Comparative Study of Transportation Modal Choice in Asian Countries

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Major cities in developing countries in Asia are afflicted with heavy transportation problems because of an excessive concentration of people. Because the population is expected to continue to grow, the development of transport networks can have a major influence in providing more efficient and livable cities. In almost all cities, public transport modes play a major role even though the level of service is generally low. The lack of a railway system is the main deficiency of urban transportation systems. Paratransit and nonmotorized modes are used mostly to fill the travel demand. In these cities, people experience intolerable difficulties, mainly in their work trips. A graphical model to analyze the modal choice pattern of major cities in Asia with the level of economic development is developed. This model shows a consistent trend in the modal share with the change in gross national product (GNP) per capita. The country's per capita GNP will decide the zonal location of the city in the introduced graphical model together with population and city size. The mixed modes of an urban transportation system are recommended in large cities of Asia. Hence, as a starting point, densely populated major Asian cities should focus on urban mass transportation systems, including railway systems accompanied by development of infrastructure facilities for other modes.

The importance of urban transport lies fundamentally in its contribution to the economy of the country associated with urban growth. More than one-quarter of the developing world's population lives in an urban area, and more than half the national output is produced in the major cities (*1*).

Every metropolitan area in Asia is afflicted with transportation problems that will continue to grow in the future. High growth rates of population, rapid increase in urban population, and increased national products and per capita income have been the primary sources of increases in volume of person trips. This rapid increase in trips causes serious transportation problems with the unbalance between supply and demand of transportation and conflicts in land use pattern in these cities.

Urban growth rates are much higher than the national growth rates in developing countries of Asia. The availability of comparably high levels of transportation facilities and a large number of employment opportunities are encouraging migration from rural areas to cities in large scale. However, the fast-growing cities of Asia have not seen an accompanying development of transportation facilities. In this respect, the development of transport networks can have a major influence in providing more efficient and more livable cities to the enlarged populations.

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This paper intends to analyze the modal choice pattern of developing cities by reviewing the transportation behavior in Asian countries with a special concentration on the change in modal choice of person trips with economical growth. Consequently, several short-range measures are proposed to overcome the prevailing problems in the urban transportation system in Asian countries.

TRENDS IN TRANSPORTATION MODAL CHOICE

Urban Travel in Asian Cities

The modal choice of person trips is a function of economic activity distribution, socioeconomic profile of the population, and land utilization pattern of the city. Ridership of each mode varies among cities of comparable size and even in cities in the same country.

Transportation of people in the developing cities of Asia was not a problem when cities were small, both in population and size, because harmonized patterns of land use made the distances between activities short. With the introduction of motorized transportation, the size of cities expanded rapidly. As a result of unplanned growth in city size, the residential areas have spread in fringe areas, with remaining major activity centers in a small area. It necessitates large volumes of person trips with increasing travel distances.

Generally the urban transportation system in the cities of Asia consists of various modes. By reflecting the relative passenger-carrying capacity and user responsiveness the system can be clustered into three major groups: public transport (bus and railway), low-cost modes of transport (jeepney, auto-rickshaw, tonga, cycle rickshaw, motorcycle, bicycle, walking), and private transport (private car).

The work trip is the most important travel need in major cities of Asia. The pattern of work trips in cities is regular in time and space. People also travel for shopping, social activities, and recreation and between various business places, but the share of these trips is comparatively less than that of work trips. The demand for time for these other modes is irregular compared with that of work trips. Social and recreational trips are especially difficult to anticipate, but one favorable aspect of these trips is that their peak demand may be different from that of work trips.

Modal Choice of Person Trips

The use of public transport has a larger share than other modes in most cities of developing countries in Asia (Table 1), even

TABLE 1 Modal Split of Person Trips in Selected Asian Cities (*2,4–13*)

Code No.	City	County's 1993 GNP /Capita US$	Population Density Pop./sq.km 1993	Year of Modal Split	Public Transport			Priv-ate Tran-sport	Other Modes of Transport								
									Para-Transit Motorized			Non-motor-ized	Total Para Tran-sit	Motor cycle	Walk and Cycle	Any Oth-er	Total of Other Modes
					Bus	Rail	Total	Car	Taxi	Other	Total						
1	Kuala Lumpur	2965	5328	1985	24.6	0.0	24.6	32.1	1.6	0.3	1.9	0.0	1.9	13.8	27.6	0.0	43.3
2	Bangkok (a)	1605	3954	1989	38.9	0.0	38.9	32.7	9.9	18.5	28.4	0.0	28.4	0.0	0.0	0.0	28.4
3	Chiang Mai	1605	1053	1977	7.0	0.0	7.0	7.0	0.0	80.0	80.0	6.0	86.0	0.0	0.0	0.0	86.0
4	Manila (b)	725	12315	1989	16.0	1.0	17.0	16.0	2.0	58.0	60.0	0.0	60.0	0.0	0.0	7.0	67.0
5	Cebu (c)	725	1625	1992	0.3	0.0	0.3	4.3	38.3	57.1	95.4	0.0	95.4	0.0	0.0	0.0	95.4
6	Jakarta (d)	605	12590	1990	50.0	0.3	50.3	25.2	3.0	4.7	7.7	0.0	7.7	16.8	0.0	0.0	24.5
7	Bandung	605	-	1991	17.7	0.0	17.7	5.6	0.0	9.7	9.7	0.0	9.7	17.3	49.7	0.0	76.7
8	Surabaya	605	-	1982	9.0	0.0	9.0	2.0	0.0	18.0	18.0	13.0	31.0	45.0	13.0	0.0	89.0
9	Colombo	510	2760	1992	69.0	3.0	72.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.0	18.0
10	Karachi (e)	400	5923	1988	52.0	6.0	58.0	18.0	3.0	15.0	18.0	0.0	18.0	6.0	0.0	0.0	24.0
11	Shanghai (f)	325	2013	1986	24.7	0.0	24.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.1	3.2	75.3
12	Beijing (g)	325	3652	1987	32.1	0.0	32.1	0.0	0.6	0.0	0.6	0.0	0.6	0.0	64.1	3.2	67.9
13	Delhi (h)	310	15669	1981	48.8	11.0	59.8	16.7	0.0	6.2	6.2	0.0	6.2	0.0	17.3	0.0	23.5
14	Calcutta	310	23438	1985	67.0	10.0	77.0	0.0	2.0	14.0	16.0	7.0	23.0	0.0	0.0	0.0	23.0
15	Bombay	310	16450	1985	34.0	34.0	68.0	8.0	10.0	14.0	24.0	0.0	24.0	0.0	0.0	0.0	24.0
16	Kanpur (i)	310	5141	1977	7.0	0.0	7.0	0.0	0.0	5.0	5.0	88.0	93.0	0.0	0.0	0.0	93.0
17	Jaipur (j)	310	243	1985	6.0	0.0	6.0	3.0	0.0	7.0	7.0	22.0	29.0	18.0	44.0	0.0	91.0
18	Hyderabad	310	10418	1977	39.0	0.0	39.0	0.0	0.0	29.0	29.0	32.0	61.0	0.0	0.0	0.0	61.0
19	Kathmandu (k)	170	1266	1992	16.0	0.0	16.0	0.0	0.0	9.0	9.0	0.0	9.0	0.0	61.0	14.0	84.0
	Average of Asia				31.1	3.6	34.7	10.0	3.9	19.2	23.1	9.3	32.4	6.5	19.4	2.5	60.8

Notes: 0.0 = None or negligible
(a) Taxi=Incl.Silor & Samlor; Other=Hired Mcycle
(b) Rail=LRT; Other=Jeepney
(c) Taxi=Incl.Tricycle,MCycle,etc.;Other=Jeepney
(d) Car=incl.pickups;Otherl=Bajaj, Bemo, etc.
(e) Other=Autorickshaw
(f) Walk=40.3%,BCycle=31.8%;Taxi=Incl.MCycle,Truck,etc.
(g) Walk=13.8%,BCycle=50.3%
(h) Bus=Incl.Rail;Car=Car,Scoooter;Taxi=Incl.Autorickshaw
(i) Non-motorized=Cycle Rickshaw
(j) Taxi=All Motorized;Non-Motor.=Cyclerickshaw
(k) Walk=56%;Other=Cycle-rickshaw,Tempo,Metertempo,MiniBus

though the levels of service and area served are inadequate. The bus system is the most typical example of all deficiencies. Although constituting a small percentage in the total vehicle composition on the roads, buses typically account for more than one-third of person trips in most developing cities, such as Bangkok, Jakarta, Colombo, Karachi, Beijing, Delhi, Calcutta, and Bombay.

Urban rail services have importance in few cities. In Bombay, for example, railways carry 34 percent of total trips. In most cities, urban railways suffer from antiquated rolling stock that is often more than 50 years old, with poor track conditions and a poor signaling system.

The deficiencies of bus and rail services are being alleviated by paratransit modes that act as an intermediate mode of transport in most Asian cities. Paratransit modes are of two forms: motorized and nonmotorized. Auto-rickshaws, silors, samlors, jeepneys, bajajs (three-wheelers), scooter rickshaws, motorcycle rickshaws (motorized) and becaks, tongas, cycle-rickshaws, and tricycles (nonmotorized) are some paratransit modes in use in Asian cities. In Manila and Cebu, one-half of trips are made by jeepneys. Nonmotorized vehicles are used extensively in most Asian countries. For example, cycle-rickshaws are dominant in Kanpur because they carry 88 percent of total person trips of the city.

A large percentage of trips in most developing countries, including trips to work, are made on foot or cycles; for example, in Shanghai and Beijing trips are made by cycling and in Kathmandu by walking. In all developing cities in Asia the facilities for pedestrians are poor. Conditions for cyclists are worse than they are for pedestrians. In Shanghai and Beijing the number of bicycles [7.20 million and 7.26 million bicycles in 1990, respectively (*2*)] is more than or equal to one-half its population, and in many other cities bicycles outnumber automobiles. Even in Beijing and Shanghai, where bicycle lanes are provided, the other related infrastructures such as lane dividers, railway, road crossings, and flyovers are not sufficient.

The low usage rate of public transport may reflect either high levels of private automobile ownership or too low an income to afford the fare. In cities such as Kuala Lumpur and Bangkok, because of increased car ownership, the modal share by private car has been increased from the last decade. The degree of motorization is closely related to the levels of income together with taxation policy and import quotas. On the other hand, low-income cities will use nonmotorized modes, as in Beijing and Shanghai (bicycle), Kanpur and Jaipur (cycle-rickshaw), and Kathmandu (walking).

Automobile ownership in Asia lags far behind that in the developed countries, and in general most of the cars are in cities. In Thailand, 70 percent of the cars are in Bangkok (*3*). In Bangkok, 47 percent of the vehicles registered were private cars in 1991, whereas for the whole country only 15 percent of the total registered vehicles are private cars (*3*).

From the available data on modal split in different cities of Asia, the following deductions may be drawn.

1. The growth in gross national product (GNP) per capita reduces the upper limit of public transport usage, whereas private care use increases when GNP per capita grows (Figure 1).

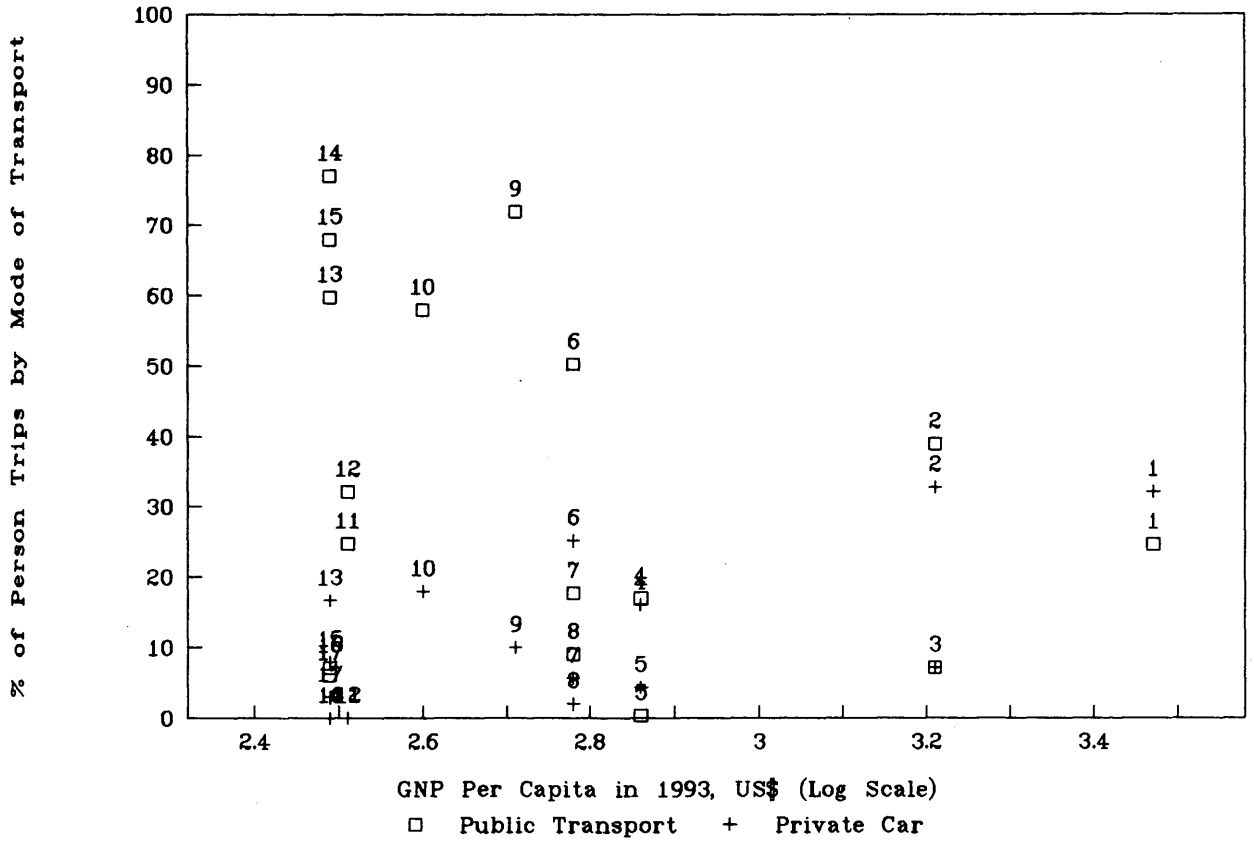

FIGURE 1 Variation in modal share by public transport and private car with per capita GNP.

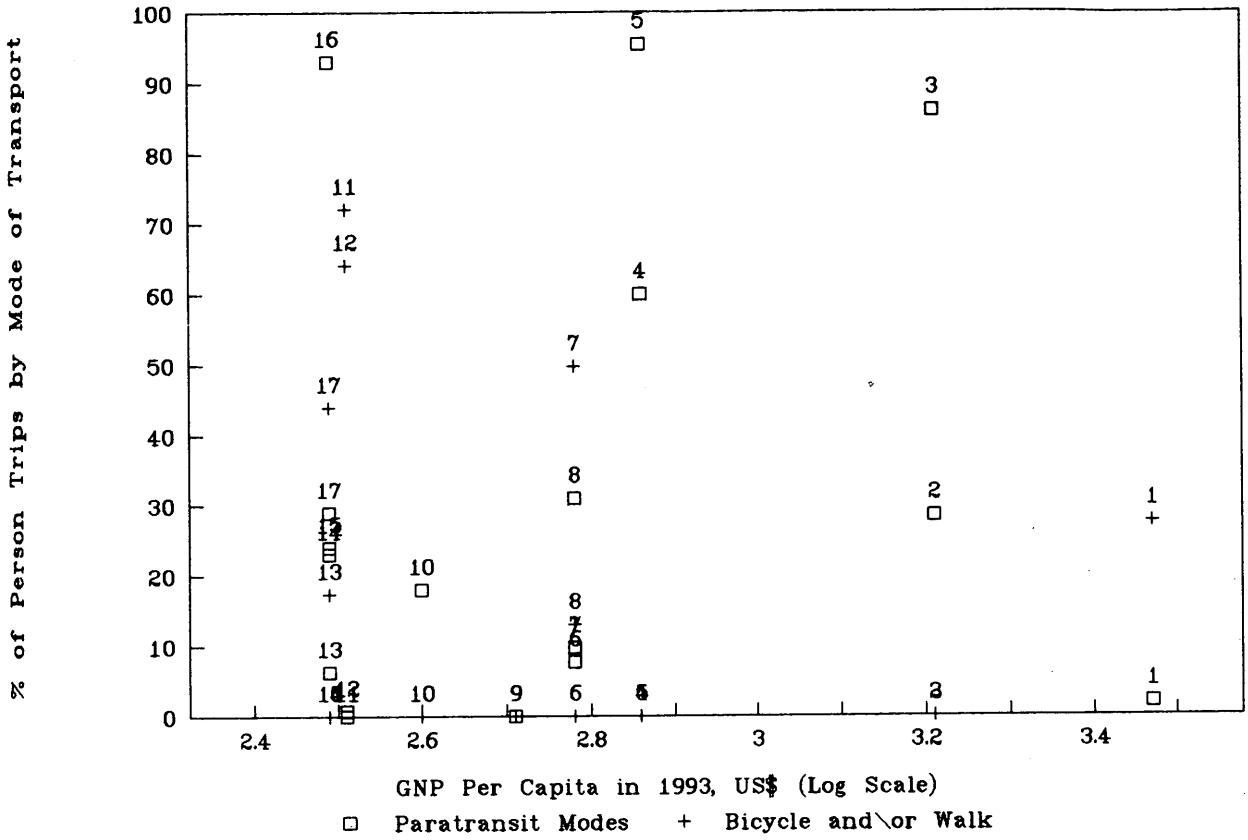

FIGURE 2 Variation in modal share by paratransit, bicycle, and walking with per capita GNP.

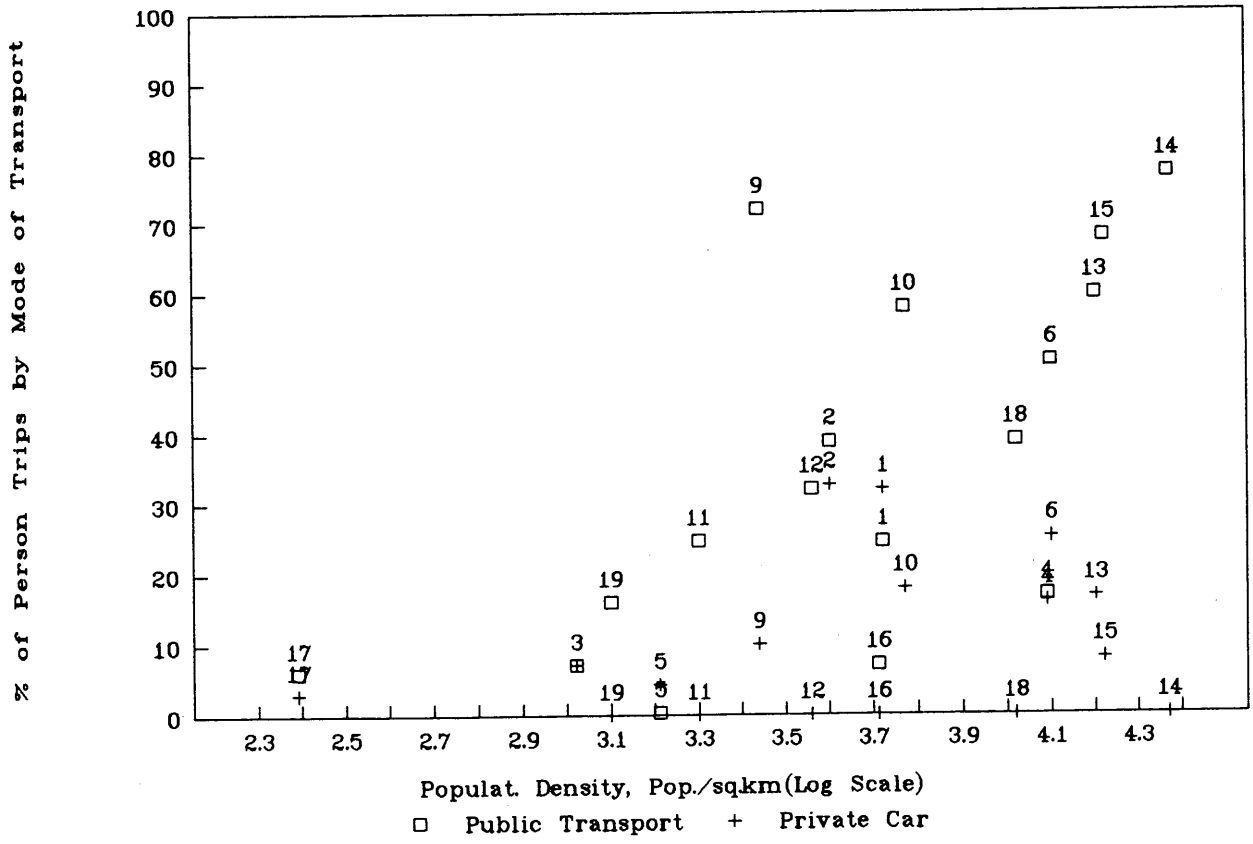

FIGURE 3 Variation in modal share by public transport and private car with population density.

2. Figure 2 shows the reduction in the share of paratransit modes with an increase in per capita GNP. The poor, who cannot afford any motorized transport and who walk and use bicycles, will increase the use of paratransit modes with the growth of income. As a result, the share of walking and cycle trips will decrease.

3. In cities of large population densities, a larger share of person trips by public transport modes can be seen (Figure 3). It may be possible to operate public transport services profitably in densely populated cities because of the attraction of more passengers as a result of its cheap fare. This results in lower usage of private automobiles.

4. When cities become more dense and major activity centers remain concentrated in the city center, people need to make more short-distance than long-distance trips because all daily activity centers can be located in the vicinity of the residential area. Therefore, people are inclined toward walking and cycling for their short-distance trips in densely populated cities of developing countries (Figure 4).

Modal Choice by Trip Purpose

The separation of residential areas from workplaces with rapid growth in urban areas has created a pendulum movement between home and work during peak periods. This accounts for a larger volume of person trips than any other type of trips. The shopping trip is the second most frequent type of urban travel. The length of shopping trips, on the average, is shorter than that of work trips.

In general, the work trips generated in all the cities make up more than 25 percent and in some cities more than 50 percent of total trips (Table 2). When the share of national products in the major or capital city is comparably larger, the city provides a larger number of employment opportunities and contains most of the industries of the country, which in turn generates larger volumes of work trips.

Figure 5 shows that with the increase in the per capita GNP of countries, the percentage of trips to work is possibly reduced. This is because fewer people may need to work and other activities may become dominant. Meanwhile, a high percentage of nonworking people generate more trips to shopping, recreation, social, and religious locations and in turn trips for other purposes increase.

Table 3 shows that more trips for work and school are made than for public and bicycle/walk trips.

COMPARATIVE ANALYSIS OF MODAL CHOICE AND TRIP CHARACTERISTICS

The population densities, GNP per capita, level of motorization, number of motorized and nonmotorized trips, and each country's modal split pattern of person trips are analyzed by developing a graphical model. In spite of few available data, there are indications of sufficient consistency in the result to warrant further

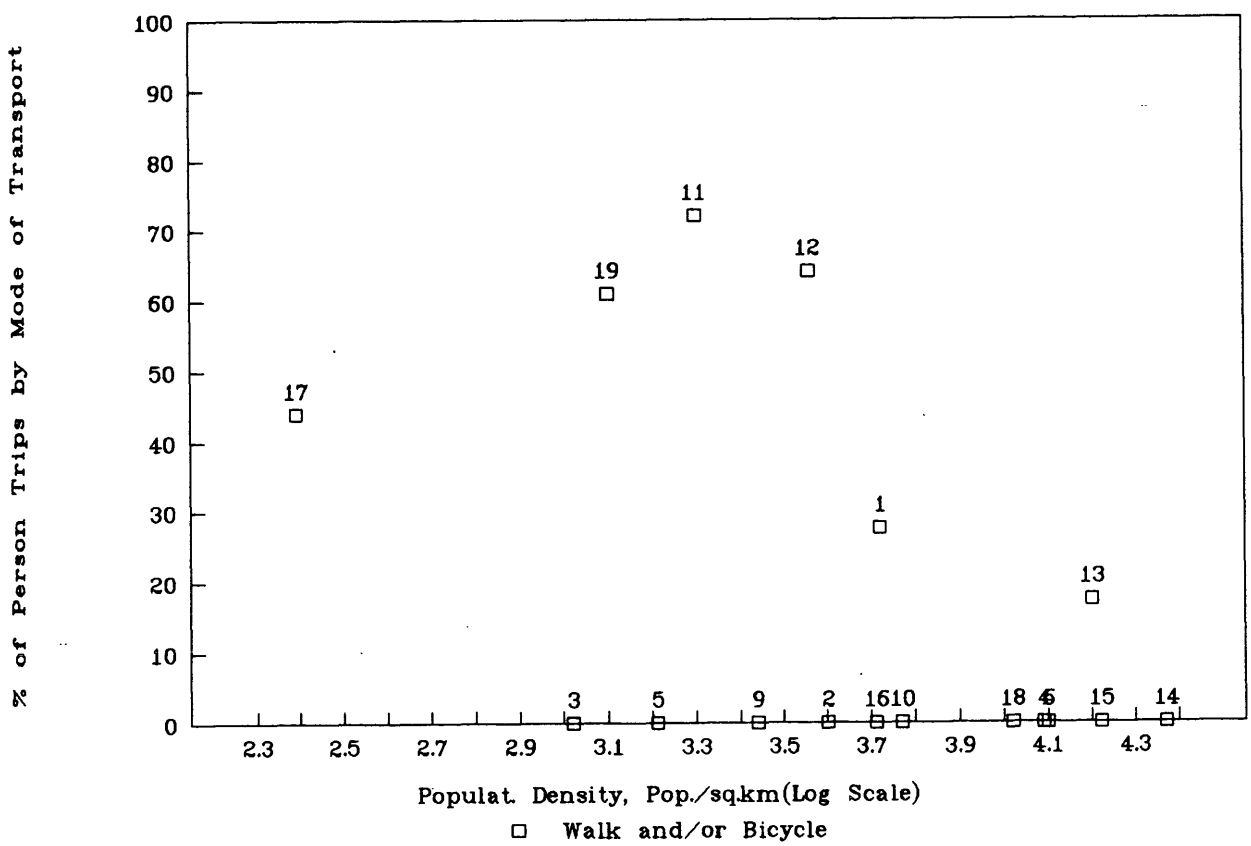

FIGURE 4 Variation in modal share by walking and bicycle with population density.

TABLE 2 Modal Split by Trip Purpose in Asian Cities (*4–7,10–12*)

Code No.	City	GNP Per Capita US$	Population Density Pop. per sq.km	Year of Modal Split	Trip Purpose											Work + Home
					Work	Schl.	Total	Shop.	Busi.	Total	Recr.	Priv.	Total	Home	Othe.	Total	
1	Kuala Lumpur	2965	5328	1985	14.6	10.6	25.2	–	6.3	6.3	–	26.5	26.5	42.0	–	42.0	56.6
2	Bangkok	1605	3954	1989	19.7	10.4	30.1	–	13.0	13.0	–	15.1	15.1	41.8	–	41.8	61.5
3	Chiang Mai	1605	1053	–	–	–	–	–	–	–	–	–	–	–	–	–	–
4	Manila	725	12315	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5	Cebu	725	1625	1992	12.3	12.0	24.3	–	5.1	5.1	–	–	0.0	48.6	22.0	70.6	60.9
6	Jakarta	605	12590	1990	22.6	11.5	34.1	4.3	7.0	11.3	–	12.4	12.4	42.2	–	42.2	64.8
7	Bandung	605	–	1991	23.5	8.5	32.0	8.6	–	8.6	–	–	–	43.4	16.0	59.4	66.9
8	Surabaya	605	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9	Colombo	510	2760	1992	–	–	68.4	–	–	12.2	–	–	11.6	–	7.8	7.8	68.4
10	Karachi	400	5923	–	–	–	–	–	–	–	–	–	–	–	–	–	–
11	Shanghai	325	2013	1986	76.3	3.9	80.2	13.6	–	13.6	3.9	–	3.9	–	2.3	2.3	76.3
12	Beijing	325	595	1990	26.2	5.8	32.0	6.0	2.4	8.4	3.3	–	3.3	45.8	10.5	56.3	72.0
13	Delhi	310	15669	1981	52.6	16.2	68.8	3.5	6.2	9.7	14.6	1.1	15.7	–	5.8	5.8	52.6
14	Calcutta	310	23438	–	–	–	–	–	–	–	–	–	–	–	–	–	–
15	Bombay	310	16450	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16	Kanpur	310	5141	–	–	–	–	–	–	–	–	–	–	–	–	–	–
17	Jaipur	310	243	–	–	–	–	–	–	–	–	–	–	–	–	–	–
18	Hyderabad	310	10418	–	–	–	–	–	–	–	–	–	–	–	–	–	–
19	Kathmandu	170	1266	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Notes: – = Data not available
Schl. = School
Shop. = Shopping
Busi. = Business
Recr. = Recreation
Priv. = Private
Othe. = Other

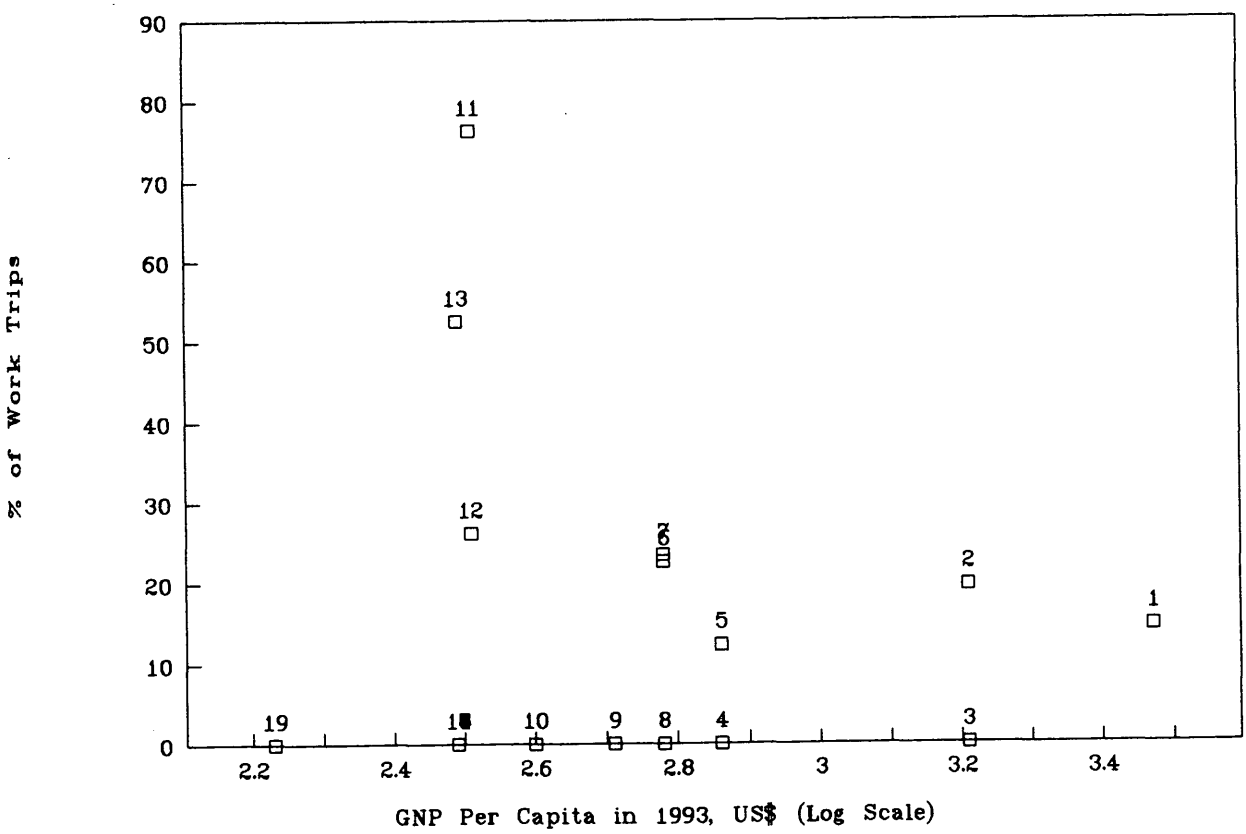

FIGURE 5 Variation in work trips with per capita GNP.

TABLE 3 Percentage Distribution of Work and School Trips by Mode (*4–7,10,11,14*)

City	Purpose	Public	Private	Para-transit	MCycle	Cycle & Walk
Tokyo	Work	52	25	0	12	11
	School	25	5	0	7	63
Bangkok	Work	59	37	2	2	-
Jakarta	Work	34	20	-	19	27
	School	26	7.5	-	3.5	63
Bandung	Work	14	5	10	18	53
	School	22	3	10	27	38
Delhi	Work	37	4	2	10	47
	School	17	0	2	0	81
Shanghai	Work	36	-	-	-	64
	School	31	-	-	-	69

TABLE 4 Modal Split Data of Selected Cities the Developed World (*14,15*)

Code Number	City	GNP Per Capita of Country US$ (1993)	Modal Split (1982-1988) Public %	Private %	Other %
A1	Tokyo	27,326	67	32	1
B	USA-country	22,550	5	89	6
B1	New York	22,550	86	12	2
C	Stockholm	22,391	52	48	0
D	Stuttgart	21,475	33	44	23
E	Paris	21,188	29	56	15
F	London	17,738	35	61	4
G	Hong Kong	14,102	79	8	13
I	Wellington	11,875	31	56	13

TABLE 5 Change in Modal Split in Selected Asian Cities (*16,17*)

Code No./City		Mode	1955	1960	1965	1970	1975	1980	1985	1990
A1	Tokyo	Public	93	92	91	75	76	71	75	65
		Private	0	0	0	18	19	23	24	30
		Other	7	8	9	7	5	6	1	5
A2	Nagoya	Public	94	92	91	60	49	39	37	33
		Private	0	0	0	32	45	55	59	64
		Other	6	8	9	8	6	6	4	3
A3	Osaka	Public	94	93	90	75	71	65	64	60
		Private	0	0	0	17	23	29	31	36
		Other	6	7	10	8	6	6	5	4
1	Kuala Lumpur *a*	Public	-	-	-	35	-	-	25	-
		Private	-	-	-	47	-	-	32	-
		Other	-	-	-	18	-	-	43	-
2	Bangkok *a*	Public	-	-	-	59	-	-	39	-
		Private	-	-	-	29	-	-	33	-
		Other	-	-	-	12	-	-	28	-
6	Jakarta *a*	Public	-	-	-	61	-	-	50	-
		Private	-	-	-	24	-	-	25	-
		Other	-	-	-	15	-	-	25	-
10	Karachi *a*	Public	-	-	-	63	-	-	58	-
		Private	-	-	-	16	-	-	18	-
		Other	-	-	-	21	-	-	24	-
13	Delhi *a*	Public	-	-	-	41	-	-	59	-
		Private	-	-	-	13	-	-	17	-
		Other	-	-	-	46	-	-	24	-
14	Calcutta *a*	Public	-	-	-	34	-	-	77	-
		Private	-	-	-	8	-	-	0	-
		Other	-	-	-	58	-	-	23	-
15	Bombay *a*	Public	-	-	-	41	-	-	68	-
		Private	-	-	-	11	-	-	8	-
		Other	-	-	-	48	-	-	24	-

Notes: - = Data unavailable.

a Data corresponding to 1985 were collected during 1980-1988.

development of the model. The constructed model has been validated by comparing the present modal split of Asian developing cities (Table 1) with some cities in the developed world (Table 4) and by testing historical data sets of some cities of Asia (Table 5).

Modes of transport in Asian countries are categorized into three main groups, as follows, to apply in the suggested graphical model.

1. Public transport: bus, rail, subway, street car;
2. Private transport: private car;
3. Low-cost (other modes): motorized paratransit (silor and samlor in Bangkok, jeepney in Manila and Cebu, and bajaj in Jakarta); nonmotorized paratransit (cycle-rickshaw in Kanpur and Jaipur); motorcycle; and bicycle and walk.

Because the percentage of trips by taxi is very small in any country under analysis, such as Kuala Lumpur (1.6 percent), Bangkok (9.9 percent), Jakarta (3 percent), and Bombay (4 percent), it is included here under low-cost modes of transport group for statistical convenience.

The modal choice pattern of cities in Asian developing countries and some selected cities of developed countries is plotted in the proposed trilinear graphical model in Figure 6 on the basis of the data presented in Tables 1 and 4.

Past and present modal split data of some cities in Japan and Asia (Table 6) are plotted in Figure 7 to illustrate the change in modal choice with the level of economic development of countries of those cities.

Figures 6 and 7 reveal that the trilinear graphical model can be divided into four zones, which gives the dominating mode of transport of the city by its zonal location in the model. Following are the four zones that derived from the model.

1. Low-cost modes of transport;
2. Public transport;
3. Mixed transport, divided into the following subzones: (a) public and low-cost modes, (b) public and private car, (c) low cost modes and private car; and
4. Private car.

Figure 8 shows the pattern of change in modal choice with the economic development of the country based on historical data. The trend in the urban tansportation system is from low-cost modes, especially nonmotorized modes, to mixed (i.e., low-cost and public), and then to public transport dependent (bus and rail mainly) as the country changes from being an underdeveloped country to a developed country. Then, as the economy continues to grow, the tendency of urban transport is toward private car dependent and, therefore, the location of the city in the model will move upwards, to the uppermost triangle by passing mixed-zone modes (public, private car, and low-cost modes). Also, there are some cases that heap their positions on the left axis, such as New York, Tokyo, Nagoya, and Osaka, where subways and urban trains play a major role. Still, in those cities the change pattern of modal choice moves upwards with the development of the economy (Figure 7).

The analysis done in this study by the trilinear graphical model is based on the available historical facts. Therefore, the derived change pattern of modal choice is not necessarily a preferable pattern with the city development level.

POSSIBLE SOLUTIONS TO PROBLEMS IN URBAN TRANSPORTATION SYSTEM

Urban Transportation System with Mixed Modes of Transport

The most preferable pattern of modal choice of person trips in Asian countries would be mixed modes (the middle rectangular

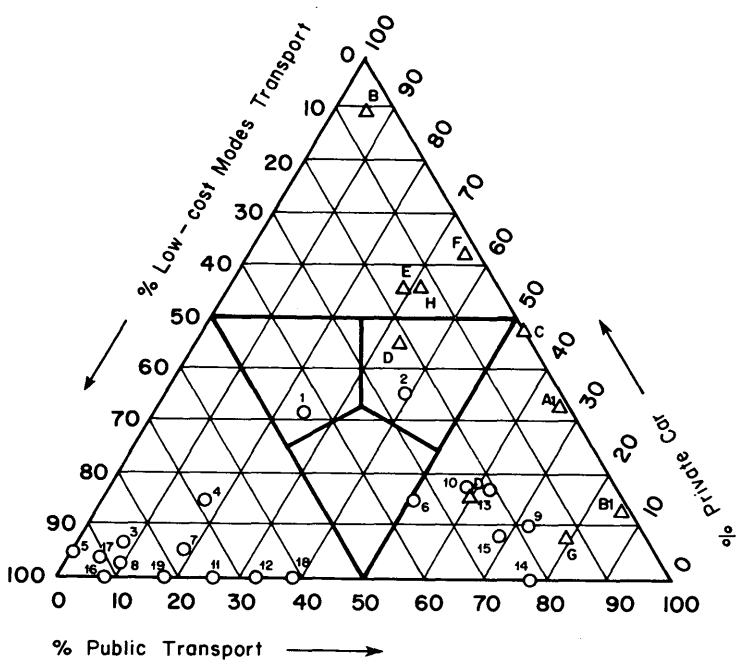

FIGURE 6 Analysis of modal split by trilinear graphical model.

TABLE 6 Classification of Developing Cities in Asia on the Basis of Modal Choice by Trilinear Graphical Model, 1993

Dominating Type of Mode	Country/City	GNP Per Capita US $	Population Density Pop./sq.km
1. Low Cost Modes of Transport Dependent	Chiang Mai	1605	1053
	Manila	725	12315
	Cebu	725	1625
	Bandung	605	-
	Surabaya	605	-
	Shanghai	325	2013
	Beijing	325	3652
	Kanpur	310	4141
	Jaipur	310	243*a*
	Hyderabad	310	10418
	Kathmandu	170	1266
2. Public Transport Dependent	Colombo	510	2760
	Karachi	400	5923
	Delhi	310	15669
	Calcutta	310	23438
	Bombay	310	16450
3. Mixed Mode Dependent			
a. Low Cost Mode & Public Transport	None		
b. Pubic Transport & Private Car	Bangkok	1605	3954
	Jakarta	605	12590
c. Private Car & Low Cost Modes	Kuala Lumpur	2965	5328
4. Private Car Dependent	None		

a Metropolitan/municipality area is not known and total area was used here.

\- Data not available.

Note: Only those cities which were mentioned in TABLE 1 are classified here.

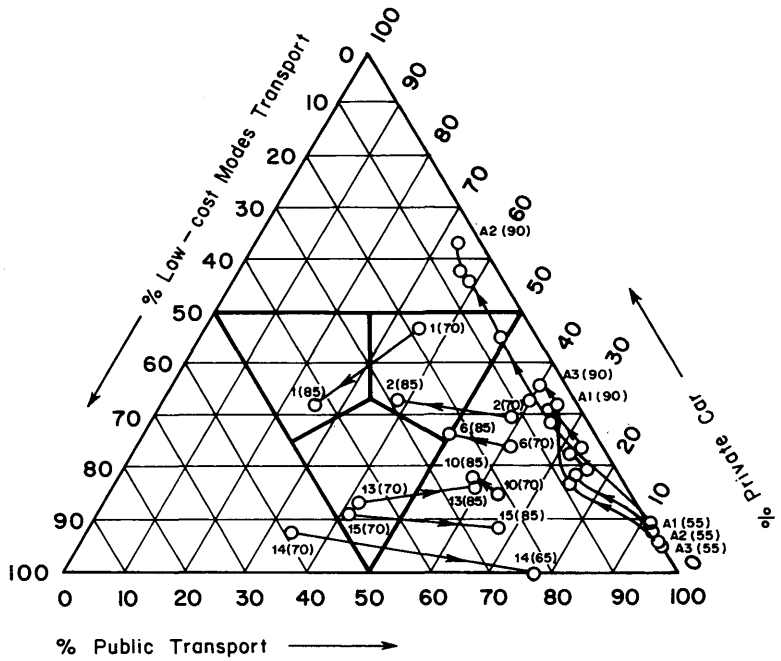

FIGURE 7 Change in modal choice in selected Asian cities.

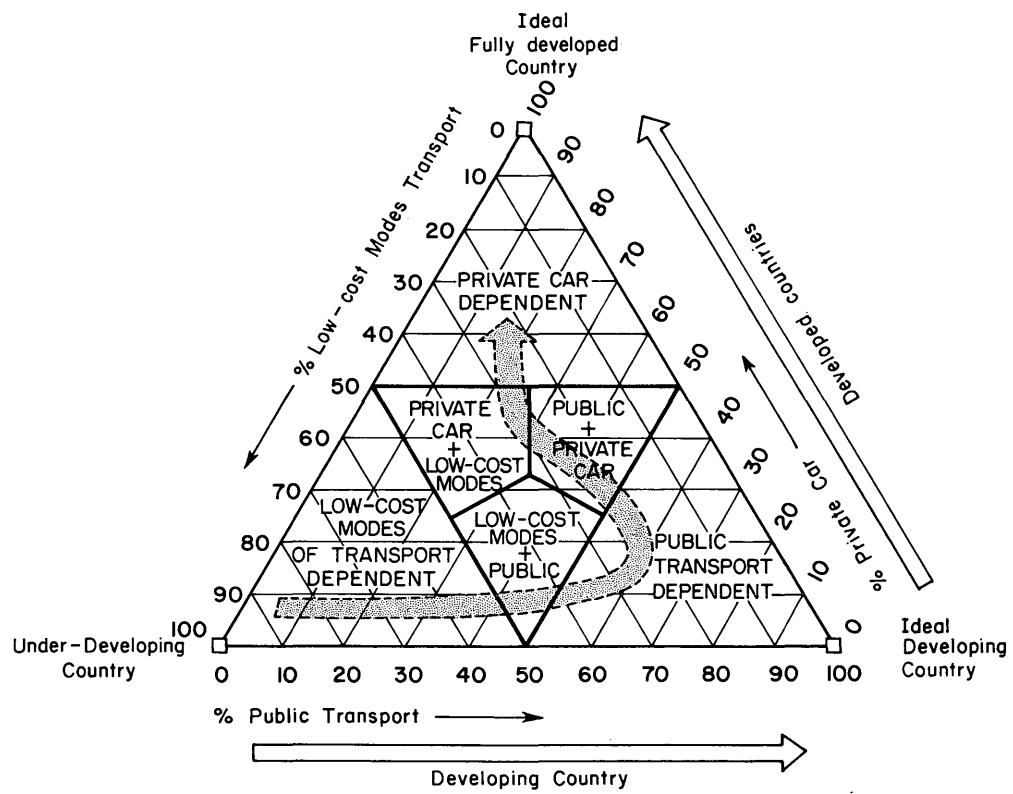

FIGURE 8 Pattern of change in modal choice with growth of per capita GNP.

zone in the model), where people have a variety of modes to choose from on the basis of their willingness, affordability, and travel need. The precise position in the middle triangle should be decided on the basis of such factors as city size, population, and GNP per capita. To approach this stage, all the developing cities in Asia would have to provide infrastructures for all types of modes. In most developing cities, railway is lacking. Hence, as a starting point, the railway system needs to be developed to complement the development of infrastructures for all modes, such as pedestrian facilities, bicycle lanes, and bus lanes. After such development, the public transport system could be used in the crowded urban areas with paratransit modes to provide feeder service. In the later stages, these cities could consider a supplementary improvement with various levels of service and comfort by mixed modes to fill the demand created by people from different income levels.

At present a railway system is being developed in Los Angeles, and a bicycle way is being developed in Holland. These projects may show that even developed cities try to go back to the middle triangle of the above-described trilinear model.

Possibility of Mass Transit

Commuter traffic in large cities by necessity is predominantly serviced by mass transport systems. A reliable mass transport system has been drawing attention recently in most of the large cities.

Bangkok, where the traffic congestion is considered to be among the world's worst (Table 7), remains as one of the major cities in Southeast Asia still without a mass transit system.

Many different forms of bus-based and rail-based mass transit systems are considered to be suitable in developing cities of Asia; these include the guided-bus way, the subway system, the skytrain, and metropolitan rapid transit. Of these mass transit systems, the most appropriate system should be selected on the basis of the type, fare structure, coordination with existing public transport systems, and finally economic and financial feasibility of the system as a first step.

Because of the availability of bus systems in all the cities of Asia, it is more appropriate to improve the present bus system as an immediate way to solve the transportation problem to some extent. Improvements can be made by providing specific require-

TABLE 7 Available Mass Transit Systems in Asian Cities (*2,4,7,8,10,11,15*)

City	Type of Mass Transit System	Status
Singapore	Mass Rail Transit (MRT)	In operation
Kuala Lumpur	Light Rail Transit and Mono Rail	----ditto---
Bangkok	Train Service	*a*
	Sky Train, Subway and Rapid Transit	Under consideration
Metro Manila	Light Rail Transit (LRT)	In operation
Jakarta	Elevated Railway	
Colombo	Train Service	*a*
Karachi	Train Service	*a*
Beijing	Subway	In operation
Shanghai	Subway	Under construction
Delhi	Train Service	*a*
Calcutta	Train Service	*a*
Bombay	Train Service	*a*

a Generally provides long distance service and not adequate with rolling stock and infrastructure to cater for the existing demand in urban transportation system.

ments such as exclusive bus lanes, improved level of service, and increased area of service. These improvements may be used when it would be possible to implement an urban mass transit system in these cities in coming years.

CONCLUSIONS AND RECOMMENDATIONS

Rapid urbanization and motorization combined with a shortage of resources are the major cause of the current urban traffic problems of most developing countries in Asia. These resource limitations in developing countries seriously impede the possibilities of increasing transport capacity in a metropolis. A shortage of surface space in central city areas remains as another limiting factor that obstructs extensive improvements in the road/railway network.

For most cities in Asia and the great majority of their populations, the choice of mode is between regular bus (31.1 percent average) and very cheap walking and cycling (19.4 percent average). Excluding taxi, paratransit (motorized) modes play a significant role in the urban transport system of developing countries, accounting for approximately 19.2 percent average users in all countries in Asia under consideration in this study. Taxis are not affordable in almost all countries. Railway accounts for only 3.6 percent average of the total because of the nonavailability of rail service in most Asian countries. Among considered countries in Asia, railway service is used for commuter trips only in a few cities such as Bombay, Calcutta, Colombo, and Karachi.

The developed trilinear graphical model shows a consistent trend in modal share change with the changed GNP per capita. Each city should find the desirable zonal location in the diagram, depending on per capita GNP as well as population, size of the city, and other secondary facts related to the level of city development.

A mixed mode of transportation system is recommended for large cities because it enables the system to cater to the person-trip demand with different levels of affordability and travel needs generated by large and dense cities of Asia. Improvement of the present bus system would be a prompt remedial action to ease the prevailing situation in these cities. Further, as a first step, it is suggested that urban mass transit systems be developed to include a railway system along with development of the infrastructure facilities that are required by all types of modes.

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