Chapter 2
Urban Transportation Trends: An Overview

2.1 Introduction

One of the major concerns of urbanization is the sprawling which directly and seriously affects the transportation system. With the growing urbanization, Indian cities have been facing outrageous growth in travel needs and the vehicle stock. The number of motorized vehicles in Indian cities has outgrown the provision of transport infrastructure. This trend is predominant in metropolitan cities owing to their higher economic growth rates and increasing rate of urbanization. Road infrastructure has not developed commensurately to support high growth in vehicle stock. This has resulted in increasing congestion, air and noise pollution, longer travel time and distance, and more accidents. Poor infrastructure results in poor fuel efficiency as well. Increased dependence on personalized modes of travel is apparent from their rising stock in metropolitan cities. Various policy initiatives taken by the Government of India have succeeded to some extent in controlling urban air pollution in some cities; however, the ever-rising vehicular stocks and lag in the application of economic tools to control traffic growth and the resulting pollution keep the situation at the same level as before. Delhi, the leading metropolitan city in India, is among the most polluted cities in the world. It is experiencing very high levels of air pollution, mostly coming from urban transportation. Though air quality in Delhi has improved after the implementation of CNG, it has started to decline soon after. Many class II cities like Hyderabad, Kanpur, and Varanasi are closely following the trends similar to what Delhi followed in the early 1990s.

This chapter presents the trends in urban transportation development and various national initiatives implemented to control the growth in transportation and the sectors' environmental emissions. The chapter discusses fuel alternatives, management measures, and policy measures taken up to achieve sustainable transportation in Indian urban centers.

Part of this chapter are derived from Yedla 2004.

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2.2 Issues in Urban Transportation

Efficient system of transportation makes key contributions to the economic growth, competitiveness, and social inclusion. Addressing the issue of urban transportation is a complex exercise, and any efforts to achieve sustainable transportation need to be holistic covering diverse aspects of travel demand, vehicular growth patterns, emissions, auto fuels, traffic management, and efficient land-use pattern. Attempts to arrive at a solution from any of these dimensions in isolation would not achieve sustainability as most of these are essentially interlinked and need to be addressed in integration.

2.2.1 Growth in Vehicular Stock

All million plus cities in India are facing consistent rise in vehicular stock and growth in demand for travel. Among all metropolitan cities, Chennai, Delhi, Kolkata, and Mumbai have registered the highest growth rate of vehicular stock. Delhi stands out among all cities with a total vehicular population equal to the aggregate vehicular stock of all the other three metropolitan cities, viz., Chennai, Kolkata, and Mumbai. Rapid expansion of city boundaries and increased number of suburbs to cater for migrating populations could be the reasons for such high growth. Table 2.1 presents the growth rates of vehicular stock in all major cities in India from 1985 to 2005. Class I cities are competing closely with the five megacities on the annual growth rates of vehicular stock. Cities like Surat, Pune, Jaipur, and Nasik have experienced tremendous growth in vehicular stock over the last two decades and are trying to catch up with the megacities. Hyderabad, Ahmedabad, and Bangalore are already comparable to the megacities with respect to the vehicular stock. Given the fact that unlike other megacities, no concrete measures/efforts are on to check the travel growth or pollution in these cities, very soon they would reach alarming levels of traffic and resulting environmental emission. Figure 2.1 presents the change of vehicular stock in different cities from 2001 to 2011.

Among the total vehicular stock, personalized modes of transport are dominating in almost all cities. Table 2.2 presents the mode-wise breakup of vehicular stock in different cities for the year 2012. Delhi and Mumbai roads are predominantly occupied by two-wheelers, and in the case of Kolkata, it is cars showing dominance. Lack of proper/efficient public transportation in Delhi could be the reason for rapid growth of two-wheeler population over time. However, it is an interesting observation that their growth rate has started declining in the very recent times. In Delhi, where two-wheelers were registering at the rate of around 0.1 million per annum, the registration has come down to around 50,000 per annum by 2002. Considering that old two-wheelers above certain age get phased out, in Delhi the total number of two-wheelers plying may actually be reducing (MoPNG 2002). In contrary, the

Table 2.1 Percentage annual growth rates of motor vehicles in major Indian cities from 1985 to 2005

City/district	1985–1990	1990–1995	1995–2005	Population in millions (2005)
Greater Mumbai UA	9.05	5.87	11.14	18.78
Kolkata UA	19.44	24.89	9.53	14.22
Delhi state	18.93	9.71	6.57	15.02
Chennai UA	29.27	11.05	10.49	6.96
Bangalore District	17.84	9.11	14.43	6.5
Hyderabad UA	26.96	13.66	9.76	6.46
Ahmadabad District	16.39	10.76	10.76	5.07
Pune District	14.35	14.13	11.95	4.41
Surat District	20.87	9.18	11.42	3.63
Jaipur District	17.24	11.97	10.79	2.73
Lucknow District	5.39	5.48	6.93	2.67
Nagpur District	24.4	8.94	11.22	2.34
Patna District	20.77	10.23	13.51	1.98
Indore District	16.98	10.14	12.95	1.88
Vadodara District	26.37	14.28	13.83	1.72
Bhopal District	6.02	8.84	5.96	1.69
Ludhiana District	23.71	9.52	15.95	1.54
Visakhapatnam District	13.66	14.32	15.32	1.58
Varanasi District	16.72	10.33	9.96	1.3
Nashik District	23.46	10.38	11.75	1.2
Jabalpur District	21.31	8.25	14.05	1.18

Source: Compiled by authors using MoSPI (2013)

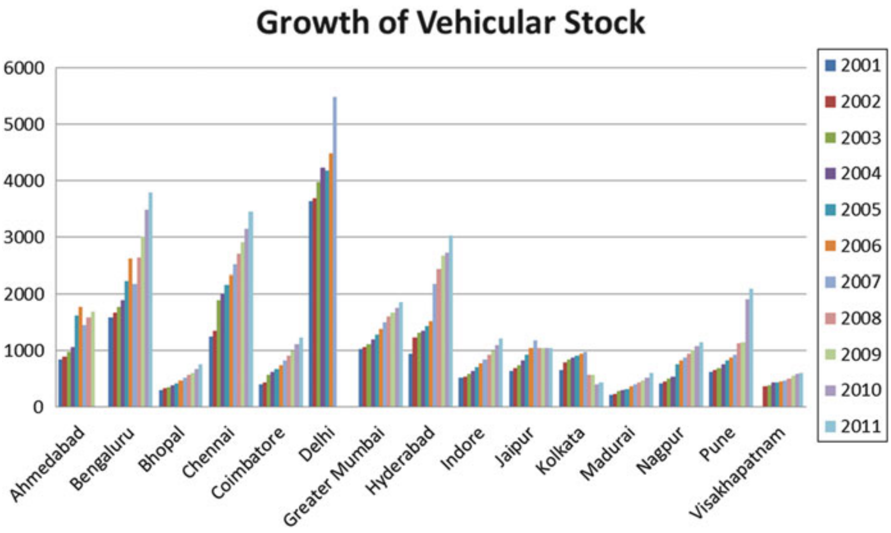

Fig. 2.1 Growth of vehicular stock in different cities from 2001 to 2011 (Source: Developed by the authors using data from http.www.indiastat.com)

Table 2.2 Total registered motor vehicles in major cities of India in the year 2012

	Two-wheelers	Cars and taxis	Jeeps and omnibuses	Tractors and trailers	Buses	LCV	HCV	Others	Total
Agra	515,154	55,021	6,322	35,736	10,515	14,294	3,866	1,654	642,562
Allahabad	584,248	57,003	7,671	8,746	10,296	8,010	8,929	2,611	687,514
Aurangabad	193,878	13,339	7,302	10,786	12,768	11,733	3,572	1,022	254,400
Bengaluru	2,624,707	757,087	53,598	13,162	163,503	73,888	76,843	20,046	3,821,304
Bhopal	602,793	101,392	1,482	16,528	17,395	11,795	7,390	1,206	759,981
Chennai	2,398,366	681,181	21,127	14,253	142,495	82,457	97,996	40,743	3,478,618
Coimbatore	1,023,414	154,382	5,682	8,372	18,373	15,406	10,632	13,430	1,249,691
Delhi	4,395,086	2,178,442	168,856	5,483	88,795	124,547	4,792	519	6,966,520
Mumbai	1,044,829	616,674	27,835	843	122,453	53,969	8,160	1,512	1,876,275
Hyderabad	2,144,410	524,278	34,650	8,283	153,171	96,642	120,718	6,892	3,089,044
Indore	930,223	163,010	4,397	25,706	25,190	27,741	46,760	2,596	1,225,623
Jabalpur	462,632	40,582	2,081	14,919	17,475	11,236	10,637	3,655	563,217
Jaipur	1,248,076	231,824	49,668	44,352	47,475	14,116	75,359	55	1,710,925
Kanpur	849,098	98,580	10,166	6,630	7,446	2,102	18,135	3	992,160
Kochi	221,157	123,615	11,185	257	28,527	24,635	5,290	4,021	418,687
Kolkata	182,087	225,985	0	82	23,745	0	15,235	701	447,835
Lucknow	970,897	171,784	16,363	19,127	10,293	14,452	6,683	3,512	1,213,111
Madurai	493,575	52,311	1,627	7,605	23,289	9,983	12,070	7,683	608,143
Meerut	306,202	46,540	1,133	58,690	5,861	3,125	4,231	0	425,782
Nagpur	967,838	92,386	29,086	10,648	22,285	21,027	16,481	1,153	1,160,904
Nashik	300,877	36,195	8,176	18,241	18,202	12,348	5,215	757	400,011
Patna	448,104	95,286	0	22,974	43,027	0	28,776	4,200	642,367
Pune	1,551,968	297,139	41,142	27,770	61,798	53,002	24,877	4,462	2,062,158
Raipur	412,707	38,426	6,028	23,780	8,367	12,354	27,039	2,840	531,541
Varanasi	426,522	44,758	8,768	22,960	16,834	13,869	9,381	400	543,492
Vijayawada	340,614	40,323	2,935	11,853	23,025	2,398	3,397	724	425,269
Visakhapatnam	469,784	72,095	5,702	12,976	38,641	10,348	14,586	1,954	626,086

Source: Compiled by the author using data from http.www.indiastat.com

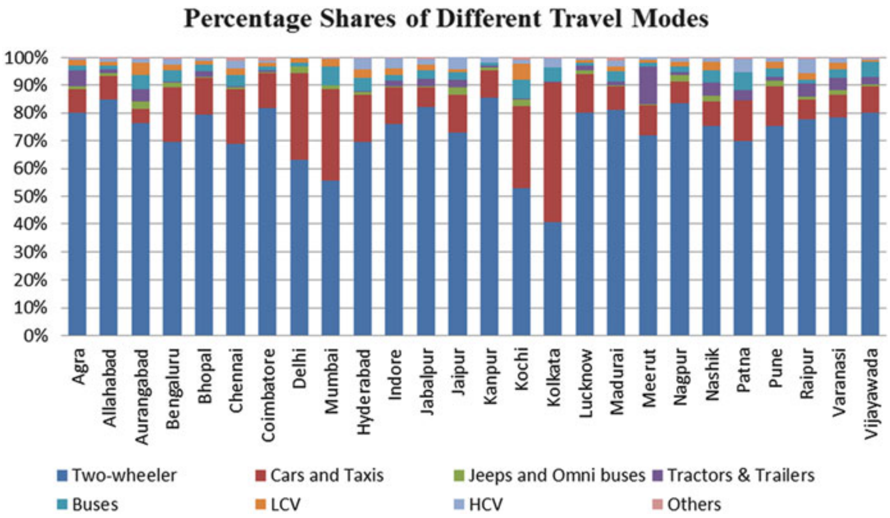

Fig. 2.2 Percentage shares of travel modes in different cities in the year 2012 (Source: Developed by the author using data from http.www.indiastat.com)

trends observed in the other cities are fast growing. The number of two-wheelers as a percentage of the total registered vehicles is considerably high among the small and industrialized cities like Pune, Surat, and Kanpur. Figure 2.2 presents the percentage share of each travel mode in various cities of India in the year 2012. City/public transport in small cities is fairly low compared to the megacities like Delhi and Mumbai. This could be due to the fact that the distance traveled to the workplace is considerably less in smaller cities compared to that of Delhi and Mumbai. Further, it could be attributed to the fact that these megacities have undergone a proper transportation planning and development of public transport so as to cater for impending travel needs, whereas the class II cities are still adapting add-on approach.

The share of public transport like buses and auto-rickshaws is high in megacities compared to the rest. Hyderabad shows alarming trends of growth in two-wheeler population, which is a dangerous indication of worsening ambient air quality.

2.2.2 *Vehicular Density*

Density of vehicles is presented as number of vehicles per thousand population. It indicates the vehicle ownership intensity of various cities/states in the country. For the entire country, the number of vehicles per 1,000 population is 109. Figure 2.3 presents the number of vehicles per 1,000 population for different states in India. Uttar Pradesh and Goa are the two states with very high vehicle density (vehicles per 1,000 population), while Bihar and West Bengal apart from the northeastern

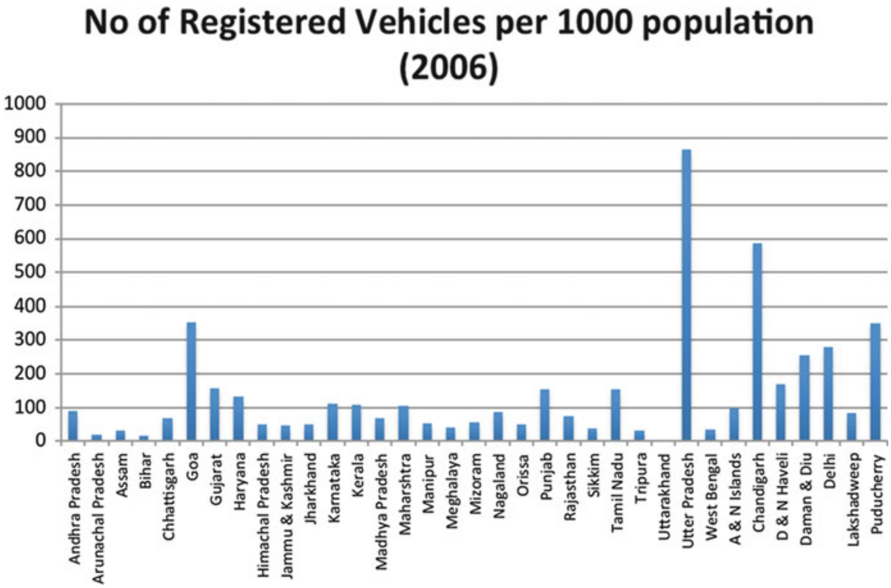

Fig. 2.3 Vehicle density (vehicles per 1,000 population) in different states (Source: Developed by the author using data from http.www.indiastat.com)

states are the lowest in vehicle density. Union territories except A & N Islands are very high on vehicle density. Increase in density results in road congestion particularly in urban centers.

2.2.3 *Travel Demand*

Different modes of vehicles have different occupancy rate. Hence, the effectiveness of any transportation mode is measured in terms of passenger kilometers (PKM)/ton kilometer (TKM) served by the respective mode. Two-wheelers have very poor occupancy (1.5 persons/vehicle) against buses (37 persons/vehicle). Passenger kilometers catered by buses are much higher than any other mode, and hence, they cover major share of the travel demand in many cities. Due to the high occupancy rate, emission per PKM is very low in the case of buses as compared to that of cars and two-wheelers. This makes the bus not only an effective transport mode but also environmentally efficient.

Owing to the rapid expansion of cities, PKM, an indicator of travel demand, is expected to grow by leaps and bounds in the major metropolitan cities in the years to come. In a study carried out by IGIDR employing econometrics and spreadsheet models, the total passenger travel demand in Delhi was estimated to increase from 73 PKM to 253 billion PKM during 1997–2020, registering an annual growth rate of 5.3 %. Freight travel demand is also expected to increase from 2.63 billion TKM to 7.18 billion TKM during the same period (IGIDR 2001). During the same period, total passenger travel demand for Mumbai is expected to grow from 32 billion to 137 billion PKM with an annual growth of 6.8 %. Flight travel demand is estimated to rise from 0.36 billion to 1.37 billion TKM. Therefore, transportation planning should aim not only to augment the infrastructure to support the increasing number of vehicles but also to improve public transport such as the metro rail system, monorail, and bus rapid transit system (BRTS).

Such systems are being implemented in all major metropolitan cities in India. In the absence of such mass transport means, the increasing travel demand can lead to more energy consumption and pollution generation. In spite of mass transport being promoted, personalized vehicle increases over time, and in order to minimize the pollution loads resulting from the increasing vehicle fleet and the use of poor-quality fuels, technological options will have to be explored in terms of improved automobile engines and fuels and also promotion of NMT.

2.2.4 *Road Density*

The number of vehicles per kilometer road length presents the infrastructure sufficiency. The average number of vehicles per kilometer road length for India is 31 (2011). Figure 2.4 presents the number of vehicles per 1,000 km road length for the different states in India. Uttar Pradesh has a very large number of vehicle

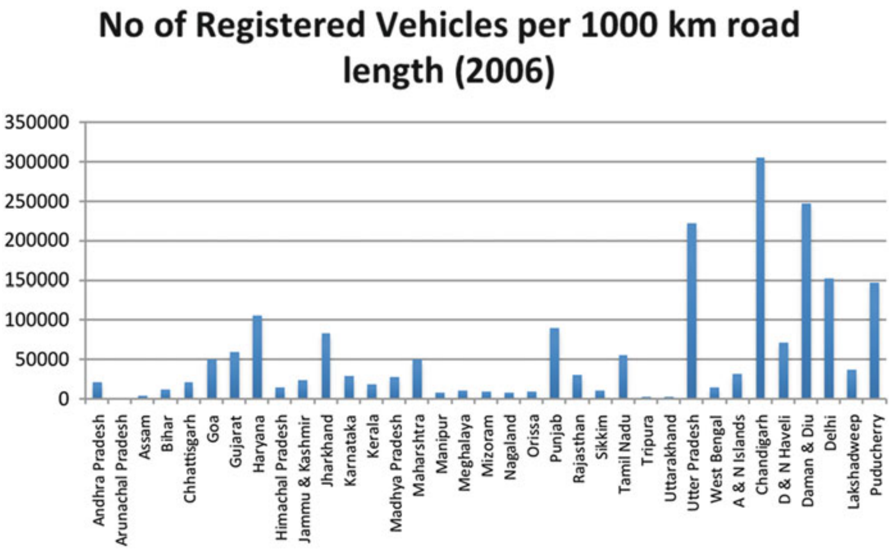

Fig. 2.4 Vehicle density (vehicles per 1,000 km road length) in different states (Source: Developed by the author using data from http.www.indiastat.com)

registers per 1,000 km road length in spite of the fact that Uttar Pradesh has a large road network. Punjab and Haryana follow UP on the number of vehicles per 1,000 km road length. All union territories exhibit high vehicle densities, which could be due to the twin effects of higher number of vehicles and low availability of road infrastructure. These indicators explain the congestion levels in Indian road transport sector.

The average density of roads (area of roads per 1,000 km^2 of land) in India is 965 km, and the per capita road density per 1,000 population (year 2008) is 2.77 km (excluding the roads under Jawahar Rojgar Yojana (JRY) and Pradhan Mantri Gram Sadak Yojana (PMGSY)). The road density in urban areas and rural areas is 3,893.48 and 920 km per 1,000 km^2, respectively. Road density per 1,000 population is 0.91 km and 3.55 km for urban and rural areas, respectively.

2.2.5 *Share of Different Modes in Providing Travel Service*

While the infrastructure development is more skewed toward motorized vehicles, NMT takes a major share of work trips in Mumbai and other cities in India. Table 2.3 presents the share of different modes used by the poor in their work trips. While 67 % of the poor uses NMT for their work trips, rail and bus cater for 30 % work trips. Urban poor are particularly dependent on NMT for various travel needs. Given the fact that it is used by the poor for their access to work and also the fact that it is the most energy efficient and environment and climate friendly, more emphasis should be given for the development of NMT in the future transportation planning. Chapters 5 and 6 discusses in detail the issues related to NMT.

2.3 Environmental Emissions from Road Transport and Ambient Air Quality

The old and poorly maintained vehicles and the growing vehicular stock result in increased environmental emission. The transport sector contributes a major share of environmental pollution (around 70 %). CO is the major pollutant coming from the

Table 2.3 Share of usage of different modes of transport by the poor in Greater Mumbai (in percentage)

Mode	Percentage share
NMT (foot and bicycle)	66.9
Rail	16.1
Public bus	14.5
Three-wheeler	1.3
Taxi	0
Two-wheeler	0.7
Car (own car+ other car)	0.2

Source: Compiled by the author from various sources

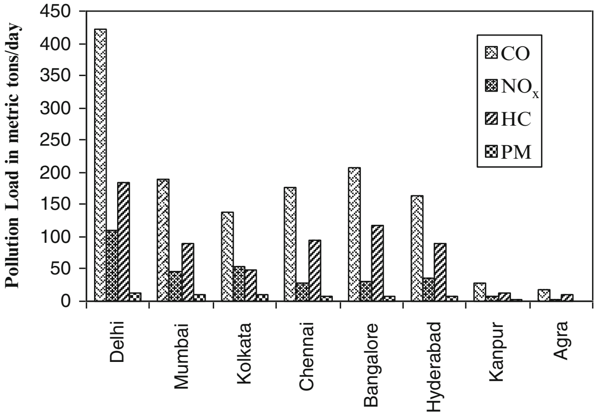

Fig. 2.5 Pollutant load from the transport sector in different cities in India (Source: Developed by the authors using data from CPCB 2012)

transport sector, contributing to almost 90 % of the total emission. Hydrocarbons follow closely. It is observed that the contribution of the transport sector to the particulate pollution is as less as 3–5 %. Most of the SPM is due to the resuspension. Pollutant emission levels have gone up substantially owning to the fast growth in vehicular stock. Delhi emits about 420 metric tons of CO everyday with almost 1,400 metric tons of total pollution every day. Daily emissions of various pollutants from the transport sector are presented in Fig. 2.5. Similar trends are observed in the other metropolitan cities such as Hyderabad, Bangalore, and Pune (Yedla 2004).

Apart from the increasing stock, it is also reported by many researchers that the growing trend of emissions is observed due to the fact that the vehicles are used for extended lifetime without proper maintenance. Ill-maintained vehicles tend to emit more pollutants than others. Improper inspection and maintenance, use of poor-quality fuels, poor road conditions, and increased congestion add to emissions. At present, owing to many initiatives from various sectors, most of the abovementioned factors are showing improvement.

2.3.1 Ambient Air Quality in Different Cities

The Central Pollution Control Board (CPCB) has been assigned various functions under the *Air Act* 1981 to plan nationwide programs for the prevention, control, and abatement of air pollutants. Accordingly, the *National Air Quality Monitoring Programme* (NAMP) had been initiated during 1984–1985 at a national level, which had been steadily expanded and at present comprises 290 monitoring stations covering 90 cities in 24 states and 5 union territories. The NAMP network is operated with the involvement of various agencies, viz., State Pollution Control Boards (SPCBs), CPCB headquarters and zonal offices, pollution control committees, and research institutes. The air quality parameters regularly monitored nationwide are SPM (8 hourly for 24 h), sulfur dioxide (SO_2), and nitrogen oxide (NO_x)

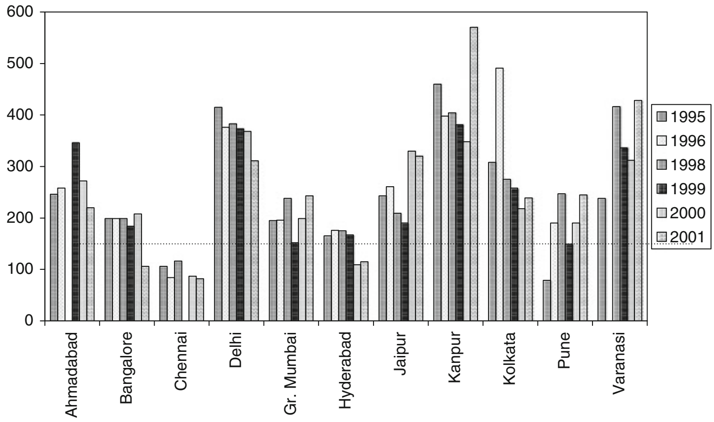

Fig. 2.6 Changes in SPM concentration (Source: Developed by the authors using data from CPCB 2012)

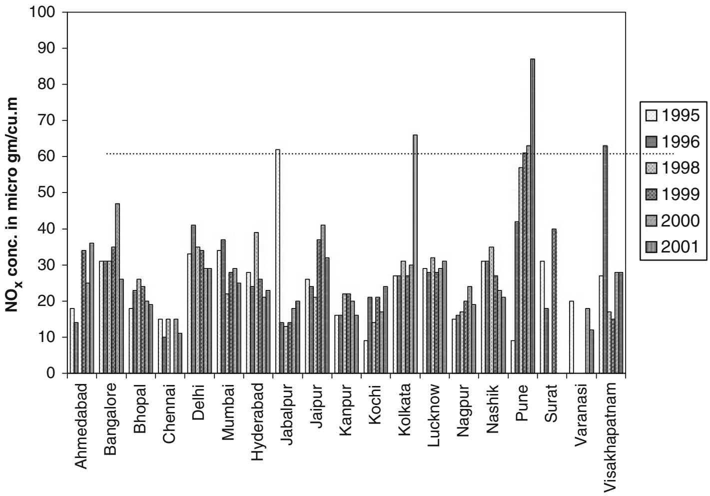

Fig. 2.7 Changes in NO_x concentration (Source: Compiled by the author using data from CPCB (2001) National Ambient Air Quality Monitoring Series (NAAQMS/8,10,15,21))

(4 hourly for 24 h), while additional parameters like carbon monoxide (CO), polycyclic aromatic hydrocarbons (PAH), ozone, respirable suspended particulate matter (RSPM), benzene, and trace metals are additionally monitored in Delhi and some other cities, but not in all the cities.

SPM is the most common air quality indicator, which exceeds the permissible level in many cities. SPM levels in different cities across the country from 1995 to 2001 are presented in Fig. 2.6. NO_x is another important air quality indicator whose dynamics are presented in Fig. 2.7. The variation in air quality is a mixed scenario

Table 2.4 Share of air pollution from different sectors

Pollutants	Sector contributing to pollution	Percentage contribution	
		Delhi	Mumbai
CO	Transport	76–90	92
	Industrial	37–13	8
	Domestic and others	10–16.3	0
NO_x	Transport	66–74	60
	Industrial	13–29	40
	Domestic and others	1–2	0
SO_2	Transport	5–12	2–4
	Industrial	84–95	82–98
	Domestic and others	0–4	0–16
PM	Transport	3–22	0–16
	Industrial	74–16	34–96
	Domestic and others	2–4	53–56

Adopted from the expert committee report on auto fuels (MoPNG 2002)

as some cities follow a rising trend with others experiencing an improvement. Kolkata, Bangalore, and Pune are experiencing a rise in NO_x over time. Delhi showed a steady fall after initial rise.

2.3.2 *Share of the Transport Sector*

Air pollution comes from various natural sources as well as anthropogenic sources. For certain pollutants like CO and HC, the major source has been anthropogenic, and others like SPM are contributed by natural sources. Even among anthropogenic sources of pollution, various sectors influence different pollutant levels in a different way. For instance, the transport sector contributes most of the CO emission. The industrial sector contributes most of SO_2. Table 2.4 presents the summary of share of various pollutants from different sectors. This depends on the location, activity, and prevailing meteorological conditions. As it can be observed from the table below, the share of sectors for various pollutants is different from Delhi to Mumbai.

2.3.3 *Vehicle Harboring and Pollution*

While the registered vehicles contribute to air pollution in urban centers, a major share of vehicles that are harbored outside the city center also contributes significantly to air pollution in urban areas. Most of the cities experience significant inflow of vehicles and passing of vehicles. In a study carried out by Central Road Research Institute (CRRI), Delhi, based on the fueling pattern and their garaging character, it was observed that a majority of commercial vehicles (trucks) filling fuel in the city fuel stations are garaged (housed) outside the city. This fact particularly influences the transportation planning and the emission estimation. Table 2.5 presents the details of garaging status by vehicle type in different cities. Most of the commercial vehicles have a major share garaging outside the city in almost all cities. It is interesting to observe that this fraction is almost two times in the case of Delhi. With the fact that commercial vehicles are more polluting and these are "unaccounted part" of the stock, Delhi ended up experiencing more pollution than the estimated levels. Among personal vehicles all cities have similar character except in the case of Hyderabad where the inflow of cars and two-wheelers is considerably high. This could be due to the fact that Hyderabad does not have suburbs. As a result people stay in neighboring places and commute to the city for daily needs. Hence, it is essential to account for this "nonresident" vehicle stock in the estimation of emission, infrastructure development, and also the transportation planning.

2.4 Alternatives Options in Urban Transportation

The following are the alternative fuels, technologies, and management measures attempted at improving transportation systems globally:

1. Natural gas vehicles (NGV) including liquefied petroleum gas (LPG)
2. Electric vehicles
3. Hybrid electric vehicles
4. Fuel cells
5. Hydrogen energy
6. Biofuels
7. Inspection and maintenance (I&M) and certification system
8. Retrofitting of emission control devices
9. Traffic management and construction of bypasses
10. Construction of metro rail, monorail, and BRTS

A detailed description and analysis of these alternatives is given in Chap. 4 of this book.

2.5 National Initiatives to Address Transportation Issues

Standards for controlling emission levels of new vehicles were incorporated into the Motor Vehicles Act (1989) as late as 1991, enforcing some quality control on the automobile industry. The mass emission standards refer to gram of pollutant

Table 2.5 Garaging status of vehicle type in different cities

	Garaging status (%)											
	Delhi		Mumbai		Kolkata		Chennai		Bangalore		Hyderabad	
Vehicle type	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
Cars	90.42	9.58	92.11	7.89	95.26	4.74	84.00	16.00	97.83	2.17	75.72	24.28
Two-wheelers	92.20	7.80	95.30	4.70	82.56	17.44	95.40	4.60	96.93	3.07	80.46	19.54
Autos	98.56	1.44	96.33	3.67	86.13	13.87	92.40	7.60	96.79	3.21	86.04	13.96
Buses	83.08	16.92	100.0	0.00	87.83	12.17	70.70	29.30	77.78	22.22	79.31	20.69
LCVs	73.53	26.47	94.46	5.54	83.65	16.35	66.00	34.00	83.76	16.24	53.53	46.47
HCVs	30.51	69.49	88.45	11.55	67.56	32.44	66.30	33.70	68.29	31.71	50.10	49.90
MCVs	35.62	64.38	70.31	29.69	66.66	33.34	71.70	28.30	50.00	50.00	65.85	34.15

Source: Compiled by the authors using data from different sources emitted per kilometer traveled under specified driving conditions as notified by the Ministry of Surface Transport and enforced by the State Transport Department. Though the Bureau of Indian Standards (BIS) for fuel started incorporating emission parameters, the standards were set according to the terms and conditions dictated by the industry. Both the regulatory authorities and the manufacturers pleaded incapacity to make any drastic improvements, and so the standards they followed were far too lax compared to those elsewhere in the world. In 1996, the government came up with mass emission standards for vehicles, which are stricter than earlier. Other measures during 1994–1996 aimed at improving emissions from the transport sector are the use of unleaded petrol and fitting of catalytic converters in the car to reduce CO emissions. Subsequently EURO I, II, and III norms also have been enforced followed by India's own emission standards Bharat Stage (MoPNG 2002; Yedla 2004).

Poor maintenance of vehicles adversely affects their emission efficiency. The role of maintenance in combating vehicular pollution was reflected in government policy for the first time in 1989, which made the certificate of fitness as mandatory for registration of public vehicles, commercial vehicles, and personal vehicles older than 15 years. The 1990 vehicular emission rules required all motor vehicles to comply with the laid-down exhaust emission standards. The transport department issues Pollution Under Control (PUC) certificates to vehicles. Vehicles owners are required to check the emission level of their vehicles every 3 months and obtain a PUC certificate. Vehicles failing to meet the standards are required to rectify the fault and obtain the certificate. The State Transport Authority fines vehicles not possessing a PUC certificate.

This is a step toward minimizing vehicular pollution by regular checks. This system, however, has come under severe public criticism due to the existing lacunae in the issue of certificates and the discrepancies in pollution readings from one station to another. Though there is a provision to levy a monetary fine of Rs 1,000 on motorists who fail to abide by the law, the enforcement has been very poor. Statistics maintained by the Automobile Association reveals that more than 50 % of vehicles in Delhi in May 1995 failed to comply with the prescribed standards. It is even more alarming that nearly 44 % of the new vehicles checked were found to be not in compliance with the standards. This shows that PUC despite being a potentially powerful instrument in controlling pollution from vehicles has failed to make an impact on vehicular pollution. This, apart from cutting down the emissions, actually created a lot of awareness among citizens for the environmental pollution.

The failure of the administration to enforce environmental regulations has led to judicial interventions. The Supreme Court has come up with several guidelines in the last few years. The Court has urged the government to accept the emissions standards EURO I, II, III, IV, etc. for the vehicles as adopted by the European Commission. India has developed its own standards, namely, Bharat Stage I, II, II, IV, etc. In last few years, the Supreme Court of India and High Court of Maharashtra and other states have issued a number of directives aiming at emission control, which are listed in Boxes 2.1 and 2.2.

Box 2.1: Directives of the Supreme Court Aiming at Environmental Emission Control

- Elimination of leaded petrol from NCT of Delhi by September 1, 1998.
- Phasing out of all commercial vehicles which are more than 15 years old by October 2, 1998.
- From June 1, 1999, Euro I norm was made effective for all private vehicles.
- No 8-year-old buses to ply except on CNG or other clean fuels by April 1, 2000.
- Entire city bus fleet to be steadily converted to single fuel mode on CNG by March 31, 2001.
- Replacement of all pre-1990 automobiles and taxis with new vehicles on clean fuels by March 31, 2000.
- From April 1, 2000, no vehicles will be registered in the National Capital Region, unless it conforms to EURO II norms.
- Supply diesel with 0.05 % sulfur content in the NCR from May 2002.
- Supply petrol with 1 % benzene content in the NCR from October 31, 2001.
- Supply of only premix petrol in filling stations to two-stroke engines by December 31, 1998.
- Ban on registering two-stroke vehicles from July 2000.
- All in-use vehicles with two-stroke engines will have to be fitted with catalytic converter.

Source: CPCB (1999)

Box 2.2: Recommendations by the Committee Constituted by Mumbai High Court

- The sulfur content in the entire diesel to be supplied in Mumbai City at all the petrol pumps should be reduced to 0.05 % by October 1, 2000. It should be further reduced to 0.035 % by April 1, 2003, and to 0.005 % by April 1, 2005.
- The benzene content in all the petrol supplied in Mumbai City at all the petrol pumps should be reduced from the present level of 3 % to less than 1 % by October 1, 2000.
- With effect from May 1, 2000, all new buses to be purchased by BEST should be CNG operated until EURO II-compliant engines become available in these new vehicles. BEST may exercise an option either to have

(continued)

Box 2.2: (continued)

CNG-operated buses or EURO II or higher version diesel engine buses in such a manner that by April 1, 2005, at least 1,000 buses are operated on CNG.

- Engines of all the existing BEST buses, which are not even EURO I compliant, must be changed to EURO II-compliant engines by October 1, 2002.
- With effect from January 1, 2001, all taxis above the age of 15 years must be converted to CNG or any other clean fuel. Further with effect from January 1, 2002, all diesel taxis above the age of 8 years should be converted to clean fuel.
- With effect from January 1, 2001, all three-wheelers above the age of 10 years should be converted on CNG or any other clean fuel. Further with effect from January 1, 2002, all three-wheelers above the age of 8 years should run on clean fuel.
- The present permissible limit of 4.5 % CO emission in respect of two- and three-wheelers should be reduced to 3 % with effect from October 1, 2000, for Mumbai City to bring it at par with the CO emission level of four-wheelers.
- All heavy commercial vehicles as well as light good vehicles to be registered in the Mumbai Metropolitan Region from April 1, 2000 must be EURO II compliant.
- With effect from January 1, 2001, all two-wheelers registered in Mumbai Metropolitan Region and which are more than 15 years old shall be scrapped and their registration deemed to have been canceled.
- With effect from January 1, 2001, all three-wheelers registered in Mumbai Metropolitan Region and which are more than 10 years old shall be scrapped unless converted to clean fuel.
- With effect from January 1, 2001, all transport vehicles other than three-wheelers and BEST buses over the age of 15 years shall be scrapped unless converted to clean fuel.
- All two-stroke two- and three-wheeler in-use vehicles in Mumbai should be fitted with a catalytic converter by July 1, 2001.
- All petrol-driven vehicles registered in Mumbai prior to April 1, 1995, should be fitted with a catalytic converter by July 1, 2001.
- All catalytic converters supplied by the manufacturers for two-wheelers will carry a warranty of effective working of the catalytic converter over a distance of 30,000 km.

Source: CPCB (1999)

Apart from regulatory and judicial moves toward pollution control, there are a number of national initiatives. Two of such major national initiatives toward emission control are enforcement of supply of unleaded petrol (gasoline) and low sulfur diesel in the entire country, though implemented in phases. These initiatives implemented in April 1, 2000, and 1999 respectively have come out with visible positive impacts on environmental quality especially in Delhi.

Unleaded Petrol (*Gasoline*): The specification of lead in Indian petrol used to be 0.56 g/l max in 1994. Lead has been phased out from gasoline gradually, and by February 2000, only unleaded petrol is produced and sold in the entire country. In the developed countries, lead phasing out was spread over a period of 10–20 years. China and many other countries in the Asia-Pacific region and in Europe, South America, and Africa have not phased out lead as yet. However, India has achieved this within a span of 6 years.

Reduction of Sulfur Content in Diesel: This desulfurization program has resulted in the reduction in sulfur content by 75 % in 4 years. It has been brought down from 1.0 % to 0.25 % in the entire country in a period of 4 years (1996–2000). The Government had approved setting up of nine diesel hydrodesulfurization (DHDS) plants in nine refineries for reducing the diesel sulfur content at a total cost of Rs. 5,568.31 crore in June 1997. This has enabled supply of diesel with 0.25 % max. sulfur in the entire country from January 1, 2000. Further, in the four metro towns, sulfur content in diesel has been further reduced to 0.05 % (accounting to 95 % reduction). Detailed schedule of unleaded petrol and low sulfur program is presented in Box 2.3.

Subsequently, the Government of India has constituted a committee to look into transportation fuels in a comprehensive assessment, and the committee came up

Box 2.3: Gasoline Lead Phase-Out Program in India

Phase I	1.6.1994	Low leaded (0.15 g/l)	Cities of Delhi, Mumbai, Calcutta, and Chennai
Phase II	1.4.1995	Unleaded (0.013 g/l)	Cities of Delhi, Mumbai, Calcutta, and Chennai
Phase III	1.1.1997	Low leaded (0.15 g/l)	Entire country
Phase IV	1.9.1998	Ban on leaded fuel	NCT of Delhi
Phase V	31.12.1998	Unleaded (0.013 g/l)	All capitals of states/UT and other major cities
Phase VI	1.1.1999	Unleaded only	NCR
Phase VII	1.4.2000	Unleaded	Entire country

(continued)

Box 2.3: (continued)

Diesel sulfur phase-out program in India

Phase I	1.4.1996	Low sulfur (0.5 %)	Four metros and Taj Trapezium
Phase II	1.8.1997	Low sulfur (0.25 %)	Delhi and Taj Trapezium
Phase III	1.4.1998	Low sulfur (0.25 %)	Metro cities
Phase IV	1.4.1999	Low sulfur (0.25 %)	Entire country

Source: Basu (2001) and CPCB (1999)

with a detailed auto fuel policy (MoPNG 2002) prescribing a number of standards for Indian automobiles and also for different types of fuels.

With the above initiative, a reduction in vehicular emission load was observed and also improvement in ambient air quality.

With the increasing awareness and need to address the issue of urban transportation and the related issues, the Government of India has come up with National Urban Transportation Policy (NUTP) in 2006. NUTP outlines comprehensive guidelines for the State Governments in their preparation of transportation systems. NUTP is the first integrated approach toward urban transportation planning. The objective of this policy is to ensure safe, affordable, quick, comfortable, reliable, and sustainable access for the growing number of city residents to jobs, education, recreation, and such other needs within our cities. The details of NUTP are presented in Chap. 8.

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