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Urban transport crisis in India

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Abstract

Indian cities face a transport crisis characterized by levels of congestion, noise, pollution, traffic fatalities and injuries, and inequity far exceeding those in most European and North American cities. India's transport crisis has been exacerbated by the extremely rapid growth of India's largest cities in a context of low incomes, limited and outdated transport infrastructure, rampant suburban sprawl, sharply rising motor vehicle ownership and use, deteriorating bus services, a wide range of motorized and non-motorized transport modes sharing roadways, and inadequate as well as uncoordinated land use and transport planning. This article summarizes key trends in India's transport system and travel behavior, analyzes the extent and causes of the most severe problems, and recommends nine policy improvements that would help mitigate India's urban transport crisis.

1. Overall situation in developing countries

Although the word 'crisis' has been used to describe transport problems in European and American cities, the term seems far more appropriate for cities of the developing world. Environmental pollution, noise, traffic fatalities and injuries, congestion, and mobility problems are far more severe in developing countries, making the problems in Europe and North America seem quite modest by comparison (Gakenheimer, 1999; Gwilliam, 2003; Pendakur, 2002; Pucher and Lefevre, 1996; Silcock, 2003; Vasconcellos, 2001).

Developing countries have several factors in common that contribute to the severity of their transport problems. Overall population growth and increasing urbanization have led to the especially rapid growth of large cities, which have been overwhelmed by the sudden jump in travel demand. The supply of transport infrastructure and services, by comparison, has lagged far behind demand. Public sector finances, in general, are so limited that funding for transport improvements is woefully inadequate. Most transport facilities are used far beyond their design capacity. Moreover, facilities for pedestrians and cyclists are virtually non-existent in most cities, thus forcing them to share crowded rights of way with rapidly moving motor vehicles.

The problem of overall low per-capita incomes in developing countries is compounded by extreme income inequality. The wealthiest tenth of the population typically earns over half of total national income (Vasconcellos, 2001). Much of the population is so poor that it cannot afford any motorized transport at all and must spend up to three or even 4 h a day for travel. Moreover, the concentration of wealth among an economic and political elite has distorted transport policies in all developing countries. While the poor suffer the most from severe and worsening transport problems in cities, government policies generally focus on serving the needs of an elite minority. For example, a disproportionate share of government funds is spent facilitating the ownership and use of private cars, while the needs of mostly low-income pedestrians and cyclists are ignored. Similarly, public transport does not get the funding or traffic priority it needs because the elite do not use it.

Rapid growth, low incomes, and extreme inequality are among the main underlying causes of transport problems in developing countries. Although the nature and extent of transport problems obviously vary from one country to another, virtually all developing countries suffer from the following:

- Unplanned, haphazard development at the suburban fringe without adequate infrastructure, transport, and other public services

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- Limited network of roads, often narrow, poorly maintained, and unpaved
- Extremely congested roads with an incompatible mix of both motorized and non-motorized vehicles traveling at widely different speeds
- Rapidly increasing ownership and use of private cars and motorcycles
- Inadequate roadway accommodations for buses and non-motorized transport
- Primitive or non-existent traffic control and management, often without even the most basic street signage
- Extremely high and rapidly rising traffic fatalities, especially among pedestrians and motorcyclists
- Overcrowded, uncomfortable, undependable, slow, uncoordinated, inefficient, and dangerous public transport
- Extremely high levels of transport-related pollution, noise and other environmental impacts, especially in large cities

As documented in this article, Indian cities share all these problems of developing countries. We examine the range of urban transport problems in India as they relate to trends in urban development and travel patterns. In the process, we also offer a critical analysis of public policies and how they might be improved.

2. Urban conditions in India

The most important factors common to India and other developing countries are population growth, increasing urbanization, rising motorization, and low per-capita income. The total urban population of India burgeoned over the past three decades, rising from 109 million in 1971 to 160 million in 1981 (+47%), 217 million in 1991 (+36%), and 285 million in 2001 (+31%) (Office of the Registrar General of India, 2001a; Padam and Singh, 2001). The largest cities have grown especially fast. By 2001, India had three megacities: Mumbai (Bombay) with 16.4 million inhabitants, Kolkata (Calcutta) with 13.2 million inhabitants, and Delhi with 12.8 million inhabitants. Chennai (Madras), Hyderabad, and Bangalore each had more than 5 million residents. And 35 metropolitan areas had populations exceeding one million, almost twice as many as in 1991 (Office of the Registrar General of India, 2001b).

The rapid growth of India's cities has generated a correspondingly rapid growth in travel demand, overwhelming the limited transport infrastructure. The sharply increasing levels of motor vehicle ownership and use, in particular, have resulted in alarming levels of congestion, air pollution, noise, and traffic danger. For most segments of the population, mobility and accessibility have declined.

India's poor have been especially disadvantaged. They have such low incomes that they cannot even afford public transport fares and thus must walk or cycle long distances. In 2002, the per-capita income of India was the equivalent of only US $2,600 (purchasing power parity), less than a tenth of average incomes in countries of North America and Western Europe (Central Intelligence Agency, 2002). With 26% of the population below the poverty line in 1999–2000 (Ministry of Finance, 2002), roughly a fourth of urban residents cannot afford the basic necessities of life, including virtually any form of public transport or even a bicycle. The urban poor live in congested slums in older, deteriorating inner-city areas or in illegal squatter settlements on the outskirts of cities. Those living near the center suffer not only from overcrowded housing but also from high levels of air pollution, noise, congestion, and traffic danger. The poor living on the suburban fringe must endure ramshackle housing conditions, largely non-existent public services, and long, time-consuming trips to menial jobs in other parts of the city.

While the poor are especially disadvantaged, the Indian middle class also struggles with inadequate housing and transport. The unavailability of good, affordable housing near the center forces a rising proportion of the middle class to live in distant suburbs. Such peripheral locations require long, exhausting commutes to jobs using either slow, overcrowded public transport or dangerous motorcycles. Even the affluent Indians who own private cars must endure long commutes on hopelessly congested and unsafe roadways.

3. Trends in land use

As Indian cities have grown in population, they have also spread outward. Indeed, the lack of effective planning and land-use controls has resulted in rampant sprawled development extending rapidly in all directions, far beyond old city boundaries into the distant countryside. That has greatly increased the number and length of trips for most Indians, forcing increasing reliance on motorized transport. Longer trip distances make walking and cycling less feasible, while increasing motor vehicle traffic makes walking and cycling less safe.

Most public policies in India encourage sprawl. In an explicit attempt to decongest city centers, government regulations limit the ratio of floor areas to land areas for buildings in the center, and thus restrict the heights of buildings and density of development in the center. For example, the so-called 'floor space index (FSI)' in sampled city centers in India was only 1.6, compared to indices ranging from 5 to 15 in other Asian city centers (Bertraud, 2002; Padam and Singh, 2001). By contrast, government regulations permit higher floor space/land area ratios in suburban developments, thus further inducing firms to decentralize. Indeed, local governments in the suburbs advertise the less stringent land-use regulations there to lure economic development to their jurisdictions. Such land-use policies obviously discourage development in the center and force both firms and residences to seek locations on the suburban fringe. Moreover, local governments have

permitted scattered commercial and residential development in outlying areas without the necessary infrastructure such as roads, public transport, and hospitals. Such sprawled development generates long trips between residences and almost all other trip destinations.

Just as in North America, most new commercial development is in the distant suburbs. For example, Tidal Park is a software center on the outskirts of Chennai; Gurgaon is a large new industrial area outside Delhi; and Pimpri-Chinchwad is a similar center outside of Pune (Bertraud, 2002). Similarly, Bangalore is planning several technology parks on its fringe as well as several circumferential highways in the suburbs, both of which will induce further decentralization. In most cases, there is inadequate transport infrastructure to serve these new suburban developments and the residences located around them. Ramachandran (1989) characterizes Indian suburbs as an 'uncontrolled mix of industrial development, dumps and obnoxious uses,' with the 'extension of urban settlement causing conditions in the overtaken villages to deteriorate, both physically and socially.' The leap-frog development typical of suburban sprawl tends to follow major highways out of Indian cities to the distant countryside.

Low-density, sprawled decentralization causes enormous problems for public transport. Just as in North America and Europe, it generates trips that are less focused in well-traveled corridors and thus more difficult for public transport to serve. In India, it has led to rapid growth in car and motorcycle ownership and use and thus increasingly congested roadways that slow down buses, increase bus operating costs, and further discourage public transport use.

4. Trends in travel behavior

As in most developing countries, a high percentage of travel in Indian cities is by walking or cycling, mainly because much of the population is too poor to afford motorized transport. Walking and cycling are most important in smaller cities, accounting for over two-thirds of all trips (see Fig. 1). As city size increases and trip distances become longer, the relative importance of walking and cycling falls to about half of all trips in medium-sized cities and about a third in the largest cities. There is considerable variation, however, even within city-size categories. Among the megacities, for example, walking and cycling are much less common in Mumbai than in Delhi, perhaps due to Mumbai's superior public transport system. Among the smaller cities, Kanpur and Lucknow have much higher proportions of walking and cycling than Pune, which has a very high level of motorcycle ownership and use (due to a large middle class), as well as extensive charter bus services organized by Pune's industrial firms for their employees (Pune Municipal Corporation, 2004). By comparison, Kanpur and Lucknow have much lower levels of motorcycle use (due to lower incomes) and minimal bus services. Instead, they rely on a mix of paratransit modes such as auto rickshaws, cycle rickshaws, jeep taxis, and tempos (large auto rickshaws).

As of 2002, private motorized transport (mainly cars and motorcycles) accounted for a small but rapidly growing percentage of travel, about 10–20% of all trips (see Fig. 1). There are no reliable time-trend data on modal split distributions, but the statistics on vehicle fleet sizes in

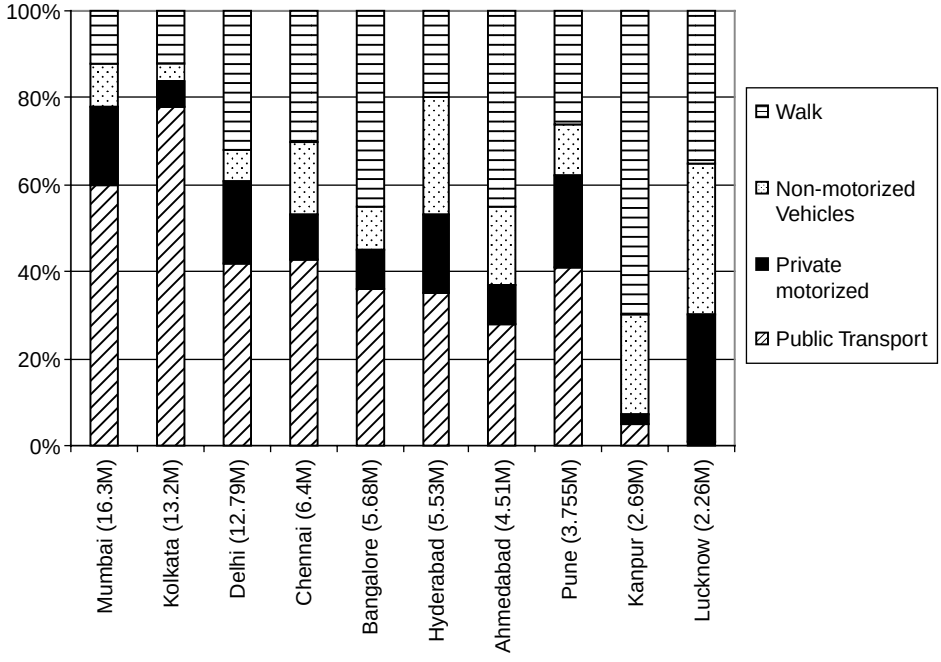

Fig. 1. Percent distribution of urban trips by means of travel for selected Indian cities, 2002. (Sources: Pendakur 2002 and World Bank 2002.)

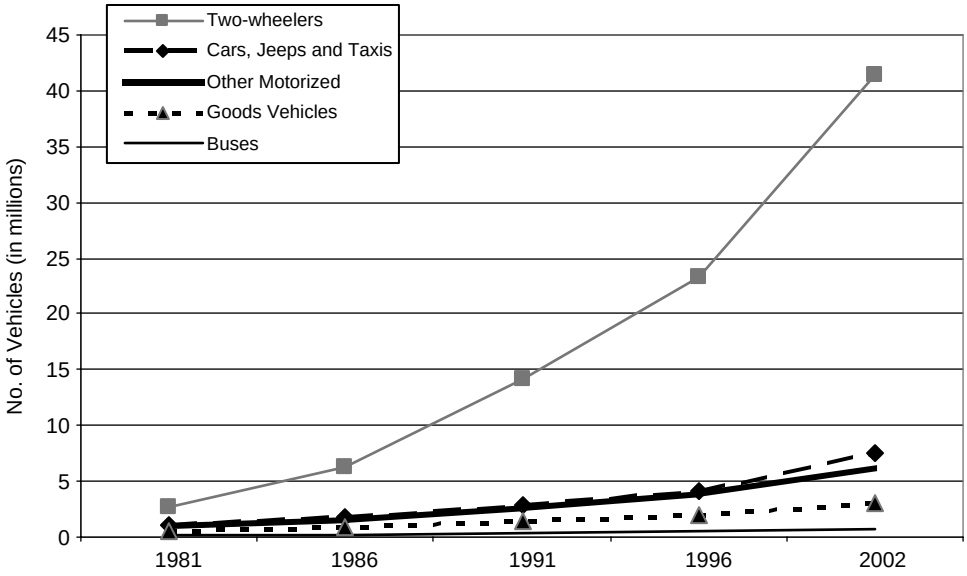

Fig. 2. Growth of India's motor vehicle fleet by type of vehicle, 1981–2002 (in millions). (Source: Ministry of Road Transport and Highways, 1999, 2000, 2003). Note: "others" includes tractors, trailers, motorized three-wheelers (passenger vehicles) such as auto rickshaws and other miscellaneous vehicles that are not separately classified.

Fig. 2 dramatize the extremely rapid growth of motorcycle ownership, which increased 16-fold between 1981 and 2002. Private car ownership increased almost 7-fold during the same period. The sprawling, low-density development around Indian cities has made cars and motorcycles increasingly necessary to get around, especially given the unsatisfactory alternative of slow, overcrowded, undependable, and dangerous public transport services. At the same time, rising incomes among the Indian middle and upper classes have made car and motorcycle ownership increasingly affordable.

While poverty is still a major problem for much of the population, real per-capita income in India grew by 37% from 1980–81 to 1990–91 (in excess of inflation) and by 40% from 1990–91 to 2000–01 (Ministry of Finance, 2004). Over the entire period 1980 to 2000, overall purchasing power of the average Indian almost doubled. That economic growth probably benefited the middle and upper classes the most, especially spurring growth in motor vehicle ownership. Nevertheless, lower-income classes have benefited as well. Indeed, the portion of India's urban population living in poverty fell by half during the last quarter of the 20th century, from 49% in 1974 to 24% in 2000 (see Fig. 3).

In recent years, public transport has not grown nearly as rapidly as private transport. Over the long term, however, the demand for public transport services has increased considerably, mainly due to the burgeoning growth of India's cities, both in population and land area. That has increased both the number and length of public transport trips.

The best statistics for public transport in India are for suburban rail services, because they are publicly owned, centrally administered, and operated throughout the country by Indian Railways. As shown in Fig. 4, suburban rail usage has increased sharply over the past five decades, with a 14-fold growth in passenger km of travel (Indian Railways, 2001). There are no comprehensive national statistics on bus service supply (i.e. bus km of service), let alone the number of riders (i.e. trips or passenger km). Nevertheless, nationwide aggregate statistics on the size of the bus fleet indicate substantial growth over the past two decades, with a 313% increase from 1981 to 2002 (Ministry of Road Transport and Highways, 2003). Similarly, the fragmented statistics for individual cities suggest considerable growth. From 1990 to 2000, for example, there was an 86% increase in the size of Mumbai's bus fleet, and a 54% increase in Chennai's bus fleet. The size of Delhi's public bus fleet actually fell during

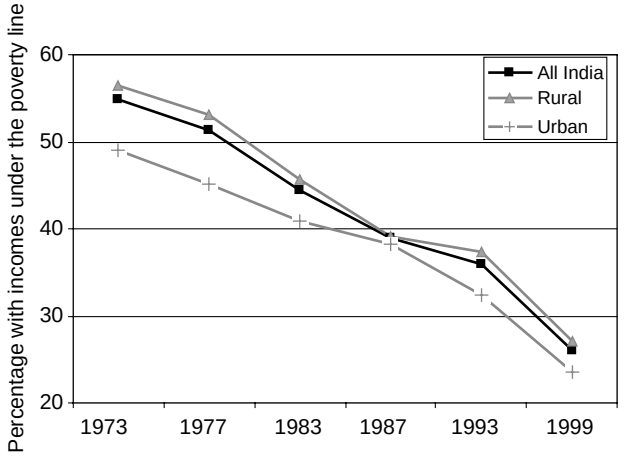

Fig. 3. Declining Percentage of Indians Living in Poverty, 1973–2000. (Source: India Budget, 2001).

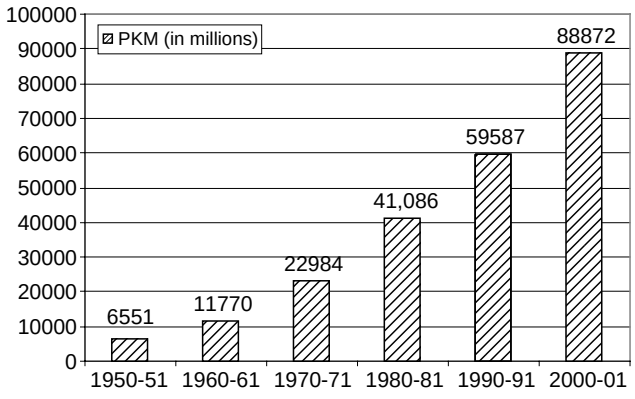

Fig. 4. Growth in Suburban Rail Travel in Indian Cities, 1951 to 2001 (in millions of passenger km). (Source: Indian Railways, 2002).

the 1990s, but the number of private buses rose by almost twice as much, yielding a net 28% increase (Association of State Road Transport Undertakings, 2002; Marwah et al., 2001).

Referring back to Fig. 2, one can see that the overall increase in the size of the total bus fleet in India has been slower than increases in private motorized vehicles. While the total number of buses quadrupled from 1981 to 2002, the number of motorcycles increased 16-fold, the number of cars increased 7-fold, and the number of goods vehicles increased 5-fold. Thus, buses account for a smaller and smaller percentage of total motorized vehicles on India's roads—only 1.1% in 2002 (Ministry of Road Transport and Highways, 2003).

Buses carry over 90% of public transport in Indian cities. Indeed, most Indian cities have no rail transport at all and rely instead on a combination of buses, minivans, auto rickshaws, cycle rickshaws, and taxis. Even in most of the largest cities, rail transport carries less than a third of public transport passengers. The only exception is Mumbai, which has India's most extensive suburban rail network, carrying over 5 million passengers a day—58% of total public transport passengers in the region (vs. 42% by bus) and 80% of total passenger km (vs. 20% by bus) (Brihanmumbai Electric Supply and Transport, 2003; Indian Railways, 2002, 2003).

In general, the larger the city size, the higher the percentage of urban trips served by public transport in India: averaging 30% in cities with population between 1 and 2 million, 42% for cities with populations between 2 and 5 million, and 63% for cities with populations over 5 million (Sreedharan, 2003). Thus, the especially rapid growth of large cities suggests a further rise in future demands for public transport in India.

As shown by Fig. 1, however, there is substantial variation among cities of the same size category. Almost 80% of all trips in Kolkata are by some form of public transport, compared to about 60% in Mumbai, and 42% in both Chennai and Delhi. Differences in land use and roadway supply explain some of the variation. Delhi and Chennai are lower-density, more polycentric, and more spread out than Mumbai and Kolkata. Delhi also has a particularly extensive roadway network, while the supply of roadways in other large Indian cities is much more limited. For example, 21% of Delhi's total land area is devoted to roads, compared to only 11% in Mumbai and 5% in Kolkata. Mumbai and Kolkata also have more restricted geographies, since both are situated on peninsulas that channel travel and land use development in only a few directions. Such focused travel corridors especially encourage suburban rail use, as in Mumbai. Delhi has no such geographic restrictions and sprawls out in all directions. Thus, Delhi currently relies primarily on auto rickshaws, motorcycles, taxis, and private cars to serve the multi-destinational, less-focused travel patterns of its residents.

The range of public transport services available also varies considerably, even among the largest categories of cities. Only Mumbai, Kolkata, and Chennai have extensive suburban rail services. Delhi has limited suburban rail services. Until recently, Kolkata had India's only underground metro system (16.5 route km), but Delhi is currently constructing a far more extensive metro (62.5 route km) (Delhi Metro Rail Corporation, 2003; Metro Railway Kolkata, 2003). Chennai has a hybrid surface and elevated metro, designated as Mass Rapid Transport System, which currently extends 8.6 km and is being expanded by another 11.2 km (Southern Railway, 2003). Finally, Kolkata has India's only remaining tram system, a 68-km double-track network of old, seriously deteriorating tracks and vehicles.

As noted previously, buses account for most public transport services, even in these large cities, and for virtually all public transport services in cities with less than 5 million residents. Moreover, all Indian cities feature large numbers of auto rickshaws (three-wheeled motorized, minicars), taxis, and cycle rickshaws (human-powered carts).

5. Urban transport problems

Indian cities are plagued by a range of transport problems. In this section, we briefly describe and, where possible, quantify the most severe problems.

5.1. Traffic injuries and fatalities

Traffic crashes in Indian cities pose a severe public health problem, resulting each year in about 80,000 deaths, 1.2 million serious injuries (requiring hospital visits), and 5.6 million minor injuries (Mohan, 2004; Ministry of Road Transport and Highways, 1999, 2000, 2003; Tiwari, 2001; Tiwari and Mohan, 1999). As shown in Table 1, the number of traffic fatalities has increased more than 5-fold since 1971. Even controlling for population growth in India, the

traffic fatality rate per million inhabitants has tripled over the past three decades, so that the average Indian is now over three times as likely to be killed in a traffic accident.

The burgeoning fleet of motor vehicles is clearly the main reason for this shocking death toll in traffic crashes. With India's 20-fold increase in the combined number of cars, taxis, trucks, and motorcycles from 1971 to 2001, it was virtually inevitable that traffic crashes would increase as well. Fatalities, in particular, increase with rising motor vehicle use, since the likelihood of fatal injuries increases sharply with speed (Mohan, 2004).

Aside from the increase in motor vehicle ownership and use, several other factors contribute to the safety problem:

- inadequate road supply and quality, often unpaved and in bad repair;
- unsafe driving behavior—which results from virtually non-existent driver training, extremely lax licensing procedures, and lack of traffic law enforcement;
- unsafe vehicles;
- inadequate or non-existent traffic signals and signage and lack of traffic management;
- almost complete lack of infrastructure for pedestrians and cyclists;
- forced sharing of narrow, crowded rights of way by both motorized, non-motorized vehicles, pedestrians, animals, and street vendors;
- overcrowding of buses, auto-rickshaws, and even motorcycles.

Whatever the safety problem faced by car drivers, it is far exceeded by the more dangerous situation facing motorcyclists, bicyclists, and pedestrians, who together account for roughly three-fourths of all traffic fatalities. The relative traffic dangers of each mode are indicated in Fig. 5, which compares each mode's share of total fatalities with its share of total trips in Delhi (Tiwari and Mohan, 1999). Motorcycles and bicycles each account for more than twice the share of total fatalities as their share of total trips and are clearly the most dangerous modes. Pedestrians account for a slightly higher percent of fatalities than their share of total trips. By comparison, cars, taxis and buses appear to be the safest modes, with their share of fatalities less than a third of their share of total trips.

Over 50% of traffic fatalities in Delhi are pedestrians, 10% are bicyclists, 21% are motorcyclists, and only 3% are car occupants. The situation is considerably different in Mumbai, perhaps due to its higher density, more extensive public transport network, and more limited roadway supply. Almost 80% of traffic fatalities in Mumbai are pedestrians, 7% are bicyclists, 8% are motorcyclists, and only 2% are car occupants (Mohan, 2004).

While the situation in other Indian cities surely varies somewhat from that in Delhi and Mumbai, pedestrians and bicyclists account for more than half of all traffic fatalities in all Indian cities. Motorcycle and scooter users account for another 10–20% of fatalities in cities. Car occupants, by comparison account for only about 5% of fatalities. Even on India's highways, pedestrians and bicyclists account for 45% of all fatalities, with motorcyclists accounting for another 24% (Mohan, 2004).

In addition to roadway safety problems, hundreds of Indians are killed every year illegally crossing rail tracks at stations, along rail lines, and around closed gates. Railroad crossing gates are easy to get around and under, thus permitting dangerous crossings by pedestrians, bicyclists, motorcyclists, and cycle rickshaws. Moreover, railroad rights of way are not adequately fenced-off, which allows

Table 1
Number of vehicles, population and road traffic fatalities in India

Year	Vehicles (millions)	Population	Fatalities (1000s)	Fatalities per 1000 vehicles	Fatalities per million population
1971	1.865	548,159,652	15	8.04	27.36
1975	2.472	625,246,123	16.9	6.84	27.03
1981	5.391	683,329,097	28.4	5.27	41.56
1985	9.17	772,196,737	39.2	4.27	50.76
1991	21.374	843,930,861	56.6	2.65	67.07
1992	23.507	861,693,859	59.7	2.54	69.28
1993	25.505	879,279,448	60.6	2.38	68.92
1994	27.66	897,223,927	64	2.31	71.33
1995	30.295	915,534,620	70.7	2.33	77.22
1996	33.558	934,219,000	71.9	2.14	76.96
1997	37.231	949,200,000	75	2.01	79.01
1998	41.368	965,600,000	80	1.93	82.85
1999	44.857	1,000,848,550	82	1.82	82
2000	48.857	1,016,118,000	78.9	1.61	77.65
2001	54.991	1,027,015,247	80	1.45	77.89

Source: Ministry of Road Transport and Highways (2003): motor vehicle statistics and statistics of road accidents in India and http://morth.nic.in/motorstat/mt3.pdf.

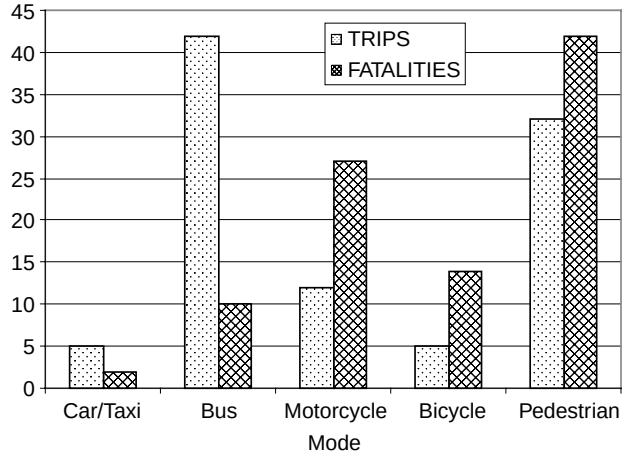

Fig. 5. Percentage distribution of trips by means of transport compared to distribution of traffic fatalities, 1994, Delhi. (Source: Tiwari, Geetam and Mohan, Dinesh, 1999).

pedestrians to risk their lives crossing tracks and permits squatters to live in immediate proximity to moving trains.

5.2. Environmental pollution

Noise, air, and water pollution are all serious problems in Indian cities, and transport sources contribute to all three kinds. The most reliable and comprehensive statistics are for air pollution. As shown in Fig. 6, levels of air pollution concentrations are highest for suspended particulate matter (SPM) and respirable suspended particulate matter (RSPM), which exceed World Health Organization (WHO) air quality standards, as well as official Indian government standards, for all of the cities shown (Bose, 1998; Vasconcellos, 2001; Padam and Singh, 2001; Ministry of Petroleum and Natural Gas, 2002; Sibel and Sachdeva, 2001). Indeed, for India's three largest cities, SPM and RSPM levels are three to four times higher than the WHO's maximum acceptable levels, and among the highest in the world, indicating a very severe health hazard (World Health Organization, 2000; Kandlikar and Ramachandran, 2000). While levels of CO, NO_x, and SO_x are generally considered moderate to low in most Indian cities, ozone levels have been increasing in virtually all Indian cities, causing a range of respiratory illnesses and irritation.

Airborne lead pollution has dramatically fallen over the past decade with the gradual phasing out of leaded gasoline from 1995 to 2000. Similarly, the Indian government has sharply reduced the allowable sulfur content in both gasoline and diesel fuels, resulting in large reductions in ambient concentrations of SO_x in all large Indian cities since 1995. Finally, the benzene content of gasoline has been limited by government regulation since 2000 (Ministry of Petroleum and Natural Gas, 2002).

One important source of air pollution remains the large and mostly old fleet of motorized two-wheelers (motorcycles and scooters) and three-wheelers (auto rickshaws) with highly inefficient, poorly maintained, very polluting 2-stroke engines (Tata Energy Research Institute, 1997). Since many auto rickshaw drivers illegally adulterate their gasoline fuel with up to 30% kerosene and 10% lubricating oil, the pollution they generate is yet further increased (Kandlikar and Ramachandran, 2000).

Diesel buses, trucks, and some taxis are the biggest transport sources of particulate pollution, but they are joined by substantial industrial emissions of particulates and also from atmospheric dust, especially in northern India, which is drier and dustier than southern India. The Indian Government has tried to mitigate particulate pollution by mandating conversion of all buses, auto rickshaws, and taxis in Delhi to CNG fuel by January 2001. Although well-intentioned, the sudden shift led to massive disruptions as well as corruption to avoid compliance (Environmental News India, 2001).

Most of the recent progress in reducing air pollution has resulted from the regulations requiring cleaner fuels. Of course, even more improvement would result from a massive shift to newer vehicles with less polluting engines, but that remains unaffordable for most Indians. Outlawing older and more polluting vehicles could have negative consequences for those who rely on them for mobility as well as employment (Raj, 2001).

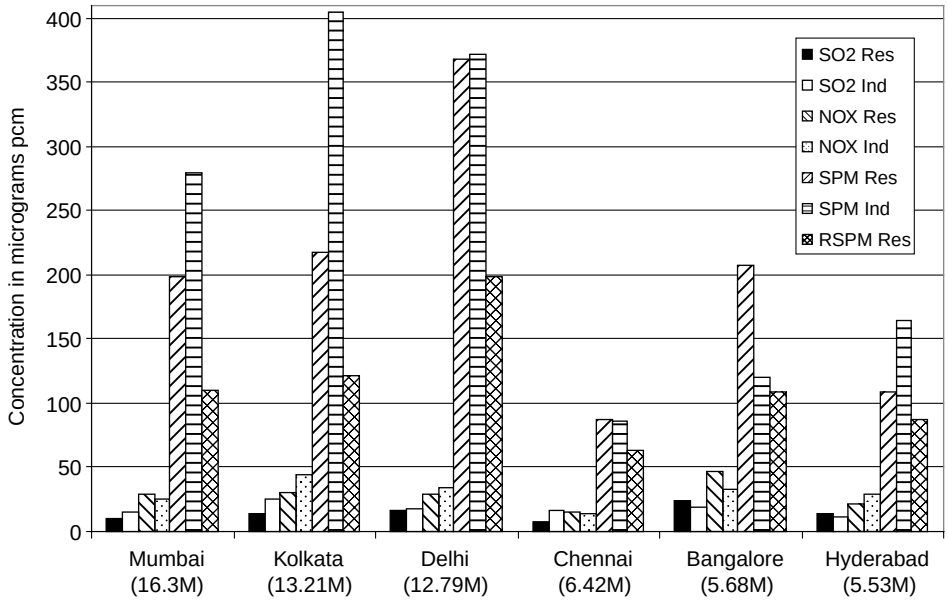

Fig. 6. Air Pollution Levels in the Largest Indian Cities, 2000. (Source: Ministry of Petroleum and Natural Gas, 2002.) Note: Shown are average ambient air pollution concentrations in Indian cities, measured in micrograms per cubic meter.

5.3. Roadway congestion

Traffic congestion is probably the most visible, most pervasive, and most immediate transport problem plaguing India's cities on a daily basis. It affects all modes of transportation and all socioeconomic groups. Most estimates as well as anecdotal impressions suggest rapidly worsening congestion. For example, average roadway speeds for motor vehicles in Mumbai fell by half from 1962 to 1993, from 38 km/h to only 15–20 km/h (Gakenheimer, 2002). In Delhi, the average vehicular speed fell from 20–27 km/h in 1997 to only 15 km/h in 2002 (Times of India, 2002). Moreover, the periods of peak congestion in Delhi now last 5 h: from 8:30 to 10:30 in the morning and from 4:30 to 7:30 in the evening. In Chennai, average speed is 13 km/h, and in Kolkata it ranges from 10 to 15 km/h overall but falls to only 7 km/h in the center (Times of India, 2003).

Traffic congestion is frustrating and time consuming for travelers. With most Indian cities sprawling outward to the periphery, average trip distances have been increasing. Combined with the slower travel speeds, suburban sprawl has greatly increased average travel time, which now amounts to 2 or 3 h a day for the trip to and from work (Gakenheimer, 2002). The stop-and-go traffic flow caused by congestion also wastes energy and increases pollution. Moreover, roadway congestion increases the likelihood of crashes, although with lower speeds, they are less likely to be fatal. Congestion within vehicles (especially on trains and buses, but also on rickshaws and bicycles) unquestionably impairs safety, with some passengers falling off overcrowded vehicles, since many are forced to ride on the roofs or hang onto the sides of vehicles that often have no shutters for the doors and windows. The overcrowding of pedestrians, cyclists, and street vendors on the shoulders of roads also creates safety problems, since they often spill over onto the roadway itself. Uncontrolled on-street parking further exacerbates congestion and safety problems by narrowing the available right of way for moving traffic.

Perhaps the most obvious cause of congestion is the rapid increase in travel demand, especially of motorized travel, compared to the very slow growth in transport infrastructure. For example, the average annual rate of growth of travel demand has been 2.2% in Kolkata, 4.6% in Mumbai, 9.5% in Delhi, and 6.9% in Chennai (World Bank, 2002). In virtually no major Indian city has the growth in roadway supply reached even one percent a year, let alone the much higher rates of growth in travel demand noted above. As discussed later, severe shortages of both financing and land sharply limit any expansion in roadway capacity.

Another important source of congestion is the very diverse mix of transport modes forced to share the limited roadway space in Indian cities. Slow non-motorized modes such as bicycles, hand-pulled and cycle-drawn rickshaws, pedestrians, and animal-drawn carts obviously slow down faster motorized modes such as cars, trucks, buses, and auto rickshaws. Such a wide diversity of roadway users also causes a range of safety problems, since the modes have very different sizes, maneuverability, capacities, speeds, and other operating characteristics, thus generating a range of conflicts.

Most roads in Indian cities are narrow, with only one lane in each direction, They usually lack sidewalks, thus forcing pedestrians to walk on the shoulder or the roadway itself, causing both congestion and safety problems. Street vendors also spill onto the roadway. Many roads are in a dismal state of disrepair, often riddled with potholes and with uneven or completely missing pavement. There is a general lack of modern traffic signals and signage, and even where they exist, travelers often ignore them, thanks to lack of enforcement by the police.

In short, the current situation on India's roads is rather chaotic, and the prospects for improvement are minimal. Largely ignoring the needs of non-motorized travelers, recent policies at all government levels have focused on trying to speed up travel for the motorized elite by constructing numerous grade-separated flyovers (overpasses) and by widening selected arterials. Those efforts will hardly suffice. Projections of continued rapid growth in travel demand virtually guarantee worsening roadway congestion in the coming years.

5.4. Equity

With a fourth of India's population living in poverty, the mobility problems of the poor are a special concern. Unfortunately, they are usually ignored in government policies of every kind, including transport policies, which focus on the needs of the urban elite and middle class (Vasconcellos, 2001; Tiwari, 2001; Low and Banerjee-Guha, 2003; Badami et al., 2004). For example, the national government has specifically targeted increased auto ownership and use as a key goal for economic development and modernization. To facilitate increased auto use, most new funding is devoted to roadway expansions and modifications (such as flyovers at key intersections). By comparison, only minimal attention has been given to the needs of pedestrians and cyclists, who comprise the poorest segments of the population.

Most of India's urban poor cannot afford any private motorized transport at all, and many cannot even afford the low fares on public transport (Mohan, 2001; Whitelegg and Williams, 2000; Badami et al., 2004). Thus, they are forced to walk or cycle increasingly long distances, with no separate rights of way of any kind, suffering the most of any modal users from the severe pollution, safety, and congestion problems noted above. As Indian cities continue to spread out, those residents too poor to afford motorized transport will be increasingly disadvantaged, further cutting them off from many employment,

recreational, educational, medical, and other sites they need to reach.

Thus, the already extreme inequity in mobility and accessibility in Indian society will probably get even worse. Not only will the poor benefit least from increasing motorization, but they will bear a disproportionate share of the social and environmental costs of that motorization: as victims of traffic crashes, as residents of noisy, polluted neighborhoods, as the least favored users of overcrowded roads (usually relegated to the shoulder), and as displaced residents of homes torn down to make way for expanded roadways.

The transport problems of the poor get little policy attention in India for the same reason most of their needs are ignored: the lack of political and economic power, and thus the inability to influence politicians who shape government policies (Vasconcellos, 2001). Moreover, since the poor get around cities mainly by walking or cycling, their specifically non-motorized transport needs are yet further ignored, since pedestrians and cyclists have no lobby or support group to advocate their interests and exert pressure on politicians and city planners (Low and Banerjee-Guha, 2003).

5.5. Inadequate public transport

Vast improvements are needed in India's public transport systems, but the necessary funding is not available (Pucher et al., 2004). Most buses and trains in small and medium-size Indian cities are old and poorly designed, inadequately maintained, dangerously overcrowded, undependable, and slow (Acharya, 2000). Public transport systems in India are generally inefficient, thanks to outdated technology, incompetent management, corruption, overstaffing, and low worker productivity. They require increasingly large subsidies, in spite of extremely high passenger volumes.

Expanding and improving public transport systems would seem to be the ideal approach to dealing with the extraordinary high volumes of passenger traffic in such dense urban conditions as those in Indian cities. Public transport might also be expected to serve the travel needs of the poor.

The enormous potential of public transport in India remains to be realized, however, mainly due to policies favoring the motorized elite. Thus, there is no traffic priority of any sort (lanes, signals, etc.) for buses, which get hopelessly stuck on congested roadways and average 6–10 km/h in many large cities (Gakenheimer and Zegras, 2003). The slowness, unreliability, danger, and overcrowding of buses and trains has forced many middle class passengers to shift to cars, motorcycles, and scooters instead, yet further congesting the roads and worsening air pollution, noise, and safety problems.

Perhaps surprisingly, few of India's poor can even afford the very low fares on buses and trains. Thus, they are forced to travel increasingly long distances on foot or by bicycle, suffering ever-lower levels of mobility and accessibility as India's cities suburbanize.

6. Public policies to deal with India's urban transport crisis

While the transport situation in India's rapidly growing cities is challenging, it is not hopeless. Indeed, local, state, and national governments could almost immediately undertake decisive actions that would greatly improve the situation, or at the very least, prevent its worsening. In this concluding section, we propose nine categories of specific policies needed to deal with India's transport crisis.

6.1. Improved rights of way for pedestrians and cyclists

One of the most crucial needs is the provision of improved rights of way for pedestrians and cyclists. Throughout the world, these non-motorized travelers are among the most vulnerable roadway users. Thus, Western European cities generally provide them with a wide range of separate facilities such as wide sidewalks (pavements), crosswalks, cycle paths, ped/bike traffic signals, intersection modifications (bulb-outs, raised surface, special lighting), car-free zones, and traffic-calmed neighborhoods (Pucher and Dijkstra, 2003). By comparison, Indian government officials and planners have largely ignored non-motorists—although they account for about half of all trips made—and thus expose them to intolerably high levels of traffic danger. It is very rare indeed to find any special provisions for pedestrians and cyclists.

While narrow roads, densely built central cities, and lack of funding obviously hinder the allocation of scarce roadway space to cyclists and pedestrians, the real problem is government priorities that favor motorized traffic. Since the powerful elite are more likely to drive private cars, they have strongly favored highway projects over improvements for pedestrians and cyclists. Policy makers rarely consider the needs of the non-motorized urban poor.

Nevertheless, a handful of Indian cities have made some promising efforts to better protect non-motorists. In the planned city of Chandigarh, for example, the local government constructed 160 km of wide cycle paths between 2001 and 2003. Such bikeways enable considerable separation of fast vehicles from slow vehicles on major arterial roads, reducing congestion and improving safety (Chhabra, 2002). On some arterials, special pedestrian paths have also been constructed. Although Chandigarh is a rare exception, there is hope that such efforts will spread to other cities as well. The national government's Ministry of Urban Affairs and Poverty Alleviation (2004) has issued a draft urban transport policy recommending 50% Central Government financing of both cycle tracks and pedestrian paths in large cities. In the first stage, it would finance 50 km of cycle tracks in all cities with at least a million residents, and

100 km of cycle tracks for all cities with at least three million residents (Ministry of Urban Affairs and Poverty Alleviation, 2004). Such a policy shift toward greater concern for non-motorists can be justified on safety, equity, congestion, and environmental grounds.

6.2. Improved traffic management

Improved traffic management is crucially needed in all Indian cities to mitigate the current traffic chaos. India's largest cities have benefited recently from modest improvements in traffic management through the introduction of more advanced technology and stricter enforcement of traffic regulations. In sharp contrast, most medium-size and small Indian cities lack even basic provisions such as stop signs, traffic signals, lane striping, and other regulatory and directional signage. Those basic provisions must be accompanied by strict enforcement of traffic regulations, especially those relating to safety. Whatever traffic regulations currently exist are not well known, thanks to lack of proper driver training, and they are rarely enforced by the police at any rate, due to laziness, poor training, and corruption. Moreover, since motor vehicle drivers are more affluent than non-motorized travelers, the police usually favor motorists, even when they are at fault. Clearly, better driver training, traffic signage, uniform regulations, and strict enforcement are needed. Chandigarh is an example of a smaller city that has vigorously implemented such traffic management measures in recent years with considerable success. It remains to be seen whether similar policies can be adopted in much larger Indian cities.

There are a few bus lanes in Delhi and Mumbai, and Chennai and Bangalore have plans to install bus lanes in the coming years. Nevertheless, most Indian cities provide no traffic priority at all for buses. Bus lanes, priority signals, and other traffic management policies favoring public transport in Europe are virtually non-existent in most Indian cities. There is a desperate need to speed up buses stuck in congested urban traffic, since deterioration of bus travel in recent years has shifted more and more Indians to more polluting, less energy-efficient, more congesting, and more dangerous means of travel. The political elite who have favored highways must be convinced of the crucial need to devote more scarce funding and right of way to public transport, even if that takes resources away from projects that would favor motorists. In the few instances where bus lanes have been built, they have been poorly designed, too narrow, and congested with slow-moving non-motorized traffic as well as a chaotic mix of motorbikes, scooters and auto rickshaws. Since bus priorities in such lanes are ignored, they provide little speed advantage to buses. Clearly, it is essential to provide buses with more exclusive rights of way on congested arterials. Strict enforcement of bus priority by traffic police is essential for any such strategy to work.

6.3. Improved public transport services

Improved public transport services are also necessary Considerable progress has been made in this area, but much more improvement is needed. For example, suburban rail and metro systems are being expanded and better coordinated in India's largest cities (Pucher et al., 2004). Delhi's new metro system will be the most extensive improvement, when completed, but Mumbai, Chennai, Kolkata, Bangalore, and Hyderabad have all been either expanding or improving their rail systems as well. For example, several suburban rail corridors in Mumbai and Chennai have been converted from 2-track to 4-track lines to enable separation of local from long-distance rail traffic, increasing both safety and speed (Mumbai Development Authority, 2003). In Bangalore, there are plans to build a metro system similar in design to the new one being built in Delhi. In Hyderabad, the state government and Indian Railways are jointly investing in expansion of the existing suburban rail system and better coordination of rail with bus services.

By comparison, very little is being done to improve bus travel, which accounts for over 90% of all public transport use in India. Most of the old, decrepit, and dangerous bus fleet in India is in desperate need of replacement by modern, safe vehicles. Thus, the main focus of public transport policy must be on improved bus transport, including more and better buses as well as some degree of traffic priority in mixed traffic to increase average bus speeds. In addition, much better coordination is needed between different bus routes as well as between bus and rail services. One recent development is the new high-capacity, express bus system now being proposed for Bangalore and possibly for Delhi as well (Transportation Research and Injury Prevention Programme, 2004; Gaur 2002). As demonstrated by the success of bus rapid transit (BRT) systems in Curitiba, Brazil and Bogota, Columbia, such express bus systems are ideal for cities in developing countries, since they provide many of the benefits of metro rail systems at much lower cost.

The TransMilenio BRT system in Bogota, Colombia is a successful model that many large Indian cities could follow. Completed in December 2000 at modest cost, it carried over 800,000 passengers a day by 2004. The Bogota BRT's high passenger volume is second only to the Curitiba BRT, which opened 40 years ago. The TransMilenio system is operated by private contractors without any government subsidy at all. One can hardly imagine a more cost-effective, quicker, or more feasible improvement to bus services in India's large and medium-size cities (Wynne, 2001; Lean and Bertini, 2003).

6.4. Privatization of bus services

Another possible approach to improving public transport services at affordable cost is selective

privatization of bus services. Several Indian cities have already privatized the operation of major portions of their overall bus services. Delhi and Kolkata have the largest private bus fleets (Pucher et al., 2004). Compared to the publicly owned, operated, and subsidized bus services in the same cities, the privately run services have higher productivity, lower costs, more passengers per bus, and higher revenues per bus km of service. Public agencies in Bangalore and Hyderabad contract out much of their bus services to private operators with similar results of higher productivity, lower costs, and less subsidy needs. While privatization appears to have significant potential for improving the efficiency of bus operations and reducing government subsidies, experience to date has shown the crucial need for public regulation of safety, route and schedule coordination, and service quality.

6.5. Improve motor vehicle technology and fuels

Given the sharply rising level of motorization in India, it becomes increasingly important to improve motor vehicle technology and fuels in order to increase energy efficiency and safety while decreasing noise and air pollution. Already, the Indian government has introduced a series of regulations that limit pollution from private cars, buses, and trucks. So far, the most successful measure was the complete phasing out of lead in fuels. The allowable levels of sulfur and benzene in fuels were also reduced. Of course, less-polluting fuels must be accompanied by less-polluting vehicle technology. Thus, between 1991 and 2000, national regulations for new vehicle emissions reduced allowable levels of carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NO_x). Further improvements are likely, since an expert commission of the Indian Government has recommended successively adopting the increasingly stringent Euro II, Euro III, and Euro IV emission standards for all new cars, taxis, trucks, and buses, first in the largest cities and then for the entire country (Ministry of Petroleum and Natural Gas, 2002).

A more difficult problem is phasing out or converting the most polluting of motor vehicles. The highly polluting two-stroke engines of motorcycles, scooters, and auto rickshaws are an especially worrisome problem, since these motor vehicles are more affordable than private cars and have been growing very rapidly in number. However unpopular it might be, it seems essential to require all new motorized two- and three-wheelers to have much cleaner engine technology. Thus, the expert commission on fuel policy also recommended much stricter emissions standards for new motorized two-wheelers and three-wheelers (Ministry of Petroleum and Natural Gas, 2002). Even if adopted, it would take many years for these regulations to have full effect, since there is a long lag time for fleet replacement. But at least any additions to the fleet would not greatly worsen the air pollution problem.

With India's worst air pollution, Delhi was forced to adopt the rather drastic policy of requiring all buses, taxis, and trucks to convert from petrol and diesel to CNG (compressed natural gas) within a period of only 3 years (Clean Air Initiative, 2004; Weaver, 2004). Although it caused much chaos in the short-run, disrupting public transit services in particular, it appears to have paid off in terms of slight improvements in Delhi's air quality, especially through reductions in particulate pollution from diesel engines. It seems rather unlikely that the same sort of policy could be implemented nationwide. Not only was there more need for such policies in Delhi—due to its critical pollution levels—but there was also more financial ability to make the transition—due to higher average incomes in Delhi. Nevertheless, the example of Delhi shows the potential of such regulations of motor vehicle technologies. Moreover, if applied to only new vehicles, it would be a much more feasible policy throughout the country. Clearly, it is easier to affect future vehicle design than to force conversions of existing vehicles.

6.6. Design new roads to accommodate the needs of buses, cyclists, and pedestrians

Given the many new roadway projects in recent years—and massive expansions likely in coming years—it will be essential to design new roads to accommodate the needs of buses, cyclists, and pedestrians. Unfortunately, most recent roadway projects have ignored the needs of non-motorists and focused instead on serving the sharp growth in private car ownership and use (Tiwari, 2001; Pendakur, 2002; Low and Banerjee-Guha, 2003). Wherever feasible, new roadways should provide bus lanes to speed up public transport as well as cycle paths and walkways to improve safety for non-motorists. The 50% Central Government funding of cycle and pedestrian paths proposed by the National Urban Transport Policy could help fund those parts of the new roadway facilities. Moreover, the Central and state governments should specifically require that any new roadways accommodate non-motorists either on the same or parallel facilities.

6.7. Better cooperation among different transport agencies, departments, and ministries as well as better overall coordination of transport and land-use policies

As noted earlier, there is a desperate need for much better cooperation among different transport agencies, departments, and ministries as well as better overall coordination of transport and land-use policies. In their proposed National Urban Transport Policy (NUTP), the Central Government's expert commission strongly recommended the creation of 'unified metropolitan transport authorities' in all cities with at least a million inhabitants (Ministry of Urban Affairs and Poverty Alleviation, 2004). These agencies would 'coordinate planning and

implementation of urban transport programs and projects and an integrated management of urban transport systems.' That would especially improve route, schedule, and fare integration between bus services controlled by state and local authorities and rail services operated by Indian Railways. Equally important, such metropolitan planning agencies would provide Indian cities their first opportunity to coordinate policies affecting land-use, urban and suburban development, parking, roadway construction, car use, and non-motorized transport. Although the specific form of regional planning organizations varies considerably from country to country, virtually every major city in Europe and North America has benefited from this sort of metropolitan-wide coordination of transport and land use (Pucher and Lefevre, 1996).

6.8. State and local governments should be encouraged to revise their current land use and development regulations to promote higher-density development at rail stations and along key bus routes

Compact, transit-oriented development would reduce the need for travel while at the same time facilitating the use of public transport, walking, and cycling for a larger percentage of whatever travel is necessary. Current regulations in most cities actually prevent such coordination of land use with transport. They sharply restrict development densities in the city center while allowing higher densities and much easier development conditions at the booming suburban fringe, which is so dependent on the private car and motorcycle for access (Pucher et al., 2004). Clearly, there must be much stricter controls on suburban development to prevent the kind of haphazard, uncoordinated, car-dependent sprawl that is rapidly spreading out around every major Indian city.

6.9. Large increases in funding

In the coming years, large increases in funding will be required for the enormous investments needed to improve Indian transport systems. Given the many social, environmental, and economic problems caused by private motor vehicles, it would make sense to place most of the financial burden of new transport expenditures on motorists and not on public transport riders, cyclists, and pedestrians. Not only do motorists cause most of India's transport problems, but they are generally much more affluent than users of public and non-motorized transport modes. Increases in petrol and diesel taxes, vehicle registration and import taxes, and driver licensing fees, and the assessment of higher and more widespread roadway tolls (especially on bridges and congested arterial roads) would generate much needed additional revenue for transport investments.

The Central Government's expert commission also recommends increased petrol and diesel taxes, as well as levies on rising land values and employer payroll taxes, to support a special urban transport fund that would provide a dependable, dedicated source of revenues for transport improvements (Ministry of Urban Affairs and Poverty Alleviation, 2004). Most European and American governments have levied such dedicated transport taxes for decades, and they will be crucial in India as well for funding the many desperately needed investments in urban transport systems (Pucher and Lefevre, 1996).

7. Conclusion

There are two main obstacles to implementing policies needed to deal with India's urban transport crisis: financial and political. Budget problems at every level of government—central, state, and local—sharply limit the extent to which public subsidies can be provided for any of the measures recommended here. Wherever feasible, increased involvement of the private sector will be necessary to alleviate shortages of public funding. Private financing seems especially appropriate for all new roadway construction, most bus operations, and new express rail services, for example. That would free up more public funds for projects such as improved pedestrian and cycling infrastructure, which primarily serve the poor and are thus unlikely candidates for privatization.

Another formidable obstacle to improved transport policies is the political influence of the automobile and highway lobbies in India, as well as affluent Indians, who benefit the most from increased adaptations of transport policies to their car-oriented lifestyles. Indeed, several Central Government policy documents indicate an overriding priority for further developing the growing Indian automobile industry as the most important measure for promoting overall economic growth and employment in India (Ministry of Heavy Industries and Public Enterprises, 2002). An explicit part of that strategy is the stimulation of maximum possible growth in car ownership and use, both through new roadway construction and provision of ample car parking. The increased car use that would generate would hardly help solve the many problems India's cities already face with travel demands far exceeding the capacity of the transport system.

Nevertheless, there appears to be growing awareness that something must be done to deal with India's worsening transport crisis. Perhaps the most hopeful development in recent years is the Central Government's proposed NUTP (Ministry of Urban Affairs and Poverty Alleviation, 2004). While it has not yet been officially approved and implemented, it presents many progressive ideas for dealing with India's urban transport crisis. It also supports increased car ownership to stimulate the Indian economy, but it recommends several measures to limit car usage in cities to minimize the problems it causes. Thus, it suggests restricted

parking supply and higher parking fees, improved public transport, greater priority for buses in mixed traffic, and higher fuel taxes. None of those measures will be easy to implement, and it is hard to imagine increased car ownership not leading to increased car use that would worsen all the existing problems.

Some of these recommendations may seem too ambitious or overly optimistic. Nevertheless, cities in other developing countries have shown that enormous progress can be made in dealing with urban transport problems through radical changes in transport policies. The very successful TransMilenio Project in Bogota, Columbia, for example, introduced a bus rapid transit system, bicycle paths, improved pedestrian facilities, and significant restrictions on private car use. The results have included impressive reductions in air pollution, roadway congestion, and traffic accidents.

The increasing severity of India's urban transport crisis may provide the widespread political support needed for the rather dramatic policy shifts recommended by NUTP. It seems highly unlikely that all the recommended measures will be adopted, but if a few innovative policies could be tried out on an experimental basis, even that would be a hopeful first step. Clearly, India's urban transport crisis has many dimensions, and the solution to that crisis will necessarily have many dimensions as well, implemented in many stages over many years.

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