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SUSTAINABLE URBAN TRANSPORT IN INDIA

Role of the Auto-rickshaw Sector

AKSHAY MANI, MADHAV PAI, RISHI AGGARWAL

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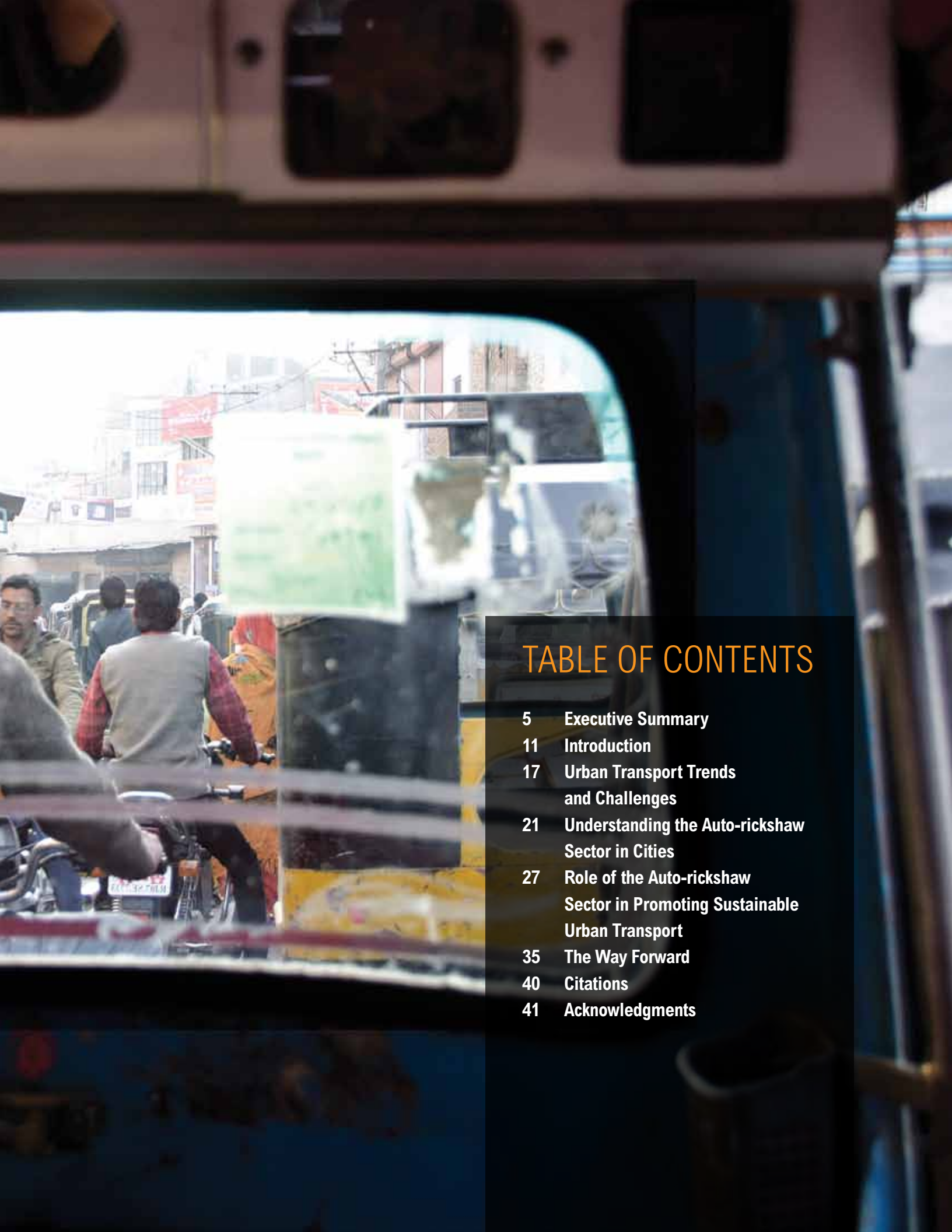
Report by:
AKSHAY MANI
Project Manager Urban Transport
EMBARQ India
amani@embarqindia.org

Madhav Pai
Director
EMBARQ India
mpai@embarqindia.org

Rishi Aggarwal
Associate Institutional Relations
EMBARQ India
raggarwal@embarqindia.org

Design and layout by:
Nick Price
nprice@wri.org

Dave Cooper
dcooper@wri.org



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ABOUT EMBARQ

The EMBARQ global network catalyzes environmentally and financially sustainable transport solutions to improve quality of life in cities.

Since 2002, the network has grown to include five Centers for Sustainable Transport, located in Mexico, Brazil, India, Turkey and the Andean Region, that work together with local transport authorities to reduce pollution, improve public health, and create safe, accessible and attractive urban public spaces. The network employs more than 100 experts in fields ranging from architecture to air quality management; geography to journalism; and sociology to civil and transport engineering.

FOREWORD

Since the introduction of auto-rickshaws in India in the late 1950s, these vehicles have become an indispensable aspect of urban mobility for millions of people.

Auto rickshaws play a vital and vibrant role in India's urban transport systems. Yet they also represent a very improvisational and increasingly inefficient sector – and they are getting lost in the changing dynamics of urban mobility in India.

Today, with increasing urban populations, there is growth in demand for urban transport, growth in private motorization and a decline in public transport share. How do auto rickshaws fit in and have a role that is efficient – for both the operators and their passengers? And how can these three-wheeled wonders contribute to urban transport sustainability – through both reductions in emissions and safety for everyone on the roads?

This report addresses how the auto rickshaw sector can play a key role in improving sustainability for urban transport, and addresses negative perceptions of rickshaws. We also introduce new models of regulation and reforms that can be adopted for a more efficient and safer system and enable the rickshaw to have an optimal role in the transport mix.

It is our hope that this study will make a useful contribution to the deliberations, planning and decision making of municipal, state and national officials to ensure the role of the auto-rickshaw sector in promoting sustainable urban transport. And we hope that it will contribute to the safety of our fellow citizens and the environmental health of our cities.

Madhav Pai
Director EMBARQ India

Executive Summary

DEMAND FOR THE AUTO-RICKSHAW

Study Objective and Approach | As the demand for urban transport increases in India, so too does the popularity of the auto-rickshaw. Production of this type of motorized three-wheeler has doubled between 2003 and 2010. In major Indian cities, it is responsible for a significant share of motorized trips. Strategies to improve urban transport must include a policy vision for this increasingly important sector. To that end, this paper examines the role the auto-rickshaw sector can play in promoting sustainable urban transport in India. It develops a policy vision for this sector and presents recommendations on reforms to address sustainability challenges.

The Avoid-Shift-Improve (ASI) framework, one of the key approaches to promote sustainable urban transport, is the basis of this study. The ASI framework is based on three key strategies: (1) avoid unnecessary trips, (2) shift to more sustainable transport modes, and (3) improve performance in all modes (Dalkmann and Brannigan 2007). In assessing the role of the auto-rickshaw sector in promoting sustainable urban transport, this paper looks specifically at how auto-rickshaws can contribute to Shift and Improve strategies, using a two-pronged approach:

- Examination of the role of the type of service (contract carriage) provided by auto-rickshaws in promoting sustainable urban transport, as part of the Shift strategy;
- Assessment of the need for improvements in the type of vehicle (motorized three-wheeler) in the auto-rickshaw sector to promote sustainable urban transport, as part of the Improve strategy.

Role of Auto-rickshaw Sector in Promoting Sustainable Urban Transport

Role of the Type of Service (Contract Carriage)

The findings from this study indicate that auto-rickshaw services in cities can help meet the objectives of the Shift strategy—of promoting public transport and reducing private motorization—based on the following aspects:

- **FIRST AND LAST MILE CONNECTIVITY TO PUBLIC TRANSPORT:** Auto-rickshaw services, integrated as a feeder mode providing such connectivity, can complement public transport systems by ensuring that all parts of the city have easy access to public transport stations.
- **DOOR-TO-DOOR TRANSPORT ALTERNATIVE TO PRIVATE MOTOR VEHICLES:** The door-to-door on-demand service provided by auto-rickshaws will ensure that transport needs requiring door-to-door connectivity, such as occasional trips to the airport or emergency trips for health care, can be met in cities without having to rely on private motor vehicles.

Vehicle Performance and Need for Improvements

This paper assesses the performance of the motorized three-wheeler (auto-rickshaw) in Indian cities with respect to two important sustainability parameters—emissions and road safety—to identify current challenges and areas for vehicle-related reforms that can improve performance:

- **EMISSIONS:** A key challenge in the auto-rickshaw sector is its emissions of particulate matter of aerodynamic diameter of less than 10 microns (PM_{10}). PM_{10} are known to have adverse impacts on health, and the conventional two-stroke engine auto-rickshaws prevalent in many cities are major sources of these emissions (Shah and Iyer 2004).
- **ROAD SAFETY:** The paper looks at the impact of the auto-rickshaw sector on the safety of both city pedestrians and the rickshaws' occupants (driver and passengers). Research conducted by EMBARQ India using pedestrian fatality data for Mumbai and Bangalore shows that auto-rickshaws lead to fewer fatal pedestrian accidents than do motorized two-wheelers and cars. This is likely a result of their lower speeds and lighter weights (Mohan and Roy 2003). There are concerns for the safety of auto-rickshaw occupants, however, particularly in multivehicle collisions (ones between auto-rickshaws and other motor vehicles). A study of auto-rickshaw injury patterns in Hyderabad revealed that multivehicle collisions were the leading cause of injury for auto-rickshaw occupants (Schmucker et al. 2009).

The Way Forward for the Auto-rickshaw Sector in Indian Cities

Policy Vision

The National Urban Transport Policy (NUTP) of the Ministry of Urban Development, Government of India, is the key guiding policy at the national level focusing on urban transport in India (MoUD 2006). With the underlying rationale of people-based transport planning, the NUTP framework focuses on planning and investments in public transport and nonmotorized transport (NMT) systems in cities.

"Auto-rickshaw services in cities can help promote public transport usage and reduce private motorization..."

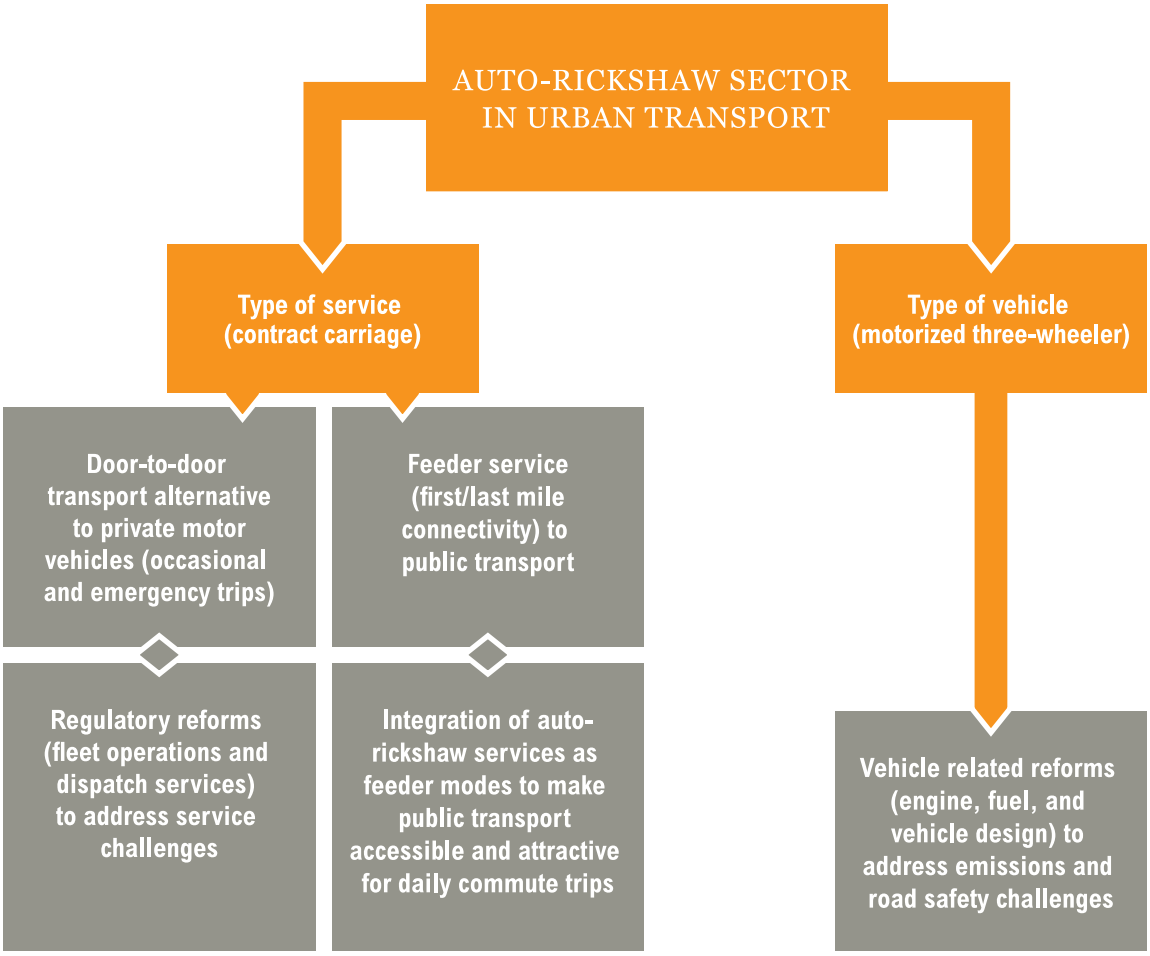
To meet the objectives of the NUTP, the findings from this study highlight the need for an overarching policy vision for the auto-rickshaw sector in urban transport (Figure E.1) based on the Shift and Improve strategies of the ASI framework to promote sustainable urban transport.

Reform Needs and Next Steps

In accordance with the policy vision, the following regulatory and vehicle-related reforms will help ensure that the auto-rickshaw sector supports public transport and provides alternatives to private vehicles, while addressing the sustainability challenges of emissions and road safety:

- **ENSURE AVAILABILITY OF DISPATCH SERVICES:** Auto-rickshaw services in the majority of Indian cities are provided by individual owner-operators rather than by fleet companies. The lack of organization makes it difficult to provide dispatch (dial-a-rickshaw) services. This needs to be addressed through regulatory reforms that enable fleet-based operations with dispatch services to enter the auto-rickshaw sector.
  - These regulatory reforms should be pursued by State transport departments, which are the nodal regulatory agencies for the auto-rickshaw sector.
- **REDUCE EMISSIONS:** Findings from this study highlight that improvements in engine technology (moving from two-stroke to four-stroke engines) is potentially the best approach to reduce PM_{10} emissions from the auto-rickshaw sector. Four-stroke engines have lower PM_{10}, hydrocarbon (HC), and carbon dioxide (CO_2) emissions than two-stroke engines (Shah and Iyer 2004). Further, four-stroke engines can reduce PM_{10} emissions by running on compressed natural gas (CNG) and other alternatives to gasoline (Reynolds, Grieshop and Kandlikar, 2011). However, higher oxides of nitrogen (NOx) emissions from four-stroke engines need to be addressed through reforms in current emission standards.
  - The engine and fuel-related reforms should be pursued by State transport departments as the nodal regulatory agencies.
  - The needed reforms in emission standards are the adoption of separate emission standards for HC and NOx emissions, instead of the current combined (HC + NOx) standard. These reforms should be pursued by the Standing Committee on Implementation of Emissions Legislation set up by the Ministry of Road Transport and Highways (MoRTH) for emissions legislation (SIAM 2011b).
- **IMPROVE ROAD SAFETY:** Vehicle design improvements such as seat belts and padding on stiff surfaces (Schmucker et al. 2009) have been noted as key reform needs to improve occupant safety in multivehicle collisions. Further, infrastructure interventions such as dedicated lanes for auto-rickshaws, narrow lanes, and speed tables on urban roads to reduce average speeds will reduce the risk of occurrence of multivehicle collisions.
  - Vehicle design improvements, through reforms in current motor vehicle safety regulations, should be pursued by the Automotive Industry Standards Committee (AISC) (SIAM 2011b) set up by MoRTH for motor vehicle safety regulations.
  - Infrastructure interventions to improve auto-rickshaw occupant safety should be pursued by City governments as part of their citywide road safety enhancement strategies.

Figure E.1 | **Policy Vision for the Auto-rickshaw Sector in Cities**




SPORT

INTRODUCTION

Objective | India is experiencing rapid urbanization. According to a recent study, the population of Indian cities will grow from an estimated 340 million in 2008 to 590 million by 2030 (McKinsey & Company 2010). In the face of this expected growth, it is critical to improve urban transport to ensure high quality of life in Indian cities, in terms of fast and reliable commutes, better air quality and public health, safe transport, and equitable mobility options for all sections of society.

INTERMEDIATE PUBLIC TRANSPORT

Intermediate public transport (IPT) refers to modes that fill the gap between private transport and formal public transport modes in cities. Depending on a city's size and transport characteristics, IPT modes may fall under two broad categories: (1) contract carriage services, which are flexible demand-based services where the passenger determines the destination, and (2) informal public transport (bus-like) services, characterized by shared fixed-route services with intermediate stops for boarding and alighting (Fouracre and Maunder 1979). While contract carriage services are ubiquitous in cities, informal public transport services are typically seen in small and medium-sized cities, which may not have any or adequate formal public transport services. Such services are called informal because of their ownership structure (individual owners) and lack of (or poor) regulation and enforcement.

The objective of this paper is to examine the role of the auto-rickshaw sector (motorized three-wheelers) in promoting sustainable urban transport in India, to develop a policy vision for this sector, and to recommend reforms to address auto-rickshaws' sustainability challenges.

Auto-rickshaws are a form of intermediate public transport (IPT). The IPT sector in cities includes two types of services—contract carriage and informal public transport—which can be further classified based on the type of vehicle providing these services. Figure 1 presents a breakdown of the IPT sector in Indian cities based on service and vehicle types.

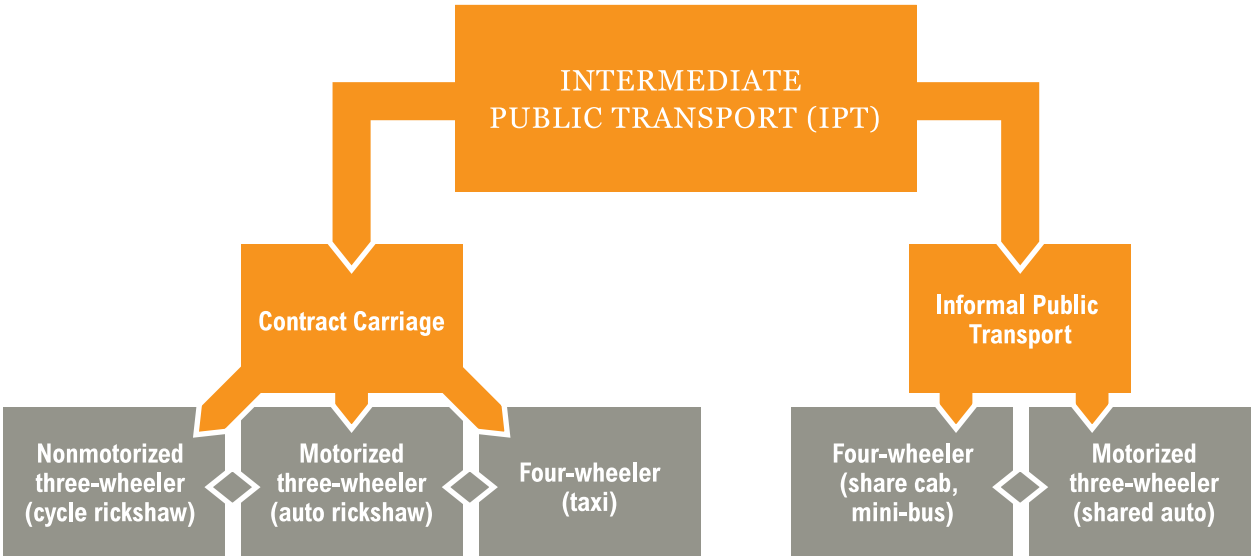
Within the above framework for IPT, this paper specifically focuses on contract carriage services provided by motorized three-wheelers (auto-rickshaws). Hereafter in this paper, the term auto-rickshaw sector will be used to refer to these services. Other forms of IPT services shown in Figure 1 exist in various Indian cities and should also be studied for their potential contribution to sustainable urban transport. However, such a study is beyond the scope of the current research effort.

Auto-rickshaws are a ubiquitous part of the urban transport system in Indian cities. It is therefore important to assess the role this sector could play in improving the sustainability of urban transport, and to identify reforms that could address auto-rickshaws' sustainability challenges, if any. The findings and recommendations of this study should inform future urban transport policy reform efforts for the auto-rickshaw sector, undertaken by decision makers at the Central and State government levels.

Approach

The Avoid-Shift-Improve (ASI) framework, one of the key approaches to improving the sustainability of urban transport systems, underpins this study. ASI sees "sustainability" in terms of reducing greenhouse gas emissions, improving energy efficiency, reducing traffic congestion, and protecting public health and safety by promoting alternatives to the private car, among other strategies (Bridging the Gap 2011). The ASI framework is based on three key strategies: avoid unnecessary trips, shift to more sustainable transport modes, and improve

Figure 1 | **Characterization of the Intermediate Public Transport (IPT) Sector in Indian Cities**



performance in all modes (Dalkmann and Brannigan 2007) (see table 1, box).

Table 1 presents the core elements of each of the three strategies within ASI and the key travel and modal outcomes that can be achieved by implementing them.

While the Avoid strategy must be pursued on the demand side, through better urban planning and land use policies, both the Shift and Improve strategies of the ASI framework are relevant to assessing the role of the auto-rickshaw sector in promoting sustainable urban transport.

Using the Shift and Improve strategies of the ASI framework, this report examines the role of the auto-rickshaw sector in promoting sustainable urban transport, and need for reforms, based on a two-pronged analysis:

- Examination of the role of the type of service (contract carriage) provided by auto-rickshaws in promoting sustainable urban transport, as part of the Shift strategy of the ASI framework. This assessment looks at whether contract carriage

Box 1 | **Avoid-Shift-Improve (ASI) Framework for Sustainable Transport**

- Avoid: Integrate land-use and transport planning in cities to avoid unnecessary trips and reduce trip lengths.
- Shift: Enable a shift from unsustainable to sustainable transport modes (or prevent the reverse shift) through the two-pronged strategy of (1) managing private motorization growth and (2) providing attractive sustainable transport alternatives, including nonmotorized and public transport.
- Improve: Improve vehicles, fuel technology, and engine efficiency in all modes to increase the safety and reduce the environmental impacts of transport.

MODE SHARE

Mode share is defined as the average share of total daily person trips occurring on various transport modes: nonmotorized transport (walking, cycling); public transport (bus, rail); intermediate public transport (auto-rickshaw, taxi); and private transport (motorized two-wheeler, car). Mode shares for a city could be defined for total trips or for trips classified by trip purpose, such as work, education, shopping, health care, recreation, and other social needs.

services provided by auto-rickshaws in cities can contribute to meeting the objectives of the Shift strategy: promoting public transport usage and reducing the growth of private motorization.

- Assessment of the need for improvements in the type of vehicle (motorized three-wheeler) in the auto-rickshaw sector to promote sustainable urban transport, as part of the Improve strategy of the ASI framework. This assessment looks at performance of motorized three-wheelers against the two key sustainability parameters in urban transport: emissions and road safety (Bridging the Gap 2011).

This paper begins with information on current urban transport trends and challenges in India (section 2). Section 3 presents key statistics on auto-rickshaw market size and mode shares to gain an understanding of the auto-rickshaw sector in Indian cities. Section 4 discusses auto-rickshaws in the ASI framework, looking at both the type of service and the type of vehicle. Section 5 presents recommendations on the way forward, in terms of a policy vision for the auto-rickshaw service in cities, as well as targeted reforms to promote improvements in the safety and environmental performance of auto-rickshaws.

Table 1 | **Avoid-Shift-Improve (ASI) Strategies—Key Elements and Outcomes**

STRATEGY	KEY ELEMENT	OUTCOMES
Avoid	Land Use	■ Unnecessary motorized trips are eliminated, and/or the need to make longer trips is reduced as a result of integrated and compact land use planning. ■ Nonmotorized trips (walking and cycling) increase as a result of compact land uses.
Shift	Modes	■ Public transport trips increase as a result of strategies to improve public transport quality and access. ■ Private motor vehicle trips are reduced as a result of strategies to manage private motor vehicle ownership and usage, in conjunction with provision of good quality modal alternatives.
Improve	Vehicles, Engines, and Fuel	■ Emissions are reduced and safety is improved for all the modes in the urban transport system, as a result of vehicle design, fuel technology, and engine efficiency improvements.

URBAN TRANSPORT TRENDS AND CHALLENGES

An analysis of literature on urban transport trends in India reveals a shift away from public transport and nonmotorized transport (NMT) modes, with increasing usage of private motor vehicles and IPT.

Some key observations:

- **GROWTH IN URBAN TRANSPORT DEMAND:** With rapid urbanization, urban transport demand in India continues to grow. Population in Indian cities is expected to increase by around 250 million in the next 20 years (McKinsey & Company 2010), bringing enormous growth in urban travel demand. It is projected that total daily passenger trips in 87 major urban centers in India will more than double from around 229 million in 2007 to around 482 million in 2031 (MoUD 2008).
- **GROWTH IN PRIVATE MOTORIZATION:** According to industry data from the Society of Indian Automobile Manufacturers (SIAM), India's private motor vehicle market (motorized two-wheelers [MTWs] and cars) grew by more than 85 percent between FY 2003-04 (around 59 million vehicles) and FY 2009-10 (around 110 million vehicles), at an average annual growth rate of close to 11 percent (CII 2011). Rapid economic growth, rising per capita incomes, ease of consumer financing options, and favorable government policies toward the automotive sector will continue to drive an unprecedented increase in private motor vehicle ownership and usage in India (EconomyWatch 2011; India Reports 2011).
- **DECLINING PUBLIC TRANSPORT MODE SHARES:** Public transport mode shares declined in Indian cities (20-70% decline in different size cities) between 1994 and 2007. This can be attributed to the inability of public transport services to keep pace with rising demand and to maintain high quality of service, coupled with increasing private motor vehicle ownership and usage in cities (MoUD 2008).
- **DECLINING NONMOTORIZED TRANSPORT (NMT) MODE SHARES:** Mode shares of NMT modes (walking and especially cycling) have declined in Indian cities. Cycling mode shares in cities have come down from an average of 30 percent in 1994 to less than 11 percent in 2007, attributed to an increase in average trip lengths as a result of urban sprawl, inadequate facilities for cycling, and growth in private motor vehicle ownership and usage (MoUD 2008).
- **USE OF INTERMEDIATE PUBLIC TRANSPORT AS PRIMARY MODE FOR DAILY COMMUTES:** City commuters are increasingly using IPT, including auto-rickshaws, as the primary mode for their daily commutes in cities. As stated in the National Urban Transport Policy (NUTP), launched in April 2006 by the Ministry of Urban Development, Government of India

“Current urban transport trends in Indian cities are leading to broader sustainability challenges for people and the environment, in terms of increasing emissions and road fatalities...”

(MoUD, 2006), the deteriorating quality of public transport in many cities has led commuters to shift to IPT for daily commutes.

These interrelated trends contribute to broader challenges for people and the environment in Indian cities. For example:

- Private motor vehicles are the single largest contributors (contributing between 50 and 90%) of total emissions[1] by the passenger road transport sector in cities (MoUD 2008).
- According to a study of road fatality trends (Mohan et al. 2009), the road fatality rate in India increased from 36 fatalities per million persons in 1980 to 95 fatalities per million persons in 2006. Though this study looks at combined urban and rural road fatality trends, it reports that the growth in private motor vehicles is a major contributor to deteriorating road safety trends in cities. Unless policies to control urban road infrastructure investments and the increasing number of motor vehicles are implemented, such trends are expected to continue in the future.
- Based on a detailed study of road fatalities and transport characteristics in 30 Indian cities in 2008, MoUD’s comprehensive study on urban transport (MoUD 2008) found that cities with public transport services were safer than those without them, and it concluded that improving public transport (and reducing private motor vehicle usage) should be a key strategy for cities to improve road safety.

1. These emissions data represent total emissions, including air pollutants and greenhouse gasses (the study does not separate the emissions into these categories and only provides total emissions estimates).

UNDERSTANDING THE AUTO-RICKSHAW SECTOR IN CITIES

This section presents key statistics on market size, sales trends, mode shares, and user characteristics for the auto-rickshaw sector in Indian cities.

Market Size and Sales Trends

The market size[2] of auto-rickshaws in cities currently varies from around 15,000 to 30,000 in Tier II cities (population between 1 and 4 million) to more than 50,000 in Tier I cities (population greater than 4 million) (Figure 2). Based on population statistics, it is estimated that Tier I and II cities have 4 to 16 auto-rickshaws serving every 1,000 people on average (Figure 2).

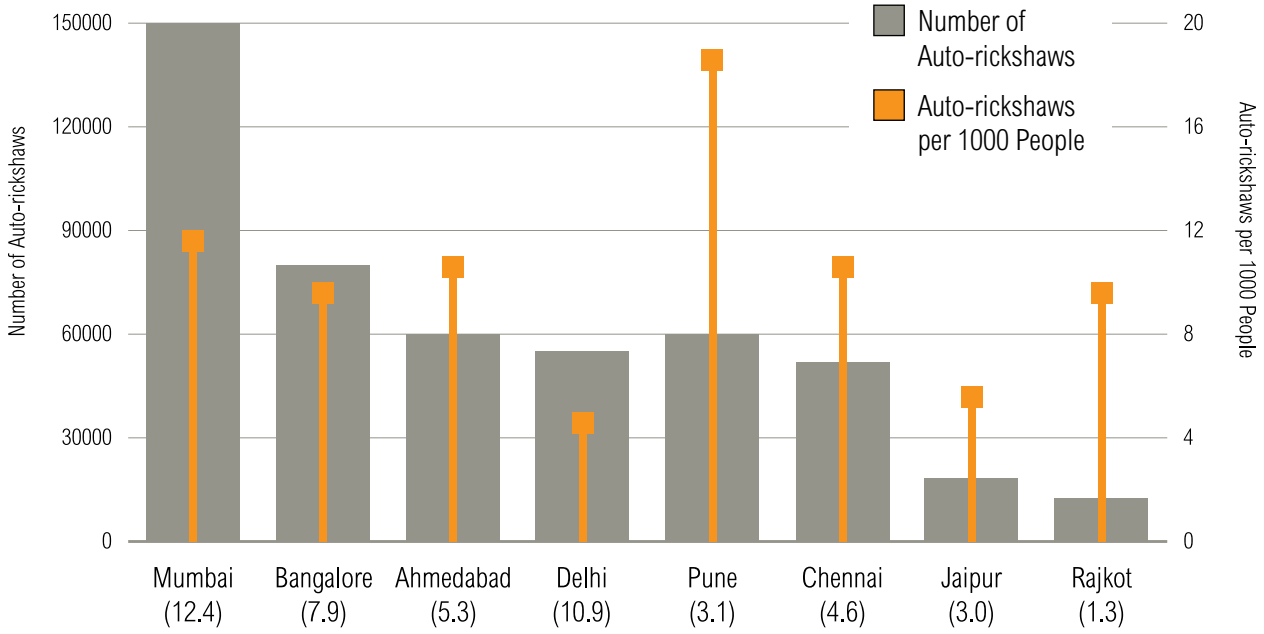
Industry statistics on auto-rickshaw production and sales between 2003 and 2010 are presented in figure 3. These statistics show that the auto-rickshaw market is growing. While part of the domestic sales are associated with the rural and semiurban market, domestic sales are being driven by the growing auto-rickshaw market particularly in Tier II and Tier III cities (Tier III cities are those with a population of less than 1 million), as well as by replacement sales—scrapping old vehicles and replacing them with new ones—in Tier I cities.

Mode Shares and User Characteristics

Analysis of mode shares for select cities (Table 2) shows that auto-rickshaws serve between 10 and 20 percent of daily person trips made on motorized road transport modes. For these cities, auto-rickshaws constitute a small percentage (2-11%) of the total number of motor vehicles, but they account for a higher percentage of mode shares since they serve multiple users over the course of a day and night.

2. Market size represents the total number of auto-rickshaws operating in a city and is measured in terms of the number of auto-rickshaws registered with the Regional Transport Offices (RTOs) of respective cities.

Figure 2 | **Market Size of Auto-rickshaws for Select Indian Cities, 2010**



Note: Numbers in brackets with city names represent 2010 population (estimated) in millions.

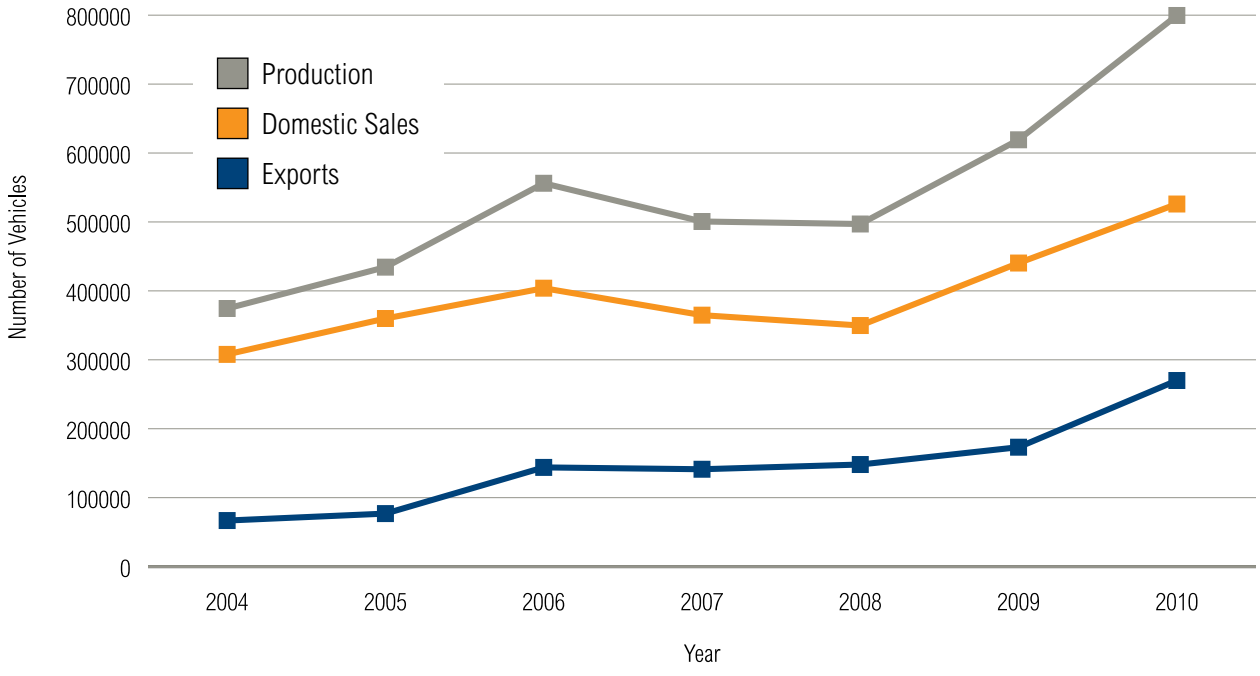
Source: 2010 city population data estimated (by interpolation) from 2001 Census population (World Gazetteer, 2011) and 2011 Census population (Census, 2011). Auto-rickshaw market size (registration) data obtained from Regional Transport Offices (RTOs) of respective cities. Cities included here (Mumbai, Bangalore, Ahmedabad, Delhi, Pune, Chennai, Jaipur, and Rajkot) are those for which market-size data could be obtained from the RTOs.

Characteristics of auto-rickshaw users can be assessed in terms of the trip purposes served by auto-rickshaws, for example, work, education, shopping, health care, and recreation. Based on published statistics linking mode shares with trip purposes for select cities, table 3 shows the mode share of auto-rickshaws for various trip purposes.

As seen from table 3, people use auto-rickshaws for a variety of purposes, including education, shopping, health care, recreational trips, and commuting to work.

The statistics presented in figures 2 and 3 and tables 2 and 3 on auto-rickshaw market size, domestic sales trends, and mode shares highlight the contribution of the auto-rickshaw sector to meeting the daily transport needs of urban citizens.

Figure 3 | **Trends in Auto-rickshaw Production, Domestic Sales and Exports in India, Fiscal Year 2004 to 2010**



Source: SIAM 2011a

Table 2 | **Auto-rickshaw Mode Shares and Share of Total Vehicle Population for Select Cities in India**

CITY	CITY CATEGORY	AUTO-RICKSHAW MODE SHARE (AMONG MOTORIZED ROAD TRANSPORT MODES)	AUTO-RICKSHAWS (AS % OF TOTAL VEHICLES)	YEAR
Bangalore	Tier I	13%	3%	2005
Mumbai	Tier I	20%	11%	2005
Pune	Tier II	11%	3%	2007
Rajkot	Tier II	16%	2%	2007

Source: Mode shares were derived from Comprehensive Transportation Studies and Development/Mobility Plans of cities (only available for the years shown in Table 2); Number of auto-rickshaws as share of total vehicles was derived for these years based on auto-rickshaw and total vehicle registration data for these years from RTOs of respective cities.

Table 3 | **Auto-rickshaw Mode Shares for Different Trip Purposes for Select Cities**

CITY	CITY CATEGORY	WORK	EDUCATION	SHOPPING, HEALTH CARE, AND RECREATIONAL TRIPS	YEAR
Delhi	Tier I	10%	23%	22%	2001
Hyderabad	Tier I	4%	7%	12%	2003
Pune	Tier II	5%	17%	23%	2008
Patna	Tier II	5%	23%	17%	2009

Note: The mode share data in table 3 represents the percent of trips under each trip purpose that occur on auto-rickshaws. For example, in Delhi, 10 percent of work trips and 23 percent of educational trips occur on auto-rickshaws.

Source: iTrans 2009


RAHUL
TRADERS
TEXTILE
PACKING MATERIALS
PACKING MATERIALS
THAKER

ROLE OF THE AUTO-RICKSHAW SECTOR IN PROMOTING SUSTAINABLE URBAN TRANSPORT

Current transport trends in Indian cities (section 2) are leading to growing sustainability challenges, such as deteriorating air quality and rising road fatalities. These trends point to the urgent need to promote more sustainable urban transport.

This assessment is based on a two-pronged approach of (1) examining the role of the type of service (contract carriage) provided by auto-rickshaws, based on the Shift strategy of the ASI framework, and (2) assessing vehicle performance and the need for improvements in motorized three-wheelers to promote sustainable urban transport, as part of the Improve strategy of the ASI framework.

Role of the Type of Service (Contract Carriage)

As an approach to advance more sustainable urban transport, the Shift strategy of the ASI framework has the following two objectives: (1) retaining and promoting public transport usage by improving public transport quality, access, and connectivity, and (2) mitigating private motor vehicle ownership and usage.

The following subsections explore the question of whether auto-rickshaw service in cities can play an integral part in achieving the above objectives.

Connectivity to Public Transport

Providing connectivity, among other parameters such as frequency, reliability, comfort, and safety, is an important aspect of public transport to retain as well as attract users. Auto-rickshaw services, integrated as feeder modes providing first and last mile connectivity for public transport services, help ensure that public transport is accessible to all parts of the city. In this role, auto-rickshaws will also ensure accessibility to public transport for commuters with special needs, such as the elderly and people with disabilities. Ahmedabad's Bus Rapid Transit (BRT) system, Janmarg, has demonstrated that successful integration of auto-rickshaw services as feeder modes is a key aspect of ensuring accessibility and usage of the BRT system (Janmarg 2010).

Door-to-Door Service as Alternative to Private Motorized Transport

The ability to make door-to-door (long-distance) trips is a clear benefit of private motor vehicles. Therefore, strategies to mitigate private motorization growth in cities have to ensure that door-to-door motorized transport alternatives are available. This is particularly important for (1) occasional trips such as trips to the airport, and for shopping and recreation, and (2) emergency trips such as for health care, where door-to-door on-demand transport is favorable.

Public transport typically does not provide door-to-door connectivity in cities, and it mostly operates on a fixed schedule. The door-to-door on-demand service provided by auto-rickshaw services can help ensure that such transport needs in cities are met without the need to rely on private motor vehicles (Mohan 2010). This has also been noted in the NUTP, which states that the primary role of auto-rickshaw (and other types of contract carriage) services in cities is to serve "occasional trips such as trips to airports or rail stations with excessive baggage, or emergency trips that have to be undertaken immediately when it is not possible to wait for public transport" (MoUD 2006).

It is important to note, however, that while auto-rickshaws provide an alternative to private motor vehicles, this paper does not assess whether they are replacing private motor vehicles or directly mitigating their usage in Indian cities.

Challenges

To ensure that auto-rickshaw services are able to play their intended role—as feeder services to public transport and as a door-to-door transport alternative to private motor vehicles—it is important to address the following challenges:

- **COMPETITION OF AUTO-RICKSHAW SERVICES WITH PUBLIC TRANSPORT:** Current trends in urban transport (section 2) highlight the usage of IPT modes (auto-rickshaws and taxis) in cities for daily commute trips, because of the poor quality of public transport. Thus, improving public transport in cities would be a key strategy in ensuring that auto-rickshaw services fulfill their intended role as feeder services instead of competing with public transport for long-distance trips (MoUD 2006).
- **CHALLENGES IN TECHNOLOGY IMPLEMENTATION FOR DISPATCH (DIAL-A-RICKSHAW) SERVICES:** Dispatch (dial-a-rickshaw) services in the auto-rickshaw sector would be important in making auto-rickshaw services an attractive door-to-door transport alternative to private motor vehicles for occasional and emergency trips. Fleet operations have been noted to be most effective

> *Transitioning from two-stroke to four-stroke engines provides the biggest opportunity to reduce PM_{10} emissions from auto-rickshaws...*

at implementing the necessary technology for dial-a-rickshaw services (Schaller 2007). However, auto-rickshaw services in the majority of Indian cities are provided by individual owner-operators rather than by fleet companies. The lack of organization poses a barrier for the provision of dial-a-rickshaw services. Regulatory reforms that allow fleet-based operations with dispatch services to enter the auto-rickshaw sector could help address this issue.

Vehicle Performance and Need for Improvements

This subsection looks at the performance of the motorized three-wheeler (auto-rickshaw) in Indian cities with respect to emissions and road safety, with the objective of identifying current sustainability challenges and areas for vehicle-related reforms in the auto-rickshaw sector to promote sustainable urban transport.

Emissions

Among the various emission categories, emissions of particulate matter of aerodynamic diameter of less than 10 microns (PM_{10}), also referred to as respirable suspended particulate matter (RSPM), is of critical concern in the auto-rickshaw sector. This can be traced to the following issues:

- **ADVERSE HEALTH IMPACTS OF PM_{10} EMISSIONS:** High ambient concentration of PM_{10} in cities in developing countries is having adverse impacts on public health, including increased morbidity and premature mortality (Shah and Iyer 2004). According to a recent national air quality monitoring study in Indian cities (Bangalore, Chennai, Delhi, Kanpur, Mumbai, and Pune) conducted by the Central Pollution Control Board (CPCB) (CPCB 2010), among all the criteria pollutants, PM_{10} is one of the most critical pollutants in almost all the study cities from a public health perspective.
- **EXISTENCE OF CONVENTIONAL TWO-STROKE AUTO-RICKSHAWS IN CITIES:** The CPCB study (CPCB 2010) found that the transport sector contributed to between 15 and 50 percent of the PM_{10} emissions in the study cities, at residential and curbside locations. Among the transport-sector sources, the study reported diesel heavy-duty vehicles and auto-rickshaws to be primary sources of PM_{10} emissions. In the auto-rickshaw sector, the PM_{10} emissions problem is caused by conventional two-stroke engine vehicles, which are noted to be major sources of PM_{10} emissions because of scavenging losses (loss of a portion of the intake fuel through the exhaust port without being combusted), misuse of lubricating oil, inadequate maintenance and poor performance or lack of catalytic converters (Shah and Iyer 2004). RTO surveys conducted by EMBARQ India for this study found that more than 80 percent of the auto-rickshaws in Rajkot, Surat, and Pune had conventional two-stroke engines.

Therefore, strategies to address the PM_{10} emissions problem in cities must consider ways to reduce PM_{10} emissions from the auto-rickshaw sector, particularly from conventional two-stroke engines. Studies have shown that it will be difficult to control PM_{10} emissions simply by retrofitting existing conventional two-stroke engines. Kojima, Brandon,

and Shah (2000) report that it may not be cost-effective to control PM_{10} emissions from two-stroke auto-rickshaws by improving catalytic converters, because the catalyst deactivates under high exhaust temperatures and needs to be frequently replaced.

Reynolds, Grieshop, and Kandlikar (2011) found the use of clean fuels such as compressed natural gas (CNG) to be ineffective at controlling PM_{10} emissions from conventional two-stroke auto-rickshaws. They state that PM_{10} emissions from two-stroke auto-rickshaws "cannot be dramatically reduced by switching to a clean fuel" alone, because of the inherent problem of scavenging losses and the release of unburned lubricating oil.

Transition to Four-Stroke Engines

These challenges indicate that reducing PM_{10} emissions from the auto-rickshaw sector would entail moving to an improved four-stroke engine technology instead of retrofitting existing conventional two-stroke engines. Shah and Iyer (2004) have noted that for the same fuel such as gasoline, four-stroke engines have significant advantages over two-stroke engines in terms of (1) fuel economy; (2) lower PM_{10}, Hydrocarbon (HC), and CO2 emissions; (3) lower noise levels; and (4) being an established technology.

The challenge with four-stroke engines, however, is higher NOx emissions compared to two-stroke engines (Shah and Iyer 2004). NOx is reported to result in the formation of tropospheric ozone, which has harmful health impacts (EPA 2011). Industry experts have noted, however, that this issue can be addressed through reforms in regulation on emission standards (Iyer 2010; e-mail from Anup Bandivadekar and Francisco Posada of the International Council on Clean Transportation, October 2011). Current regulation, which requires compliance on a combined HC and NOx standard (HC + NOx), allows four-stroke engines to meet the combined standard, thanks to their low HC emissions, even if NOx emissions are high. Thus, there is a need to separate out the emissions standards for HC and NOx in order to bring NOx emissions from four-stroke gasoline engines within acceptable levels, and to make a four-stroke engine transformation strategy for the auto-rickshaw sector more environmentally sustainable (e-mail from Bandivadekar and Posada, October 2011).

Alternative Fuels and Electric Vehicles

A transition from two-stroke to four-stroke engines also provides an opportunity to reduce PM_{10} emissions further by moving from gasoline to alternative fuels such as CNG and liquefied petroleum gas (LPG) (Shah and Iyer 2004). Reynolds, Grieshop, and Kandlikar (2011) report that four-stroke engines have lower PM_{10} emissions with CNG than do two-stroke engines. However, the feasibility of alternative fuels in the auto-rickshaw sector as a PM_{10} emissions mitigation strategy has to take into account issues such as (1) the adequate availability of fuel and distribution infrastructure and (2) the long-term economics of alternative fuels vis-à-vis gasoline (Shah and Iyer 2004).

Electric vehicles may present a plausible long-term alternative to the transformation of two-stroke to four-stroke engines in the auto-rickshaw sector. The biggest advantage of electric vehicles is the elimination of tailpipe emissions, which can help improve urban ambient air quality. However, the feasibility of electric vehicles for the auto-rickshaw sector would depend on life-cycle costs, the presence of recharging infrastructure for batteries, payload weight, range of vehicle, and favorable government policies, which remain to be seen in India (Shah and Iyer 2004).

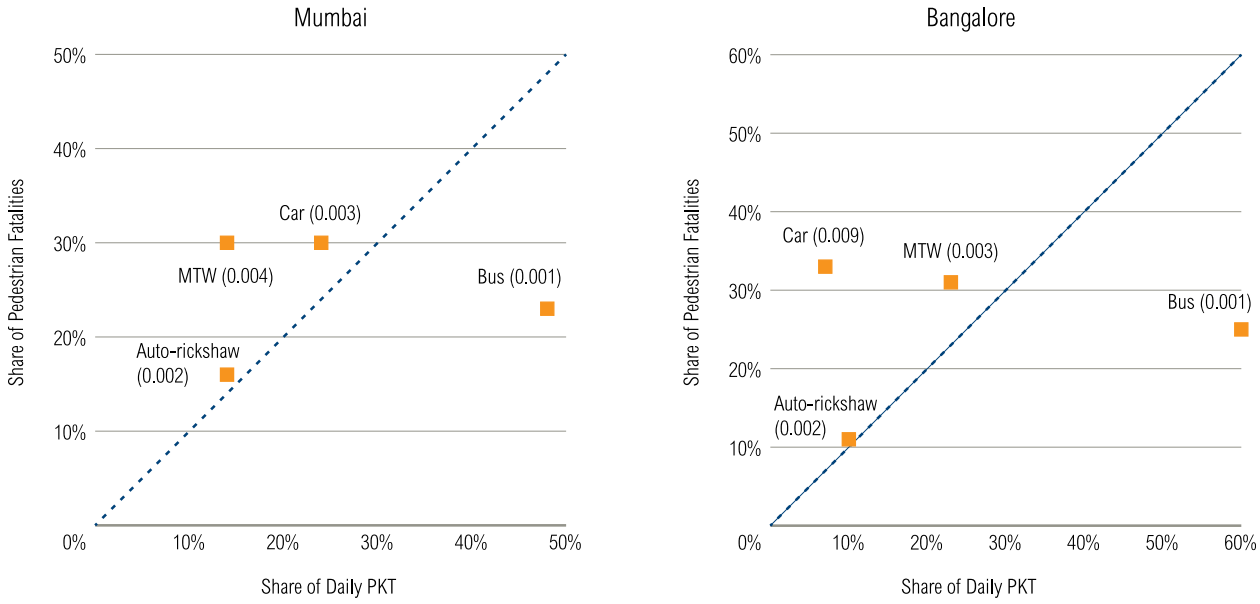
Road Safety

This subsection assesses the safety aspects of auto-rickshaws for both pedestrians and occupants (driver and passengers).

Box 2 | **Summary of Emissions-Related Challenges in the Auto-rickshaw Sector**

- PM_{10} Emissions from conventional two-stroke auto-rickshaws in many Indian cities
- Increase in NOx Emissions by moving from conventional two-stroke to four-stroke auto-rickshaws

Figure 4 | **Pedestrian Safety Comparisons across Motorized Modes, Bangalore (2007) and Mumbai (2008)**



Sources: Mumbai Traffic Police: road fatality data for Mumbai by mode; National Institute for Mental Health and Neuro-Sciences (NIMHANS): road fatality data for Bangalore by mode; Comprehensive Transportation Study for Mumbai: modal PKT data for Mumbai (MMRDA 2008); Comprehensive Traffic and Transportation Plan for Bangalore: modal PKT data for Bangalore (KUIDFC 2007).

Note: The numbers in brackets represent pedestrian fatality rates (number of pedestrian fatalities per 100,000 PKT) for each mode. The 45^0 lines illustrate the position on the graph where share of contribution to pedestrian fatalities equals the share of PKT for a mode. The farther below the line a mode appears, the better its comparative pedestrian safety.

Pedestrian Safety Impacts

Discussion of road safety issues surrounding motorized transport modes should focus not only on the safety of in-vehicle passengers but also on the safety of NMT users (pedestrians and cyclists) of the roadway system. This is particularly important in Indian cities, where NMT accounts for large mode shares and a significant share of road fatalities. Published urban mode share data shows average NMT mode shares in Indian cities of close to 40 percent (MoUD 2008). Road fatality data from 2003-04 indicate that pedestrian fatalities were 78 percent and 53 percent of total road fatalities in Mumbai and Delhi, respectively (Mohan 2004).

To assess the pedestrian safety impacts of auto-rickshaws, EMBARQ India compared pedestrian fatality data and modal passenger kilometers traveled (PKT) data for two cities for which data was available, Mumbai and Bangalore. In this analysis, EMBARQ India assessed different modes—auto-rickshaws, buses, cars, and motorized two-wheelers—in terms of their contribution to pedestrian fatalities per 100,000 PKT. Figure 4 depicts each mode's contribution to pedestrian fatalities in relation to its share of PKT.

This analysis indicates that auto-rickshaws are the second safest motorized mode of travel (after buses) for pedestrians, in terms of contribution to fatalities, in both Mumbai and Bangalore. This inference is consistent with information presented by Mohan and Roy (2003), who state that "because of lower speeds and lighter weights, [auto-rickshaws] can't

produce fatal accidents among pedestrians and bicyclists easily as compared to cars."

It is important to note that this analysis does not consider the safety aspects of auto-rickshaws relative to other modes in terms of pedestrian nonfatal injuries, because there is a lack of data in this area. Further study is needed to get insights into the contribution of auto-rickshaws to pedestrian nonfatal injuries.

Safety of Auto-rickshaw Occupants

Another important aspect of road safety in this sector is the safety of auto-rickshaw occupants (driver and passengers). In urban areas, the greatest safety risk to occupants is posed by potential collisions between auto-rickshaws and other motor vehicles (multi-vehicle collisions).

Collision of auto-rickshaws with other vehicles is a growing problem in Indian cities because of increasingly mixed traffic flow conditions, driven primarily by the growth in private motor vehicles. In these mixed traffic flow conditions, potentially conflicting situations may arise as a result of the differences in average speeds between auto-rickshaws and other motor vehicles. A study of auto-rickshaw occupant injury patterns and severity in Hyderabad revealed that multivehicle collisions were the leading cause of injury for auto-rickshaw occupants (Schmucker et al. 2009). The study made the following observations regarding injury severity and injury patterns of occupants:

- The risk of injury to most body parts and fatal outcome for auto-rickshaw occupants were higher in multivehicle collisions than in single-vehicle collisions (collisions of auto-rickshaws where no other vehicles are involved) and in overturning.
- The injury patterns of auto-rickshaw occupants involved in multivehicle collisions were found to be similar to those of vulnerable road users (pedestrians and motorized two-wheeler users) involved in vehicular collisions.

These findings raise concerns about the design and crashworthiness of auto-rickshaws, to withstand impact in multivehicle collisions. Discussions with manufacturers have revealed that safety regulations for auto-rickshaws are not as stringent as those for other contract carriage vehicles (four-wheelers), which has led to the occupant safety issues around vehicle design described above (e-mail from A. K. Jindal, September 2011; Rao 2011).

Schmucker et al. (2009) have suggested design improvements for auto-rickshaws to address occupant safety concerns. These modifications, including the provision of seat belts and the padding of stiff surfaces, need to be considered as part of reforms in vehicle safety regulations. Such improvements will also improve occupant safety in single-vehicle collisions. Further, infrastructure interventions such as dedicated lanes for auto-rickshaws, and design solutions such as narrow lanes and speed tables to reduce average speeds on urban roadways, will reduce the risk of multivehicle collisions involving auto-rickshaws, and should be key part of the strategy to improve safety for auto-rickshaw occupants.

Box 3 | **Summary of Road Safety Challenges in the Auto-rickshaw Sector**

- Risk of auto-rickshaw occupant injuries and fatalities in multivehicle collisions on urban roadways (because mixed traffic-flow conditions and vehicle design deficiencies increase the vulnerability of occupants to injuries and fatalities).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THE WAY FORWARD

Policy Vision for the Auto-rickshaw Sector in Cities |

The National Urban Transport Policy (NUTP) of the Ministry of Urban Development, Government of India, is the key guiding policy at the national level. With the underlying rationale of people-based transport planning, the NUTP framework focuses on planning and investments in public transport and NMT systems in cities. This section presents the way forward for the auto-rickshaw sector in terms of a policy vision and targeted reforms that should be pursued to ensure its role in promoting sustainable urban transport.

As noted in Section 4, the NUTP envisions auto-rickshaw (and other types of contract carriage) services as modes that serve "occasional trips such as trips to airports or rail stations with excessive baggage, or emergency trips that have to be undertaken immediately when it is not possible to wait for public transport" (MoUD 2006). Given the increasing usage of auto-rickshaws as a substitute where quality public transport services are lacking, the NUTP stresses the need in cities to improve public transport in order to restore auto-rickshaw and other contract carriage services to their intended role of serving occasional and emergency trips (MoUD 2006).

The NUTP, to an extent, provides the right policy vision for promoting sustainable urban transport in cities by focusing on planning and improvements in public transport and NMT. However, for the policy vision to adopt the strategies of the ASI framework (in particular, the Shift strategy) it must recognize the role auto-rickshaws play in the following:

- **PROMOTING PUBLIC TRANSPORT USAGE THROUGH IMPROVED CONNECTIVITY:** In addition to serving occasional and emergency trips, auto-rickshaw services can play an important role in making public transport accessible to all parts of the city, and encouraging daily commute trips on public transport by providing first and last mile connectivity. As feeder services, auto-rickshaws will ensure that public transport is accessible to commuters with special needs, such as the elderly and people with disabilities.
- **REDUCING PRIVATE MOTOR VEHICLE USAGE AND PROVIDING QUALITY DOOR-TO-DOOR TRANSPORT ALTERNATIVES:** While the NUTP recognizes the role of auto-rickshaw services in serving occasional and emergency trips, it does not acknowledge that auto-rickshaws provide a door-to-door transport alternative to private motor vehicles. As discussed earlier, reducing private motor vehicle usage while providing quality transport alternatives is an integral part of the ASI framework to promote sustainable urban transport. Thus, the policy vision should recognize that provision of quality auto-rickshaw service in cities is an important part of the strategy to help reduce private motor vehicle usage. It should also highlight the need to improve auto-rickshaw services to make them an attractive door-to-door transport alternative to private motor vehicles in serving occasional and emergency trips.

In addition to the role of the type of service (contract carriage), the policy vision should present the way forward for the type of vehicle (motorized three-wheeler) in the auto-rickshaw sector, as part of the Improve strategy of the ASI framework. The findings in this study highlight the need for vehicle-related reforms in the auto-rickshaw sector to meet emissions and road safety challenges.

Figure 5 depicts the policy vision for the auto-rickshaw sector to promote sustainable urban transport in cities, looking at both the type of service (contract carriage) and the type of vehicle (motorized three-wheeler).

As indicated in Figure 5, regulatory and vehicle-related reforms are needed in the auto-rickshaw sector to ensure its role in promoting sustainable urban transport. These reforms are presented in the following subsection.

Reform Needs

Recommendations for both regulatory and vehicle-related reforms are summarized in table 4.

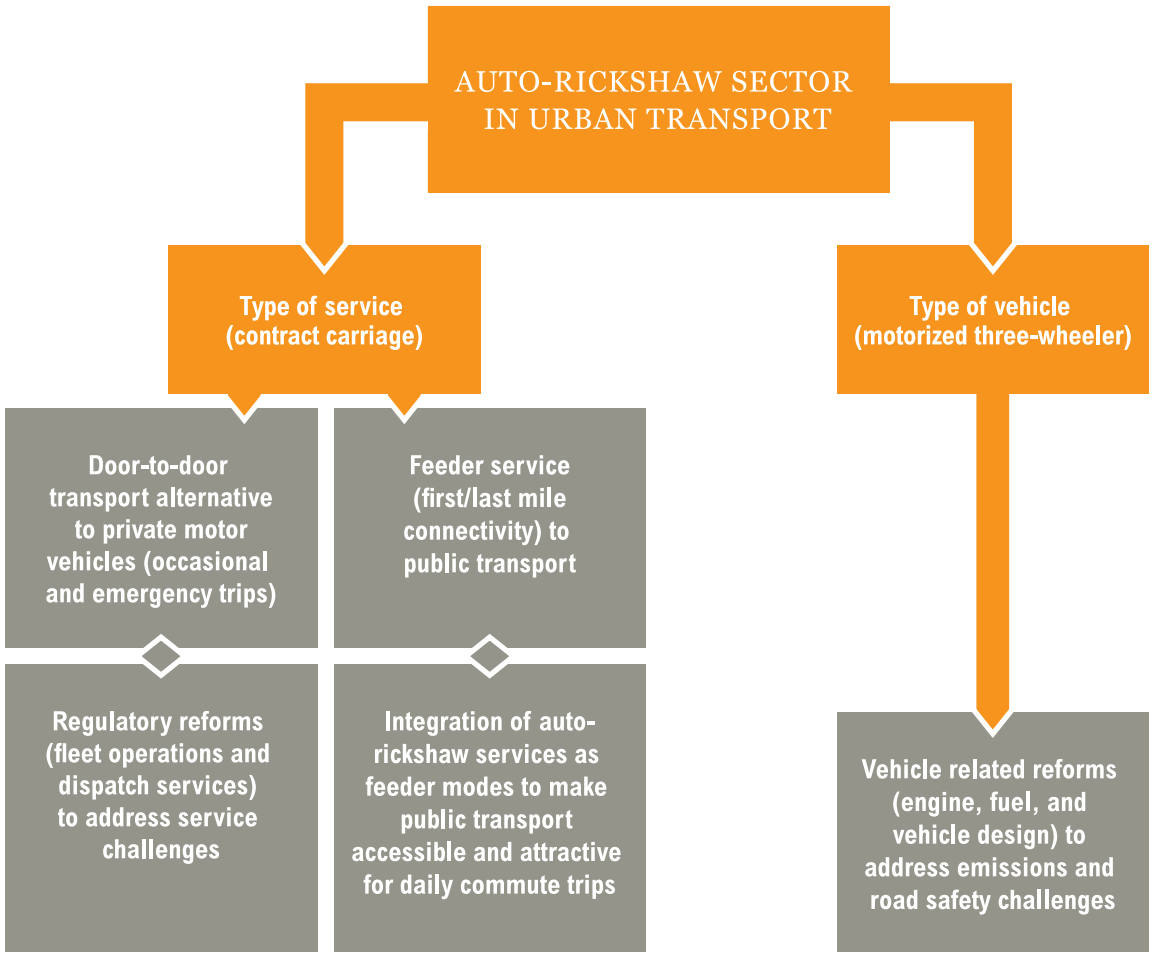
Regulatory Reforms to Introduce Dispatch Services

Contract carriage services in cities can be separated into dispatch and "walk-up" services (e.g., use of cab stands or street hail) (Schaller 2007). In accordance with the policy vision (figure 5), in order for auto-rickshaws to fulfill a role as both a feeder service for public transport and a door-to-door alternative to private motor vehicles, both dispatch and walk-up service must be readily available (this is because feeder services to public transport would typically be walk-up services at public transport stations, while dispatch services, as noted earlier, would be important to enable auto-rickshaws to serve as an attractive door-to-door alternative to private motor vehicles).

However, as noted in section 4, the majority of Indian cities have walk-up services but lack dispatch (dial-a-rickshaw) services, because the auto-rickshaw sector is not organized (having individual owner-operators) and lacks fleet-based operations, which would enable implementation of technology for dispatch services.

According to Schaller (2007), promoting dispatch services in the auto-rickshaw sector would require adopting a two-tier permit framework—existing set

Figure 5 | **Policy Vision for the Auto-rickshaw Sector in Cities**



"The policy vision for the auto-rickshaw sector should recognize its role in promoting sustainable urban transport..."

of permits for walk-up services, and a new set of permits for fleet operations, with entry qualifications, including technology implementation and provision of dispatch services.

Vehicle-Related Reforms

As discussed in section 4, vehicle-related emissions and road safety challenges in the auto-rickshaw sector need to be addressed to enable its role in promoting sustainable urban transport. Table 4 summarizes the vehicle-related reforms to address these challenges. To realize the full emissions reduction and road safety benefits of the vehicle-related reforms (table 4), it is important that the following nonvehicle related reforms are pursued and implemented as well.

- **EMISSIONS:** To address the NOx emissions problem from four-stroke auto-rickshaws, existing emission standards should be reformed from a combined HC + NOx standard to separate standards for HC and NOx, to bring the NOx emissions from four-stroke auto-rickshaws to acceptable levels.
- **ROAD SAFETY:** In addition to reforms in vehicle design, reducing the risk of multivehicle collisions of auto-rickshaws in cities will be important in improving safety of auto-rickshaw occupants. Infrastructure design changes, such as dedicated lanes for auto-rickshaws, and speed control solutions on urban roads—narrow lanes and speed tables—will be an important part of the overall strategy to promote road safety in the auto-rickshaw sector.

Next Steps

Using the ASI framework, this paper shows how the type of service (contract carriage) and the type of vehicle (motorized three-wheeler) in the auto-rickshaw sector fit into strategies to promote sustainable urban transport. The policy vision for the auto-rickshaw sector in cities (figure 5) should serve as the framework for regulating and reforming the sector in Indian cities.

Key next steps to take these reform recommendations forward include (table 4):

- **REGULATORY REFORMS:** Auto-rickshaw permits in cities come under the purview of the State transport department. Thus, implementation of two-tier permit policies to promote dispatch services in the auto-rickshaw sector should be undertaken by the State transport departments for their respective cities.
- **REFORMS FOR EMISSIONS MITIGATION:**
  - Vehicle related reforms for emissions mitigation include improved engine technology (moving from two-stroke to four-stroke engines) and use of alternative fuels (CNG or LPG). These reforms should be undertaken by the State transport departments as the nodal regulatory agencies for urban transport, depending on the applicability of these strategies for the auto-rickshaw sector in their respective cities.
  - Nonvehicular reforms for emissions mitigation include reforms in emissions standards, to address NOx emissions from four-stroke engines. These reforms should be undertaken by the Standing Committee on Implementation of Emissions Legislation (SIAM 2011b) set up by the Ministry of Road Transport and Highways, Government of India, for advice on motor vehicle emissions regulation.
- **REFORMS FOR ROAD SAFETY:**
  - Vehicle related reforms for road safety include improvements in vehicle design to improve safety of auto-rickshaw occupants. These reforms should be undertaken by the Automotive Industry Standards Committee (AISC) (SIAM 2011b) set up by the Ministry of Road Transport and Highways to review the safety aspects in the design of motor vehicles.
  - Nonvehicle reforms for safety of auto-rickshaw occupants include infrastructure design changes for slow speeds and segregation of auto-rickshaws from other motor vehicles. These reforms should be undertaken by City governments, based on an assessment of the feasibility of implementing these changes at the City level.

Table 4 | **Reform Needs in India's Urban Auto-rickshaw Sector and Next Steps**

SPECIFIC ISSUE TO BE ADDRESSED	REFORM AREA	REFORM DETAILS	APPLICABILITY	NEXT STEPS
Lack of dispatch (dial-a-rickshaw) services for door-to-door connectivity	Permits	Two-tier permit framework—new permits for fleet operations	■ Applied to cities lacking dispatch services in the auto-rickshaw sector	To be pursued by State transport departments as nodal regulatory agencies to enable fleet operations with dispatch services
PM_{10} emissions from conventional two-stroke engines	Engine technology	Shift from conventional two-stroke to four-stroke engines	■ Applied to cities with conventional two-stroke auto-rickshaws	To be pursued by State transport departments
	Alternative fuels (CNG or LPG)	Shift from gasoline to alternative fuels such as CNG or LPG	■ Applied to four-stroke engines to achieve maximum emission reduction benefits ■ Long-term fuel supply and distribution infrastructure essential	To be pursued by State transport departments as per applicability/feasibility
NOx emissions from four-stroke auto-rickshaws	Emission standards	Adoption of separate emission standards for HC and NOx emissions, instead of the current combined standard	■ Nationally implemented for all cities	To be pursued by the Standing Committee on Implementation of Emissions Legislation set up by Ministry of Road Transport and Highways (MoRTH) (SIAM 2011b) for emissions legislation.
Safety risk for auto-rickshaw occupants (multivehicle collisions)	Vehicle design	Provision of seat belts and padding on stiff surfaces	■ Applied to all existing and forthcoming models	To be pursued by the Automotive Industry Standards Committee (AISC) set up by MORTH for motor vehicle safety regulations
	Infrastructure	Provision of segregated lanes for auto-rickshaws; adoption of solutions for speed reduction—narrow lanes and speed tables	■ Applied to all cities with state of infrastructure that poses increasing risk of multivehicle collisions	To be pursued by City governments as part of road safety enhancement strategies.

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INSTITUTE

10 G STREET NE
SUITE 800
WASHINGTON, DC 20002, USA
+1 (202) 729-7600
WWW.WRI.ORG

INDIA
GODREJ AND BOYCE PREMISES
GASWORK LAND, LALBAUG
PAREL, MUMBAI 400012
+91 22 24713565
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