure and sustainable environment**.**
- To study relationships between **public transport systems and smart mobility initiatives** in Mumbai.
- To identify major **mobility challenges arising from vehicle growth and infrastructure constraints**.
- To share ideas for enhancing sustainable urban transport systems.

3. Research Methodology:

3.1.Research Design - The study is descriptive and analytical in nature.
3.2.Data Source - The research is based on secondary data collected from:

- Government transport reports
- Urban mobility studies
- Smart city and transport planning reports
- Academic research articles
- Transport indicator dataset used in this study
- Analytical Methods

The following analytical tools are used:

- Transport indicator analysis
- Comparative evaluation of infrastructure and vehicle growth
- Spider (radar) diagram for mobility performance assessment

- Conceptual economic modelling of transport and productivity

4. Review of Literature:

Numerous academics have investigated the connection between economic development and urban transport systems. David Banister emphasized that sustainable urban mobility requires reducing dependence on private vehicles and promoting public transport and integrated land-use planning. Jean-Paul Rodrigue highlighted that efficient transport infrastructure enhances accessibility, reduces transport costs, and improves economic productivity. Research by Ian Docherty suggests that smart mobility systems using digital technologies can improve traffic management and reduce congestion.

Economic growth theories developed by Robert Solow and Paul Romer emphasize the role of technological innovation and infrastructure investment in enhancing productivity and long-term economic growth Furthermore, studies show that urban transportation significantly contributes to environmental pollution. Hence, adopting sustainable mobility strategies—such as promoting electric vehicles, expanding public transport, and implementing intelligent traffic management systems—is crucial for reducing emissions in large cities.

5. Analysis of Transport Indicators for Urban Mobility and Environmental Sustainability in Mumbai

Transport indicator research offers insights into the performance of Mumbai's urban mobility system and its environmental implications. The data include indicators related to transport infrastructure, vehicle population, public transport usage, and environmental emissions. These indicators help evaluate the sustainability and efficiency of the city's transportation system

Indicator	Latest Estimate	Explanation
Total Road Length	~2,000 km	Road network length in the city has remained nearly constant despite rapid vehicle growth.
Total Registered Vehicles	~46–50 lakh vehicles	The vehicle population has grown significantly in recent years.
Vehicle Density	~2,300 vehicles per km of road	Among the highest densities in Indian cities.
Daily New Vehicle Registrations	~193 cars and 460 bikes per day	Continuous growth in private vehicle ownership.
BEST Bus Fleet	~2,900 buses	Declined from earlier levels despite high ridership demand.
Daily Bus Ridership	~33 lakh passengers	Indicates heavy dependence on public transport.
Road Transport CO_2 Emissions	~5–6 tonnes CO_2 per km of road	Highest emission intensity among major Indian metros.
Average Vehicle Density Growth	From 1,150/km (2014) → 2,300/km (2024)	Nearly doubled within a decade.

Source Ministry of Road Transport and Highways (2023); Municipal Corporation of Greater Mumbai (2023).

Interpretation: According to the data, Mumbai's vehicle population growth and road infrastructure growth are significantly out of balance. The number of registered vehicles has increased although the overall length of the

road has stayed mostly stable at about 2000 miles.Mumbai has one of the highest vehicle densities in India, with almost 2300 cars per kilometre of road, as a result of a sharp increase in the number of vehicles to almost 50 lakhs. As a result, Mumbai has one of the highest vehicle densities in India, with approximately 2300 vehicles per kilometer of road. This high density contributes to severe traffic congestion, longer travel times, and increased fuel consumption. The daily addition of nearly 650 new vehicles (cars and two-wheelers) further intensifies the pressure on existing infrastructure. Without significant expansion of road capacity or effective mobility management strategies, congestion and mobility challenges are likely to worsen.

Metro Transport Infrastructure in Mumbai	
Indicator	**Estimate**
Operational Metro Lines	3 major operational corridors
Existing Operational Metro Length	~60 km (approx.)
Planned Metro Network	~300+ km
Key Corridors	Line 1 (Versova–Ghatkopar), Line 2A, Line 7, Line 3 (under development)
(Data compiled from urban transport planning reports and metro expansion plans.)	

Source: Data compiled from infrastructure planning reports of the Mumbai Metropolitan Region Development Authority (MMRDA) and metro project updates from the Mumbai Metro Rail Corporation Limited.

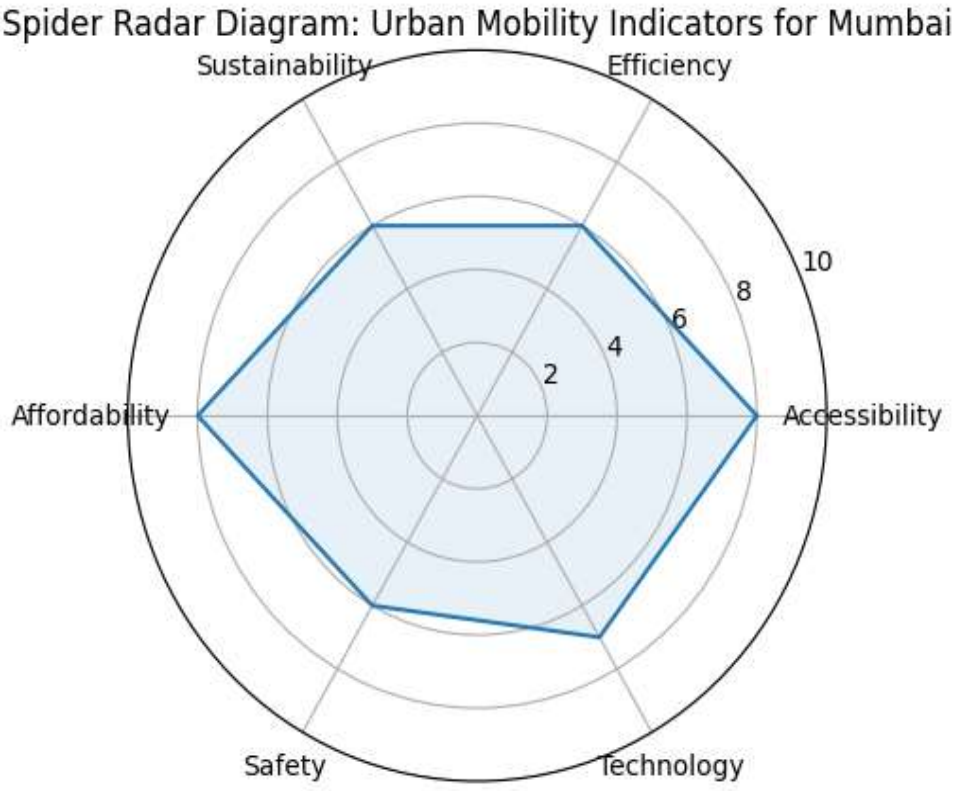
Interpretation: Public transport remains the backbone of urban mobility in Mumbai. The BEST bus system carries approximately 33 lakh passengers daily, indicating heavy dependence on public transport for commuting. However, the bus fleet has declined to around 2900 buses, which is significantly lower compared to earlier years. The reduction in fleet size can lead to overcrowding, longer waiting times, and reduced service efficiency.The expansion of the Mumbai Metro network represents a major initiative aimed at improving urban mobility. Currently, approximately 60 kilometres of metro lines are operational, while the planned expansion aims to create a network of more than 300 kilometres. The metro system is expected to reduce pressure on suburban railways and road transport while improving travel efficiency and connectivity across the metropolitan region.

Environmental Indicators Related to Transport		
Indicator	**Value**	**Significance**
CO_2 emissions per km of road	5–6 tonnes	Highest among Indian metros due to high vehicle density.
Major transport pollutants	CO, NOx	Dominant emissions from road transport.
Vehicle density ranking	Highest among major Indian cities	Indicates severe congestion and pollution pressures.

Source: Data compiled from reports of the Central Pollution Control Board (CPCB), the Ministry of Environment, Forest and Climate Change, and urban mobility studies from the World Bank.

Interpretation: Transport-related emissions are a major environmental concern in Mumbai. The data indicate that road transport generates approximately **5–6 tonnes of CO_2 emissions per kilometre of road**, making it one of the highest emission intensities among major Indian cities.The primary pollutants emitted by road transport include **carbon monoxide (CO) and nitrogen oxides (NOx)**, which contribute significantly to urban air pollution and health problems.The increasing number of private vehicles is the main contributor to these emissions. Although public transport systems such as buses and suburban railways are widely used, the growth in private vehicles has increased the environmental footprint of the transport sector.To improve environmental sustainability, policies such as **electric mobility adoption, expansion of metro networks, and improved traffic management systems** are essential.

Indicator	Score (0–10)
Accessibility	8
Efficiency	6
Sustainability	6
Affordability	8
Safety	6
Technology	7



The diagram indicates that **accessibility and affordability are strong, while efficiency and environmental sustainability require improvement**.

6. Discussion

Explanation of the Spider Diagram The spider (radar) diagram provides a visual idea of the performance of Mumbai's urban transport system across six important mobility indicators.

6.1. Accessibility (Score: 8): Accessibility refers to how easily individuals can reach workplaces, educational institutions, and services using public transport.(Rodrigue, Comtois, & Slack, 2020; Litman, 2020). Mumbai scores high in accessibility due to its extensive suburban rail network, bus services, and expanding metro corridors. These systems enable millions of commuters to travel across the city daily.

6.2. Efficiency (Score: 6): Transport efficiency reflects travel time, congestion levels, and traffic flow management. Mumbai faces heavy traffic congestion due to high vehicle density and limited road expansion. Although intelligent traffic management systems have been introduced, overall efficiency remains moderate.

6.3. Environmental Sustainability (Score: 6): Sustainability relates to pollution levels, carbon emissions, and the adoption of environmentally friendly transport solutions. The growing number of private vehicles contributes to higher emissions. However, initiatives such as electric buses and metro expansion are helping improve environmental sustainability.

6.4. Affordability (Score: 8): Affordability refers to the cost of transportation relative to income levels. Public transport in Mumbai, especially suburban railways and buses, remains relatively affordable compared with many global cities. This allows large sections of the population to access mobility services.

6.5. Safety (Score: 6): Transport safety includes road accident rates, pedestrian safety, and infrastructure quality. While improvements have been made through traffic surveillance and enforcement systems, road safety and pedestrian infrastructure still require further development.

6.6. Technology Integration (Score: 7): Technology integration includes the use of smart transport solutions such as digital ticketing, intelligent traffic management systems, and real-time transport information. Mumbai has adopted several smart mobility initiatives, but further integration across transport modes can enhance system efficiency.

The spider diagram indicates that Mumbai performs relatively well in **accessibility and affordability**, reflecting strong public transport usage. However, **efficiency, safety, and environmental sustainability require improvement** due to congestion, increasing vehicle numbers, and pollution. Strengthening smart mobility solutions, expanding metro networks, and promoting electric mobility can significantly improve these indicators and support sustainable urban transport development.

The analysis shows that Mumbai's transport system faces major challenges due to high vehicle density and limited road infrastructure. Although public transport carries a large share of commuters, the increasing number of private vehicles contributes to congestion and environmental pollution. Metro expansion, electric buses, and intelligent traffic management systems are important initiatives that can improve mobility efficiency. However, further investment in public transport infrastructure and sustainable mobility policies is necessary.

7. Conclusion

Urban mobility and environmental sustainability are deeply interlinked in megacities such as Mumbai. An analysis of transport indicators highlights that the city is grappling with significant mobility challenges driven by rising vehicle density and constrained infrastructure growth. Although public transport usage remains substantial, issues of congestion and emissions persist. Therefore, adopting sustainable mobility measures—such as metro expansion, promotion of electric vehicles, and implementation of smart traffic management systems—is vital for enhancing transport efficiency and environmental outcomes. Policymakers need to emphasize integrated transport planning and sustainable solutions to support long-term urban development.

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