Chapter 8

Low-Carbon Transport in India

Assessment of Best Practice Case Studies

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Abstract India is the world's fourth largest emitter of greenhouse gases. Transport contributes 13 % of India's GHG emissions (MoEF. India: green house gas emissions 2007, Indian Network for Climate Change Assessment (INCCA), Ministry of Environment and Forests (MoEF). Government of India, New Delhi. Accessed 13 Sept 2013, 2010). Driven by rising population, income, and urbanization, under a business-as-usual scenario, India's energy demand from transport is projected to increase sixfold in 2050 from current levels. This has vital impact on key national sustainable development indicators like energy security and air pollution. In response, several national and subnational policies and measures were initiated to ameliorate the adverse impacts of transport decisions on sustainability. These include national policies and programs for fuel efficiency, low-carbon technologies, investments in public transport infrastructure, and climate change mitigation. These aside, several bottom-up interventions that are initiated locally are showing promise.

This chapter offers an overview of transport sector in India and presents selected best practice case studies that identify good practices. Evidently, the challenge is to replicate and scale up these practices to gain sizable CO₂ mitigation together with co-benefits vis-à-vis various national sustainable development goals. The assessments show that successful implementation of national policies at the subnational level requires widely agreed goals and targets and support from the national government. The support can be in the form of capacity building, technology, or finance. In the overall, the chapter argues for (1) integrating transport policies with local, national, and global objectives, (2) a comprehensive assessment of the impacts (co-benefits and risks) of policies and project from the planning to the post-implementation stage, and (3) cooperation and knowledge sharing among cities and regions facilitated by the national government for cross-learning and transfer of best practices. The lessons from these studies provide important

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learnings for designing policies and projects elsewhere including other developing countries.

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Key Message to Policy Makers

- Transport “best practices” deliver sustained carbon mitigation and co-benefits.
- Best practice cases include policies and projects which are replicable and scalable.
- Case studies demonstrate contextual effectiveness of methods and practices.
- Best practices align sustainability and low-carbon goals spatially and temporally.
- Rational transport system needs integration of inter- and intracity transport choices.
- Technology cooperation and carbon finance are vital for replication and scalability.

8.1 Introduction

This chapter examines selected case studies which represent “best practice” vis-à-vis sustainable low-carbon transport policies, measures, technologies, and investments in India. The term “best practice” is used contextually. The central idea for this chapter is not to look for a perfect blueprint of a policy or plan but to critically evaluate what has been or is being implemented and is proven to work. The key “best practice” criteria considered in assessing the case studies are clear vision, assessment of delivered or demonstrated co-benefits of low-carbon choices, as well as their replicability and scalability. The case studies are selected, keeping in view the diversity of transport sector and the multiple interfaces of the sector with development and environment.

The overarching transport policies are framed, mandated, and facilitated by the national government. The implementation in most cases involves subnational governments or sector-specific departments or organizations. The projects are implemented by agencies, including those operated under public-private partnership (PPP). The case studies are therefore selected belonging to both policy and project domains. Successful low-carbon integration between national and subnational governments is essential for successful implementation of policies which requires integration between national policies and subnational initiatives

(Matsumoto et al. 2014). The cases selected here look at both national and subnational initiatives on low-carbon transport policies and infrastructure.

The three case studies on policies include major initiatives by the Government of India to improve local environment and/or energy security, but also have bearing on greenhouse gas emissions from transport. The three project case studies include new areas where either the first project is recently initiated (e.g., dedicated freight corridor), the first project is identified (e.g., high-speed rail), or an initial set of projects are already under implementation (e.g., bus rapid transit).

8.1.1 Current Transport Scenario in India

India's transport sector is a rapidly growing sector and contributes 6.4 % to the GDP of the country. The sector is largely oil dependent and accounts for 13 % of the country's energy-related CO₂ emissions (MoEF 2010). Crude oil imports have been increasing steadily and making India the third largest oil importer globally. Nearly 80 % of India's current crude oil consumption comes from imports raising challenges of national energy security.

Intercity transport is mainly met by road (88 %), rail (11 %), and a limited share of air transport. Indian railways are among the largest rail networks globally and transport 23 million passengers and 3 million tonnes of freight daily (GoI 2015). Despite its extensive network, railways are faced with issues of capacity constraints and poor infrastructure. The share of rail has dropped from over 40 % in 1970 to 11 % in 2010 due to high competition from road transport. Similarly, rail dominated freight transport in India; however, this share is on the decline in recent years.

In urban areas, road transport dominates. Present status of urban transport is characterized by increasing trip distances, increasing share of private motorized transport, and declining share of public and non-motorized transport. These trends are leading to increasing problems of poor air quality, road safety, noise, and congestion.

8.1.2 Transport Scenarios for India

India is witnessing a unique period of population growth, economic growth, and urbanization. A third of India's population lives in urban areas. Urban population is expected to grow in the future, and by 2050, half of India's population is projected to reside in cities (UN 2014). India's GDP is also expected to grow at a healthy rate with per capita incomes reaching USD 15,842 (2010 prices) in 2050. Population, income, and urbanization are expected to drive vehicle ownership, travel demand, and freight transport demand.

Intercity travel demand will increase by 4.3 times between 2010 and 2050. In business-as-usual (BAU), this demand will be met by road-based transport and a

growing share of air transport resulting in a higher energy demand resulting in challenges of national energy security and greenhouse gas emissions. In cities, increasing travel demand, reliance on private motorized modes, and declining share of public transport and non-motorized modes will increase energy demand and GHG emissions from cities (Dhar et al. 2013).

Under a BAU scenario, oil will dominate as the energy source, despite a minor diversification into natural gas, electricity, and biofuels. Increasing electrification of intercity rail, urban rail, and freight transport will increase electricity demand from transport. Transport emissions in the BAU are expected to reach around 1 billion tCO₂ in 2050—an increase of 5.5 times increase from 2010 levels (Dhar and Shukla 2014). It is increasingly becoming clear that the BAU will not deliver the desired level of GHG mitigation. For policy makers in the Indian transport sector, this growth poses multiple challenges. Besides the impact on climate change, this raises other issues on how to offer wider mobility access at affordable rates, limit the health impacts of air pollution, and reduce traffic congestion and dependence on fossil fuels.

8.1.3 Need for Assessment

Concerns in developing countries exist regarding the costs imposed by mitigation targets and their impact on economic growth (Olsen 2013). The “co-benefits approach” helps identify actions that balance the short-term development concerns with long-term goals of climate change mitigation (IGES 2011; Creutzig and He 2009). Opportunities exist to mitigate GHG emissions from India’s transport sector and facilitate sustainable mobility by integrating transportation policies with environment, development, and climate change policies. Key interventions include reducing travel demand through planning and sustainability measures, a shift of passenger and freight transport from road-based modes to rail and from private transport to public transport and non-motorized transport in cities, and increase penetration of alternate fuels and vehicles including electric vehicles and hybrid vehicles. These measures will also diversify the fuel mix with a higher share of electricity, natural gas, and biofuel (Dhar et al. 2013).

The sustainability focus is evident in policies of the Government of India. For instance, India’s National Action Plan on Climate Change (NAPCC) highlights a mix of measures, including higher share of public transport, penetration of biofuels, and significant improvements in vehicle efficiency (GoI 2008). Several cities are proactively initiating infrastructure investments in mass transit, urban planning for better land use transport integration, and upgrading existing public transport. These policies and interventions have reduced GHG emissions and at the same time have delivered social and environmental benefits. Since these are limited to few cities, they have not realized the desired mitigation potential. Evidently, there is scope for replication to deliver higher emission reduction and deliver wide-ranging economic, social, and environmental benefits.

At the same time, some of these initiatives are beset with challenges during planning and implementation. It is essential to carry out a comprehensive assessment of good practices for three reasons: (1) this assessment can help highlight the mitigation potential and other benefits to guide policy makers in replication or scaling up, (2) it can highlight unique approaches or co-benefits, and (3) it can help understand challenges during planning and implementation which can be integrated during the next stage to avoid adverse impacts post-implementation.

For instance, the successful implementation of the Auto Fuel Policy 2003 catalyzed the development of a roadmap for further improvement till 2025. The success of transport initiatives in cities can facilitate cross-learning among subnational governments and help to bring in measures early. As an example, successful implementation of a mass transit system in a city can deliver useful lessons to subnational governments on developing mobility plans and leveraging finance for implementation. It is essential therefore to take critical and comprehensive assessment of objectives and impacts to guide future policies to better align these with development goals.

The central idea of this chapter is to look at selected case studies and highlight the success factors and critically examine issues in order to make informed decisions for replication in future. The paper is divided into four sections. After the introduction section, the second section outlines the key transport policies and plans in India. These include existing and proposed policies, planned investments including major infrastructure projects, and urban initiatives. A detailed assessment of case studies is described in Sect. 8.3. The final section concludes with the key highlights from the case study assessment.

8.2 Transport Policies in India

The Government of India has initiated several policies and initiatives for the transportation sector with the objective of enhancing passenger mobility, improving logistics of freight transport, increasing rail use by improving efficiency, raising the average speed, promoting low-carbon transport, and at the same time improving energy security and local benefits of air quality and congestion (Table 8.1). Cities have initiated urban transport initiatives including infrastructure for public transport and non-motorized transport and urban planning and zoning interventions to facilitate transit-oriented development.

Transport sector takes up a share of 45 % in the total infrastructure investments in India. There are plans to increase investments from 2.6 % of GDP between 2006 and 2011 to 3.6 % of total GDP in the period between 2018 and 2022. The Government of India policies highlight rapid expansion and modernization of transport infrastructure. Some of these include expansion and upgradation of roads and highways, reducing congestion in railways, electrification of rail corridors, investments in dedicated freight corridors, and expansion of air infrastructure

Table 8.1 Overview of selected transport policies in India

Sector	Policy/plan	Highlights
Urban transport	National Urban Transport Policy	Enhancing mobility to support economic growth and development
		Reduce environmental impacts
		Enhancing regulatory and enforcement mechanisms
	National Mission on Sustainable Habitat	Submission under India's National Plan on Climate Change
		One of the key components is promotion of urban public transport
Alternate fuels and vehicles	National Policy on Biofuels	5 % blending of ethanol in petrol in 20 states and eight union territories
		Financial incentives
		Waiver on excise duty for bio-ethanol and excise duty concessions for biodiesel
	National Electric Mobility Mission Plan	Investments in R&D, power, and electric vehicle infrastructure
		Savings from the decrease in liquid fossil fuel consumption
		Substantial lowering of vehicular emissions and decrease in carbon dioxide emissions by 1.3–1.5 % in 2020
		Phase-wise strategy for research and development, demand and supply incentives, manufacturing and infrastructure upgrade
Intercity passenger transport	High Speed Rail Project	High Speed Rail Corporation of India Limited (HSRC) formed for development and implementation of high-speed rail projects
		2000 km high-speed railways network (HSR) by 2020
		14 corridors identified
Efficiency	Fuel Economy Standards for cars	Binding fuel economy standards starting 2017
		Fuel efficiency improvement in cars by 10 % in 2017
		20 % in 2022
	Auto Fuel Policy	30 new cities are planned to move to Euro IV by 2015
		Euro V in the entire country by 2020
Freight	Dedicated freight corridors	Double employment potential in 5 years (14.87 % CAGR)
		Triple industrial output in 5 years (24.57 % CAGR)
		Quadruple exports from the region in 5 years (31.95 % CAGR)

investments in high-speed rail and mass transit in cities. Improving water-based transport is now receiving some attention, and this has been mentioned as one of the focus areas in the National Urban Transport Policy.

Table 8.2 Chronology of transport initiatives implemented

Year—measure implemented
1991—First set of mass emission norms for all vehicles introduced
1995—Catalytic converters made compulsory
1995—Unleaded petrol introduced in Delhi
1996—Diesel with 0.5 % S introduced in four metros and Taj Trapezium
1997—Low-sulfur diesel (0.25 %) in Delhi and Taj Trapezium
1998—Low-sulfur diesel (0.25 %) in three metros
1999—Euro I equivalent norms for passenger cars in Delhi
2000—Auto Fuel Policy Committee formed; unleaded petrol in the country; low-sulfur diesel (0.25 %) in the country; (0.05 %) in four metros
2000–2001—Euro II equivalent norms for passenger cars in four metros
2002—All public transport converted to CNG in Delhi
2003—Phase out of old taxis
Three-wheelers to CNG in Mumbai
2005—Low-sulfur diesel (0.05 %) in the entire country; (0.035 %) in metros
2005—Euro III equivalent norms for all cars in seven megacities
2008—BRTS becomes operational in Delhi
2009—BRTS becomes operational in two other cities
2010—Low-sulfur diesel (0.035 %) in the entire country; (0.0005 %) in ten metros
2010—Euro IV equivalent norms in major cities; Euro III equivalent for the rest of the country
2011—Delhi Metro Phase II completed
2012—National Electric Mobility Mission Plan announced
2013—Ahmedabad BRTS ridership reaches record high
2014—Dedicated bicycle track in Diu
2014—Low-carbon comprehensive mobility plan for three cities
2015—Electric rickshaws legalized in Delhi

Compiled from: GoI (2003), CPCB (2008)

Emerging policies highlight the focus on multiple benefits of meeting the transport demand and delivering environment and development benefits (Table 8.1). An example is the recent initiative to develop high-speed rail corridors in the country (GoI 2014a) which is expected to benefit cities along major corridors by improving their connectivity.

Historically, transport interventions in India have been driven by various push factors. For instance, in Delhi, a public interest litigation regarding air pollution prompted a Supreme Court directive authorizing the conversion of public transport to CNG. This was a landmark achievement as Delhi's success prompted several other cities to bring in CNG vehicles. Similarly, the success of electric auto-rickshaws in Delhi was driven by favorable economics and not necessarily government intervention (Shukla et al. 2014). Table 8.2 documents the range of policies and interventions on improving air quality that were been implemented successfully since the 1990s.

8.3 Transport Policy at the National and Subnational Levels

8.3.1 *Selection and Assessment Criteria*

Assessment of best practice is a popular approach, and literature has focused on different facets of best practice research. The terms “best practice” and “good practice” are also debated. The central idea for this chapter is not to look for a perfect blueprint of a policy or plan but to critically evaluate the policies implemented or under implementation that are showing initial benefits. Vesely (2011) classifies good practices into (1) those that depend on functionality that were successful and generated replicable outcomes, (2) practices that emphasized a unique methodology that helped to achieve the objectives, and (3) practices where new approaches were introduced.

For the selection of case studies, we followed a stepwise method. The first step included listing potential case studies covering major transportation subsectors. These included policies, programs, and projects at the national, regional, and city levels. We used a broad-brush method to evaluate these on the three criteria based on the information available: (1) clear vision, (2) evidence or potential of reducing GHG emissions, and (3) delivered or demonstrated the potential of economic development and/or environmental advantages. The idea was to consider diverse case studies from national and subnational levels and from different subsectors of the transport sector—passenger, freight, technology, infrastructures, as well as policies.

Few peer-reviewed studies that comprehensively examine these policies are available. The assessment in case studies therefore relies on peer-reviewed studies (where available), research, gray literature including project reports, reports from think tanks, or other organizations that analyze experiences, published case studies, as well as official documents. Six case studies were studied for impacts at various dimensions and ongoing or post-implementation issues. For developing criteria, we referred to other similar assessments available (Vesely 2011; GGBP 2014). The cases were then assessed for (1) vision and impact (whether the policy/project had clear objectives and was implemented successfully), (2) replicability (whether the practices were scaled up or replicated in other contexts or have the potential for replication), and (3) co-benefits (the intervention has delivered or has the potential to deliver co-benefits). The range of benefits includes GHG mitigation, local air quality benefits, and social and development impacts. The first three case studies are implemented, and we have attempted to draw insights on impacts and challenges. The next three case studies are emerging practices and have the potential to deliver low-carbon sustainability benefits. We believe the insights coming out of each case will enhance understanding of these interventions to enable replication and deliver the ultimate goal of a low-carbon transport transition for India.

8.3.2 Case 1: Delhi Metro

The Delhi Metro Rail Corporation Limited (DMRC) was established to implement the construction of a mass rapid transit system in Delhi. The objective was to develop a mass transit system to enhance mobility and simultaneously to ease congestion and reduce air pollution in Delhi.

The first phase of the metro corridor with a length of 65 km was completed in less than 3 years. An additional 125 km in Phase 2 became fully operational in 2011, taking the present network to 193 km covering 140 stations. The infrastructure covering four phases totaling 245 km is expected to complete by 2021. The project was funded with a joint contribution of Japan International Cooperation Agency (JICA), joint equity contribution by the national and state governments, and a small proportion coming from property development (DMRC 2015). The Delhi Metro has not only improved connectivity within the city but has also improved transport integration through its airport-city link and regional connectivity through its planned connections to towns in the neighboring state of Haryana.

8.3.2.1 Impacts

Delhi Metro has a daily ridership of 2.6 million passengers (DMRC 2014b). A recent study has reported that about 0.3 million vehicles have been taken off the road due to the introduction of the Delhi Metro (CRRI 2011). Expansion of the metro network delivered air quality benefits of reduced NO₂, CO, and PM_{2.5} (Goel and Gupta 2014). In 2011, shifting of commuters from road-based transportation to metro rail in Delhi saved 1320 tons of NO_x, 107 tons of particulate matter, and over 3880 tons of CO₂ (Sharma et al. 2014).

This is the first urban rail CDM project globally and has achieved significant reductions in GHG emissions. This is also a landmark project for the country as it has already registered three successful projects under the Clean Development Mechanism (CDM) (DMRC 2014a). These include the carbon credits from regenerative braking, the Modal Shift Project, and the Energy Efficiency Project under CDM and Gold Standard which are expected to reduce approximately 570,000 tCO₂ annually. The project saved 90,000 tons of CO₂ from regenerative braking between 2004 and 2007 and continues to claim credit. Increasing ridership, modal shift, and energy conservation practices will deliver further mitigation benefits in the future (Sharma et al. 2014).

In response to the success of DMRC, the Government of India has submitted the MRTS Program of Activities (PoA) to The United Nations Framework Convention on Climate Change (UNFCCC). The PoA will cover a series of rail-based MRTS projects (like metro rail, LRT, monorail) implemented across India. The objective of MRTS PoA by DMRC is to promote implementation of mass transit systems to reduce GHG emissions and support with implementation for the construction of an MRTS projects by providing fast-track carbon funding and risk-free registration of future projects (UNFCCC 2014).

Khanna et al. (2011) carried out scenario analysis to demonstrate that a rail-dominated mass transit system in Delhi can deliver 61 % reduction in energy use compared to 31 % reduction for a bus-dominated system. A cost-benefit analysis of the Delhi Metro calculated a 22 % social rate of return, a financial rate of return of 17 %, and an economic rate of return of 23.9 % including gains from air pollution reduction (Murty et al. 2006). The study reported that Delhi Metro generated benefits to the stakeholders including citizens and government; however, other transport providers suffered from income losses (ibid).

The implementation of the Delhi Metro has resulted in social impacts including relocation of people and reduced accessibility of the relocated low-income households (Tiwari 2011). The DMRC faces challenges due to land acquisition issues. Metro infrastructure projects are being planned or are under construction in nearly 20 cities—several of which will follow the Delhi model. It is crucial to address issues of equity and development to minimize adverse social impacts during project implementation. An additional concern is the vulnerability of cities and infrastructures to the risks from climate variability, especially extreme weather events (Garg et al. 2013; Pathak et al. 2014). These considerations should be factored in as far as possible into planning of long-term transport infrastructure.

8.3.2.2 Replication and Scalability

The key lessons emerging from the Delhi Metro case study are as follows: (1) - low-carbon mobility projects can leverage financing through the international carbon market, (2) large infrastructure projects provide a good opportunity for technology cooperation between a developed and a developing country, (3) public transport projects, if implemented effectively, can deliver mitigation benefits and lead to environmental co-benefits from reduced congestion and improved air quality, and (4) large infrastructure projects should make all efforts to minimize adverse social impacts during planning and implementation.

8.3.3 Case 2: Auto Fuel Policy (AFP)

The Government of India set up the Auto Fuel Policy Committee in 2000 to prepare a policy for setting up of emission norms and fuel quality standards in the country and to provide a roadmap for its implementation (GoI 2003). In addition, the policy recommended improvement of fuel economy, reducing pollution from in-use vehicles, submitting vehicle for inspection and maintenance, and augmenting public transport.

The Committee recommended a progressive implementation of fuel quality norms and Euro equivalent exhaust emission norms for vehicles. Taking into account technical, financial, and institutional considerations, the roadmap suggested the implementation in a phased manner in the country starting from the

Fig. 8.1 Vehicular Emission norms in India: Implementation and future roadmap of India’s Auto Fuel Policy (Sources: Authors. Adapted from: GoI 2003; 2014c; ICCT 2013a, b. Note: BS refers to Bharat Stage emission norms. These norms are broadly equivalent to Euro norms. This roadmap is for four wheelers including passenger cars, light commercial vehicles and heavy duty diesel vehicles)

implementation of Bharat Stage II fuel/emission norms in 2005 and progressively going to Euro IV in 2010. The implementation was to be initiated in 11 major cities followed by the rest of the country. Subsequently, in 2014, the Government of India outlined the Auto Fuel Vision and Policy that laid down future vehicle and fuel improvement roadmap for the country till 2025 (GoI 2014b). According to the roadmap, Bharat Stage (BS) IV will be adopted by 63 cities by the end of 2015 and adopted countrywide by April 2017. The implementation roadmap is shown in Fig. 8.1.

8.3.3.1 Impacts

Following the recommendation of the Auto Fuel Policy (GoI, 2003), implementation emission and fuel quality standards have been progressively modified in India. Euro I equivalent norms were introduced in the year 2000 starting with 11 identified cities including metros and subsequently implemented across the country. Subsequently, Euro II and Euro III equivalent norms were also introduced across the country in the year 2003 and 2005. India’s Auto Fuel Policy report brought about significant air quality benefits compared to the “no-policy” scenario.

A detailed assessment showed that actions outlined in the policy were largely implemented in accordance with the policy roadmap (ICCT 2013a). There has been a reduction in sulfur content in gasoline (from 2000 ppm to 150 ppm) and diesel (from 10,000 ppm to 350 ppm). In selected 20 cities, sulfur content has been brought down to 50 ppm. As a result, SO₂ levels have come down significantly in Indian cities and remain well within WHO standards (CPCB 2012). Other improvements include a reduction in benzene levels in gasoline and increase in the use of zero-sulfur CNG and LPG in buses and auto-rickshaws. A recent study reported a

significant decrease in PM_{10} vehicular emissions throughout the previous decade and a slowing of growth of NO_x emissions. This resulted in 21,500 deaths avoided from reduced $PM_{2.5}$ emissions (ICCT 2013a). The clear vision, process of implementation, and success of the AFP 2003 helped replicate and upscale Auto Fuel Policy Vision 2025.

8.3.3.2 Replication and Scalability

Despite the progressive vision and roadmap and successful implementation of the policy, India's fuel quality and emission norms still lag behind international standards, and air quality remains a serious problem in all parts of the country. Efforts are required to advance the implementation of BS IV and V than scheduled in the Policy Vision of 2025. A study has shown that accelerating implementation of stringent fuel quality and vehicle emission standards in India will avoid approximately 48,500 premature deaths. This would impose an additional cost of USD 45 billion; however, the economic benefits of these avoided deaths would amount to USD 90 billion, making a strong case for advancing the roadmap (ICCT 2013b).

When the Auto Fuel Policy Committee was formed in 2000, the focus was to address air quality issues in the country. However, a decade later, energy security and climate change are simultaneous national priority issues. Recently, the government has proposed fuel economy standards for cars starting 2017 (BEE 2014). According to this draft proposal, fuel economy of cars will improve by 10 % in 2017 and 15 % by 2020. The Auto Fuel Policy Roadmap 2025 can consider conjoint mitigation of local pollutants and GHG emissions. The key lessons from the case study are as follows: (1) clear vision and targets at the national level were important factors in successful implementation; (2) a phase-wise implementation roadmap taking into account existing technical, institutional, and financial considerations; (3) consideration of stakeholders' concerns; and (4) future policies can aim for conjoint mitigation of local air pollutants and greenhouse gas emissions.

8.3.4 *Bus Rapid Transit System*

The National Urban Transport Policy was announced by the Ministry of Urban Development (MoUD) in 2006. Key focus areas of the policy included encouraging use of public transport and facilitating the introduction of high-quality multimodal public transport systems (MoUD 2006). Simultaneously, the National Urban Renewal Mission (NURM) committed substantial funds for bringing about improvements in urban infrastructure which included funds for BRTS projects in the country. Presently, over a dozen Indian cities have BRTS systems which are operational, and few other cities are planning to construct BRTS. The BRTS in Ahmedabad is among the most successful systems in the country. The BRTS in Ahmedabad was introduced in 2009 in order to promote public transport, to reduce

the rapid growth of private vehicles, and to ease congestion. Based on a PPP model, the BRTS was implemented in a phased manner.

8.3.4.1 Impacts

The Ahmedabad Bus Rapid Transit System (BRTS) network has grown rapidly over the years and now operates a 52.5 km network with another 36 km under planning. The ridership started from 18,000 trips per day and has currently reached 0.1 million trips per day. In addition to increased ridership and revenue, the BRTS has resulted in other co-benefits including reduced travel time and other environmental benefits (NIUA 2014). Ahmedabad BRTS has improved mobility choices and reduced travel time (Rogat et al. 2015). The system has led to a reduction in CO₂ emissions and at the same time delivering social and economic benefits through enhanced mobility (UNFCCC 2015). The success of Ahmedabad BRTS encouraged several cities to implement BRTS based on the Ahmedabad model.

8.3.4.2 Replication and Scalability

A modal shift from private to public transport at lower cost can be facilitated by making public transport more attractive with a comprehensive plan that facilitates intermodal integration (Bubeck et al. 2014). The construction of two metro corridors in the city is commenced, the first phase of which is expected to initiate operations in 2018. Efforts are under way to integrate the networks of BRTS, metro rail, and local busway system in the city (Fig. 8.2). Ahmedabad Metro, though planned later, will be integrated with BRTS, and both BRTS and metro form an integral part of the Ahmedabad Urban Development Plan of 2021. The corridors are planned to ensure connectivity and coverage across the city. The routes for the local bus systems are now being planned for these to complement the BRTS network. BRTS is now integrated in the local and regional development plans looking at transit corridors to ensure wider coverage (AUDA 2015). The project is among the most successful public transport projects implemented on a public-private partnership model.

Despite several successful initiatives, BRTS implementation in India has experienced challenges and replication. Key challenges include lack of ownership of the system by the planning and implementing agencies, reluctance from private vehicle owners to share road space, and inadequate clarity in implementation (Mahadevia et al. 2013a). It was observed that BRTS systems fail to benefit the urban poor due to flaws in design and fare structure. While emission reductions achieved are modest, the system has potential to bring about sizable mitigation benefits. Evaluation of BRTS projects should be done in a slightly longer time frame as impacts may not be evident during initial years. Challenges of attracting private transport users, if overcome, can make the BRTS an attractive option. This will require supporting measures including pricing policies for private motorized vehicle users

Fig. 8.2 Existing and proposed BRTS and Metrorail corridors in Ahmedabad (Sources: AMC 2012; AUDA 2015 and GoG 2014)

and supporting infrastructure including feeder systems and parking facilities at stations. For BRTS to become a best practice, efforts will have to bring in social equity by enhancing infrastructure for non-motorized transport along BRTS

corridors, introduce measures to facilitate modal shift from private modes, and integrate the BRTS with other public transport systems in the city (Mahadevia et al. 2013b). Inclusiveness will depend on understanding the mobility needs and capacities of the users and integrating these into the plan. Planning of BRTS projects should be based on a comprehensive assessment to include all sections of the population, their travel patterns, and mode choices based on age, gender, and economic status.

8.3.5 Low-Carbon Comprehensive Mobility Plan Toolkit

In 2008, the Ministry of Urban Development (MoUD) released a toolkit for the preparation of a Comprehensive Mobility Plan (CMP) for cities. This was to encourage cities to prepare CMPs to fund urban transport projects under the Jawaharlal Nehru National Urban Renewal Mission (JnNURM). An assessment of submitted plans showed that these were not comprehensive in looking at social, economic, and environmental sustainability issues (GoI 2014c). Driven by concerns of climate change and sustainable development, the Ministry of Urban Development released a revised CMP toolkit in 2014. As part of a UNEP-supported project, a low-carbon comprehensive mobility plan was prepared for three cities in India—Udaipur, Rajkot, and Visakhapatnam.

The toolkit provides clear guidance on integrating land use and transport planning in order to align the transport plan with the development plans/master plans of the city. The revised toolkit incorporated learnings from implementation of earlier CMPs and from the three city case studies. The revised document was therefore more comprehensive—it incorporated elements of environmental sustainability and inclusiveness including poverty and gender issues. The revised document moves away from a deterministic approach to a more flexible scenario-based approach. This allows cities to look at the impacts of the conventional scenario where land use will follow the development plan or master plan and explore specific interventions in the alternate scenario including land use, infrastructure, public/non-motorized modes, and regulations (GoI 2014c). For instance, the Low Carbon Mobility Plan for Rajkot focuses on alternate transport scenarios based on land use, public transport and non-motorized transport, and technology-based scenarios.

8.3.5.1 Replication and Scalability

The toolkit is a comprehensive document as it integrates multiple objectives of environmental quality, inclusiveness, gender balance, and emission mitigation. This is also a unique initiative at the national level aimed to enable subnational transport plans. The process involved active stakeholder engagement by involving experts, city officials, and other stakeholders and incorporating these suggestions into the final document. The process also included a review of all existing

documents and policies including government reports, reports of the expert committees and groups on urban transport of the 11th and 12th five-year plans, national missions, guidelines and codes, and global case studies on transport plans.

The methodology can highlight strategies and projects for implementation in the short term, medium term, and long term allowing cities to integrate these within the overall plans (UNEP 2015). This will generate a common and comparable database of cities on transport indicators that will further facilitate adoption by a number of cities especially smaller cities. In addition, a robust methodology will enable cities to develop proposals for funding including international climate finance.

8.3.6 Dedicated Freight Corridor (DFC)

The Dedicated Freight Corridor Project is initiated by the Government of India to develop transport corridors dedicated for freight transport (DFCCIL 2014). This key objective is to facilitate faster freight transport and meet market needs more effectively. In addition, the creation of the extensive infrastructure will facilitate the growth of industrial corridors and logistic parks leading to regional and national economic benefits. The primary reasons for undertaking the project of this scale were the rapidly rising demand for freight transport and the inadequacy of the existing rail infrastructure. Presently, there are plans for developing two corridors—the western DFC and eastern DFC.

The western corridor covers 1483 km between Delhi and Mumbai. The introduction of the corridor is expected to result in a major shift from road- to rail-based transport. In terms of energy implications, this will increase efficiency and reduce the demand for oil while increasing the share of electricity. By 2046, the western DFC project is expected to bring down a substantial 81 % reduction in annual CO₂ emissions compared to the “no-project scenario.” With increasing decarbonization of electricity in the future, this will generate significant low-carbon benefits. This will result in a cumulative emission reduction by nearly 170 million tons of CO₂ over 30 years (Pangotra and Shukla 2012). The corridor will enhance regional connectivity, a critical input to deliver regional economic benefits.

8.3.6.1 Highlights

Historically, Indian railways had dominated the inland movement of goods. Over time, economic growth led to a significant demand for freight transport; however, rail transport infrastructure did not meet the growing demand resulting in a growing share of road transport in overall freight transport (RITES 2009). A common corridor for passenger and freight resulted in high transaction time and costs due from inefficient operations. The modal shift from rail to road is not favorable given the efficiency of rail in terms of energy and CO₂ emissions. The dedicated corridor for freight transport will deliver emission reductions from modal shift and

additionally from increased efficiency of movement. In addition, India will be able to leverage global economic opportunities through better internal connectivity between centers and ports. This will facilitate industrial development along the corridor generating significant jobs in small towns and villages along the route. The case study highlights that large transport infrastructure projects have major impact on CO₂ emissions. A strong case for replication of freight corridors is the additional dimension of sustainability from simultaneous environmental and development benefits for the country.

8.3.7 National Electric Mobility Mission Plan

Recently, the Prime Minister of India launched the National Electric Mobility Mission Plan (NEMMP 2020) (GoI 2012) with a view to enhance national energy security, mitigate adverse environmental impacts of vehicle, and develop domestic manufacturing capabilities. The Plan envisions the sale of around seven million electric vehicles resulting in fuel savings of nearly 2.5 million tonnes. The NEMMP focuses on demand creation, manufacturing, R and D, and development of charging infrastructure (GoI 2012). Within these, the plan proposes phase-wise targets and strategies for implementation.

EVs could have vital implications for energy security, local air quality, GHG mitigation, and increasing renewable share in the electricity sector. It is obvious that electric vehicles will play a significant role in India's sustainable transport transition. Around the year 2000, only a couple of electric two-wheelers were available in the Indian market. However, the market has expanded, and over two dozen different two-wheelers are available in the market at present. Efforts are under way by electric vehicle manufacturers to provide options that can reduce charging time and increase awareness among consumers regarding lower fuel and maintenance costs of E4Ws compared to conventional cars.

8.3.7.1 Highlights

The NEMMP is a good starting point to give an impetus to the country's manufacturing sector, enhance research in electric vehicles, and upgrade infrastructure, all of which will be instrumental in the penetration of electric vehicles in the country. The policy sets the direction and signals to manufacturers including private players.

The NEMMP is a comprehensive policy that will facilitate green growth by enabling environmental innovation and facilitating the development of a competitive domestic market for electric vehicles, green jobs, and local air quality benefits. By laying down actions in a phase-wise manner, it sets down initial direction and sets long-term targets for scaling up.

EVs are at a relatively initial stage in India. Scaling up EV penetration in India and making these competitive vis-à-vis conventional vehicles will require financial incentives for electric vehicles, improved infrastructures for charging and other local incentives (Shukla et al. 2014). Supportive and enabling policies have the potential to increase the share of electric two-wheelers from 40 to 100 % and electric cars to 40 % and reduce oil demand by 39 Mtoe. EVs will require upfront investments; however, savings from the reduced oil demand as a result of shift to electric mobility will far exceed the support provided, thereby making this economically viable.

8.4 Conclusion

Transportation has multifarious interfaces with economic development and environment. Transport networks create access to markets and render economic efficiency. In an emerging nation like India, the demand for transport will grow through this century driven by urbanization, industrialization, and rising income. The experience of developed countries shows that the business-as-usual transport policies lead to energy-intensive and oil-dependent transport leading to high GHG emissions.

India is a geographically diverse and vast country. National transport policies are crafted keeping in view the diversity of transport demand, appropriate mix of modes, technologies, fuels, and corresponding infrastructures. The transport system architecture varies at national and subnational levels and so do policy interventions. Transport decisions interface with numerous other development policy domains, e.g., land use, energy, environment, technologies, and finance. The transport decisions have inherent long-term lock-ins lasting several decades. The transport policy making needs long-term perspective and concurrent attention to interface with multifarious development goals. Climate change is now an added interface to which transport policy makers have to pay their attention. The assessment of development policies and plans of several countries in Asia shows that their development policies were not aligned with climate change goals, though their focus on other development and environment objectives like energy security and local air pollution has led to reduced GHG emissions (ADB 2012). For India, the studies have shown opportunities to align policies to simultaneously ensue multiple development and climate objectives (Menon-Choudhury et al. 2007). This chapter presents selected best practices that have shown the promise of gaining multiple co-benefits which are scalable and replicable (Table 8.3). The case studies also show that governance system, including monitoring, reporting, evaluation, and correction, is vital for ensuring replication and scalability.

The case studies represent best practices related to policies and projects. Evidently, the challenge is to replicate and scale up these practices to gain sizable CO₂ mitigation together with co-benefits vis-à-vis various national sustainable development goals. The global mitigation agreements now provide the opportunity to

Table 8.3 Summary assessment of best practice case studies

Sector/ scale	Measures for direct CO ₂ benefits	Sustainability Co-benefits	Elements of replicability and scalability to gain sustainability and low-carbon benefits
Policy-related case studies			
<i>CMP Toolkit Focus:</i> urban mobility <i>Scale:</i> national, city	Integrates transport modes with land use Fuel/technology mandate Measures to reduce transport demand	Lower cost to consumer Lower congestion Improved air quality Safety and security Inclusive and affordable transport	Proactive and continuous stakeholder engagement Integration of climate, inclusiveness, environ- ment, and quality of life Methodology for compara- ble and consistent data- bases across cities Cities have flexibility to tailor context-specific interventions Enables capacity building and early interventions in smaller cities
<i>NEMM Plan Focus:</i> EVs <i>Scale:</i> national, city	Electric vehicles using low-carbon electricity can reduce CO ₂ sizably	Local air quality benefits Energy security co-benefits Reduced noise Batteries help electric load management and backup power	Charging infrastructure is easy to replicate and upscale Two-wheeler manufactur- ing is easy and is readily replicated Subnational policy makers have incentive to attract EV manufacturers, and this can help replication and scalability
<i>Auto Fuel Policy Focus:</i> clean air/fuel <i>Scale:</i> national, city	Direct GHG benefits can accrue from fuel economy standards GHG co-benefits from local emissions targets	Local air quality co-benefits National energy security co-benefits	AFP 2003 helped replicate and upscale Auto Fuel Pol- icy Vision 2025 AFP process was stake- holder intensive which helped in acceptance and replication AFP process is amenable for conjoint mitigation of local pollutants and GHG emissions
Project-related case studies			
<i>Delhi Metro Focus:</i> mass tran- sit in cities <i>Scale:</i> city	CO ₂ emission reduc- tion due to modal shift from motorized transport Low-carbon electric- ity in the future can deliver sizable CO ₂ mitigation	Air quality co-benefits Reduced congestion Improved connectivity Efficient technology enhances energy security	Scalability in Delhi and replication in a number of cities has happened Incremental carbon finance is expected to help replica- tion under NAMAs frame- work Delhi Metro co-benefits

(continued)

Table 8.3 (continued)

Sector/ scale	Measures for direct CO ₂ benefits	Sustainability Co-benefits	Elements of replicability and scalability to gain sustainability and low-carbon benefits
			assessment provides methodology and benchmarks for replication and scalability elsewhere
<i>BRTS</i> <i>Focus:</i> mass transit <i>Scale:</i> city	Modal shift delivers CO ₂ mitigation System efficiency delivers CO ₂ mitigation	Air quality co-benefits Saves time due to rapid mobility Higher safety from dedicated lanes	Replicated in several other cities in India Better integration with other public transport systems, into the city development plan, and within the larger regional context PPP model is suitable for BRTS and it is replicable and scalable
<i>Dedicated freight corridor</i> <i>Sector:</i> freight <i>Scale:</i> regional	CO ₂ savings due to shift to efficient rail mode away from road transport Low-carbon electric traction will mitigate CO ₂ in low carbon future	Facilitates development of industrial parks along the corridor leading to regional and national economic benefits Promotes industrialization along the corridor	Comprehensive view of economic and environment benefits Improve efficiency of freight movement Scaling up to facilitate national economic development and deliver sizable mitigation benefits Integration of coastal and landlocked areas which is very essential for balanced national development and global integration

leverage additional funding from climate finance instruments like Green Climate Fund as well as Nationally Appropriate Mitigation Actions (NAMAs). The additional funds can be the lever for fast-track replication and upscaling of current best practices. Globally, cities have proposed projects under NAMAs that include implementation of low-carbon mobility plans and demand management including road pricing, parking policies, investing in mass transit, and increasing the share of non-motorized and public transport.

The overarching vision of the case studies in the chapter is largely focused on aligning national transport policies in line with the global target of 2 °C temperature stabilization by the end of the century. However, given the climate risks to infrastructure projects, the protection of transport assets from the future climate change is one of the areas where more attention is needed. While climate risks are not formally factored into the existing transport policies and projects, the methodologies to identify and mitigate major climate risks to the transport projects by improved design and construction methods is gaining attention.

The case studies presented in the paper represent just a few of the promising interventions. There are equally promising initiatives such as investing in non-motorized transport. Recently, India's Ministry of Urban Development has released the bicycle sharing toolkit to promote non-motorized transport in cities. Several cities including Ahmedabad, Delhi, Vishakhapatnam, and Chennai have initiated construction of infrastructure for non-motorized transport and cycle-sharing schemes. This is an important focus area as it can deliver multiple gains of mobility, safety, emission reductions, and social inclusion.

The "best practice" assessment presented in this chapter shows promise of delivering multiple objectives and the possibility of replication and upscaling. The policies and projects represented in the case studies show that urbanization is the key driver of future transport system choices in India. Rational transport system therefore needs integration of inter- and intracity transport choices. The lessons from these studies provide important learnings for designing policies and projects elsewhere. The assessments of case studies show that successful implementation of national policies at the subnational level requires widely agreed goals and targets and support from the national government. The support can be in the form of capacity building, technology, or finance. Overall, the chapter argues for (1) integrating transport policies with local, national, and global objectives, (2) a comprehensive assessment of the impacts (co-benefits and risks) of policies and project from the planning to the post-implementation stage, and (3) cooperation and knowledge sharing among cities and regions facilitated by the national government for cross-learning and transfer of best practices.

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