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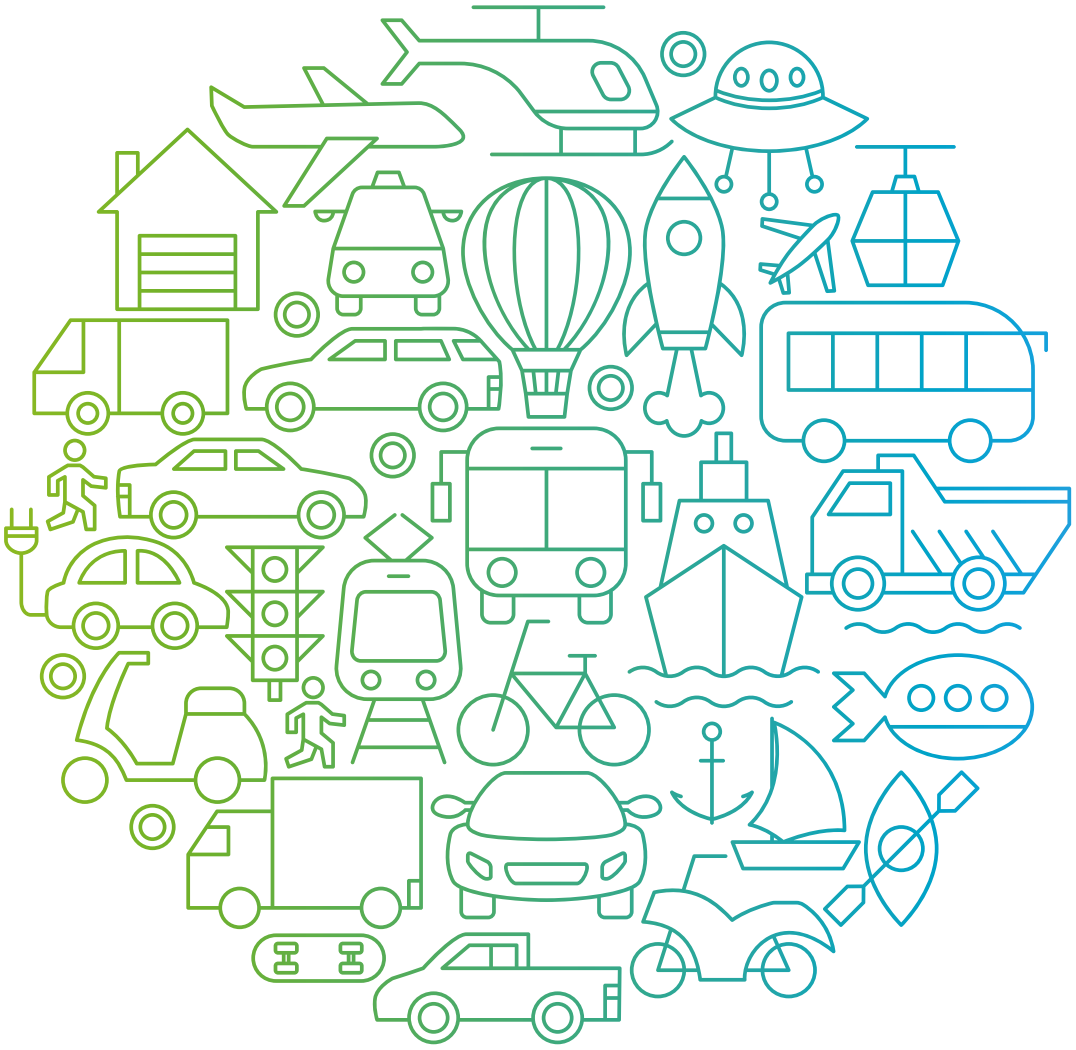

# Smart Urban Mobility in India

## Revolutionising urban transport for sustainable and resilient growth through innovative technology

**August 2024**

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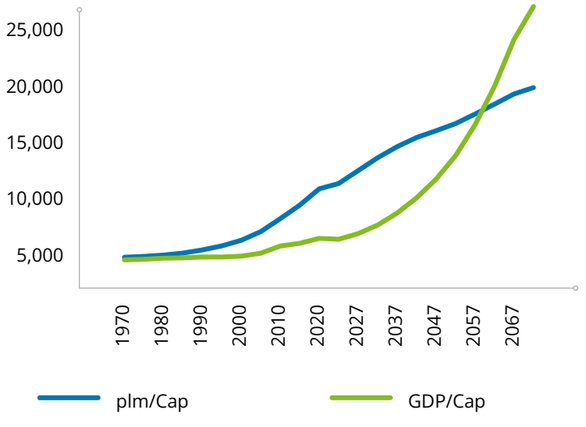
# Introduction

### India’s ascendancy: A nation on the move

India stands at the cusp of a transformative era. With a population of 1.4 billion and an ambition to become the third-largest economy by 2030, this dynamic growth is reshaping the country’s economic landscape and driving a surge in mobility demand as millions seek more significant opportunities and a better quality of life.

**Per capita travel demand vs GDP per capita**

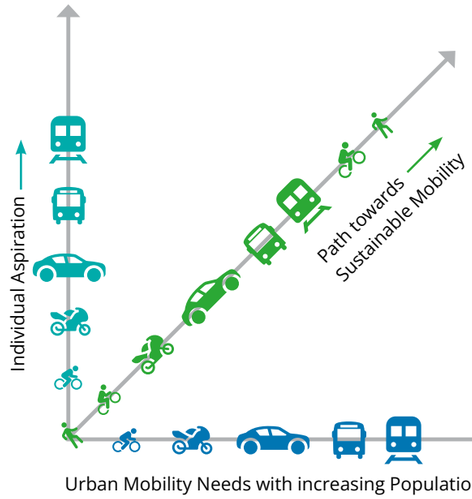







### The mobility dilemma: Individual desires vs. urban necessity

In a rapidly urbanised India, owning a personal vehicle symbolises independence and social status. However, cities are increasingly challenged by the need to shift towards mass transit systems to move large populations in limited urban spaces efficiently. The central question is: How can we align individual aspirations with the collective need for efficient and sustainable public transport?




### The high stakes of inaction: Escalating environmental and social costs

If the current trajectory continues, the consequences will be severe. Carbon emissions from the transport sector are set to nearly double, leading to increased air pollution, worsening congestion and longer travel times. The growing use of private vehicles undermines public transport's reliability and poses significant risks to commuter safety and environmental sustainability. If this trend persists for the next few decades, the average carbon emissions from India's transport sector will nearly double, rising from 271 kg $CO_2$ to 448 kg $CO_2$ .

### Governmental leadership: Paving the way for a sustainable future

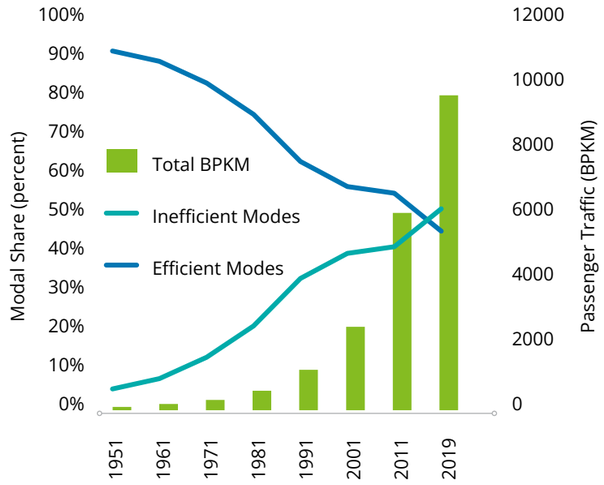
Recognising the urgency, the Indian government has implemented various strategic initiatives, including the Smart City Mission, AMRUT and the National Infrastructure Pipeline. These programmes aim to realign India’s urban mobility with

[4]RBI press release
[5]NSO, May 2024
[6]Economic Outlook, Deloitte, April 2024

### Navigating the path to sustainable mobility

The journey towards sustainable urban mobility faces many obstacles. These include a growing preference for private vehicles, financial strains on public transport and fragmented urban planning. These issues lead to a decline in public transport usage, resulting in pollution, congestion and safety concerns, significantly threatening urban liveability.

**Passenger traffic modal shares in India**




sustainability and resilience goals, ensuring that cities can efficiently support their growing populations while minimising environmental impact.

### Smart mobility: The catalyst for urban transformation

Smart mobility is becoming increasingly crucial for urban transformation. By integrating advanced technologies with transport infrastructure, smart mobility can connect service providers and end-users, creating a seamless, accessible and inclusive transport ecosystem that improves sustainability and safety across modes.

### Building the future: Five pillars of smart mobility

To build a sustainable urban future, focusing on developing five key pillars of smart mobility is crucial. These pillars will help create a resilient, efficient and user-friendly transport system, ensuring that Indian cities can meet today’s demands and prepare for future challenges.

**S** **Sustainable**

Sustainability can be achieved through smart mobility by integrating efficient, connected, and eco-friendly transportation solutions that reduce emissions, energy consumption, and traffic congestion.

**M** **Multimodal and seamless**

With smart services, all modes of transport from first mile, middle mile and last mile can be available on a single platform. Users can plan the journeys in advance and book tickets on a digital platform which reduces the waiting time and enables a seamless experience.

**A** **AI Enabled**

The availability of big data and AI models to process this data to execute decisions for mobility services have the capacity to enable smart solutions to identify patterns, predict mobility demand hotspots and help the users and service providers to plan operations well in time.

**R** **Resilient & Safe**

Resilient and safe cities can be ensured through smart mobility solutions by integrating real-time data, adaptive infrastructure, and advanced technologies to optimise traffic flow, enhance safety, and reduce environmental impact.

**T** **Technology transition**

Sustainability can be achieved through smart mobility by integrating efficient, connected, and eco-friendly transportation solutions that reduce emissions, energy consumption, and traffic congestion.





# Sustainable (**S**MART): Catalyst for transport transition

**Environmental**
Environmental sustainability refers to the city's alignment to Net-Zero targets

**Financial**
Financial sustainability refers to the ability of a city to generate surplus revenues to sustain its expenses

**Operational**
Operational sustainability of a city refers to the capacity of a city to maximise service efficiencies

### Achieving sustainable development in Indian cities: Three-pillared approach

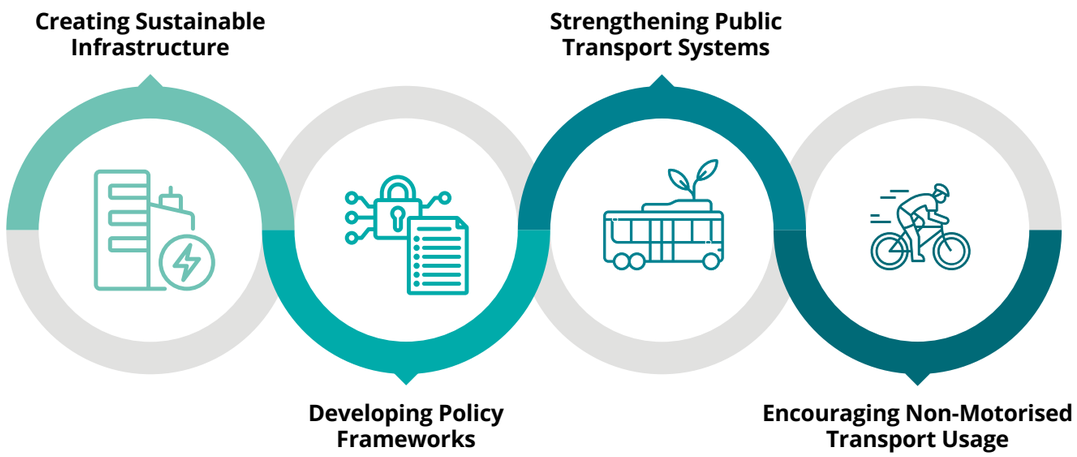
Sustainable development at the city level comprises three components: financial, operational and environmental sustainability. India is currently experiencing rapid urbanisation and population growth, which heavily strains the existing infrastructure of cities. The transport system within a city must operate optimally and minimise unnecessary travel and waiting times for efficient fuel consumption to achieve operational sustainability, especially with the city's population expanding rapidly. Achieving financial sustainability requires a significant focus on creating efficient financial frameworks that are self-sustainable in the long run. Environmental sustainability requires aligning with India's net-zero target, focusing on reducing pollution and emissions and promoting sustainable, green solutions to improve liveability in cities.

### Driving urban sustainability: India's multi-level initiatives for a greener future

India is currently implementing sustainability initiatives at national, state and city levels. These initiatives focus on environmental, operational and financial sustainability. For instance, the Electric Mobility Promotion Scheme (2024) seeks to increase the use of eco-friendly transportation by offering support for developing and manufacturing electric vehicles in India. These efforts integrate sustainability into the transportation ecosystem and infrastructure development, making it more attractive to consumers while aligning with government objectives and commitments.

### Driving sustainable mobility in India: Strategies for transportation

India's transport sector accounts for ~14% of the country's energy-related $CO_2$ emissions. As transport is one of the most significant contributors towards emissions and significantly impacts development, ensuring sustainability in transportation becomes vital. This could be done by creating sustainable infrastructure through an EV charging infrastructure network and policy frameworks that support sustainable initiatives through regulations and fiscal/non-fiscal incentives on EVs. Strengthening public and non-motorised transport should also be a focus area to reduce the dependency on private vehicles to meet travel demand. This will minimise peak-hour congestion and facilitate the transition towards green mobility alternatives.




A central monitoring unit for all activities within the city should be created to ensure that all the resources are deployed with intelligent solutions to optimise productivity and result in maximum uptake of sustainable and green solutions. Awareness programmes need to be developed around sustainability and the increasing risks involved if authorities and citizens do not implement sustainable mobility solutions.





**Case: Healthway cycle track made in Hyderabad is India's first 23km dedicated cycle track segregated with a green buffer with a solar roof. The solar panels provide shade to cyclists, generate 16MW of electricity that powers streetlights and illuminate the 800km stretch of street with lights. The excess power generated will be contributed back to the primary grid. This cycle track is 4.5m wide bidirectional, thus encouraging the users to use active mobility to reach their destination.**

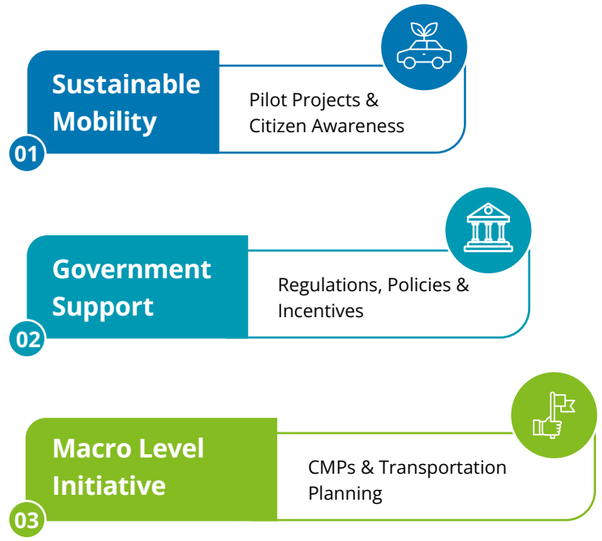
### Role of smart solutions in advancing sustainable transportation in India

Smart mobility can accelerate the adoption of sustainable transportation solutions in India. Improving efficiency, safety and resilience can ensure operational, financial and environmental sustainability. Reduced congestion leads to increased efficiency, saving cities and industries billions of dollars in productivity and fuel costs. Electric vehicles, including Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs), help reduce pollution and reliance on fossil fuels. Connected vehicles improve safety and efficiency through communication technology for Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) interactions. Mobility-as-a-Service (MaaS) has immense potential, integrating numerous services on a single platform for seamless user planning. Smart mobility solutions also offer real-time data analytics for predicting future patterns. They can be used to create infrastructure plans that promote sustainability through collaboration between the government, industry and end users.

### Challenges and opportunities in implementing sustainable smart mobility solutions

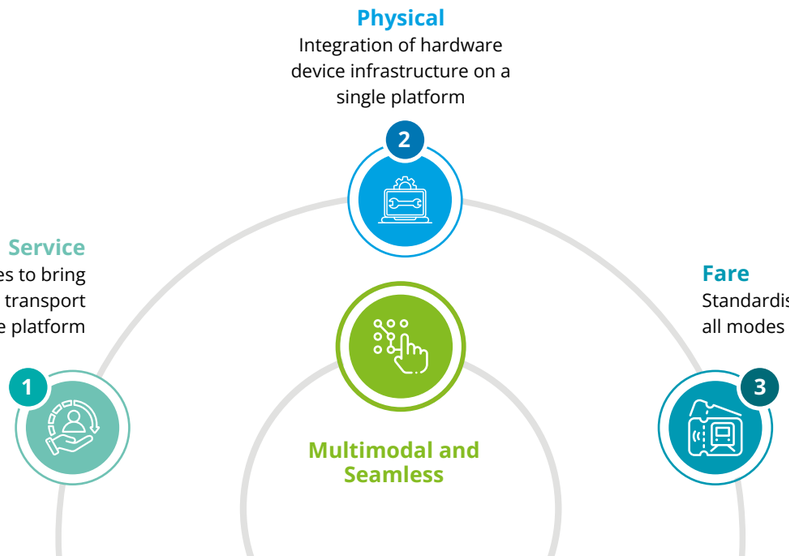
Although sustainability can be strengthened using smart mobility systems and services, various constraints and challenges may function as roadblocks. Outdated infrastructure and lack of clear regulations and standardisation can affect integrating smart mobility solutions within the transport infrastructure. There is a high entry barrier to implementing smart mobility solutions in the form of excessive upfront costs leading to financial constraints. While public motive and acceptance of sustainable solutions for mobility, such as electric vehicles, non-motorised transport, public transport and mobile applications for integrated transport, are essential, sensitising the public on the benefits of upgrading their user experiences and unlearning the age-old methods of transit is also highly essential. Transition to renewable energy sources shall also provide operational and environmental sustainability, especially for electric vehicle charging, which faces major hurdles in the form of infrastructure issues such as space constraints, high upfront costs and financial risks. Addressing the challenges of smart mobility at the city level in the initial phases of uptake can benefit the cities and increase the effectiveness of sustainable transport solutions.

### Enhancing sustainability in India through smart initiatives




Sustainability in India can be enhanced by implementing smart mobility infrastructure and services. A strategic approach is necessary to achieve this. Pilot projects should be initiated in cities, and citizens should be educated about sustainability through various programmes. Successful pilot programmes should be scaled up through government regulations, policies, incentives and other programmes to develop key infrastructures such as vehicle tracking systems, fuel technology, route optimisation tools, solar rooftops and electric vehicle charging networks. In the long term, comprehensive mobility and city-level transport planning should align with India's sustainability goals, promoting sustainable infrastructure to increase operational efficiency and maximise profitability.

# Multimodal and seamless (S**M**ART): Creating the connected experience




## Transforming urban mobility: Role of seamless multimodal transport systems

The focus is on providing transport infrastructure with high-quality, real-time information systems to connect routes, schedules and fares. Thus, seamless multimodal transport in urban areas involves creating an integrated system where various transportation modes work together, such as buses, trains, bicycles and ride-sharing services. This integration ensures smooth transitions between transport options, enhancing users' convenience and overall mobility. Such systems are crucial for improving the liveability of cities by reducing commuting stress, expanding access to resources and supporting economic growth through better connectivity. Centralised ticketing, real-time information and coordinated infrastructure also help streamline travel and make urban areas more sustainable and equitable, ensuring that all residents benefit from improved transport options.

## Towards integrated mobility: Enhancing efficiency, sustainability and user experience in India

India’s multimodal transport system faces several challenges, including fragmented planning, lack of institutional coordination and inconsistent technology integration. Different modes of transport, managed by various agencies and levels of government, often operate in silos, leading to inefficiencies and a disjointed user experience.

A comprehensive transportation strategy must be developed to promote coordination among government authorities. This strategy should streamline the process of finding mobility solutions, planning, ticket booking and making digital payments through a single application platform. Enabling such seamless integration can boost the economy and sustainability, enhance user experiences, reduce travel times, optimise government resources and increase public transport ridership.

## Steps for seamless multimodal integration: Key to sustainable urban mobility in India’s rapidly expanding cities

There is a need for increased focus on multimodal integration, as cities are expanding into suburban areas, and the population is growing rapidly. As the commute from suburban areas to commercial zones and cities gets longer, there arises a need for shifting between two to three modes of transport, including a mix of public and private modes. Integrating smart mobility technologies is essential to enhance multimodal and seamless transport services and meet the growing demand in India. This involves developing unified digital platforms that consolidate various transport modes into a single app, offering real-time data for improved decision-making, and streamlining ticketing systems with contactless and integrated payment solutions.

**Case: The urban transport system in London exemplifies integration across all three pillars. Transport for London (TfL) is the governing authority that oversees comprehensive urban transport planning and operations. The system integrates fixed infrastructure and operations by linking interchange stations, which are physically connected and designed to handle high passenger volumes efficiently while accommodating multiple transport modes. Features such as island platforms and dedicated passages facilitate smooth transfers between lines. Fare integration is achieved using Oyster cards, which are valid across all urban transport modes under a unified fare system.**

### Unlocking seamless transportation: Role of smart mobility solutions in India's multimodal transportation

Smart mobility solutions are the key to enhancing seamless user experience across multimodal transportation services. They increase efficiency using unified digital platforms and offer real-time data for users to plan their trips and purchase tickets through a single platform. Smart technologies, including vehicle-to-everything (V2X), 5G networks, blockchain and the Internet of Things (IoT), can facilitate fare and service integration for seamless user experience.

The multimodal approach of smart mobility is all about making the movement of people and goods more efficient and flexible. The proper mode of transportation for the right trip allows travellers to get to their destination on time and with minimal disruptions. Multimodal mobility requires the government to improve infrastructure and create larger, eco-friendly, energy-efficient public transit fleets, including buses, streetcars and light rail.

### Navigating obstacles in India's smart mobility landscape

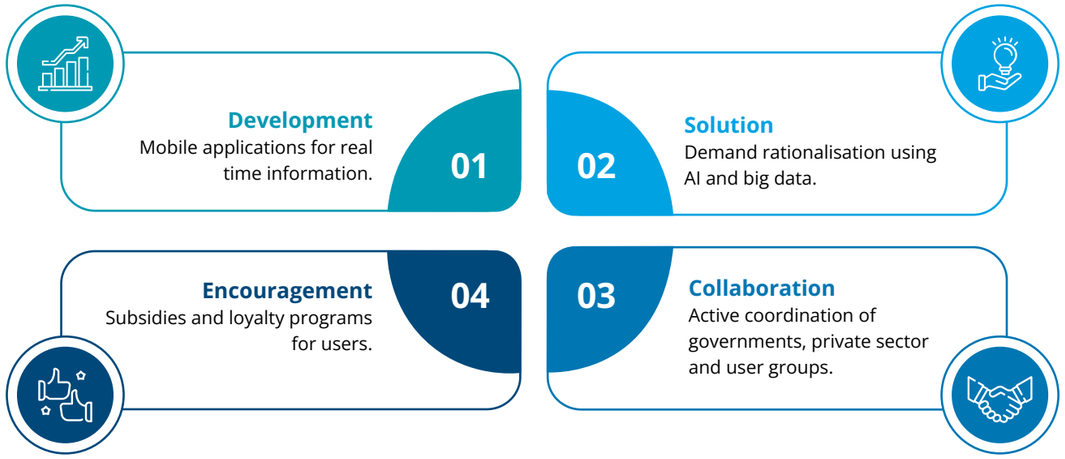
In India, integrating multiple modes of transport faces several challenges. However, smart mobility implementation can address some of these issues. The government and industry stakeholders must collaborate and establish standard processes to achieve this. One of the challenges is the inconsistent funding for all modes of transportation and the integration process. The government can promote multimodal integration and a unified platform for transportation services, but the success of such initiatives depends heavily on public support.



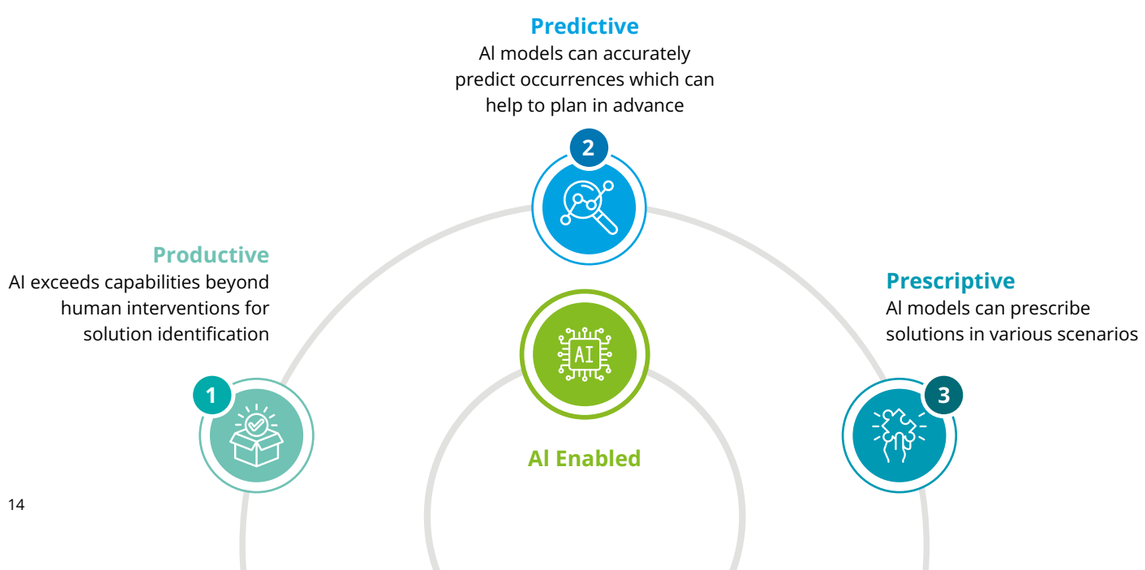


### Enhancing smart mobility in India through unified mobile applications and real-time data integration

Developing unified mobile applications or a unified platform that provides real-time information to users and service providers must be prioritised. Solutions can be created using AI and big data to optimise public transport routes. Subsidies and user loyalty programmes can also be provided to promote these systems. Collaborations can be promoted between governments, private sector entities, technology providers and user groups through events and active coordination. Collaboration services embedded in applications through communication platforms could allow authorities to deliver real-time communications, such as messaging, voice and video, updates, travel information and emergency notifications. These features delivered through a unified platform can simplify and enhance user experience.




# AI enabled (SM**A**RT): Transforming the mobility ecosystem








## The expanding role of AI in development and decision-making

AI can simulate human intelligence in machines to perform complex problem-solving and decision-making tasks. Big data is the backbone of AI, comprising extensive datasets procured from various sources. AI systems can be customised for problems and predict patterns to prescribe solutions. Hence, they have a vast scope for redefining transportation in India. AI solutions can be:

- **Reactive** – Transport authorities deploy data to identify data trends without the causal analysis behind the trends.
- **Predictive** – Authorities go beyond the causal analysis and explore the impact of multiple measures on the data trends.
- **Prescriptive** – They analyse the data to explore the critical trends and their underlying causes and propose solutions.

**Case: Siemens Mobility uses AI, including adaptive traffic control and predictive analysis, to improve urban mobility and manage traffic flow. At the 2019 ITS World Congress in Singapore, it showcased its advanced traffic systems, which reduce gridlock by centralising and managing urban traffic. By integrating data from smart infrastructure, these systems help drivers optimise routes and minimise environmental impact. Through advanced data analysis and predictions, traffic regulation is made more efficient.**

In tandem with other emerging technologies, AI provides many opportunities and new horizons for vehicle interconnectivity, paving the way for more efficient, advanced and safer transportation systems.

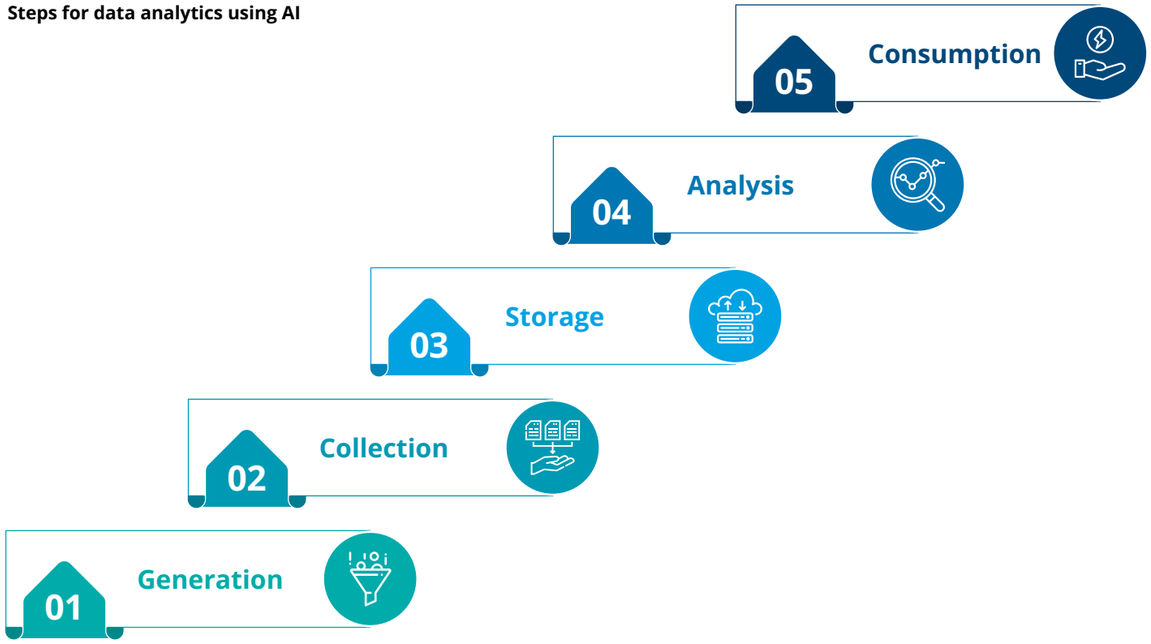
## The emerging role of AI in optimising India's transportation systems

AI implementation in transportation systems in India is still in its early stages, primarily due to data privacy and accuracy concerns. However, there is great potential for using AI in transportation systems. Intelligent traffic management systems integrate the data from sensors and cameras to optimise traffic flows and reduce congestion, thus optimising urban mobility. Ride-sharing platforms also use AI models to predict demand and supply during peak hours for dynamic pricing and efficient ride matching that benefits users and service providers. Thus, beyond automation and error reduction, AI is expected to become adept at predicting upcoming trends, ushering in a new era of proactive decision-making.

**Case: AI implementation in public transport systems such as Delhi metro for predictive maintenance and scheduling can increase the efficiency and reduce operational downtime of the entire system.**

**Case: Hitachi is a leader in using AI for transportation and is renowned for its advanced predictive fleet maintenance software. Its fleet management system uses AI to analyse data from vehicle sensors and historical maintenance records, helping to prevent unexpected failures and optimise fleet performance. Through the Smart City Mission, the Indian government has collaborated with Hitachi India Pvt. Ltd.'s R&D centre to harness its technological expertise for intelligent transport solutions. The collaboration focuses on traffic prediction, in-bus crowd estimation, video classification of vehicle types, and analysis using acceleration sensors to strengthen and enhance the bus transportation system in India.**

**Steps for data analytics using AI**

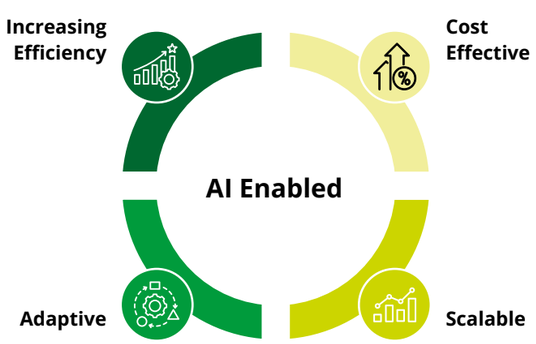



AI can foster analytics in the transport data ecosystem through a comprehensive value chain. The value chain concentrates on the following aspects:

- **Data generation:** Focus on public and private data generators. Some key examples include GPS devices used in buses, private vehicles and vehicles capable of transmitting data independently.
- **Data collection:** Analyse agencies that collect data for their internal consumption and other stakeholders in the ecosystem. Examples include transport departments, metro rail corporations, MoRTH, vehicle manufacturers, operators, regulators and city agencies.
- **Data storage:** Identify preferred data storage medium (online, offline, etc.) among stakeholders.
- **Data analysis:** Examine annual reports, performance booklets and data subscriptions offered for external consumption by multiple agencies.
- **Data Consumption:** Focus on identifying consumers that use transport data for different purposes, e.g., vehicle manufacturers, technology payers, commuters, transport operators and non-transport services.

### Enhancing urban mobility in India through AI-driven smart solutions

The role of AI in traffic management and transportation is paramount, including using data analytics to optimise traffic flow, minimise congestion and enhance overall transportation efficiency. Mobility solutions integrated with traffic lights, basic sensors and static public transport schedules may not yield positive results in a dynamic environment. Smart mobility solutions can be empowered with AI to predict future travel demand and create personalised travel recommendations for users. This can make a case for adaptive, scalable, cost-effective and seamless smart mobility solutions in cities.





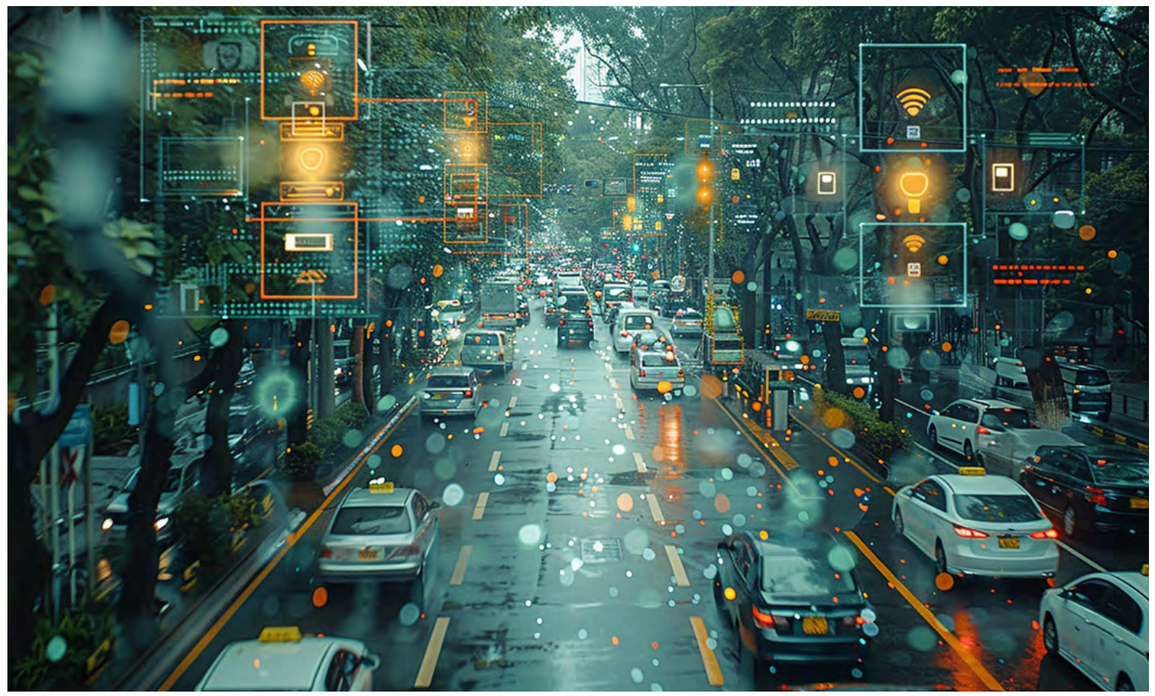



**Case: The Land Transport Authority (LTA) of Singapore uses AI and data analytics to monitor its rail infrastructure and network by predicting and preventing potential failures to enhance reliability and minimise service disruptions. This is done with two key systems: Fusion Analytics for Transport Event Response (FASTER) and Rail Enterprise Asset Management System (REAMS). These AI tools offer a comprehensive view of interconnected rail systems and provide real-time updates on train service issues and mitigation measures, ensuring efficient operations and optimal service for passengers. These models can forecast when and where maintenance will be needed based on the current state of the system and historical trends.**

### Transforming India's transport sector: Role of AI in efficiency, safety and sustainability

AI can revolutionise route planning and operational efficiency, especially in public transportation. Moreover, AI-powered predictive maintenance can identify potential issues in vehicles and infrastructure before they escalate, ensuring the reliability of public transit systems. Policymakers can also significantly benefit from AI's insights into existing policies effectiveness and prediction of proposed policies impact. Thus, by staying at the forefront of technological advancements, cities can pave the way for a more connected, efficient and eco-friendly transportation landscape.

**Case: Dubai has been experimenting with smart vehicle number plates, using AI and access to tools that can inform emergency services about the details of a crash or incident. These plates can even connect to a bank account to pay parking fines.**



### Addressing risks and challenges of AI Implementation in India's transport sector

Despite significant advantages, AI poses risks regarding data security, safety and privacy. Currently, there is a lack of standardised practices on the use of AI, which can cause problems regarding the reliability of AI-based solutions. AI can also create risks in the transport sector, such as job displacement and integration complexities. The lack of a clear set of policies governing the use and implementation of AI-based services in India remains a major concern. AI solutions use various components, including IoT and data analytics software and different communication protocols. They can handle multiple data formats, such as real-time data streams. Poor integration can push AI to base its analysis on fragmented sources and inconsistent datasets, delivering inaccurate predictions.

### Strategic integration of AI in India's smart mobility: Addressing policy, data and workforce challenges

**Integrated AI**

Effective integration of AI into India's smart mobility infrastructures, a comprehensive strategy that addresses policy gaps, data management, infrastructure needs, workforce and skilled labour development must be put in place

**Government Focus**

The government should focus on creating a national AI strategy which has regulatory frameworks and innovation related funds so that clear data privacy and safety standards can be set while innovators advance the usability and applications around AI in India.

**Data Security**

Cybersecurity measures can also be strengthened further because the data which is processed by AI can be used in the public domain.

**Awareness**

Awareness campaigns around the benefits and risks of AI along with training programs for educational institutions and skills development programs for working professionals shall be beneficial for the country to create new opportunities and enhanced livability of cities.






# Resilient and safe (SMA**R**T): Balancing mobility, environment and efficiency while prioritising safety

### Building resilient cities: Enhancing safety and adaptability in urban environments

Urban resilience refers to a city's ability to withstand, adapt and recover from various stresses and shocks. These may include natural disasters or economic disruptions, all while maintaining the functionality of essential services. In this context, transport resilience is crucial as it ensures the continued movement of people and the capacity to adapt and recover from disruptions. However, challenges in the transport ecosystem, such as the absence of robust benchmarks for monitoring and timely improvements, can hinder resilience. The robustness of a transport system directly affects how well it withstands disruptions. The less impacted a system is, the more resilient it is. Thus, resilience is a critical focus for cities aiming to enhance the quality of life, foster inclusion and safety and promote sustainable growth.

### Strengthening urban resilience in India: Role of Smart Cities Mission in sustainable development

Resilience is central to India's development, as exemplified by the Smart Cities Mission, which focuses on liveability, economic viability and sustainability. The mission aims to enhance disaster management systems through sustainable development and infrastructure improvements. At the national level, initiatives by the Ministry of Housing and Urban Affairs (MoHUA), such as the National Urban Digital Mission and the Geospatial Management Information System (GMIS), work towards making cities self-reliant and better equipped to handle disruptions. At the state level, various initiatives have been launched, including the formulation of EV policies, bicycle plans, awareness campaigns on sustainable transportation, safety of women in public transport and safe travel for children. Locally, cities develop comprehensive mobility plans, conduct road safety audits and implement traffic management strategies. Collaborations with development institutes further aid in managing emergencies, monitoring infrastructure, engaging citizens and fostering resilient and safe urban environments.

### Smart mobility for enhanced urban safety and resilience

Smart mobility is integral to urban resilience and safety, particularly in mitigating the effects of climate change. Before establishing public transport systems, cities should conduct comprehensive flood and climate change risk assessments. Innovative approaches, such as historical data and climate change predictions, can inform risk assessments. Smart mobility solutions, such as adaptive traffic monitoring and vehicle-to-everything communication, help reduce traffic congestion and accidents in real time. Infrastructure related to mobility can be monitored using sensors and cameras, enabling proactive measures such as mobile flood gates and early warning systems linked to local weather services. Emergency response teams can be empowered with smart mobility systems for efficient city-wide monitoring and resource deployment during emergencies. Thus, technology plays a crucial role in connecting city authorities and citizens, fostering safe and resilient infrastructure. Inclusive smart devices and apps offer simplified access to mobility services for all, including women and people with disabilities.

**Case: The Second Basic Plan on Transport Policy (FY2021–2025) in Japan emphasises key strategies for enhancing safety and resilience within the country's transportation system. It introduces new policies focused on integrating disaster prevention management into transportation enterprises and implementing comprehensive traffic management strategies during disasters. These measures are designed to make the transportation system safe and disaster-ready. The plan employs 119 KPIs to assess progress and effectiveness to achieve these goals. The aim is to develop a "next-generation transport system" offering sustainable, resilient, high-quality services.**

### Overcoming barriers to smart mobility: Addressing public awareness and safety concerns

Overcoming barriers to smart mobility requires a comprehensive approach, including infrastructure investment to upgrade physical systems for advanced technologies such as traffic management. Addressing cybersecurity risks and public concerns about data safety is essential to building citizen confidence in smart mobility systems. Ensuring durable and resilient infrastructure and technologies is critical for the physical safety of citizens. Public education and involvement in the planning process are necessary to demonstrate the benefits of smart mobility. As modern technologies are introduced, cities must navigate unforeseen technological integration risks and physical safety risks.

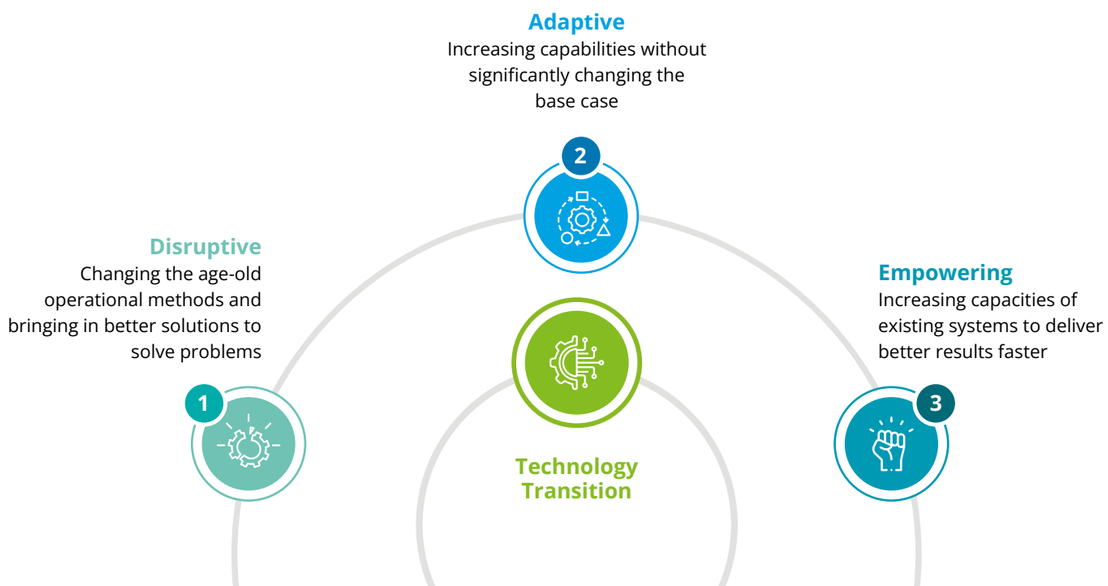
### Phased approach to enhancing urban resilience and safety through smart mobility in India

India can enhance city resilience and safety through a phased approach to smart mobility. The initial phase involves engaging key stakeholders and assessing gaps in existing transportation infrastructure to set clear goals for a resilient city. Pilot projects, such as adaptive traffic signals and IoT sensor implementation, can be introduced across cities. Modernising the bus fleet and digitising public transport systems will enhance user-friendliness and sustainability. Digital technologies, such as new battery monitoring systems, will increase the resilience of city transport systems. National policies should advocate for these technologies, making resilience a core objective of transport policies. A balanced approach between proactive and reactive strategies is necessary, supported by horizon scanning, risk assessment and transport modelling methods, to predict vulnerabilities and enhance urban resilience.





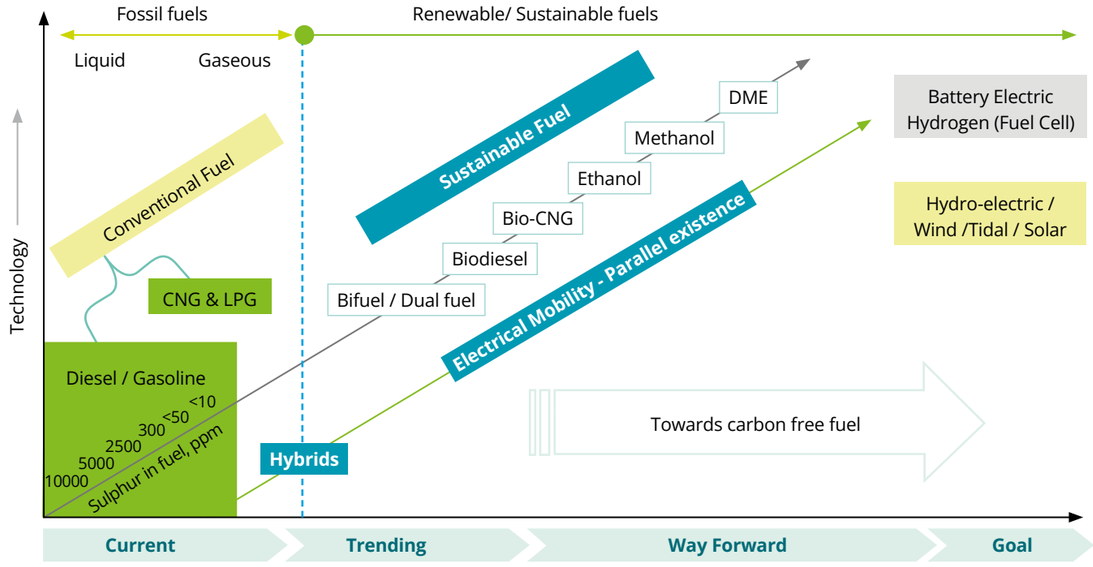
# Technology transition (SMAR**T**): Unleashing innovations in fuel technology



## Transformative role of technology in creating liveable cities

For decades, the transport sector has relied on ICE vehicles. However, concerns about energy security and the impact of GHG emissions have propelled interest in alternative fuel technology. The shift is essential for building a sustainable future with liveable, economically prosperous cities. As the world steps towards a decarbonised future, investments in supporting infrastructure have increased. New fuel technologies will lead to increased efficiency and reduced emissions.

**Fuel Technology Axis Towards Sustainability**




## Transforming India's urban landscape: Shift in fuel technology

India's fuel technology landscape is rapidly evolving. There is a transition to greener fuels while using other technological advancements. The electric vehicle market in India is estimated to reach US$7.09 billion (INR50,000 crore) by 2025, and 30 percent of total car sales are projected to be of electric vehicles. Countries such as Norway and the Netherlands are leading the way with high adoption rates of EVs and extensive charging infrastructure.

**Case: Norway leads the world in EV adoption due to its policy measures and wealth. EVs in Norway account for 20 percent of passenger vehicles, and in 2022, more than 80 percent of the new vehicles that were sold were electric. Norway has waived import duties and car registration taxes for electric vehicles, thus, subsidising EV purchases, achieving parity in the total cost of ownership between EV and ICE cars. Free parking, toll exemptions and access to bus lanes have further accelerated EV adoption. Most of the country's electricity is produced from hydropower, making electric car use in Norway largely clean.**





| | Natural Gas (NG) | Liquified Petroleum Gas (LPG) | Biofuel (BF) | Green Hydrogen (GH) |
|---|---|---|---|---|
| | CNG is the main type of NG used in ICE vehicles. Other NG alternatives include LNG and bio-CNG. | LPG is also highly compatible with ICE vehicles, such as NG. | Bioethanol can be blended with petrol and commonly used in flex fuel engines; biodiesel is suitable for diesel engines. | GH is used to power the motors of FCEV. It can also be used as a combustible fuel for ICE vehicles. |
| Sustainability |  |  |  |  |
| Scalability |  |  |  |  |


Besides vehicle electrification, fuel diversification is crucial to meet energy needs and sustain economic growth. CNG/LPG/ LNG/Hydrogen and biofuels such as ethanol/methanol/biodiesel are alternative fuel options.

Since April 2023, all petrol vehicles launched in India are material compliant with 20 percent ethanol-blended petrol. With an increasing number of such vehicles, the advent of flex-fuel vehicles (compatible with more than 20 percent up to 85 percent ethanol-blended petrol) and the phasing out of old vehicles, India is expected to achieve a blending of 20 percent ethanol in petrol by 2025-26. Thus, as the ecosystem and infrastructure become robust, India must increase its efforts to transition to greener alternatives in the long run.

## Advancing transportation in India: The role of smart mobility technologies

The transition to green fuel alternatives is crucial for India to address inefficiencies in the transport sector and foster urban development. Alternative fuels are environmentally friendly, economical and have better storage efficiency. For instance, LNG requires less storage space than CNG, providing a better driving range for long-haul and heavy-duty vehicles. The fuel-carrying capacity of LNG buses is ~2.5 times more than that of CNG counterparts. Thus, the government must embrace modern technologies for effective urban mobility and growth rather than relying on outdated approaches.

**Case: Sweden is at the forefront of producing and testing new biofuels, and it boasts one of the highest shares of biofuels in the transport sector within the EU. Due to the availability of raw materials, liquid biofuels such as bioethanol and Hydrotreated Vegetable Oil (HVO) are crucial for achieving fossil-free road transport in Sweden. As of 2018, biofuels in Sweden benefitted from significant incentives, including full tax exemptions, bonuses for fuel-efficient vehicles and the "pump law," which requires major fuel retailers to provide at least one biofuel pump. Consequently, HVO 100 is entirely exempt from carbon and energy taxes, keeping its price competitive with fossil diesel. Additionally, there is substantial financial support for climate action initiatives. Bioenergy accounts for 63 percent of Sweden's total primary energy supply from renewables, reflecting its high priority in the country's energy strategy.**

### Navigating challenges in adapting emerging fuel technologies in India's diverse landscape

India faces several unique challenges in its transition towards green fuel technology, including high upfront costs and the slow pace of policy implementation. Some blended fuels' physical and chemical properties and their corrosivity present operational challenges. Challenges also arise due to lower electricity conversion efficiency, which is expected to limit the growth potential in the short term. In addition, the low availability of alternative fuels limits private participation in the current context, further limiting scalability. For instance, currently, state-run companies sell ethanol-blended petrol, while private players sell unblended petrol. To address these challenges, instead of a singular approach, tailored strategies need to be developed through collaborative efforts of the government and private sector.

### Enabling mobility through alternative fuel technology in India: Infrastructure, policy and stakeholder engagement for a technological transition

As the transition of fuel technology in India is essential for enabling smart mobility and enhancing the efficiency of transportation services, current technologies, which are obsolete and age-old, need to be discarded. Identifying inefficiencies and gaps is essential to set clear objectives and targets for alternative fuels. Creating necessary infrastructure, such as renewable sources and EV charging stations, is extremely important to support modernising transport services. Establishing robust policy frameworks that incentivise technologically advanced solutions and standardise regulations by deploying successful pilot projects for both public transport and private vehicles is essential for India. Programmes for technologically advanced systems that employ private sector partners and bring in funding, skill development and manufacturing support shall ensure a comprehensive transition to efficient and technologically advanced integrated mobility systems.





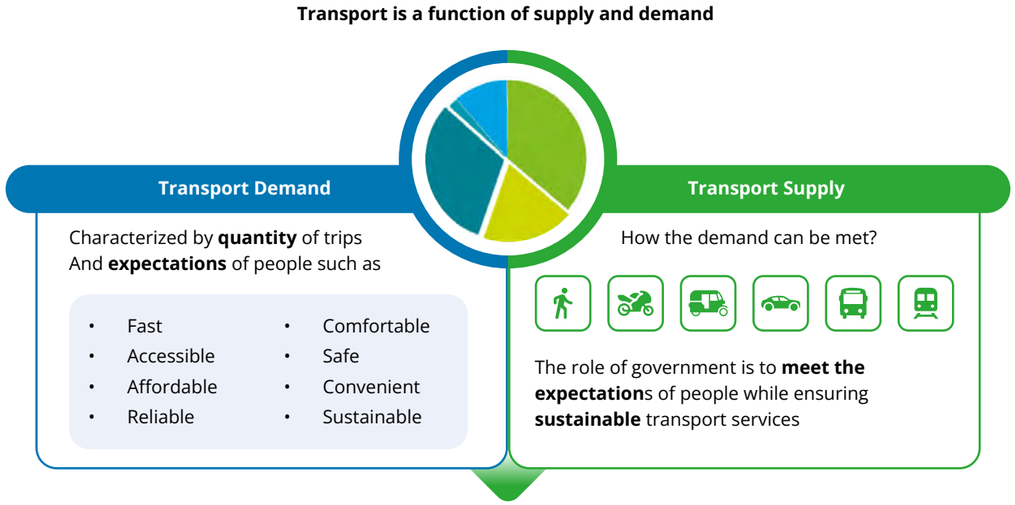
# Conclusion

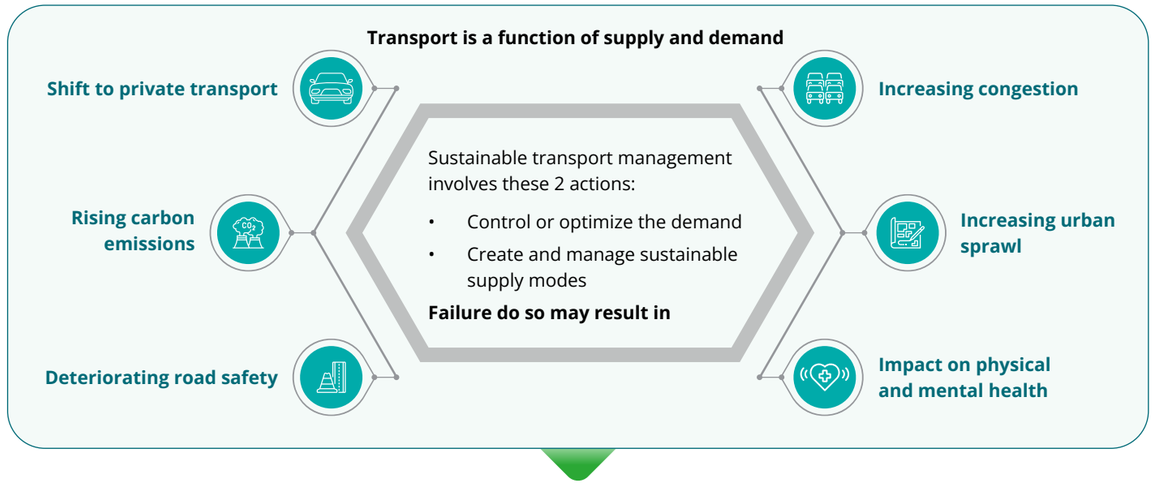
"SMART" mobility, emphasising the use of digital platforms and technological innovations to manage passenger journeys end-to-end, is expected to reshape the mobility ecosystem in future. In future, smart mobility will facilitate the smooth integration of various transportation modes, encompassing on-demand and autonomous alternatives, along with ancillary services that have not typically been included in the traditional travel experience. With technology disruptions happening at an unprecedented rate, consumers' acceptance of new mobility solutions and policy regulations will be pivotal in bringing mobility revolutions.

The growing importance of smart mobility offerings is expected to transform the current modal split among different transportation options. The introduction of smart mobility solutions will nudge customer behaviour and mobility patterns towards sustainability.

The continuous innovations and evolving business models will impact the future movement of people and goods, enabling them to access advanced mobility solutions.

## Summary graphic




**Need for multi-dimensional solutions**

| S Sustainable | M Multimodal and seamless | A AI Enabled | R Resilient & Safe | T Technology transition |
|---|---|---|---|---|
| Financial sustainability | Service Integration | Productive solutions | Flexible solutions | Disruptive technology |
| Operational sustainability | Physical Integration | Predictive solution | Safety-focused solutions | Adaptive technology |
| Environmental sustainability | Fare Integration | Prescriptive solution | Future-proof solutions | Empowering technology |

# Connect with us

**Sumit Mishra**
Executive Director, Deloitte India
sumitmishra@deloitte.com

# Contributors

**Aashima Garg**

**Rushabh Gandhi**

# Acknowledgement

**Ashkait Kapoor**

**Sahil Bhandare**

**Shreya Bajaj**

Deloitte.