

Importance of Nonmotorized Transport in India

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The urban population in India has been growing rapidly. Although the present levels of urbanization are low compared with those of the developed countries, it is estimated that by the turn of the century 35 percent of the total population in India will be living in urban areas. The number of cities with a population of 0.1 million and greater will increase from 216 in 1981 to 423 by 2001. Cities are growing in size, resulting in more complex transportation problems. Motor vehicle ownership levels, which vary considerably from city to city, are generally low. A considerable proportion of urban population depends on nonmotorized modes for transportation. To improve the transport infrastructure, transportation studies should be conducted in Indian cities of all sizes so that more realistic transportation plans can be prepared in keeping with the prevalent socioeconomic environment. Greater attention has to be paid to nonmotorized modes, pedestrians, and poorer sections of society, which form a majority of the urban residents.

The present-day traffic and transportation problems in urban areas of India result from a wide variety of reasons, and solutions to these problems need to be compatible with the socioeconomic environment that prevails. Some of the important factors that contribute to the traffic and transportation problems of Indian cities are as follows:

- Urbanization patterns,
- Socioeconomic and industrial development,
- Growth in the number of motor vehicles,
- Mixed nature of traffic flow,
- Inadequacy of the infrastructure,
- Growth in transport demand, and
- Lack of effort in urban transportation planning.

URBANIZATION PATTERNS

Since India's independence in 1947, the population has been growing rapidly and has been moving from rural areas into complex and densely populated urban areas. Table 1 presents the population trends in India. The urban population as a percentage of the total population, which was around 24 percent in 1981, is expected to increase to 34.5 percent by the turn of the century. In absolute numbers, the urban population will increase from 159.7 million in 1981 to 326.0 million by 2001, thus accounting for a twofold increase in a span of two decades. Although the urban population in India is increasing rapidly over the years, the urbanization levels are

quite modest compared with some developed and developing countries in which the share of urban population ranged between 38 and 86 percent compared with 20 percent in India during 1970/1971.

The Indian census categorizes urban population into six classes of cities and towns designated Class I cities (population more than 10,000) to Class VI cities (population less than 5,000). The population figures of such cities show that although the relative share of Class I cities with a population of 10,000 and above is increasing over the years, that of other classes of cities has either stagnated or registered a decline. The growth in the number of Class I cities is presented in Table 2. Those with >1,000,000 population (metropolitan cities), which numbered 9 in 1971, increased to 12 in 1981 and are expected to increase to 26 by 2001. The total number of Class I cities is expected to increase to 423 in 2001, compared with 152 in 1971 and 216 in 1981.

Transport Systems in Indian Cities

Transportation demand of urban residents in India is met through a vast variety of vehicles. The vehicles may be grouped in the following categories:

1. Private vehicles: cars, jeeps, passenger vans, scooters, motorcycles, and bicycles.
2. Public vehicles: buses, minibuses, passenger tempos, and passenger vans.
3. Hired vehicles: taxis, three-wheeler motorized autorickshaws, three-wheeler nonmotorized cycle rickshaws, and animal-drawn vehicles.
4. Goods vehicles: trucks, minitrucks, goods tempos, tankers, animal-drawn *rehras*, and hand carts.

In addition, in some major metropolitan cities like Bombay, Calcutta, Madras, and Delhi, besides the road-based transport modes, suburban trains and other short- and long-distance trains cater to commuter needs.

Growth of Motor Vehicles

Table 3 presents the growth of motor vehicles registered in the metropolitan cities in India. In most of the cities as well as in India as a whole, the number of motor vehicles has increased significantly over the years. One peculiarity about the growth in motor vehicles is the explosion in the number of two-wheelers like motorcycles, scooters, and mopeds. In

TABLE 1 POPULATION TRENDS IN INDIA (1)

Year	Total Population (millions)	Urban Population (millions)	Percent of Total Population
1901	238.3	25.9	10.8
1911	252.0	25.9	10.3
1921	251.2	28.1	11.2
1931	278.9	33.5	12.0
1941	318.5	44.2	13.9
1951	361.0	62.4	17.3
1961	439.1	78.9	18.0
1971	548.2	109.1	20.2
1981	685.2	159.7	23.7
1991 ^a	801.2	230.1	28.7
2001 ^a	945.4	326.0	34.5

^aCentral Statistical Organization estimates (1986).

TABLE 2 GROWTH IN NUMBER OF CLASS I CITIES IN INDIA

Year	Number of Cities by Population (millions)			Total
	>1.0	0.5–1.0	0.01–0.5	
1971 ^a	9	9	134	152
1981 ^a	12	28	176	216
1991 ^b	16	56	230	302
2001 ^b	26	78	319	423

^aCensus of India Reports (1).

^bCentral Statistical Organization estimates (1986).

TABLE 3 GROWTH IN NUMBER OF MOTOR VEHICLES REGISTERED IN METROPOLITAN CITIES IN INDIA (3)

City	No. of Motor Vehicles (thousands)		Percentage of Growth
	1977	1985	
Calcutta	147 (22.4) ^a	286 (30.1)	95
Bombay	245 (23.3)	432 (31.7)	76
Delhi	389 (61.7)	841 (68.8)	116
Madras	69 (47.8)	139 (51.8)	101
Bangalore	109 (56.9)	279 (68.1)	156
Hyderabad	N.A.	172 (70.9)	—
Ahmedabad	68 (58.8)	177 (67.8)	160
Kanpur	32 (62.5)	89 (77.5)	178
Pune	75 (50.7)	160 (68.1)	113
Nagpur	N.A.	83 (71.1)	—
Lucknow	27 (66.7)	82 (74.4)	204
Jaipur	34 (61.8)	127 (62.2)	273
Total ^b	1,195 (47.0)	2,867 (59.1)	140

^aValues in parentheses show percentage of two-wheelers (motorcycles, scooters, mopeds, etc.).

^bTotal number of vehicles for all of India: 1977—3,260,000 (43.4 percent two-wheelers); metropolitan vehicles as percent of total in India, 37. 1985—8,796,000 (56.4 percent two-wheelers); percent of total in India, 33.

most of the metropolitan cities (except Calcutta and Bombay), two-wheelers constitute between 50 and 78 percent (with an average figure of about 59 percent) of the registered motor vehicles. In India as a whole, two-wheelers constituted about 56 percent of total vehicles registered in the country in 1985.

Importance of Road System

The transport sector in India has recorded substantial growth during the last three decades both in its spread as well as in

the output of its system. Despite the impressive performance, the capacity of the transport system continues to fall short of the demand, resulting in ever-increasing congestion on roads, leading to a decline in productivity and city efficiency.

In view of the large number of cities in India and the prevalent socioeconomic environment, the road-based systems will continue to play an important role in the movement of passengers in cities of all sizes. Not only is the road network inadequate but also the quality of roads is fast deteriorating because of the lack of proper maintenance. This problem has resulted in adverse consequences such as increased fuel consumption, lowering of speed, greater chances of accidents, and increasing discomfort to riders in general.

Transport problems of Indian cities are unique and need to be understood in a systematic manner, and facilities need to be planned for healthier growth of the urban areas.

Urban Transport Planning

Urban transport, which is the most important component of the urban system, has not been given its due so far in India, largely because its role and implications are not clearly understood. Urban transport has to be an integral part of urban planning and is closely linked to land use planning. Comprehensive traffic and transportation studies for major cities in India have been conducted in the past, generating voluminous data bases and complex transport models as well as ambitious transport plans. However, the success in terms of implementation of the proposals so far has been limited. If any success is to be achieved in planning a realistic urban transport system, greater understanding of the travel characteristics of urban residents along with more practical tools will be needed for urban transport planning exercises. It has been argued that motorized and nonmotorized vehicles have to coexist in urban India. However, the proportion of these two types of vehicle streams depends largely on the city size as well as on the economic base of the city. In the absence of any policy on urban transport (including public transport), the growth of traffic in Indian cities is haphazard, which also affects urban development and the environment.

URBAN TRAFFIC AND TRANSPORT DEMAND CHARACTERISTICS

Growth of Road Traffic

Traffic flow characteristics on the Indian road system differ significantly from those in other countries, developed or developing. Hence, in most situations the solutions to traffic problems have to be innovative rather than adapted from other countries. The low level of public transport supply in Indian cities has to a large extent led to the enormous growth of nonmotorized and motorized vehicles, particularly the motorized two-wheelers.

Heterogeneous Nature of Traffic

Traffic flow on roads in urban areas of India consists of a wide variety of vehicles ranging from animal-drawn slow ve-

hicles to motorized fast vehicles. Cycles constitute a significant proportion of the traffic stream in most cities. Heterogeneous traffic is not easy to manage efficiently in terms of quality and quantity of traffic flow. The composition of traffic flow on roads also varies from city to city.

Road Safety

In addition to their ill effects on the environment, motor vehicles kill or injure people and damage property. The road accident trends for 12 metropolitan cities of India are presented in Table 4. The total number of accidents, persons killed, and persons injured has increased over the years. In 1985, as compared with the all-India level, around 29 percent of accidents occurred in 12 metropolitan cities, whereas the proportions of persons killed and injured were around 11 and 19 percent, respectively. From available statistics, the road users killed or injured in road accidents are mostly pedestrians and cyclists who constitute between 50 and 80 percent of the population in most of the cities.

Road accidents, besides creating social problems, also cause economic losses. According to some estimates, the total cost of road accidents in 1978 was INR 2370 million (U.S.\$1 = INR 18), which was about 0.3 percent of the national income of India. Again, comparison of fatality rates per 10,000 motor vehicles for India and those for developed countries suggests that there is a wide gap, and considerable work has to be done to make the road system safer in India.

Transport Demand Growth

Passenger transportation demand in urban areas has been growing over the years. Comprehensive transportation studies have been carried out in a few metropolitan cities and are in progress for other selected cities. In addition, limited transportation studies have also been carried out in many other cities. The daily passenger transportation demand in most cities is estimated to nearly double by the turn of the century as compared with 1981 levels (2).

Motor Vehicle Ownership Levels

The dependence on public transport and on nonmotorized modes is reflected by the motor vehicle ownership trends in Indian cities. Motor vehicle ownership levels per 1,000 population are low in all cities in India compared with those of developed countries as well as many developing countries. Within India, these ownership levels also vary considerably, largely because of the inadequacy of the public transport system or generally lower income levels.

Socioeconomic Aspects and Mobility Levels

Socioeconomic characteristics of households for five selected cities are presented in Table 5. The following observations can be made:

- The variation in average family size and number of earners per household was not significant in the five cities.
- Average household monthly income varied between INR 1452 in Cochin to INR 2582 in Delhi.
- The proportion of households owning motor vehicles (cars, motorcycles, motor scooters, etc.) varied between 48 percent in Delhi and 65 percent in Ahmedabad.

The effect of household income and type of vehicle owned is presented in Figure 1 and Table 6. Daily one-way trip rates (including walk trips) increase with increasing household income. The mobility levels of households owning motor vehicles are higher compared with levels of households owning bicycles or no vehicles. The trends also suggest higher mobility levels of different population groups in larger cities. The mobility levels of low-income households are low compared with those of higher-income households.

Quality of Transport Services

In many Indian cities, with the exceptions of the three major metropolitan cities of Bombay, Calcutta, and Madras, in which

TABLE 4 ROAD ACCIDENT TRENDS IN METROPOLITAN CITIES IN INDIA (3)

City	1977			1985		
	Total Accidents	Persons Killed	Persons Injured	Total Accidents	Persons Killed	Persons Injured
Ahmedabad	1,491	149	1,491	2,279	143	2,077
Bangalore	3,523	247	2,931	4,805	419	3,892
Bombay	25,743	660	9,545	26,759	657	8,002
Calcutta	10,611	358	3,783	8,108	421	3,170
Delhi	4,032	694	3,874	6,254	1,269	6,366
Hyderabad	965	210	879	1,493	221	691
Jaipur	N.A.	N.A.	N.A.	641	133	572
Kanpur	450	73	352	458	130	345
Lucknow	N.A.	N.A.	N.A.	814	150	664
Madras	5,177	199	2,811	5,155	397	4,558
Nagpur	N.A.	N.A.	N.A.	1,303	132	824
Pune	2,136	145	1,255	2,895	250	1,538
Total	54,128	2,926	26,918	60,944	4,322	32,699
Total in India	135,000	20,100	95,600	208,000	39,000	168,900
Percentage in metropolitan cities to total in India ^a	40.1	14.6	28.2	29.3	11.1	19.4

^aFor nine cities.

TABLE 5 SOCIOECONOMIC CHARACTERISTICS OF HOUSEHOLDS IN SELECTED CITIES (4)

City	Average Family Size	Average No. of Earners per Household	Average Monthly Household Income (INR)	Proportion of Households Owning Motor Vehicles ^a
Delhi	4.44	1.5	2,582	48
Ahmedabad	4.28	1.3	2,194	65
Lucknow	4.16	1.3	1,955	60
Madurai	3.49	1.4	2,018	49
Cochin	3.60	1.4	1,452	49

^aCars, motorcycles, motor scooters, etc.

suburban rail transport plays a vital role, buses are the only public transport mode. Bus transport plays a key role in providing mobility to urban dwellers and, in conjunction with other motorized and nonmotorized modes, serves the transport needs of the cities. Thus, the quality of transport services available in the cities depends largely on the number of different types of vehicle in any particular city.

The per capita availability of various types of transport services varies from city to city as presented in Table 7. The availability of buses per 1,000 population in Delhi is around 2.5 times that of other cities like Vadodra, Jaipur, and Patna. In Vadodra, there is a large number of autorickshaws, whereas in Jaipur and Patna cycle rickshaws ply in large numbers compared with the situation prevailing in Delhi. In other words,

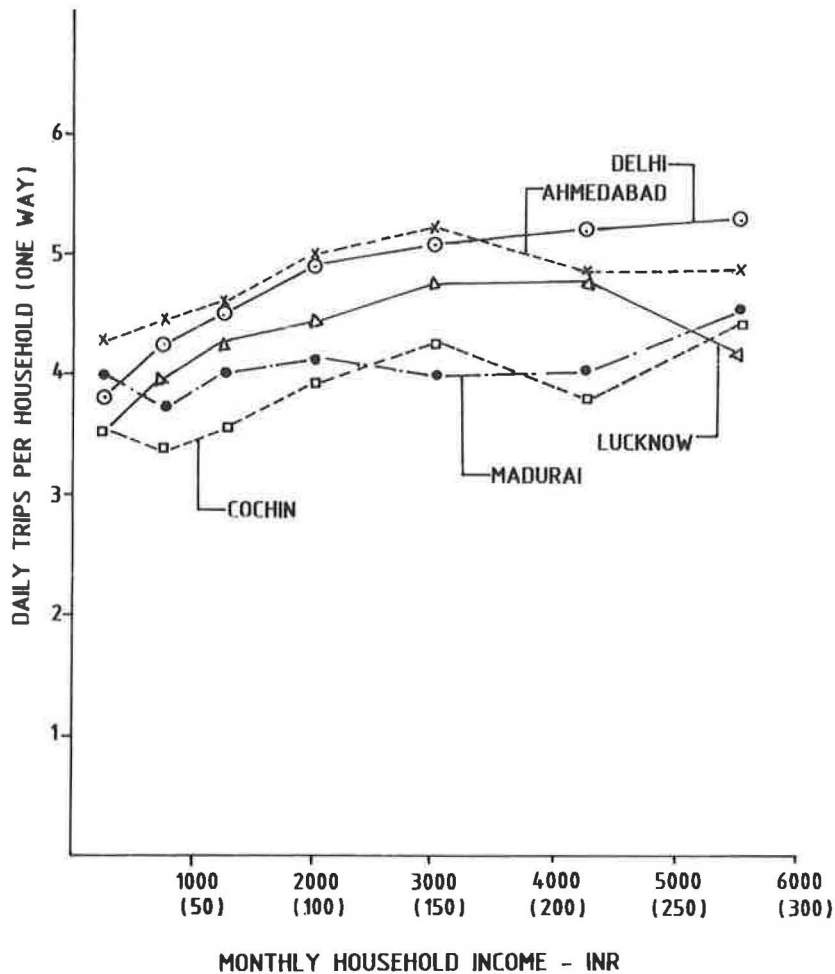


FIGURE 1 Effect of household income on trip rates (values in parentheses are equivalent U.S. dollars).

TABLE 6 EFFECT OF VEHICLE OWNERSHIP ON DAILY TRIP RATES PER HOUSEHOLD (4)

Type of Vehicle	Trip Rate ^a by City				
	Delhi	Ahmedabad	Lucknow	Madurai	Cochin
More than one car	5.21	4.23	3.44	4.09	4.74
One car	5.02	5.11	4.10	3.68	3.81
Motorcycle or scooter	5.16	4.89	4.51	4.11	3.67
Cycle	4.65	4.57	4.20	4.04	3.84
No vehicle	4.53	4.30	3.51	3.97	3.40
Average	4.84	4.78	4.26	4.00	3.70

^aOne-way trips.

TABLE 7 AVAILABILITY OF TRANSPORT SERVICES IN SELECTED CITIES OF INDIA (4,5)

City	Vehicles per 1,000 Population					
	Public Modes			Private Modes		
	Buses ^b	Auto-rickshaws	Taxis	Cycle Rickshaws	Cars	Scooters and Motorcycles
Vadodra	0.25	7.9	—	—	13	45
Jaipur	0.27	2.4	—	7.1	15	86
Patna	0.17	—	—	39.0	11	52
Delhi ^a	0.61	4.1	1.3	1.1	22	74

^aFrom Central Road Research Institute report (4).

^bConventional bus and minibus.

in medium-sized and small metropolitan cities, the population has to depend mainly on intermediate public transport modes rather than buses. The availability of personalized fast modes like motorcycles and motor scooters is high in most of the cities. Car ownership rates are significant in Delhi.

IMPORTANCE OF NONMOTORIZED MODES

Nonmotorized modes in Indian cities, besides walking, consist of slow modes like bicycles, three-wheeled nonmotorized cycle rickshaws, horse-drawn vehicles, and many other types of slow vehicles. The nonmotorized vehicles share the road space with the motorized modes. The proportion of slow vehicles in the traffic stream varies from city to city (Figure 2). Transportation planning studies conducted thus far in Indian cities have been biased toward motorized modes. In most of the cities, facilities for bicycles have not been developed and pedestrian facilities have been completely neglected.

Walk Trips in Selected Cities

The distribution of trips by walking and vehicular modes, including fast and slow vehicles, as presented in Table 8 shows variations in the proportion of walk trips for different purposes in selected cities. The proportion of trips by walking for "other purposes," which includes social, recreational, and health, is high in all the cities, whereas for "education," it is significant in most of the cities.

Share of Nonmotorized Modes

The nonmotorized passenger transport modes that generally ply the road systems in Indian cities include bicycles, cycle

rickshaws, and other slow vehicles. Based on a study (4), the modal share of these nonmotorized modes for five selected cities is presented in Table 9. The share of nonmotorized modes is high in Lucknow and significant in Ahmedabad and Madurai.

Traffic Flow in Selected City Corridors

Composition

The composition of traffic flow on arterials of selected cities of different population sizes is presented in Table 10. In major cities like Bombay and Delhi and some smaller cities like Cochin and Mangalore, motor vehicles dominate the traffic flow, but in the majority of the cities studied, the share of nonmotorized modes in the traffic flow is significant.

Modal Share

The modal shares of passenger flows on arterials of selected cities are presented in Table 11. Wherever public transport modes are inadequate, the greater proportion of trips are catered to by fast modes and the nonmotorized modes. The share of nonmotorized modes in catering to transport demand is significant in most of the cities.

CONCLUSIONS AND ISSUES

The analyses presented indicate that nonmotorized modes play a significant role in catering to the transport demand in



FIGURE 2 Traffic flow composition in Indian cities.

TABLE 9 MODAL SHARE OF NONMOTORIZED MODES IN SELECTED CITIES (4)

City	Percentage of Trips by Mode		
	Mass Modes	Other Fast Modes ^a	Nonmotorized ^b Modes
Delhi	62	33	5
Ahmedabad	22	52	26
Lucknow	7	44	49
Madurai	49	32	19
Cochin	56	36	8

^aIncludes cars, motorcycles, autorickshaws, taxis, etc.

^bIncludes bicycles, cycle rickshaws, other slow vehicles.

most of the Indian cities with less than 2.5 million population. Despite the growing economic affluence and fascination for owning motor vehicles in urban areas, the dependence on nonmotorized transportation modes will persist in the foreseeable future. The transportation planning studies conducted so far in metropolitan cities have not paid the attention needed for providing facilities for nonmotorized modes. Some of the issues that need to be addressed relating to Indian cities are as follows:

- For assessing precisely the requirements of nonmotorized modes, transportation studies need to be conducted in medium-sized and small cities to match transport facilities with transport demand patterns. The transport systems to be developed for such cities should have a blend of all transit modes, including facilities for nonmotorized modes.

- Cycle rickshaw is a popular paratransit mode that provides door-to-door service in congested parts of most Indian cities. The requirements of this mode need to be studied and better understood in relation to the socioeconomic environment.

- Pedestrianization schemes, particularly in central congested areas, need to be planned and implemented to improve environmental and safety aspects.

- In the majority of the cities, a large proportion of road users killed or injured in road accidents is composed of users of nonmotorized modes (pedestrians and cyclists). Studies need to be conducted to assess the socioeconomic aspects of these users to minimize fatalities among them.

TABLE 8 DISTRIBUTION OF TRIPS BY WALK AND VEHICULAR MODES IN SELECTED CITIES (4)

City	Population (millions)	Percent of Trips by Purpose							
		Work		Education		Other		All Purposes	
		Walk Trips	Vehicle Trips	Walk Trips	Vehicle Trips	Walk Trips	Vehicle Trips	Walk Trips	Vehicle Trips
Delhi	5.7	6	94	50	50	84	16	51	49
Ahmedabad	2.5	9	91	41	59	71	29	46	54
Lucknow	1.0	9	91	28	72	64	36	42	58
Madurai	0.8	17	83	27	73	62	38	34	66
Cochin	0.5	13	87	28	72	60	40	38	62

TABLE 10 TRAFFIC FLOW COMPOSITION ON ARTERIALS IN SELECTED CITIES (4,6)

City	Population (millions)	Percent Range by Mode		
		Motor Vehicles	Nonmotorized Modes	
			Slow Vehicles ^a	Bicycles
Bombay	8.2	86-99	0-6	1-11
Delhi	5.7	74-90	0-14	10-19
Ahmedabad	2.5	55-66	0-3	33-44
Kanpur	1.7	29-34	15-21	45-51
Lucknow	1.0	15-40	9-26	49-59
Varanasi	0.8	32-47	23-32	25-40
Indore	0.8	56-62	0-3	30-40
Madurai	0.8	21-51	6-13	40-66
Cochin	0.5	86-89	0-1	10-13
Chandigarh	0.4	49-62	8-11	28-40
Mangalore	0.3	87-94	0-2	6-13

^aMostly three-wheeled nonmotorized cycle rickshaws.

TABLE 11 MODAL SHARE OF PASSENGER FLOWS ON ARTERIALS IN SELECTED CITIES (4,6)

City	Population (millions)	Percent by Mode			
		Mass Modes	Other Fast Modes	Nonmotorized Modes	
				Cycles	Other Slow Vehicles ^a
Delhi	5.7	62	3	5	— ^b
Ahmedabad	2.5	34	45	21	— ^b
Kanpur	1.7	24	27	30	19
Pune	1.0	59	25	16	— ^b
Lucknow	1.0	29	18	34	19
Varanasi	0.8	39	20	21	20
Indore	0.8	54	30	16	— ^b
Chandigarh	0.4	54	27	15	4
Mangalore	0.3	77	21	2	— ^b
Moradabad	0.3	40	17	25	18

^aMostly three-wheeled nonmotorized cycle rickshaws.

^bNegligible.

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