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TRAFFIC CHARACTERISTICS OF INDIA

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Abstract: The revolution in the automobile industry and liberalised economy has led to tremendous increase in the vehicle ownership levels. This has resulted in changing traffic characteristics on road network. In this paper an attempt has been made to analyse the changing traffic composition trends, speed characteristics and travel patterns by taking few case studies. Further, the impact of changing traffic composition trends and emerging issues thereof are discussed

Key Words: Traffic characteristics, travel patterns, heterogeneous traffic.

1. INTRODUCTION

Comparatively urbanization is moderate in India. The urban population has grown from ten percent in 1901 to twenty eight percent in 2001. The skewed distribution of the urban population amongst a few cities is a matter of concern to the planners and administrators of urban infrastructure. Nearly seventy percent of the urban population is located in Class-I cities (population of one hundred thousand and more). Further 38 percent of the total urban population is located in metropolitan cities (population of one million and more) numbering about thirty-five. This heavy concentration of population in a few centers has resulted in the expansion of cities in density as well as area. With the increase in population and economic activities the travel demand has increased many folds. The inadequate public transport and the easy availability of financing facilities for private vehicles have resulted in increased vehicle ownership levels and their usage. Further, the changes in urban form and structure in terms of lad use, density of population and concentration of activities have changed the travel pattern. In other words the traffic problems are increasing in the cities in general and the situation is becoming complex especially in core areas of the city.

This paper presents the traffic characteristics in major cities of India. The comparison of traffic composition, volume and speeds on important roads over a period of time is made and discussed in the paper. Finally based on the analysis and the type of problem probable solution(s) are suggested to ease the traffic problems.

2. POPULATION GROWTH

The population of India is growing rapidly with a national average growth rate of 2.1 percent per annum(Census of India,2001). The growth is even higher in some of the urban areas of India. Figure 1 shows the growth trend of population in the top six cities of India. Delhi, the capital city of India has been very fast growing with an average annual population growth rate of about 4.5 percent, followed by Bangalore (3.38 percent) and Mumbai (2.68 percent). It can be observed from the graph that the growth of population is more or less uniform in Kolkata from 1951 to 2001. Further, Bangalore and Hyderabad have more or less similar growth trends and are competing with each other. Mumbai has experienced higher growth rate during 1981-1991 as compared to other mega cities.

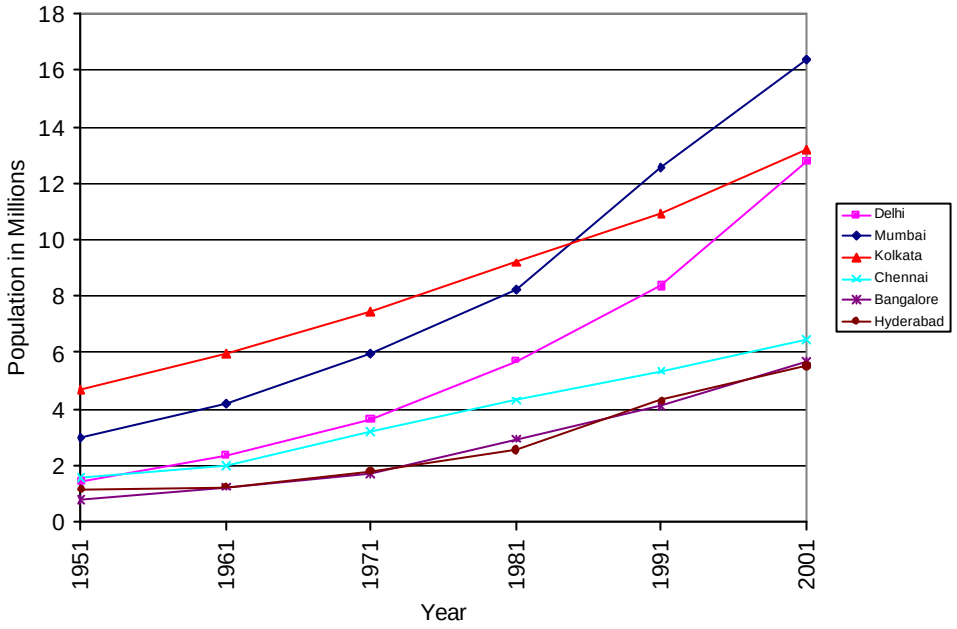


Figure 1. Growth of Population in Metropolitan Cities of India

3. VEHICULAR GROWTH

The uncontrolled and ill planned growth of urban centers has resulted in a number of problems like traffic congestion, shortages of water and electricity, deteriorating environment and public health. The growing cities have generated the high levels of demand for travel by motor vehicles in the cities. To match the increasing travel demand commensurate efforts have not been made to develop the mass transport systems. On the other hand, the Government of India has permitted the manufacture of automobiles. This has resulted in tremendous increase in the population of automobiles in the cities. The growth trends (MOST, GOI, 1998) of automobiles at National and City levels are as indicated in Table 1. The automobile population in India has increased from a mere 0.3 million in 1951 to more than 45 million in 2001. The registered two wheelers constitute nearly seventy percent of the vehicle population in almost all the cities. Due to higher income levels and greater needs for mobility in the urban areas, more automobiles are owned and operated in them. More than 90 percent of the automobiles are located in urban centres. This trend is observed to be changing in the recent past mainly due to the development of better quality road network connecting rural areas and richer communities of rural areas going in for the automobiles.

Table 1. Growth Trend of Motor Vehicles in India and Mega Cities

Year	Total Vehicles Registered in Thousands									
	All India	Delhi	Mumbai	Kolkata	Chennai	Bangalore	Hyderabad	Ahmedabad	Kanpur	Agra
1981	5371	536	307	-	120	175	89	103	-	-
1986	10577	961	480	339	228	307	237	201	94	70
1991	21374	1813	629	475	544	577	443	374	161	135
1996	33783	2630	724	588	812	900	764	572	224	204
1998	40939	3033	860	664	975	1130	887	686	294	260

However, as it can be seen from the above table, the concentration of automobiles (22 percent) is in eight urban areas. Delhi is having total registered vehicles of more than 3.5 million (2002) with the predominance of two wheelers and cars, used as private passenger vehicles as shown in Figure 2. In the other three mega cities i.e. Mumbai, Kolkata and Chennai also the two wheelers and cars are predominant. However, in the case of Mumbai till 1993 cars were more than two wheelers but the scenario has changed in the last ten years. The declining growth trend of cars and two wheelers observed in Mumbai is due to updation of registers of the Road Transport Authorities by discarding the condemned and transferred vehicles. Similar trend in growth of two wheelers is observed in Kolkata also. While the motor vehicles in metropolitan cities have grown in multi-folds, the road network has grown at a much slower rate leaving a huge short fall in the capacity required to carry the motor vehicles plying in the cities.

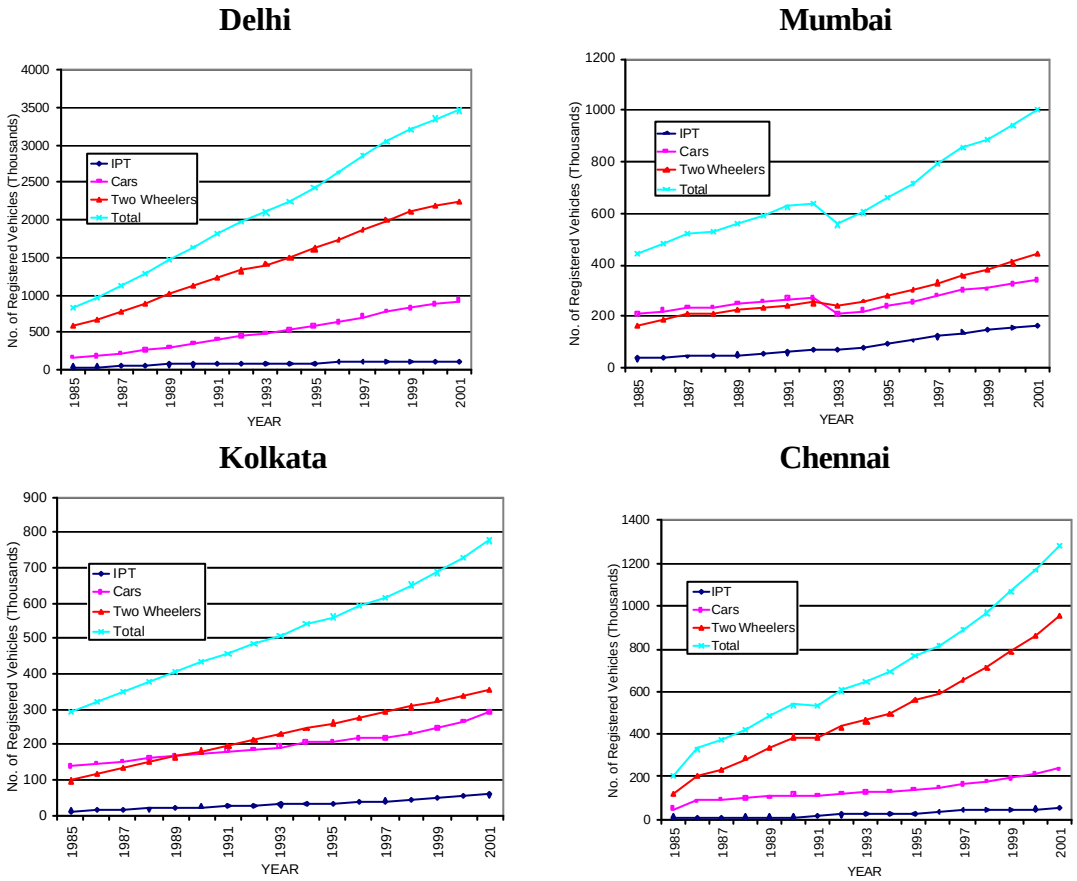


Figure 2. Growth Trend of Motor Vehicles in the Four Mega Cities of India

4. TRAFFIC CHARACTERISTICS

This section describes the traffic characteristics such as traffic volume and composition, Travel

patterns and speed measurements on major roads in few case studies in Delhi, Mumbai and Bangalore. Comparison is made as to how the traffic characteristics are changing over a period of time and the emerging issues are highlighted.

4.1 Case Study of Delhi

4.1.1 Study Area

The area of Delhi is divided into three parts (i) inner, (ii) middle and (iii) outer areas as shown in Figure 3. As can be seen from the figure the inner area is the core area of Delhi consisting of Connaught Place, New Delhi Railway Station, walled city and surrounding areas. The middle area includes mostly the NDMC area and is bounded by the Ring Road. The outer area is the area outside the Ring Road and within the boundary of Delhi as shown in Figure 3. The data obtained through traffic surveys in Delhi were analyzed based on the above areas.

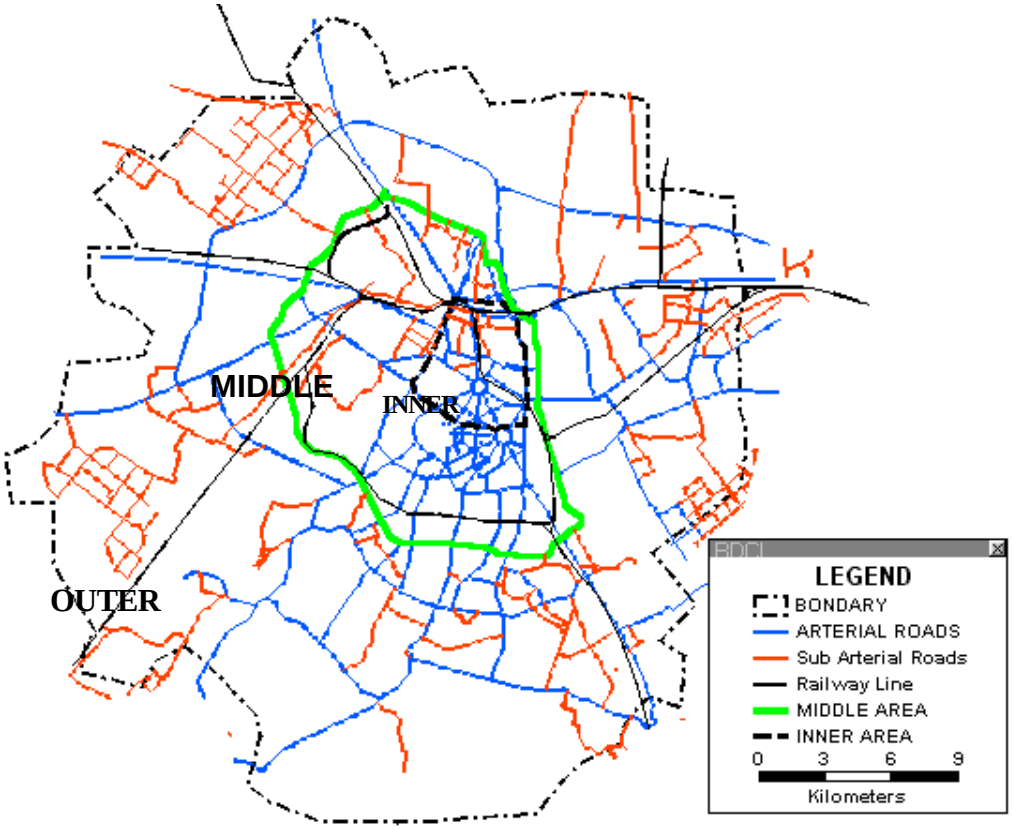


Figure 3. Major Road Network Of Delhi And Delineation Of Areas

4.1.2 Traffic Volume

Classified traffic volume count surveys were carried out in 1969(CRRI,1972), 1991(CRRI,1991) and 2002(CRRI,2002) at several (around 50 mid-blocks) locations. Appropriate proformae were used to record the number of vehicles moving across the count point during a given time. From these traffic counts, volume of traffic in different hours of the day has been enumerated at all the count points and the data has been analysed to understand the composition of traffic. In order to understand the change in traffic characteristics and also to account for the newly developed areas/land use the traffic survey locations were selected judiciously. Therefore, around 50% of the

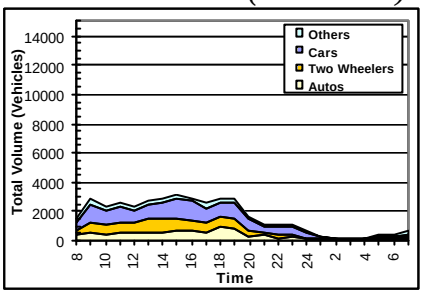
locations in 1991 were repeated in 2001 as well while remaining 50% were new. The traffic volume counts have been conducted at all the locations for a minimum of 16 hours period *(morning 6.00 to 10.00 in the night)* and a few locations were selected to make 24-hour counts to understand the flows during night hours. Table 2 presents the traffic volume observed in 1991 and 2002.

Table 2. Comparison of observed traffic volume in 1991 and 2002 in Delhi

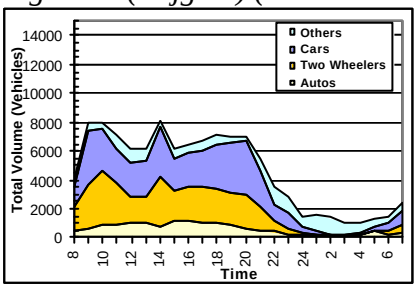
Description of Area	Maximum Volume		Minimum Volume		Average Volume	
	1991	2002	1991	2002	1991	2002
Inner	78100	131800	18400	25500	40700	74300
Middle	94300	135400	37200	45900	57620	74800
Outer	92600	149707	6000	14306	37200	60918

It can be observed from the table that the traffic has grown tremendously on the road network of Delhi in all the areas. The maximum average growth was observed in the inner area (8% per annum) followed by outer area (6% per annum) and middle area (3% per annum). The typical hourly variation of traffic volume on selected road sections in each of the areas is shown in Figure 4. It can be observed from the figure that in all the areas goods traffic is generally low during daytime and the same is predominant during night hours (22:00 to 04:00). This is due to time/entry restrictions that are in vogue as part of the traffic management measures.

Barakamba Road (Inner Area)



Ring Road (Rajghat) (Middle Area)



G.T. Road (NH-1) (Outer Area)

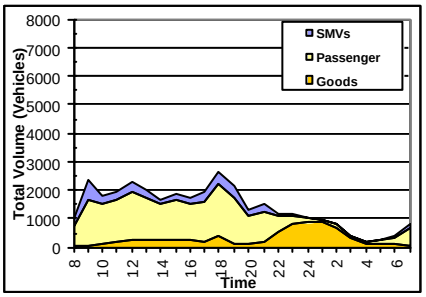


Figure 4. Traffic Flows on Selected Roads in Delhi (2002)

4.1.3 Traffic Composition

The broad analysis (Santosh.A & et al,2002) of traffic composition of vehicles in the inner, middle and outer areas is presented in Figure 5 (1969 &1984 (CRRI,1984)) and Figure 6 (1991 &2002). From the figure it can be observed that the composition of traffic has changed in all the areas from 1969, 1984, 1991 and 2002. The details are described area wise in the following sections.

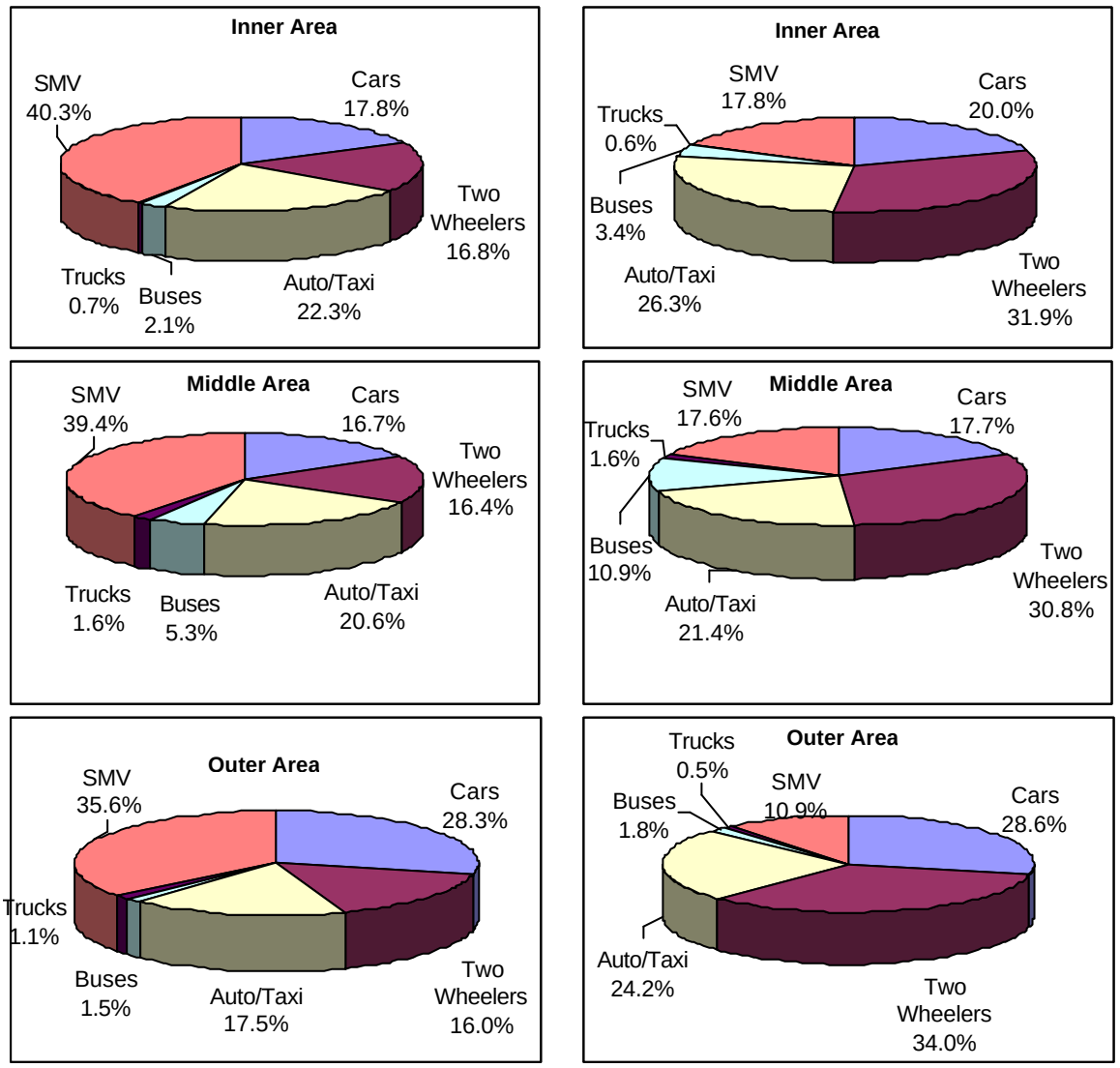


Figure 5. Comparison of Traffic Composition in 1969 and 1984 in Delhi

4.1.3.1 Inner area

Between 1969 and 1984, the share of SMVs (bicycles) has drastically reduced from 40% to 18% respectively whilst there is a significant increase in the share of two wheelers. Further, in the inner area of Delhi (Figure 6) cars and two wheelers constituted about 60% in 1991 while their share has increased to about 70% in 2002. It is interesting to note that the share of two wheelers has reduced by around 4% whilst that of cars has increased by 42% during the period 1991 to 2002. The increase in the share of private modes is offset by the reduction in the share of public transport (17%) and IPT modes (19%). This indicates the shift towards personalized modes of travel. Further,

a significant change that can be observed from the figure is the reduction in the share of Slow Moving Vehicles (SMVs), which has reduced from 10 % in 1991 to 4% in 2002 (60% reduction). All these changes will have a direct impact on the available infrastructure. For example, the increase in personalized modes of travel would demand more parking spaces in the core area in addition to additional capacity of carriageways.

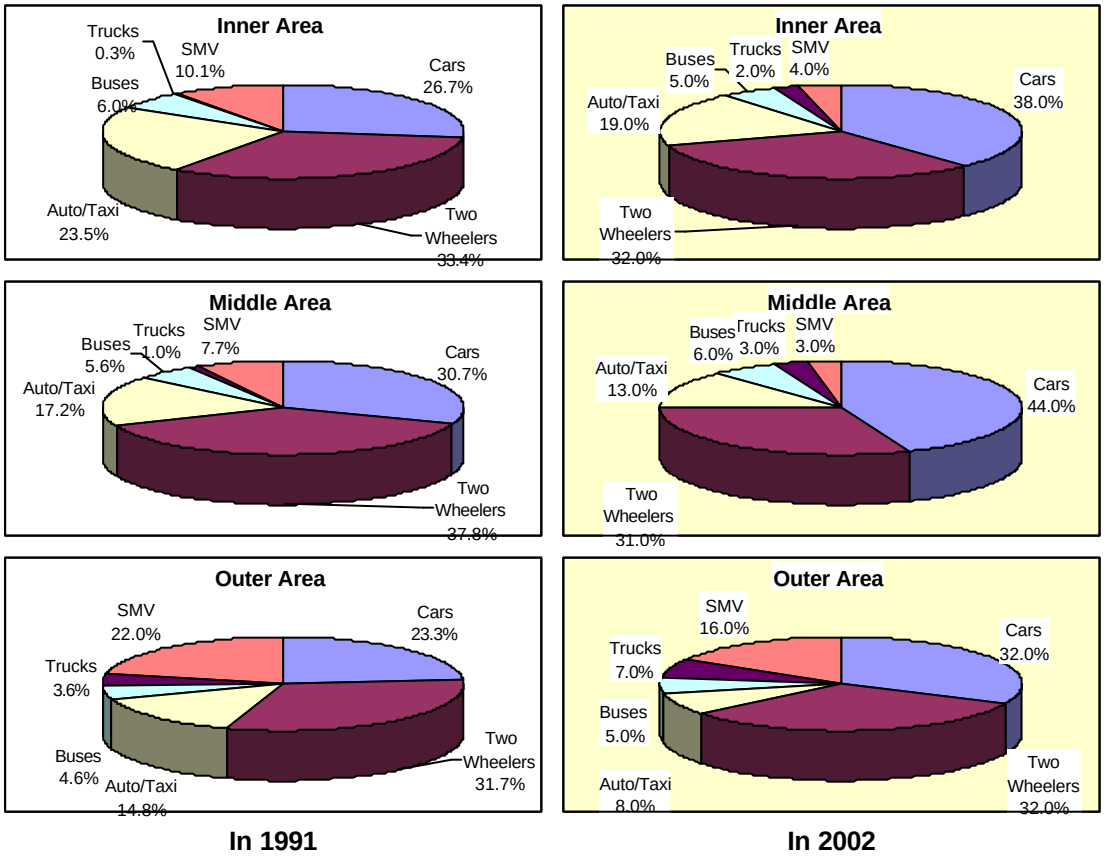


Figure 6. Comparison of Traffic Composition in 1991 and 2002 in Delhi

4.1.3.2 Middle area

The comparison of traffic composition between 1969 and 1984 indicates major shift towards fast moving vehicles, especially two wheelers. As observed from the figure, in the middle area of Delhi, the share of two wheelers has reduced by around 18% whilst that of cars has increased by 43% during the period 1991 to 2002. The increase in the share of private modes is offset by the reduction in the share of IPT modes (24%). The share of buses has remained more or less constant (around 6%). This again shows the increasing trend towards personalised modes of travel. Even in the middle areas it can be observed from the figure that the share of SMVs is declining. SMVs have reduced from 8 % in 1991 to 3% in 2002, which is more than 60% reduction.

4.1.3.3 Outer area

The comparison of traffic composition between 1969 and 1984 indicates major shift towards fast moving vehicles, especially two wheelers, Auto and Taxies. The outer area of Delhi represents relatively low densification in terms of population and concentration of activities. In this area, the

share of two wheelers and cars has increased from 55% in 1991 to 64% in 2002. However, even though the share of two wheelers has remained constant during the above period but that of cars has increased by 37% during the same period. The increase in the share of private modes is offset by the reduction in the share of IPT modes (46%). The share of buses has remained more or less constant (around 5%). This again shows the increasing trend towards personalised modes of travel. In the outer areas also the share of SMVs is declining. SMVs have reduced from 22% in 1991 to 16% in 2002. This can be attributed mainly to the availability of motorised vehicles, increased trip length and non availability of proper facilities for SMVs

4.1.4 Spot Speed Measurements

The quality of traffic flow is judged on the basis of journey speed and running speed of the vehicles. The ratio of running to journey speeds describes the quality of flow. Higher the ratio better is the quality of flow. With lower quality of flow more will be the speed changes during the journey. The quantum of pollutants in the exhaust will change with speed changes and the vintage of the vehicles. With a view to understand the quality of flow indicatively spot speed measurements have been made at a few of the selected mid-block locations. The comparative results of the spot speed studies for selected road sections at inner, middle and outer areas are indicated in Figure 7 in the form of cumulative frequency distribution of speeds. From the figure it can be seen that the spot speeds are higher as one goes away from inner to outer area *(i.e. from Barakhamba to Aurobindo)*. A summary of the observed spot speeds on selected road sections in Delhi are given in Table 3. From the above figure and table, it can be deduced that the composition of the vehicles and the location of the road has direct influence on the observed spot speeds. It can be observed from the table that the speed is maximum in the case of cars followed by two wheelers except Netaji Subhash Marg where the speed of two wheelers is higher. The lower speed of cars at the above location could be attributed to frequent congestion occurs on the road due to interaction with slow moving vehicles.

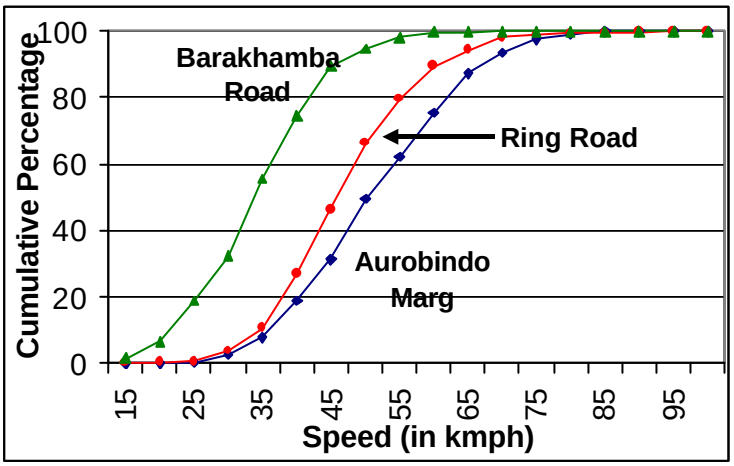


Figure 7 : Cumulative Distributions of Speeds on Selected Locations in Delhi

Table 3 : Observed Spot Speeds of Vehicles on Selected Road Sections in Delhi

S. No.	Name of the Road	Time Period	Spot Speed in KMPH						
			Cars	Taxis/ RTVs	2-Ws	Autos	Buses	LCVs	HCVs
1	Janpath	09:00 - 14:00	49.8	41.0	46.0	39.4	40.9	39.7	45.0
2	Barakhamba Road	08:00 - 09:30	37.0	29.4	37.0	31.6	32.0	29.3	*
3	Netaji Subhash Marg	07:30 - 09:30	33.4	*	38.4	31.0	29.0	26.8	24.3
4	Ring Road *(RajGhat)*	15:30 - 18-30	51.6	*	48.5	*	37.2	*	*
5	Tilak Marg	08:00 - 10:30	53.3	*	47.6	39.4	38.6	43.7	43.0
6	Lala Lajpatrai Marg	07:00 - 11:00	58.9	45.6	47.2	43.6	48.6	48.6	43.6
7	Aurobindo Marg	08:00 - 09:00	55.4	*	45.8	41.0	45.4	46.2	47.0
8	Ring Road *(BRO Naraina)*	09:00 - 12:00	52.5	*	47.4	46.5	41.1	40.7	39.5
9	New Rohtak Road	08:00 - 12:00	37.5	*	36.6	32.6	31.3	34.3	*
10	Ashok Vihar Road	09:00 - 12:30	37.4	*	36.0	32.0	35.4	27.8	32.8
11	Shyam Nath Marg	15:00 - 19:00	38.3	*	37.1	*	27.8	*	*
12	ISBT Flyover	07:00 - 12:00	55.6	*	48.5	*	42.2	46.3	*
13	ITO Bridge	08:30 - 12:00	49.2	45.6	43.7	41.8	43.1	43.9	38.7
14	Madangir Road	07:00 - 11:00	50.7	37.1	44.4	36.9	39.6	40.8	36.3
15	Janak Setu	07:00 - 11:00	49.0	*	41.1	37.9	38.9	31.1	*
16	Pankha Road	14:30 - 17:30	46.7	39.5	45.5	36.9	39.6	36.0	35.6
17	Najafgarh Road	09:00 - 12:00	46.4	*	45.9	38.2	36.4	37.9	32.5
18	Bawana Road	07:30- 12:30	39.1	32.8	36.7	27.7	32.5	34.2	34.2
19	Pusa Road	12:30- 19:00	41.1	33.7	39.2	33.6	33.4	31.2	29.3

** indicates adequate sample not collected to get a true representation of spot speeds*

4.1.5. Traffic Load on Road Network

The classified traffic counts conducted at 42 mid block, 10 outer cordon stations and 14 intersections provided extensive data on traffic flows on the road network of Delhi. Employing this data, the traffic flows have been arrived at on the adjoining links in the neighborhood of the count points. Thus the traffic flows along with composition have been worked out for each of the links of the road network identified for the purpose of this study. To validate the figures of traffic arrived at on neighboring links sample traffic counts were made to confirm the same. The estimated traffic load along each of the links is translated into pictorial form using digitized map of Delhi and *GIS Software, TRANSCAD* and the same is presented in Figure 8.

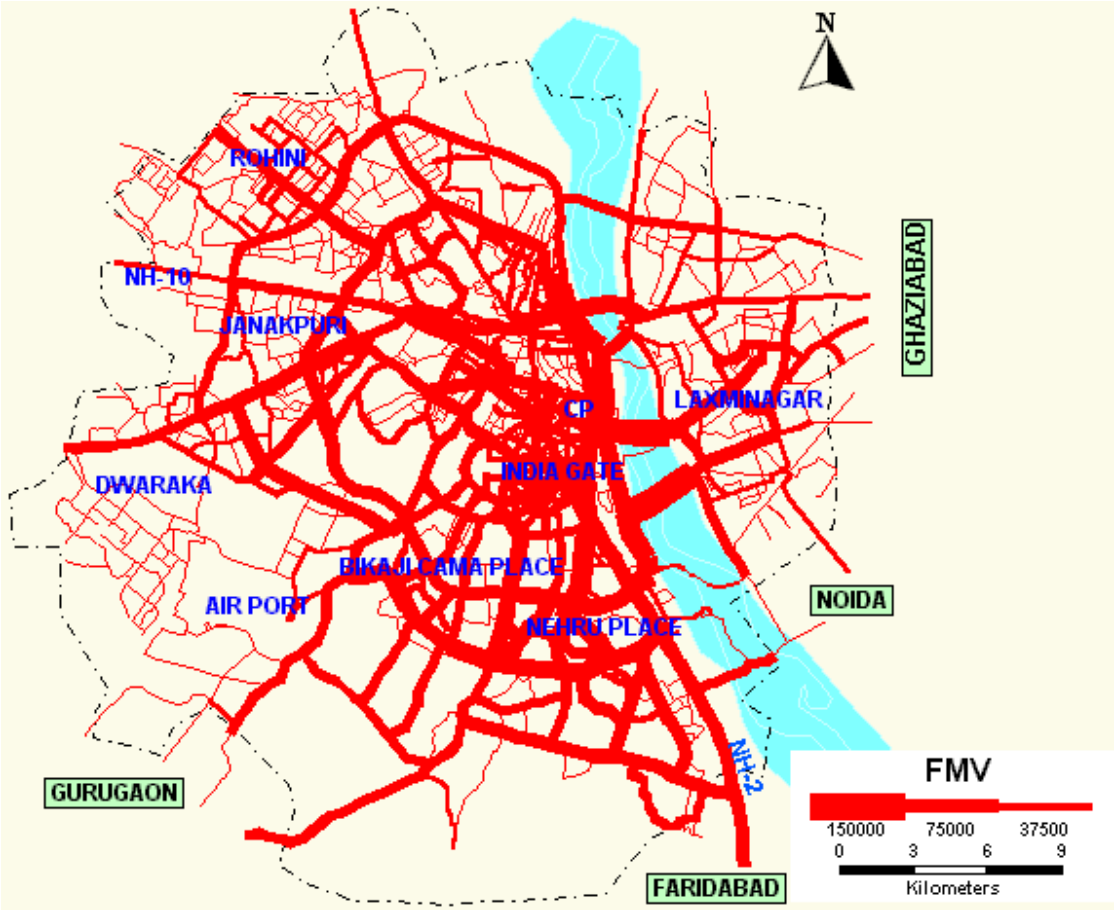


Figure 8 : Traffic Flow Pattern in Delhi

From the figure it can be seen that the radials and ring roads carry major portion of traffic movements in Delhi. Using the link traffic loads and composition of traffic by vehicle type, vehicle - kilometers traveled on each of the links have been estimated and in turn the total vehicle kilometers traveled by each category of vehicles on the road network of Delhi have been estimated. Table 4 presents the estimated travel *(from roadside counts)* made by different vehicles on a normal working day in Delhi using the primary road network. To validate this data, comparison has been made by estimating the vehicle - kilometers traveled on the basis of data obtained from the surveys at the fuel stations (CRRI,2002) and vehicles in use *(estimated from vehicle vintage and registration*

data). Comparisons are presented in the above table and it can be seen that the estimated vehicle - kms of travel from road side and the fuel station interviews do not exactly match because most of the external traffic may not get accounted for at the fuel stations. It can be further inferred that the maximum proportion of travel *(80 percent)* is made combinedly by two wheelers and cars. This is followed by three wheelers corresponding about 12 percent of the total vehicle - kilometers while buses and goods vehicles have almost equal share of 3 percent each. A close observation of the overall registered vehicles and the estimated in-use vehicles in the above table reveals that only about 55 percent of the registered vehicles are in use. This clearly reflects that most of the decade old vehicles have been either phased out or transferred out of Delhi to other cities *(through second-hand sales)*. This can be corroborated with the increasing number of New Brand Cars and 4 - stroke Two Wheelers as observed from the roadside counts.

Table 4 : Estimated Daily Traffic Load on Delhi Road Network

S. No.	Vehicle Type	Vehicle - Kms / day *(in Millions)*		Registered Vehicles *('000)*	Estimates of In-use Vehicles *('000)*
		Roadside Counts	**Fuel Stations**		
1	Cars + Taxis	30.689 *(38.7)*	26.799 *(34.9)*	Private Cars - 921	711
				Taxis - 18	
2	Two Wheelers	33.823 *(42.7)*	38.700 *(50.5)*	2231	1062
4	Autos	9.357 *(11.8)*	5.779 *(7.5)*	87	87
5	Goods Vehicles	2.514 *(3.2)*	2.990 *(3.9)*	158	64
6	Buses	2.851 *(3.6)*	2.428 *(3.2)*	41	NA
Total		**79.234** ***(100.0)***	**76.696** ***(100.0)***	**3457**	**1924**

Note: :i. Figures within brackets refer percentages

ii. NA - Not Applicable because of the non-representative sample size in the case of buses from Fuel Station Surveys

4.2 Case Study of Mumbai

4.2.1 Traffic Composition

The area of Mumbai is broadly divided into Mumbai island and suburbs for the purpose of this analysis. The traffic characteristics are studied in detail for the year 1979 and 2002. The details of traffic composition in island and suburbs of Mumbai are shown in Figure 9 and 10.

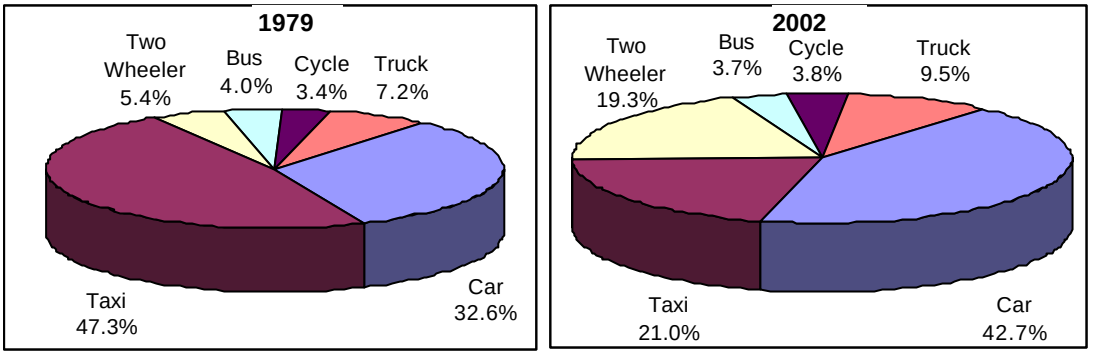


Figure 9. Comparison of Traffic Composition in Mumbai Island

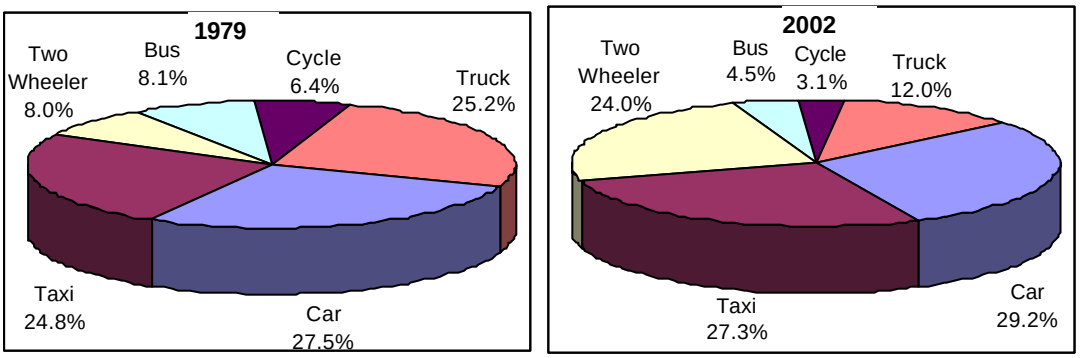


Figure 10. Comparison of Traffic Composition in Suburbs of Mumbai

From the above figures the following inferences can be drawn:

In the island the share of cars and two wheelers has increased whilst that of taxi has declined. The share of Cycles has remained more or less constant. The share of buses has marginally reduced where as that of goods vehicles has increased.

In the suburbs the share of two wheelers has drastically increased whilst that of cars has shown marginal improvement. The share of taxies has marginally reduced The share of Cycles has reduced from 6.4% in 1979 (CRRI,1983) to 3.1% in 2002. Similarly the share of buses has declined from 8.1% in 1979 to 4.5% in 2002. Further, the share of goods vehicles has drastically reduced.

4.2.2 Spot Speed Measurements

With a view to understand the quality of flow indicatively, spot speed measurements have been made at a few of the selected mid-block locations. The comparative results of the spot speed studies for selected road sections at inner, middle and outer areas are indicated in Figure 11 in the form of

cumulative frequency distribution of speeds. These observations were made during peak hours. From this figure it can be seen that spot speeds on S.V. Road are relatively low as compared to that on N.S.C Marg and EEH because of the lack of access and frontage control on S.V. Road. A summary of the observed spot speeds on selected road sections in Mumbai is given in Table 5 From the above figure and table, it can be deduced that the composition of the vehicles and the location of the road has direct influence on the observed spot speeds.

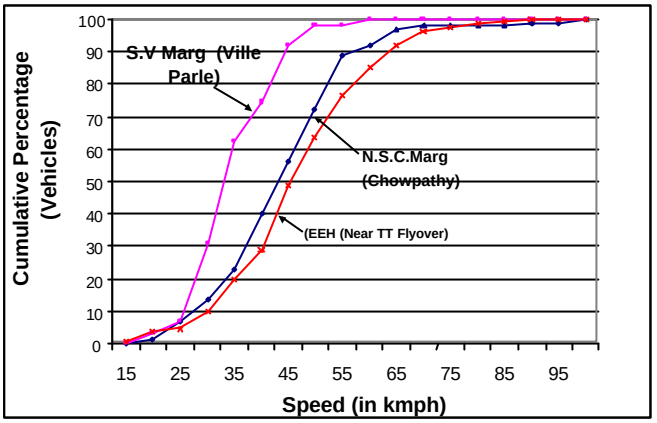


Figure 11 : Cumulative Distribution of Speeds on Selected Locations in Mumbai

Table 5 : Spot Speeds on Selected Road Sections in Mumbai

(in kmph)

S.No	Name of the Road	Time Period	Car	Taxi	Scooter	Motor cycle	Auto	Bus	LCV	HCV
1	Lady Jagmohan Das Road *(Near Priyadarshini Park)*	09:00-12:00	44	39	46	54	-	38	31	29
2	S.V Marg *(Vile Parle)*	09:00-12:00	35	34	35	36	36	33	33	26
3	R.C. Chemburkar Marg *(Infront of Basant Cinema)*	09:00-19:00	47	43	46	51	41	36	39	36
4	Senapati Tatyatope Marg, *(Near TT Flyover)*	16:00-19:00	54	51	51	57	47	40	42	40
5	N.S.C. Road *(Marine Drive, Near Chowpati)*	12:00-19:00	73	57	66	56	-	55	-	-

4.3 Case Study of Bangalore

4.3.1 Traffic Composition

In the case of Bangalore, the traffic characteristics are studied for the year 1965, 1988, 1998 and 2002. The details of traffic composition in Bangalore are shown in Figure 12.

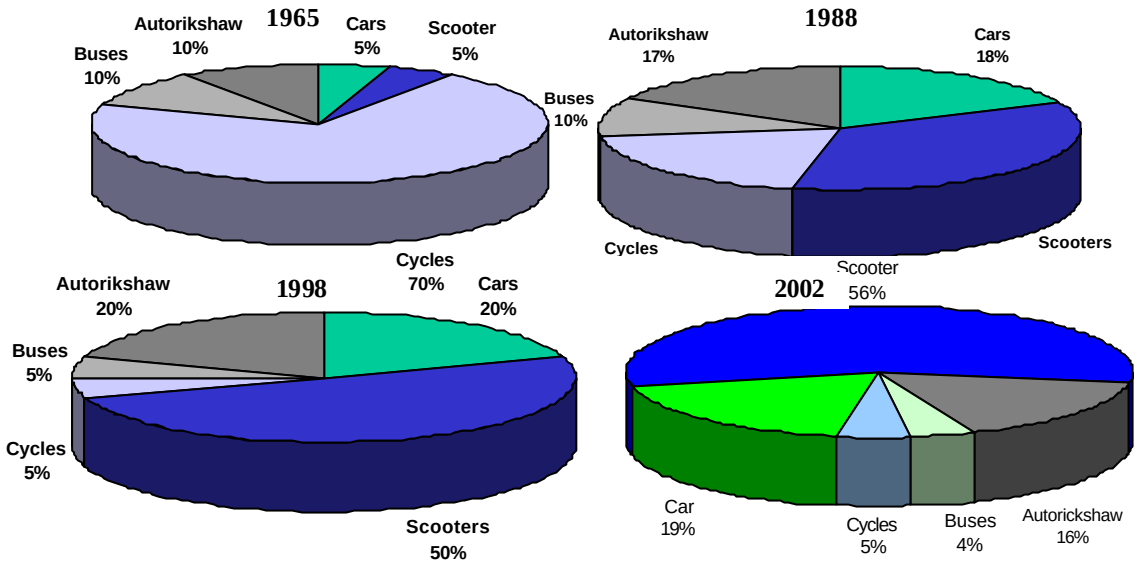


Figure 12. Changing Trends of Traffic Composition in Bangalore

From the above figures it can be noted that the share of cycles has steeply reduced from 70% in 1965 to 20% in 1988. It has further declined to a mere 5% in 1998 and has remained constant since then. On the other hand the share of private modes i.e. cars and two wheelers has steeply increased. Further it can be noted that the share of public transport has declined over the period 1965 to 2002 whilst that of IPT has increased.

4.3.2 Spot Speed Measurements

The comparative results of the spot speed studies for selected road sections in inner, middle and outer areas are indicated in Figure 13 in the form of cumulative distribution of speeds. From this figure it can be seen that all roads are operating uniformly. This can be attributed to the fact that the traffic is heavy on all the roads and the traffic is managed efficiently. From the above figure, it can be deduced that the vehicle composition and geometrics of road has direct influence on the observed speeds.

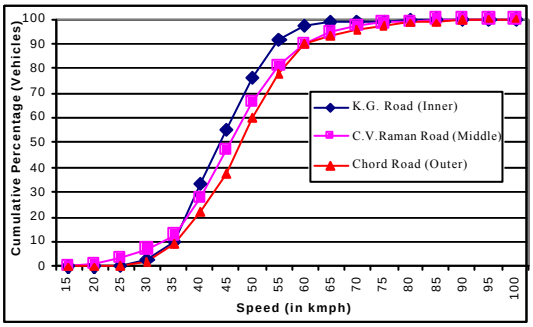


Figure 13 : Cumulative Distributions of Speeds on Selected Locations in Bangalore

5. CHANGING TRAFFIC COMPOSITION AND EMERGING ISSUES

The previous section described the changing trends of traffic composition in Delhi, Mumbai and Bangalore. Based on the details of the data available an attempt was made, wherever possible, to segregate the data into core (inner), middle and outer (fringe) areas that commensurate with development. This section presents the summary of changing traffic composition and focuses on the emerging issues thereof.

5.1 Summary of Changing Traffic Composition

From the previous sections it can be inferred that in all the cities studied there is significant shift from the share of cycles towards fast moving vehicles i.e. two wheelers and cars, irrespective of the location in the city. Further, in the past decade the share of cars is increasing as compared to two wheelers. Generally it was found that the share of public transport (buses) is declining. These changes in traffic composition will have varying impact on the operation and management of traffic, which are discussed below.

The traffic composition has changed drastically over period of time in all the cities of Delhi. In general the shift is towards personal modes of travel such as two wheelers and cars. Therefore, emphasis should be given to address the following issues:

Speed of Operation: Generally the homogeneity of traffic improves the speed of operation on the roads which further influences the geometric design aspects.

Safety: The increasing speeds would result in reduced safety especially in core areas where pedestrian and vehicular conflicts are more.

Capacity of Roads: The increasing growth of fast moving vehicles will require improved capacity of roads to accommodate growing traffic, maintain required level of service and efficiency.

Infrastructure Facilities: The shift towards cars, two wheelers, autorickshaws and taxies will require appropriate facilities like parking spaces and auto/taxi stands etc. to be developed.

Traffic Control at Signals: The traffic controls at signals in the road network of the cities require to be redesigned to accommodate the changing traffic.

Segregation of Traffic: In order to increase safety and efficiency of traffic operation the fast moving vehicles and slow moving vehicles need to be segregated.

Hierarchical Road System: The increasing trend towards fast moving vehicles would require well defined hierarchical road system (Arterial, Collector/Distributors and Access Roads) to be developed in the cities for faster and safe movement of traffic.

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