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Evaluation of Sustainability Elements in Transportation Sector of India.

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Abstract

Although the transportation industry is known to be crucial for supporting economic expansion and infrastructure, we also have to acknowledge that it plays a significant role in pollution. Speaking is not as easy as doing. The delicate balancing act would require indulgence at the governmental level, with strong technological assistance. The International Energy Agency (IEA) estimates that 12.9% of India's total carbon emissions came from the country's transportation sector. In terms of figures, it was 295 MT of CO2.

This article discusses the current situation as well as the commercial initiatives implemented to obtain sustainability on the road to achieving efficiency in the transportation sector.The publication includes several original studies that need to be reviewed and presented. It is impossible to ignore the government's zeal and sincerity, as seen by the numerous environmental and sustainable regulations that center on this issue. Important obstacles and methods for lowering greenhouse gas (GHG) emissions are also described.

Key words: sustainability, green practices, transportation in India, sustainable transportation,

1 Introduction

India's economy is expanding along with its population, therefore the number of passenger automobiles on the road has increased and is expected to continue rising. Elevated public transit levels are a frequent and sensible demand, yet the growth of the passenger vehicle segment is unabated. Indeed, a move to the electric sector would help to lower greenhouse gas emissions from the levels that have been suggested. A logical result of the public's rising desires will be an increase in the other area of transportation, namely civil aviation.

The variety of transportation available in India contributes to the problem's complexity. Non-motorized modes of transportation include buses, trains, three-, four-, and two-wheelers as well as air travel. In terms of carbon emissions, trucks (freight) accounted for the largest share. It exceeded the total greenhouse gas emissions from two-wheelers, three-wheelers, and four-wheelers, according to 2020 statistics.

In 2021, the Prime Minister of India, Shri Narendra Modi declared that the nation's goal was to have net zero carbon emissions by 2070. All of these, point to a 4 GT CO2 reduction from 2021 to 2050 compared to the current regulatory framework. Increased biofuel use, a quicker uptake of electric vehicles (EVs) along with the necessary infrastructure and more robust energy efficiency gains in internal combustion engine (ICE) vehicles all result in further savings up to 2030. Electrification, especially of cars and trucks, then accounts for much of the remaining potential for abatement.

2 Literature Review

The topics under sustainable transport are vast. However, we intend to cover as many aspects of the same. We made an attempt to maintain the review up to date by looking through the most recent case studies, books and academic papers.

In 2009, Ramachandra, T V, and Shwetmala conducted a comprehensive investigation on the effects of emissions resulting from transportation in India. They used nitrous oxide, volatile organic compounds, and particulate matter to measure the same things. The combination of field data and analysis was rigorous. Among the conclusions were the correlation between pollution and cardiovascular disorders, the relationship between traffic and meteorological patterns and pollution concentration, and the consequences of various vehicle kinds.

Specifically, a 2017 study by Joshi, Minu and Vaidya, Ajay et al examined the value of smart transportation options for smart cities. They placed a strong emphasis on creating models for improving policy, technology, and citizen involvement. With the ecology and sustainability in mind, they provide a range of solutions to the mobility problem. They suggest specific bike infrastructure, an intelligent transportation system, and the use of electric vehicles in the smart city concept. The researchers also made it very evident that, of the six characteristics of a smart city—smart citizen, smart living, smart environment, smart mobility, smart economy, and smart governance—mobility or transportation is the most crucial component.

Saharia, Priyanka and Raj, Krishna did a detailed investigation in 2020 to study the relationship between airline business growth, aviation fuel prices, fuel efficiency and fuel prices with data points from 1988 to 2017. They used the ARDL model of Bound test approach and Toda-Yamamoto test. They found that although the per capita ATF usage increased due to

increased usage, the efficiency also increased due to technological improvements. When determining the amount of ATF that can be used to reduce CO2 emissions, energy efficiency is a key factor. The use of aircraft with improved technology that reduces fuel consumption can be considered as the main cause of improved fuel efficiency.

The preferences of citizens toward public and private transportation systems were attempted to be investigated in 2023 by Arora, Kashish, Zheng, Fanyin, et al. The study looks into what influences people's preferences for individual versus shared transportation. Additionally, they explore the topic of congestion surcharge and provide numbers for easy understanding. They determined that significant reductions in carbon emissions might be achieved by increasing the pooled transport system's efficacy.

In 2023, Mohapatra, Subhashree and Mohanchandran, Dileep et al. conducted a thorough analysis of the sustainability practices used in developing nations throughout the world. It discusses policy frameworks, infrastructure difficulties, societal ramifications, and technology concerns. It decides on an integrated strategy for India that strikes a balance between environmental considerations and economic necessities. Cases from Rwanda, Jordan, and Jamaica were chosen for assessment. Cities in India, Thailand, Indonesia, Turkey, Russia, Columbia, and Peru were all studied for traffic congestion. Research on urban sustainability certification is also available, encompassing the US, the UAE, Australia, Qatar, and Germany.

In 2023, Irfan, Mohd and Mahapatra, Bamadev et al. conducted a detailed analysis of the impact of energy conservation techniques using a random panel frontier approach. They conducted separate analysis for road, air and sea transport.

In 2023, a qualitative analysis of intermediate public transit (IPT) was conducted by Bhuyan, Atanu, Roy, Vivek, and others. For their research, they employed interviews, concentrated group discussions, and paper analysis. Among other things, their results included policy frameworks, financial sustainability and inefficiencies.
An investigation of the relationships and significance of public planners in formalizing public transportation networks was conducted by Regmi and Madan in 2024. They discovered that important chair holders, such as mayors, governors, and other important administrative figures, had a considerable impact. They also saw that the public's usage of contributions was restricted. The study focused on the following topics: developing policies, putting them into action, involving stakeholders, the role and contribution of technology, aligning policies with the SDGs, and coordinating the necessary steps for implementation.

In 2024, Mishra, Nirmalendubikash and Pani, Agnivesh et al. placed a strong emphasis on forecasting the amount of pollution and emissions coming from India's transportation industry. To forecast the upcoming emission, they looked at the expansion of every area of India's transportation system. For this exercise, the ARIMA and ARIMAX models were used to data spanning from 1970 to 2023. Their study also covers the enhancement of overall distribution network efficiency, legislative initiatives, and incentives for cleaner technologies and greener cars. This segment's issues are likewise clearly outlined, along with a suggestive list of answers.

According to Singh, Vedant and Tejyan, Sachin et al. (2024), longer and heavier cars would have the greatest influence on transportation-related emissions due to environmental and sustainable concerns. To bolster their argument, they use rigorous quantitative methodologies. This drive's difficulties and possible advantages are also discussed. The writers place a strong emphasis on the cost reductions brought about by economies of scale, a notable reduction in emissions, meticulous infrastructural support (roads, parking, hubs, etc.), and regulatory incentives.

In 2024, Gandhi, Nevil, and Kant, Ravi et al. conducted research to determine the significance of switching from the widely used road transport system to an intermodal rail freight system. The problem was addressed via a comprehensive assessment of the literature. It was a difficult and slow shift. The study also looked into the underappreciating of the advantages of modal shifts. But there was a clear advantage in terms of cost-effectiveness, lower emissions and fuel efficiency.

2024 saw the emphasis of research by Balasubramanian, Nataraj, and Dhalmahapatra, Krantiraditya et al on the variables influencing the purchasing of electric vehicles in India. To uncover the contributing components, they employed conjoint analysis, focused group talks, and Twitter text mining. Discussions were held on the environment, costs, the condition of the infrastructure, policy support, and societal influence.

In 2024, Shardeo, Vipulesh, and Sarkar, BishalDey explore a significant facet of hydrogen utilization in the transportation sector. They share the advantages of the change in terms of fewer emissions as well as the difficulties associated with the

transition. Through the cooperation of business, government, and academic institutions, it provides a strategic perspective. Their study also suggests funding future investigations to create the ideal model for various freight industry subsectors.

In 2024, Joseph, G. and Elias, A.A. conducted a thorough qualitative investigation on the Kochi Water Metro. Throughout the study, direct observations, interviews, and qualitative content analysis were employed. Aspects such as adoption of sustainable practices, operational resilience, and community engagement become teaching points for other cities. Because it provides in-depth knowledge on sustainability, lowering carbon footprints, reducing traffic, and other related topics, it is discussed in relation to project management.

2024 saw the recommendation of Gandhi, Nevil, and Kant, Ravi et al. to use an intermodal railroad freight transportation system. They assessed a range of hazards in order to do this, including technological, infrastructural, demand-related, environmental, economic, social, and operational concerns. They subsequently classified each of the aforementioned dangers into 36 distinct sub-risks. 39 important recommendations were made after a discussion on each of them.
An detailed study of the green and sustainable activities being taken and which could be undertaken for the transport segment in India was conducted in 2024 by Singh, Prince, Antonyraj, Maria S. et al. Tough questions on the organization's comfort level with reviewing environmental operational practices, waste management in the transportation sector, the environmental friendliness of the transport vehicles being used, the frequency of energy and environmental-friendly audits within the organization, and other topics were included in the questionnaire that was used as a tool.

In 2024, Pradha, Rudra, and Nair, Mahendhiran S. et al. examined the transportation sector's emissions for 79 emerging nations from 2005 and 2022 and contrasted them with the expansion of their economies and their infrastructure. Additionally, integrated development—which encompasses both economic and sustainable transportation—is emphasized.

3 Importance of sustainability

It is crucial to define sustainable development and establish certain baselines before we shape our study into it. Development that satisfies current wants without jeopardizing the capacity of future generations to satisfy their own needs is what is meant by this (Brundthlan Report, 1987).
The foundation of sustainability is a straightforward idea: everything we require for life depends on the natural world, either directly or indirectly. The goal of sustainability, according to the USA Environmental Protection Agency, is to establish and preserve the circumstances that allow people and the natural world to coexist peacefully for the benefit of both the present and the future.
Environmental justice, human health, engagement, education, resource security, and sustainable communities all fall under the category of social sustainability. When we talk about economic sustainability, we also talk about employment, incentives, costs, pricing, accounting for natural resources, and supply and demand. Therefore, economically feasible, socially just, and environmentally sustainable development must be achieved. The four main tenets of sustainability are: conserving biodiversity, utilizing renewable energy sources sustainably, reducing the use of non-renewable resources, and limiting environmental damage.
The Sustainable Development Goals (SDGs)—which include eradicating poverty, promoting health and well-being, guaranteeing high-quality education, achieving gender equality, providing clean water and sanitation, encouraging sustainable production and consumption, reducing inequalities, fostering industry and innovation, promoting decent work and economic growth, addressing climate change, protecting life on land and under water, ensuring justice and strong institutions, and forming partnerships to support these goals—are also appropriate to reiterate in this context.
When it comes to our inquiries into the sustainability of the Indian transportation sector, these theoretical elements serve as our standards. As a result, the government will develop integrated policy frameworks, adopt efficiency measures in fuel utilization, adopt cleaner technology, and build sustainable infrastructure.
In order to advance economic and social development for the benefit of present and future generations, sustainable transport refers to the provision of services and infrastructure for the movement of people and goods in a way that is resilient, efficient, cost-effective, accessible, and safe while minimizing carbon and other emissions and environmental impact (as per UNDESA, 2014). Sustainable transport aims to achieve three main objectives: social (social equality, human safety, affordability, community cohesion, and cultural preservation), environmental (pollution reduction, climate change emissions, resource conservation, open-space preservation, and biodiversity protection) and economic (efficient mobility, local economic development, and operational efficiency).
The 5Is are: Infrastructure, Innovation, Integration, Intelligence and Investments. The 5Cs are: Clients, Centres, Corridors, Congestion and Complementarity (as per UNDESA, 2014).
While we theoretically discuss these, it is important to mention the performance indicators. They are as follows:
Economic Sustainability: Per Capita GDP, Per Capita Transport Energy consumption, Per Capita congestion delay, et al (Todd Litman, 2021)

Social Sustainability: Per Capita traffic casualty, traveler assault rates, land use mix, walkability and bikability, et al (Todd Litman, 2021).
Environmental Sustainability: Per Capita emissions, Per Capita fuel consumption, Per Capita impervious surface area et al (Victoria Transport Policy Institute, 2013)

4 Overview of the transport scenario in India

While discussing the overall transport scenario in India, we will be discussing the metrics as well as the emissions and some of the efforts taken by the respective sectors to reduce GHG emissions.

4.1 Rail transport

India has the largest and second-largest railway systems in Asia that are managed by a single entity. As of 2011, 8,241 stations are part of a route network that spans over 64,460 kilometers. Over 19,000 trains, 229,381 wagons, 59,713 coaches, and 8,417 locomotives are operated by it. One of the busiest railway networks in the world, the Indian railway system moves more than 1 billion tonnes of cargo annually. Moreover, it is reported to have transported an astounding 8,397 million passengers between 2013 and 2014. As a result of burning diesel, using electricity, and using other liquid fuels, there is a considerable emission of greenhouse gases (GHGs).
More than 6.84 million tons of carbon dioxide equivalent emissions were emitted in 2007, with more than 90% of them being in the form of carbon dioxide.
Because of its extension, the rail line industry is an inexorably enormous supporter of GHG outflows. While thinking about all variables in monetary navigation, rail arises as the most important choice in the Indian setting. Given the criticality of this fragment to decrease of GHG discharges, World Bank has delivered a credit of USD 245 Million to modernize rail and cargo strategies.
The establishment knows about its responsibility on SDGs. Other than modernizing, it is likewise advancing other green drives. As a component of it, 140.85 MW of sun oriented plants and 103.4 MW wind-based power plants have been introduced. According to the help Trucks on Trains (Child), there was a decrease of 2190 tons of CO2 outflows by a fuel reserve funds of 8.3 Lac Ltrs (Indian Railroads Yearly Report and Records English 2021-22).

4.2 Air transport

Notwithstanding being a minor giver, the flight area is putting forth a coordinated attempt to decrease its negative ecological impacts. With in excess of 100 air terminals and 170 million travelers took care of by them between the monetary years 2013 and 2014, India is a rising flight market. A portion of the endeavors taken by common flight are as per the following: Air terminal Cooperative Navigation (A-CDM), Air terminal Cooperative Direction (A-CDM), energy effectiveness measures for terminals, energy productivity through Coordinated Building The board Framework (IBMS), LEDs across structures of air terminals, Fuel Hydrant frameworks, advancement of CNG Vehicle Activity, utilization of electrical pulls and carts, Multimodal Network for Street and Metro, adherence to Climate The executives Framework (ISO 14001) and reception of Green House Gas Detailing Framework (ISO 14064) and Energy The executives Framework (ISO 50001) and execution of Air terminal Carbon License Projects. Obviously that Finishing and Tree Manors across the open spaces are basic to decrease of GHG outflows as well. The Service has taken endeavors to profit Bio-Avionics Turbine Fuel by planning with Service of Oil and Flammable gas (MoP&NG).

4.3 Maritime Transport

In 2019, around 2,000 traveler and 1,600 freight vessels involving inland streams in India were enlisted. Starting around 2019, the business for streams transport (IWT) created more than 277,000 tons of CO2 (tCO2). Starting around 2019, India had around 970 functional beach front delivery vessels, utilizing 1.6 million tons of fuel oil and producing 5.1 million tons of CO2 (MtCO2). It is to be noted here that assuming the whole oceanic vehicle were to move to LNG, the investment funds would be 27% of discharges. On a similar hand, on the off chance that the whole sea transport were to move to sun oriented, the reserve funds would be 52% of emanations. Both these figures would be for the benchmark of 2030.
The conceivable outcomes of maintainability in this area are huge. Some of them are as per the following: clean fuel advances, sun powered helped boats, use of LNG freight, improvement in the maintenance eco-framework, mindfulness improvement, utilization of clean advances and some more.

4.4 Road transport

The problems associated are: congestion, GHG emissions, increasing private vehicles, increasing road accidents and deteriorating air quality.

Category → / Year ↓	*2 wheelers*	*Cars, jeeps & Taxis*	*Buses*	*Goods vehicles*	*Others*
1951	27000	159000	34000	82000	4000
2000	34.12 Mn	6.1 Mn	0.5 Mn	2.7 Mn	5.3 Mn
2016	169 Mn	30 Mn	1.8 Mn	10 Mn	18.5 Mn

Table 1: Growth of vehicles in India
(**Source:** Ministry of Road, Transport and Highways, 2016, abridged as of date)

One can clearly observe that there has been exponential increase in count of registered vehicles across all categories of vehicles.
India as a country saw the usage of 105 million personal motor vehicles from 1951-2008. But in the next six years (2009-2015), we saw an exact amount of addition. As per another statistics, the ownership increased 438% in 2019 as compared to 2001 (Source: Ministry of Road Transport and Highways). The percentage of two wheelers as a share of the total number of vehicles has been over 70 percent since 2000.
Such a pressure on road transport is bound to have its toll on pollution. It is estimated that 1.1 Mn people in India die every year because of air pollution (WHO, 2018). The reason why we are discussing this is because of pollution because of transportation is roughly 1/3rd of the total air pollution (WHO, 2018).
So much importance is given in the paper to road transport because it contributes to 90 percentage of the GHG emission from the entire transportation sector.

Transport Sector	*GHG emissions (Gg CO2)*	*% share*
Road Transport	225155.51	90.1
Civil Aviaton	14009.68	5.6
Railways	7775.36	3.1
Water borne navigation	3002.10	1.2
Total	***250172.79***	***100.0***

Table 2: Transport sector emission by category in India
(**Source:** Ministry of Environment Forest and Climate Change, 2014, abridged as of date)

Air pollution's emission due to transportation increased to 305.33 Mntonnes of CO2 equivalent in 2018 making India the third in the category after United States and China (statista.com). Strangely, we are the lowest in terms of per capita transport emission because of our population (Climate Transparency Report, 2020).
Between 2013 to 2018, India's increment of per capita transport emission was 28%, second only to Turkey among G20 countries.

4.5 Electric vehicles

The electric vehicle market in India is small but growing. EV sales accounted for more than 4% of new car sales in 2022, a significant increase from the 1.8% recorded in 2021. Shares range from more than 50% for three-wheelers to as low as 4% for two-wheelers and less than 1% for cars, due to differences in acquisition and running expenses. Throughout their lifespan, electric tricycles cost 70% less than gas-powered ones, as indicated by a total cost of ownership (TCO) analysis. In other regions, electric vehicles are also affordably priced, even though their high upfront expenses might deter potential buyers. India is implementing actions to address this issue. As an example, the cost of electric scooters was nearly three times higher than that of a comparable gasoline scooter in 2022. Nevertheless, due to the FAME incentive and favorable tax policies, this gap has now increased by a factor of two.
It is anticipated that electric car sales will make up nearly 35% of total vehicle sales by the year 2030. In order to align with the 2070 goal, this sector must reach a 50% share. The speed at which India decreases its carbon footprint in the power industry (primarily fueled by coal), will impact the overall amount of CO2 emissions that electric vehicles can help to reduce. India's EV fleet is currently preventing almost the same amount of CO2 emissions as power plants produce to charge the cars. However, things will be different in the coming years: India's electric vehicle (EV) fleet is projected to reduce around 5 Mt CO2 emissions by 2030, with potential variations between 110 and 380 Mt CO2 by 2050 depending on the EV fleet's scale and growth rate.

4.6 Efforts by Government of India

Though the Government has been taking many initiatives around sustainability, we are covering select aspect of the same.

4.6.1 Green railways with net zero emissions by 2030

With the extensive rail network in the country, it is feasible to shift significant traffic from alternative transportation methods to trains. As per the plans set by Indian Railways, the goal is to increase from the current level of 35-36 percent to 45 percent by 2030. Construction on Dedicated Freight Corridors (DFCs) has already commenced.

According to this Vision, the project includes planning for: both traction and non-traction networks, incorporating a mix of renewable energy sources, implementing energy efficiency measures, engaging in international partnerships, setting carbon emissions targets, establishing more carbon sinks through afforestation, blending bio-fuels, and setting energy reduction goals.

4.6.2 Dedicated Freight Corridor (DFC)

This project is solely managed by the Ministry of Railways under the Government of India. It is anticipated that over the initial 30 years, more than 450 MT of CO2 emissions will be reduced (UNDESA, 2014). The main reason for introducing the DFC is two-fold: firstly, to shift freight transport from roads to environmentally friendly rail options; secondly, by embracing new technologies, freight rail will naturally become more energy-efficient. In 2041-42, GHG emissions were projected to be 33.2 million tons of CO2 in the "No-DFC scenario," compared to 5.97 million tons of CO2 in the DFC scenario. In the absence of DFC, total GHG emissions would have reached 582 million tons of CO2 over 30 years, whereas in the DFC scenario, emissions would have been much lower at 124.5 million tons.

4.6.3 Green Highways Policy 2015

This policy includes Plantation, Transportation, Beautification, and Maintenance. The goals focus on: decreasing the effects of air pollution, offering shade, preventing soil erosion, minimizing noise pollution, and generating job opportunities for residents. The policy specifies the specific plantation type based on soil type and outlines protection measures.

Afforestation on a large scale is integrated into green highways to enhance biodiversity and provide ecological benefits. Green lanes are improved by using native tree and plant species to boost air quality and reduce soil erosion. Green corridors not only house wildlife, but also help maintain ecological equilibrium.

4.6.4 Smart Cities Mission

Within this mission, Mobility plays a crucial role. The goal has been to encourage the use of public transportation and decrease pollution (and emissions). While we don't have specific information on the reduction or containment of GHG emissions, we have completed 1516 projects at a cost of Rs 36048 Cr. Besides this, we currently have 191 ongoing projects with a total proposed cost of Rs 5335 Cr (Smart City Mission, dashboard update). It should be highlighted that this mission includes built-in features like Air Pollution Index, alert for petrol fumes, multi-modal authentication, and other measurement-related features.

Digital platforms and data analytics provide valuable insights into travel patterns, traffic management, and infrastructure growth. Using big data and artificial intelligence can enhance transportation operations, reduce traffic congestion, and enhance the overall user experience.

4.6.5 National Clean Air Program

The goal is to lower pollution levels in the Top 100 most polluted cities. This strategy includes building electric vehicle (EV) infrastructure, developing bypasses and additional side roads to ease traffic, and improving parking options to lessen congestion. Other measures include: the use of bio-ethanol, establishing green zones, installing water fountains, and applying blacktop to roads.

Furthermore, the National Action Plan on Climate Change not only offers mutual advantages in tackling climate change but also focuses on steps that support our development goals. The primary aims include raising awareness about climate change, adaptation, and mitigation efforts, improving energy use efficiency, and conserving the environment's natural resources. These objectives are broken down into eight "National Missions" that constitute the National Action Plan on Climate Change. Each mission is comprehensive, long-lasting, and designed to achieve significant goals within the framework of climate change. The eight distinct missions are: National Mission for Sustainable Agriculture (NMSA), National Mission for Enhanced Energy Efficiency (NMEEE), National Mission for a Green India (GIM), National Mission on Sustainable Habitat (NMSH), National Mission for Sustaining the Himalayan Ecosystem (NMSHE), National Mission on Strategic Knowledge for Climate Change (NMSKCC), National Solar Mission (NSM), and National Water Mission (NWM).

4.6.6 Bharat Stage Emission Standards

India leapfrogged into the Bharat Arrange VI guidelines from Arrange IV in 2020. The point was to decrease vehicular contamination. Fuel's sulfur concentration has been radicallydiminished, as per BS-VI, by a stunning five times, to 10 PPM. It moreover limits the sum of debilitate that cars fueled by gasoline can discharge. The greatestsum of carbon monoxide in diesel models ought to not be more than 0.50 g/kg. Also, it caps the discharge of Hydro Carbons and Nitrogen Oxide at 0.15 g/km. The most extreme release level of respirable suspended particulate matter for gasoline-powered automobiles is 0.05. Cars would emanate 80 percent less particulate matter and 70 percent less Nitrogen Oxide in comparison to BS IV. There was tremendous capital venture to be done by refineries as well as fabricating companies but it was sought aftertruly and it was completed.

4.6.7 FAME

In April 2015, the first phase of the Faster Adoption and Manufacturing of Electric Vehicles in India was initiated. It was introduced in the 2015–16 budget. Beginning in April 2019, the second phase went into effect. Between 2015 and 2019, Rs 529 Cr was invested on Phase I. The revised FAME II program in India offers an extra 50% subsidy for electric scooters and motorbikes, up to Rs 15,000 per kWh. The government launched the FAME II program in 2019. The goal of the recently introduced FAME II incentive was to encourage India to adopt and produce electric vehicles more quickly.

The goals are to lower the initial cost of EVs, encourage manufacturers to produce them, reduce emissions, build infrastructure for charging them, and achieve a 30 percent share of electric vehicles by 2030. We have 175 models from 56 registered OEMs as of July 21, 2023, and 832824 automobiles were sold under FAME II.

4.6.8 Maritime India Vision 2030

This envisages the following:

Port Infrastructure Development: Create new ports and update those that already have LNG terminals with the goal of easing traffic.

Inland Water Transport: There are plans to increase the traffic from the present level of 2 percent to 5 percent by 2030

Public-Private Partnerships (PPP): PPPs are encouraged by MIV 2030 in order to maximize private sector investment and efficiency. Presently, 58 projects totaling around $5 billion are being implemented using PPP models at different phases.

Sustainable maritime sector: Trigger activities around emission reduction, renewable energy usages and improvised waste management.

It has some other aspects also but we will restrict ourselves to the ones concerning sustainability.

5 Case studies on sustainable mobility in India

We have some good cases related to mobility in India which have strong elements of sustainability

5.1 Delhi Metro

It has contributed significantly to the annual reduction of at least 6.3 Lac tonnes. Delhi Metro was recognised by the UN as the world's first metro rail system to receive carbon credits for lowering greenhouse gas emissions. It is serving as Delhi's and the satellite cities' carbon reduction agent. Several fundamental concepts pertaining to the project are as follows: At least thirty percent of the energy used is derived from renewable sources. The EV industry benefits from this as well, as they provide infrastructure for EV charging within their buildings, use regenerative braking technology to improve energy efficiency, educate their customers, manage their waste, install rainwater harvesting systems, and operate an electric bus fleet.

5.2 Kochi Water Metro

Kochi Metro Rail Limited and the Keralan government jointly own this business. It combines the significance of the environment with commercial connectivity. This idea is revolutionary since it uses water transport instead of cars and the associated traffic, which is more environmentally beneficial due to lower emissions. Although modal change presents challenges, commuters have been swayed by the green transition, efficiency, accessibility, safety, and ease of use. It claims to have the biggest assortment of electric boats. By providing cycles at each terminal outlet, the project considers sustainability factors in addition to water transportation. It is anticipated to carry 34000 passengers per day and to cut the city's carbon footprint dramatically—44,000 tonnes of CO2 less annually, on average once fully operational (Department of Economic Affairs, Ministry of Finance, Government of India).

5.3 Mahindra Electric: Leading the Charge in EV Adoption

Mahindra and Mahindra is a conglomerate with various businesses focused on manufacturing. Its goal is to achieve carbon neutrality by 2040. The conglomerate's large size and diverse manufacturing operations in tractors, farm equipment, spare parts, two wheelers, and automobiles present a challenge. Several initiatives have been implemented, including the

installation of a heat exchanger for energy efficiency, the use of renewable energy to avoid 79000 tCO2 emissions per year, planting 2.1 million trees for carbon offsetting, and focusing on Science-based targets.

6 Environmental Impact Assessment in India

Prior to delving into EIA, it is important to grasp the definition and history of the concept. Environmental assessment (EA) involves assessing and recording data on natural systems and resources to support sustainable development planning and decision making, as well as to predict and mitigate the negative impacts of proposed projects (Barry Sadler, 1996).

Environmental impact assessment (EIA) is a process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of proposed projects and physical activities prior to major decisions and commitments being made (Barry Sadler, 1996). Utility, integrity and sustainability are at the core of EIA.

In the 1970s, the Planning Commission of India directed the Ministry of Science & Technology to assess projects related to river valleys, thus initiating EIA in the country. Ministry of Environment & Forests enacted a law regarding this matter in 2006. Following that, the new draft was officially announced in 2020. The Environment Protection Act 1986 serves as the legal foundation for EIA in India.

It should be emphasized that EIA is a crucial aspect of every project in India. Therefore, the sustainability of transportation infrastructure (such as roads, waterways, and airports) must undergo an Environmental Impact Assessment (EIA) process. This serves as an effective tool for the government to be aware of sustainability in the transportation industry.

7 Suggestions

Basis the understandings from the evaluation of relevant papers andthe study of the government policies in the country, the authors arrive at some suggestions.

1. The country has no exclusive mission or project in the area of Non-motorised transport which is a low emission space and it is inexpensive in comparison to two-wheelers and three-wheelers. The planners can think of having one.
2. Emphasizing the importance of obtaining electric buses through bulk procurement is recommended. Revise and enforce rules on fuel efficiency in the trucking sector. India may support pilot schemes for electric and fuel cell trucks, as well as provide incentives for zero-emission vehicle (ZEV) trucks, while also improving freight transport logistics.
3. While stressing the importance of public transport mobility, the policies of AMRUT, JNORM, and Smart Cities Mission have mainly focused on improving road traffic and amenities for individual transport using the allocated funds. A review of the projects is necessary.
4. Since road transport is the biggest contributor to the emission from the transport segment, it is critical to introduce emission accounting to the DPRs of every highway project (atleast) so as to bring an element of seriousness among all stakeholders towards green materials and carbon emissions.
5. Green bonds rules for definitionshould be relaxed for the transportation segment and retail investors should be given tax incentives for investments.
6. The Government should encourage the establishment of research and development centers to increase the widespread adoption of environmentally friendly products and technologies. To achieve this, the Government might seek assistance from the top educational establishments. Advancements in technology such as Intelligent Transport Systems, Connected Autonomous Vehicles, and digital platforms have the potential to revolutionize the transportation sector. Implementing these innovative concepts can enhance efficiency, safety, and environmental sustainability.
7. Sustainable transportation projects depend heavily on public knowledge and participation. A move towards sustainable mobility can be facilitated by educating the public about the advantages of sustainable practices, supporting behavior change, and increasing the use of non-motorized and public transportation.
8. There should be a SDG metrics for all major transportation projects in India.
9. It is recommended to maintain the existing demand incentives beyond 2024, when FAME officially ends, in order to reduce the upfront cost gap between EVs and ICEs and retain beneficial tax policies. Potential regulations such as setting targets for the number of zero-emission vehicle sales or placing restrictions on the registration of internal combustion engine vehicles may be considered, given that electric three-wheelers are currently highly cost-effective in terms of overall ownership expenses. Demand incentives for cars will need to be implemented alongside stricter fuel economy regulations. Implementing low-emission zones and offering preferred parking can boost the adoption of electric vehicles without adding more pressure on government finances.
10. While discussing technical capabilities in the engineering space across all modes of transport, it is also important to improve the technicalities in financial options for promoting usage of EVs.
11. School and college curriculum must include the significance of sustainability in transportation as it affects and covers every citizen of the country. Who knows, some seriousness may build up across few of the students and they would be environmentally-conscious citizens when they grow up.
12. A supportive ecosystem for sustainable transportation requires balancing policies across many governmental departments and private industries. Implementing policies consistently and effectively should be ensured by coordination

between the central government, ministries, state government and local bodies (read Municipalities and ZilaPanchayats). Developing integrated and comprehensive strategies requires including stakeholders from a variety of industries, including energy, transportation, and urban planning.

8 Limitation of the study

1. The study does not cover the efforts being taken by various Municipalities and other state level bodies in the country.
2. It does not consider the individual aspirations and choices for electric vehicles.
3. In-depth developments of technology could have been discussed in a better manner.

9 The path ahead

India's transportation industry being emission heavy in nature demands critical attention. Implementing is an issue in the country but with resolute policies of the government, it is not impossible. Already, Smart Cities Mission is in vogue and transportation is a key part of it. Since the structure is already there, it should be actually be easy to have the same spelt across 100 cities of the country.

One has to accept the fact that within transportation, one has to have more focus on reducing GHG emissions in the road space as this is the largest contributor to emissions. Electrification and provision of infrastructure around it for two-wheelers, buses and three-wheelers will hold key. Road transportation is a major cause of urban air pollution and currently contributes 12% of India's energy-related CO2 emissions. By 2050, energy consumption and CO2 emissions from road transportation could quadruple in India as it tries to accommodate the country's growing demand for private transportation and the movement of products. According to the IEA's Stated Policy Scenario (STEPS), which represents the trajectory suggested by the current policy framework, energy demand and CO2 emissions will peak in the 2040s and then only slightly decrease from there. The surge is driven by the growing fleet of trucks and the constantly rising use of personal vehicles, both of which continue to run on gasoline and diesel. Although two-wheelers still make up the majority of vehicles in India, their energy requirements and emissions are beginning to decrease as a result of rapid electrification.
A key factor which has contributed to the increasing usage of passenger cars is Covid. As per a research done by TERI (2020), there was a sharp increase in number of passenger cars usage post Covid and there was a substantial dip in people using metros and buses. This is one factor which is clearly beyond the hands of the administrators and planners.
The nation today is self-dependent on technologies; educational institutes are ready to provide the necessary advice and we have forward looking civil servants who can take on the mantle of change management. Here, it is important that we do not do away with the private sector either in terms of technical institutions or the private academic community.

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