CHAPTER 1

ROAD ACCIDENT SCENARIO IN INDIA AND ABROAD

1.1 BACKGROUND

An accident is defined as an unplanned and uncontrolled event in which action and reaction of an object, substance or person results in personal injury or damages to the property [Kumdar et al., 1988]. A traffic accident may be taken as failure of the road-vehicle-driver system to perform one or more operations necessary for completing a trip without damage or injury [Jayachandran, 1981]. Necessary and sufficient cause of an accident is a combination of simultaneous and sequential factors, each of which is necessary but none of which is by itself sufficient. The task of ensuring safe traffic on urban roads in India is difficult mainly due to the mix of slow and fast moving vehicles, sharing the same carriage way [Gupta, 1988]. The other important factors contributing to increase in accidents in India are poor road geometries, lack of traffic education among road user and poor traffic enforcement system, and road user behaviour. An accident may occur due to the interaction among two or more factors such as vehicles, road, driver, road user and environment. Each accident occurs as a result of an independent sequence of events affected by many independent factors and conditions [Anitha Sreedar, 1990]. The steep growth of traffic on the Indian roads in recent years has caused a sharp increase in the incidence of traffic accidents [Kumdar et al., 1988].

The road accident scene in India, as in many developing countries, is characterized by mixed traffic comprising human-powered vehicles such as bicycles and tricycles [cyclerickshaws], animal-drawn carts, and motor vehicles of various sizes, shapes and speeds, without adopting traffic segregation measures. Due to resource constraints, the development of roads in quantity and quality has not kept pace with the growth of vehicles. All these have caused great concern to engineers, planners and administrators. Efforts are being made to study the traffic accident scene in Indian context in order to take suitable measures to bring down the accident rate.
1.2 ROAD ACCIDENTS IN INDIA

It is a matter of serious concern that the number of road crash deaths in India has increased more than ten fold from 4,500 in 1960 to over 50,000 in 1990 [Dinesh Mohan, 1992]. The total number of accidents has consistently increased from 55,478 in 1960, to 114,079 in 1970, to 152,076 in 1980 and further to 255,278 in 1988. Similarly the number of persons injured has consistently increased from 37,731 in 1960, to 70,642 in 1970 to 108,973 in 1980, and further to 206,060 in 1988 [Srinivasan, 1991]. It is estimated that every 4 minutes, one accident occurs, killing or injuring one person on an average on Indian roads [Srinivasan, 1985].

Number of studies have shown that highway fatality rates per 1,000 vehicles are generally higher in poor countries as compared to relatively more industrialized countries [Mohan and Bava, 1985; and Wintemute, 1985]. It is startling to find out that number of accidents has increased faster than population in India. It takes about 30 years for population to get doubled, whereas it takes about 10 years for accidents and 8 years for fatalities. However, number of vehicles has shown much faster growth rate. It is taking about five years for vehicles to double in number. Road length has been increasing relatively at slower rate taking about 15 years to double in length [Srinivasan, 1991]. To compare the accident figures at the state level, a method of determining Accident Risk Index has been evolved from a detailed study. The analysis of accident risk index showed that Maharashta had the highest value of 277.16, followed by Tamil Nadu with 211.39, Kerala with 200.83 and West Bengal with 196.45. Lowest value of ARI was observed for Assam with 31.25, followed by Punjab with 36.94 [Srinivasan, 1991].

1.2.1 Accident Scene in Metropolitan Cities

Cities are accident infested areas with high risk of involvement in some sort of accident. Though only about 27 % of the population of the country live in urban areas, about 75 % of the accidents occur in cities and towns. The big cities alone account for more than 50 % of road accidents in the country, and their share of the accidents in the state concerned is also high [Srinivasan, 1991]. Calcutta, for example, accounted for about 66 % of the accidents recorded in West Bengal and Bombay for 63 % of those recorded in Maharashta. Between 1980 and 1986 the road traffic accident in metropolitan cities of India increased from 51,214 to 62,617 whereas the number of persons killed increased from 3,027 to 4,305 and the number of persons injured increased from 2,5313 to 32,818 [Subramaniam, 1988]. Hence there is a necessity for studying of the urban accident scene in detail. With in India,
among metropolitan cities, Madras has the highest road traffic fatality rates per 10,000 vehicles [Dinesh Mohan, 1986].

1.3 ROAD ACCIDENTS ABROAD

In the year 1985, the number of accidents per 1000 vehicles was as high as 23.1 in India, compared to 6.7 in France, 10.7 in West Germany, 3.6 in Sweden and 8.6 in Japan. The fatality rate of 4.33 per 1000 vehicles was also high in India, compared to 0.26 in the U.K., 0.37 in France, 0.27 in West Germany, 0.17 in Sweden and 0.14 Japan [Srinivasan, 1991]. In 15 developing countries, road accidents accounted for nearly 17 per cent of total deaths due to all causes, the deaths due to tuberculosis and malaria being 16 per cent and 2 per cent respectively [Jacobs and Bardsley, 1977]. At the same time the number of traffic fatalities per 100,000 population in 1985 was 5.2 for India and the corresponding value for 1984 was 21 for France and 10 for Japan [Victor, 1989 and IATSS, 1986].

1.4 TRENDS OF URBANIZATION IN INDIA.

Indian population was estimated at 843.9 million in 1991. About 16% of the world's population lives in India with a density of 267 persons per sq.km. During 1981-91, about 160 million people were added which is more than the total population of Japan. The urban population in India has increased from 26 million in 1901 to 156 million in 1981 and 232 million in 1991, and thereby the proportion of urban to total population went up from 11 to 23 and 27 per cent in 1901, 1981 and 1991 respectively [Subramaniam, 1988 and Mahendra, 1991]. At present, India has 23 metropolitan cities having plus 1 million population. The state of Tamil Nadu which has 33 percent of its population in urban centres is the second largest urbanized state, the first being Maharashtra with 35 per cent of its population in urban areas. By the year 2001, it is forecast that 50 per cent of Tamil Nadu population would live in urban areas. About 46 per cent of the urban population lives in the state's five largest cites, namely Madras, Madurai, Coimbatore, Trichy and Salem [Madras Metropolitan Development Authority, 1991a]. The population of Madras Metropolitan Area, tended to increase at a faster rate [3.49 per cent annually] than the over all rate for urban population in all urban centres [2.90 per cent] [Madras Metropolitan Development Authority, 1991a].
1.5 GROWTH OF VEHICLES IN INDIA

There were only 306,313 vehicles in 1951 which increased to 1.865 million in 1971 and further to 16.693 million in the year 1989. Thus during the last four decades the number of motor vehicles increased by more than fifty five times. Among different types of vehicles, the maximum growth has been shown by two wheelers. In the year 1951, India had only 26,890 registered motor cycles and scooters. In the year 1977 the number of motor cycles and scooters swelled to 0.576 million and further to 10.617 million in 1989. This phenomenal increase in two wheelers might be one of the factors for spurt in traffic accidents in India [Srinivasan, 1991]. Para-transit modes including taxis, cars and autorickshaws have registered moderate growth. The number of taxis, cars, jeeps has increased from 0.159 million in 1951 to 2.481 million in 1989. Between 1966 and 1986 bicycles increased from 5.1 million to 33.8 million, cyclerickshaws increased from 0.32 million to 0.67 million and bullock carts increased from 11.9 million to 15 million [Srinivasan, 1991]. Road Transport demand has been forecast by Kadiyali [1987]. The bus population which increased from 34,000 in 1951 to 206,000 in 1985 is projected to be between 0.7 to 0.9 million in 2000 A.D. The bus passenger movement which increased from 31 billion passenger km. [BPK] in 1951 to 739 BPK in 1985 is projected to be between 3000 to 4000 BPK in 2000 A.D. The car population which increased from 0.1 million in 1951 to 1.3 million in 1983 is projected to be between 4 million to 5.5 million in 2000 A.D. The passenger km. travelled by car has increased km. 4.2 BPK in 1951 to 54.14 BPK in 1983. The two wheelers population which increased from 27,000 in 1951 to 3.5 million in 1983 is projected to be between 10 million to 13 million. The passenger km. travelled by two wheelers increased from 0.2 BPK in 1951 to 25.96 BPK in 1983.

The population of three wheeler autorickshaws increased from 5,000 in 1961 to 182,000 in 1983. The passenger km. travelled in bicycles increased from 2.2 BPK in 1951 to 56.6 BPK in 1985. The passenger km. travelled by cyclerickshaws increased from 2.8 BPK in 1951 to 8.38 in 1985. The population of light commercial vehicles [LCV] which increased from 15,000 in 1961 to 182,000 in 1985 is projected to be between 700,000 to 1,000,000 in 2000 A.D. The population of heavy commercial vehicles [HCV] which increased from 82,000 in 1951 to 581,000 in 1985 is projected to be between 0.19 million to 0.23 million in 2000 A.D. The freight moved by LCV in billion ton km. [BTK] increased from 0.6 BTK in 1961 to 6.6 BTK in 1985. The freight moved by HCV increased from 9.8 BTK in 1951 to 237.5 BTK in 1985. The population of three wheeler goods vehicles increased from 1100 in 1961
to 48,000 in 1983. The freight movement by three wheelers increased from 0.02 BTK in 1961 to 1.25 BTK in 1985. The freight moved by bullock cards increased from 2.3 BTK in 1951 to 3.4 BTK in 1985. The population of tractors increased from 8,600 in 1951 to 516,000 in 1982. The freight moved by tractors increased from 0.02 BTK to 1.31 BTK. The freight moved by road increased from 12.1 BTK in 1951 to 243.5 BTK in 1985 [Kadiyali, 1987]. Between 1961 and 1987 the production of trucks, buses and light commercial vehicles have increased from 27,500 to 106,000 where as the increase in production of jeeps has been from 5500 to 32,000, cars from 19,100 to 149,000 three wheelers from 500 to 60,700 two wheelers from 17,000 to 1,390,800 [Mohinder Singh and Kadiyali, 1990]. The production of bicycles in india increased from 5.2 million in 1985 to 7.2 million in 1991 [Mohanraj, 1992].

1.6 ROAD SYSTEM IN INDIA

The road length in km. per 100 Sq. km. area in India is 46.7 compared to 294.7 in Japan, 101.6 in Sri Lanka, 274.5 in France, 195.1 in West Germany, 142.8 in U.K, 152.8 in Switzerland, 66.8 in U.S.A., 34.3 in New Zealand and 11.3 in Australia. The road length in km. per million population in India is 2,290 compared to 9,470 in Japan, 4,606 in Sri Lanka, 28,080 in France, 7,894 in West Germany, 6,258 in U.K., 9,918 in Switzerland, 28,400 in U.S.A., 29,703 in New Zealand and 60,052 in Australia [Borcar and Ramakrishnan, 1985]. The road net-work in India is one of the largest in the world. The total road length in the country in 1950-51 was about 0.4 million km. Today it is about 2 million km. [Yojana, 1991]. Between 1980 and 1983 the road length in India has been increased from 475,343 km. to 1,587,000 km. which reflects an annual average increase of 9.35 per cent [Kumdar et.al, 1988]. In road transport, predominant role is played by primary system comprising National Highways whose total length is at present 33,612 km. During the seventh plan 1902 km. of road has been added to National Highways net-work. About one-third of the total road traffic is carried by these national highways although they constitute less than two per cent of the total road length [Yojana, 1991].

1.7 ECONOMIC LOSS DUE TO ACCIDENTS

In a study it is brought out that India is loosing Rs. 350 crores per annum in road accidents. During Seventh Five Year Plan the Government had to invest Rs. 795 crores per year on road development. Thus, the sum equivalent to 44 per cent of annual investment will be lost due to road accidents. Further the following costs have also been estimated at 1982 price level [Nayak, et.al, 1986]. The costs are Rs. 101,016
per fatality; Rs 47,243 per serious accident; Rs. 2,911 per minor accident; Rs. 14,938 for damage to a heavy vehicle; Rs. 719 for damage to a medium vehicle; Rs. 480 for damage to a light vehicle; and Rs 52,220 for damage to property.

Central Road Research Institute [1982] has arrived at the cost of fatal accident as Rs 110,000, the cost of severe injury accident as Rs 65,000, the cost of slight injury accident as Rs 710 and the cost of property damage accident as Rs 12,000. Victor [1990] estimated the loss due to road accidents as Rs 7.5 billion, which amounts to about 0.4% of the nation's Gross National Product. An estimate suggested by the Transport and Road Research Laboratory of U.K. puts the value of the accident loss at 1 per cent of Gross Domestic Product [Fouracre and Jacobs, 1976].

1.8 NEED FOR DETAILED ROAD ACCIDENT ANALYSIS

It has been shown that road accidents in Indian cities is a serious issue resulting in huge economic loss. There is a need to bring down the accident rate, for which a detailed analysis of the factors which are responsible for causing accidents has to be made. Even though road accidents are influenced by a large number of factors related to road conditions, traffic flow, environmental state and road user behaviour, number of models have been built ignoring the complexity of the factors associated in causing accidents and involving only one or two variables like population, vehicle ownership and road length. Such models are aggregate in nature and they attempt to over simplify the complexities of the accident incidence.

Number of authors have attempted to study accidents by relating to econometric and social variables like real earned income, alcohol consumption, speed, percentage of male drivers to total drivers, rural to urban driving ratio, ratio of motor cycles to cars, industrial activity and safety regulation. These models are better than the previous group since they have considered at least a set of variables which indirectly influence the occurrence of road accidents. However, they too would not be useful in an urban context where the contributing factors are large in numbers from road conditions and its environment, road user behaviour and traffic flow. Some authors have built models using traffic volume and road features like road curvature, pavement width and number of junctions per km. Models discussed here suffer due to their failure in taking all important variables directly contributing to accidents. These models also do not reflect and account for mixed traffic scene seen in urban areas of developing countries. Road traffic in a developing country like India consists of slow moving vehicles like bicycles, tricycles, cyclerickshaws and animal drawn carts, and fast moving vehicles.
like buses, trucks, tractors, cars, autorickshaws and two wheelers. The vehicles are of varying sizes, shapes and operated at different speeds. In many cities, due to various reasons the road network could not be maintained at a desirable level of service condition. Many traffic management measures introduced to streamline the flow and reduce conflicts within and among various sets of travel modes have not met with success, since the road users have not responded in the right direction. All these have contributed for an increasing trend in our traffic accident scene resulting in considerable economic loss to the society.

Modelling the traffic accident scene bringing together the influence of all relevant factors related to road conditions and its environment, road user behaviour and traffic flow requires careful analysis of the complex situation. Even though such an attempt may require detailed data base, there is still a need to have an improved comprehensive model to study the accident scene in mixed traffic conditions prevailing in major urban centres.

1.9 MODEL DEVELOPED

A comprehensive model has been developed to estimate the number of road traffic accidents per half yearly period by considering independent variables relating to modewise average daily traffic volume, interaction between different modes, road geometries and segregation measures.

1.10 BRIEF REVIEW OF WORK DONE

Chapter 1 deals with road accident scenario detailing out the growth of vehicles, economic loss due to accidents, road system and the need for detailed analysis of road traffic accidents.

Chapter 2 gives the details of traffic accident studies made in different countries. The studies have been classified and discussed under the following groups - based on vehicle ownership and population; based on econometric and social variables; and based on traffic volume, road geometry and speed. Incidentally this helps to identify some of the variables which influence the occurrence of accidents.

Chapter 3 deals with traffic accident scene in Madras city by giving details regarding travel characteristics, highway system, growth of vehicle population and traffic accident occurrence. The need for detailed study is also emphasized.
Chapter 4 gives the brief methodology for building up a model to estimate road traffic accidents and test the same for suitability.

Chapter 5 deals with the major factors causing road traffic accidents and the environment prevailing in Madras City.

Chapter 6 gives the details of developing a comprehensive model for estimation of road traffic accidents. Independent variables related to traffic volumes of different modes, interaction among different modes, road conditions and segregation measures are listed out. Anna Salai and Periyar Salai, the two major arterials in Madras City are selected for the study. Using the data collected on the independent variables, for eight half yearly periods [1985 to 1988] a stepwise regression analysis is carried out to build a model for estimating the number of accidents in a half yearly period. The results of field studies made to find out modewise traffic volume, pedestrian violators, mean journey speed etc. in various sections of the arterials are also presented. The details of stepwise regression is presented along with five models obtained by truncating the stepwise regression at different stages.

Chapter 7 deals with forecasting of traffic volume of different modes. The independent variables influencing the growth of traffic are listed out and 8 models for estimating the modewise traffic volumes are built using interactive regression. These models are used for estimating the traffic volumes in the next three periods [namely January to June, 1989; July to December, 1989; and January to June, 1990]. The estimated volumes are compared with the recorded traffic volumes. The models are further used to estimate the volumes of traffic upto 2001 A.D.

Chapter 8 deals with the selection of the most suitable of the 5 models already obtained by truncating the stepwise regression at different stages as detailed out in Chapter 6. Number of accidents estimated by the 5 models are compared with the recorded accidents for three periods [namely January to June, 1989; July to December, 1989; and January to June, 1990]. Criteria like R^2, Adjusted R^2, Chi-square for differences, Standard error of estimate and Theils U-statistic are used. The model selected is used for estimating accidents upto 2001 A.D. It is also used for estimating the accidents by prohibiting the use of certain modes and by introducing improvement measures like pedestrian guard handrail and bicycle tracks for segregation.

Chapter 9 gives the summary and conclusion based on the analysis.