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Analysis & Prediction of Road Accident Data for NH-19/44

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Abstract
Increased traffic congestion in highways and urban areas with an increase in traffic accidents on road networks—which were never intended to handle the volumes and types of traffic they are now required to carry—are results of growing urbanisation and the rise in the number of vehicles in many developing countries. Unplanned urban growth has also resulted in a wide range of confrontations between vehicles and pedestrians, as well as incompatible land users. Many new urban residents are unaccustomed to such high traffic levels as a result of the migration from rural to urban areas. As a result, there has frequently been a considerable deterioration in driving conditions, as well as an increase in risks and rivalry between various groups of road users. Additionally, poor road upkeep, poorly designed junctions, and insufficient provisions for pedestrians frequently make the inherent dangers worse. The quantity of traffic on the roadways has been increasing recently, which has raised the likelihood of traffic accidents. Road traffic accidents are the fifth most major cause of mortality worldwide, according to evidence from both industrialised and developing nations, and they are on the rise. They are responsible for a sizable part of injuries, fatalities, and disabilities among the population. The route of NH 19/44 between Mathura and Agra has been chosen as the study area. The study span is 36 kilometres long in total. Aside from vehicles owned by the Transport Corporation, the majority of heavy vehicles that travel between Mathura and Agra are trucks transporting industrial items, containers, and vehicles used to transport construction materials. There are steel plants, textile mills, foundries, schools, colleges, banks, gas bunks, etc. on both sides of the stretch at regular intervals. Along the stretch under consideration, there were nine police stations. Information about the road inventory was gathered directly from the study stretch. The entire 67 km route was divided into three sections with various segment lengths based on the number of police stations and jurisdiction. Police stations are scattered throughout these parts, spaced 10 to 12 kilometres apart.

Keywords - *Pedestrians, Road Traffic Accidents, Motor Vehicle population, Road Transport, Traffic Management.*

1. INTRODUCTION
Accidents on the roads are one of the most pressing global issues. Infections and malnutrition-related deaths are no longer as common as they were just a few years ago. On the other hand, the death rate from accidents is still high and has grown for a number of different types of accidents. Accidents, on the other hand, are becoming increasingly important as disease control improves. Every year, tens of thousands of individuals lose their lives, and the number is rising. Each year, more than a million people suffer injuries that range in severity from minor to life-altering, necessitating the use of expensive medical services and resulting in the death of many more. This is a public health crisis that requires immediate response. And it's become a major issue for public health as a result. It's a situation that's just going to become worse.
Accidents have been found to be the leading cause of death in many developed nations. Even in emerging countries like India, it's quickly becoming a leading cause of mortality, according to the World Health Organization. For every fatality caused by an accident, 10-15 people are left with severe injuries, and 30-40 people are left with minor injuries. Many more people are able to "narrowly escape" terrible incidents, increasing their self-confidence and ego to the point where they are more likely to commit the same mistakes again, increasing their risk of death. A moderate-scale war is waged every year as a result of man's own actions, resulting in thousands of deaths each year. At least 10 children and adolescents will be hospitalised for 30 days because of their injuries every time one of them dies in an accident; about 1000 more will have an accident that does not necessitate hospitalisation, according to a WHO Regional Office for Europe estimate.

Owing to the multiplicity of factors operating in the causation of Road Traffic Accidents, it is unlikely that there can be any single preventive measure adequate to produce effective minimization of accidents. The complete prevention of all Road Traffic Accidents, which result in death or serious injury, seems at the present time an impossible ideal. But the problem is a relatively new one, having arisen on a large scale only in the past half-century and new and effective measures are needed to combat it. No one can tell at present what the minimum number of Road Traffic Accidents is causing personal injury that can be achieved in any given community; but it is certainly much smaller than present day figures.

Although the numbers of road accidents are high, one difficulty in studying them is the relative rarity of accidents in relation to the large number of vehicles and road users. This unfortunately provides some justification for the commonly held "It can't happen to me" attitude, which is not conducive to safety. The tragedy of Road Traffic Accidents is that they particularly involve the young, perhaps the young and adventurous. Young males are especially involved; fatal accidents in this group represent not only tragic family losses but also a serious economic loss to the community, for their education and training have been wasted. One more reason why accidents should be a matter of great public concern is that a person disabled or killed by an accident represent such a great loss, in WHO's phrase defining health, of "socially and economically productive life".

Accidents today are among the leading causes of death. The number of serious as well as minor injuries and the human suffering and economic loss due to disabilities caused by accidents is inestimable. Thus while medical science has conquered the ravages of many diseases, accidents have become a new "epidemic" of public health importance calling for equal effort for control and prevention. Any problem in public health can be considered a priority problem if it occurs frequently and/or is serious and is amenable to measures for its treatment or, better still, its prevention. Accidents are a frequent problem, although our knowledge of their frequency is poor and biased. They have potentially serious consequences in terms of mortality, morbidity and disabling sequelae. But there are real possibilities for treatment and also for prevention. Contrary to many preconceived ideas, accidents or more precisely their sequelae, like any other health problem, can often be prevented if approached scientifically. Epidemiological approach not only demonstrate that the relative importance and urgency of the accident problem, but that the process is a means of arousing interest and community action to eliminate specific accident hazards.

The attention of public health department should be directed towards the prevention of this new epidemic. Medical care and rehabilitation are already in hand, albeit some improvements in these may be necessary. But, what of Prevention? Community thinking should be reoriented in the direction of the question "Is there such a thing as a Road Traffic Accident for which no one is to blame?" Criteria for legal liability are fairly clearly established, but a high standard of personal moral responsibility is also necessary. The public conscience should be so developed that every individual automatically thinks preventively about Road Traffic Accidents. And this is a problem of health education.

Aside from the fact that both can be fatal, accidents and diseases have a lot more in common. When it comes to Road Traffic Accidents, there is no such thing as a one-size-fits-all explanation for their occurrence; they have an underlying cause and aren't random acts of bad luck. In view of the fact that the vast majority of accidents may be avoided, a number of countries have launched important accident prevention programmes, and others are considering similar efforts. The World Health Organization (WHO) also chose the 1961 World Health Day topic of "accidents and their prevention" in order to make the international population aware of the growing problem.

A solution to the problem of accidents could be found through economic growth alone. To get to the point where they collectively became a burden on the national economy, individual economic factors came into play long before individual drivers and car owners were able to adjust their own, often unconscious, trade-offs between mobility and safety. The cost of a car accident includes everything from the person's precious life to the seemingly insignificant issues of morbidity. It does not affect everyone in the same manner that a restriction in mobility does. The word "cost of travel" does not include the risk of an accident in most people's perceptions since they believe they are in control of their own destiny. Using the phrase "accidents will happen" as a catchphrase indicates a common, fatalistic conviction that little can be done to prevent them. Even if the most severe safeguards are taken, accidents will still occur, but this is no excuse for not making every effort to decrease the number and severity of these incidents as much as possible. Accidents aren't destined to happen, because they may be avoided.

Road accidents are caused by man himself. A terrible penalty of mortality has already been paid as the cost of integrating the motor vehicle into modern life. This epidemic has attacked people in developed and developing countries and yet it is regarded more fatalistically than the plague in the middle ages? Why do so many people shrug and say, "That's the price you have to pay for progress." There are signs, however, of an awakening public interest, and it is to be hoped that public opinion will demand effective preventive action. A healthy and aggressive social attitude towards Road Traffic Accidents and their prevention is of great

importance and can be encouraged by educative procedures. There is no panacea that will prevent all Road Traffic Accidents; organized teamwork by people in many disciplines, such as educators, engineers, medical practitioners, psychologists, and enforcement officers, is necessary for effective prevention. At present the Road Traffic Accident problem does not appear to be under control.

2. LITERATURE SURVEY

(Daniel, 2012) The number of vehicles on the road in Ghana has grown dramatically in recent years. As the country's economy grows, so does demand for transportation by car. Many people have died or been seriously injured in traffic accidents as a result of an increase in the number of vehicles on our roads. The failure of brakes and the resulting increase in traffic accidents in Ghana's Kumasi metropolis are the focus of this investigation. An online survey was utilised to collect the data for this study, and the results were analysed using information gleaned from the responses. Survey respondents agreed on one thing: brake failure is caused by a lack of or shortage of brake fluid, whereas 158 (33 percent) thought it was caused by overheating of the brakes. When it comes to brake servicing, just 69 (14 percent) of drivers will have their car serviced every five thousand kilometres, while the majority 189 (39 percent) of drivers will have their vehicle repaired only when the brakes develop a problem. There were 402(83%) who agreed that brake failure could cause an accident and that the vehicle should be repaired periodically in order to limit the risk. There should be a greater emphasis on regular brake servicing checks in the country by the National Road Safety Commission (NRSC), the Driver and Vehicle Licensing Authority (DVLA), and other law enforcement organisations, according to the report.

The authors (L. Daina and colleagues, 2012) state that Despite the fact that Romania's national car park has grown and there has been an increase in the number of driving licences issued, the infrastructure of the current road network has not kept pace with the needs of today's traffic. Traffic accidents are made more likely by factors such as distracted driving, inexperienced driving, and flagrant disregard for the rules of the road. In Romania, there is a 136.28 percent chance of a traffic collision resulting in a fatality. It is estimated that from 2017 to 2011, 6.75 percent of all Romanian traffic accidents occurred in Bihor County; 2.14 percent of new vehicle accident injuries are considered serious; and 2.57 percent of all road accident deaths are accounted for. Drunken walking is a major contributor to traffic accidents because of three main factors: speeding, failing to yield the right of way, and pedestrian carelessness. Traffic accidents can be prevented by both drivers and pedestrians using safety precautions.

In 2012, (Kayvan Aghabayk, et. al.) Kayvan Aghabayk Traffic flow in metropolitan areas is being affected by an increase in the number of heavy trucks on the road. In particular, their presence in the traffic stream has an impact on driver behaviour, which in turn has an impact on the capacity of the road. This study proposes a model that may be used by policymakers to examine the influence of a road's heavy vehicle fraction on its capacity. An actual highway data set from the United States was utilised to examine the headways between subsequent vehicles in the following technique. All four types of PC/HV pairings were analysed in this study. HV following PC, PC following HV, PC following PC and HV following HV are examples of these combinations. Speed-dependent headways were found among the combinations studied, according to the study's results. The model created can account for these variations and estimate the flow of each lane under various traffic circumstances and the fraction of heavy vehicles in the traffic stream..

The author's 2012 [12] publication] Road traffic deaths have been linked to car ownership, population expansion, and economic development in the context of Smeed and Andreassen models. As of yet, Smeed's law has not been thoroughly tested in India. Smeed and Andreassen generalised models were developed using 1991–2019 panel data from all states; structural changes impact on traffic fatalities were evaluated; and individual (time and regional) models were examined to see if they are more relevant for application in relation to the generalised model. It was determined that seven models (Smeed: original; generalised; time-variant; and state-variant; and Andreassen: generalised) were built and assessed for fit with the real data. The per-vehicle fatality rate closely approximated Smeed's formulation, according to the findings. Using the Chow-test, we found that the models for four discrete time blocks deviate structurally from the 19-year generalised model by a considerable amount (F-stat). Additionally, the log-linear form was rotated counterclockwise, which indicated decreased fatality rates. However, while new government policies, reduced vehicle operating speeds and better healthcare may be influences, greater research is needed to understand the reasons for mortality rate reductions. Because the time-series models demonstrated a high stability and just minor variations in comparison to the 19 year generalised models, this suggests that the latter are more practical for use. Studies of trends and tendencies suggest that regional formulations may be more useful. Evidence for time-invariance but state-specificity is provided for Smeed's law in this study, demonstrating its robustness.

In a recent study by Linu, KJ et al. The findings of a case study on road user characteristics and road safety are presented in this article. Road user awareness and road user conduct were the two most important factors in the study. An investigation into the impact of road user awareness on road safety was conducted Questionnaire surveys were conducted in order to determine the influence of age and educational attainment on road user awareness and to construct a Road Safety Awareness Index (RSAI). Age and educational attainment aren't the only determinants of road user awareness, according to research. Road user behaviour surveys were conducted in order to identify the causes of traffic violations. It is also examined to see if any other authentic elements that promote traffic offences, such as previous accident history and enforcement tactics, were taken into consideration. And the writers were able to deduce that there was a close connection between them.

To put it another way: [[Vijaya R B] An analysis of total fatalities (F) as a function of both the number of vehicles (V) and the total population (P) using mathematical formulas is presented in this study, which assumes state-by-state variations in the factors that influence traffic accidents. State-specific and time-specific models were employed in the Smeed's model, which projected the number of fatalities per vehicle from 2018 to 2011. This model can be used to gauge the impact of recent efforts to improve road safety in the South. Chi-Square statistics were used at a 5% and 1% level of significance to determine the established mathematical model's goodness of fit. In the light of the findings, conclusions were taken about the vehicle's fit and the number of fatalities it had to deal with.

(Hana, A, et al., 2015) It is the goal of this study to look into and analyse Kuwait's safety issues and rising accident rate. Following a review of relevant literature that included a piloting of a questionnaire, the data has been collected. The primary research was conducted in 2013. 430 completed responses were returned after 810 questionnaires were given. A lack of data is owing to a lack of available time. According to the findings, Kuwaiti road users' behaviour is influenced by a variety of socioeconomic, attitude, and work-related factors. Modeling and analysing elements that influence drivers' attitudes toward safety are mostly unexplored in Kuwait.

3. OBJECTIVES

- The primary goal of this study is to examine all intersections in metro-Politian cities in terms of road traffic accidents.
- Analysis demonstrates that the distribution of road accident deaths and injuries in cities differs based on age, month, and time of year.
- In order to design a system that would prevent an accident by sending a notification if the region has a high volume of traffic and a history of mishaps.
- There are numerous safety measures in place, but they may not be adequate to satisfy the needs of consumers, so this new method may provide a sense of security.
- We already know that a significant volume of accidents occurs due to heavy traffic during rush hour. The increase in traffic was due to an increase in the number of vehicles on the road. As a result, the system's central notion must be implemented by counting the number of vehicles in each zone.
- Clustering algorithms are used to indicate which zones were active and inactive.
- The user who travels at night should find this feature particularly helpful.

4. PROPOSED METHODOLOGY

The complexity of traffic accident scene is rapidly increasing due to urban expansion, increase in population and motorized and non-motorized vehicles, difficulties in introducing various traffic management measures etc., as discussed in previous chapter. The following operations are carried out to analyse highway traffic accident scene in National Highway-19/44.

Detailed review of various accident studies made and models built in different countries to understand the accident scene is made. Critical review of the models used by various researchers reveals the efficiency of the models already built. The need to have a regression model to suit traffic conditions and road environment prevailing in Indian Highways has been established. Important factors directly contributing to the highway accident scene under different traffic characteristics and road environment conditions commonly seen in Indian highways are identified and discussed in detail.

A model with important variables is identified. It is found to be a Multiple Linear Regression type to account for important independent variables associated with the accident scene. Based on jurisdiction under respective Police stations, nine segments of varying length are identified in NH-19/44. Data pertaining to important variables required to 'build, calibrate and evaluate' the behaviour of the model and its properties are estimated. Data from secondary and primary sources are collected. Model is

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based on stepwise regression analysis using SPSS software. Techniques are devised to decide the variables which should form part of the model to be used. Model is tested for its acceptability by considering its applicability to estimate accidents recorded in the past.

The model is used to estimate the accident scene for the given segment with different conditions. The sequential operations in this study are explained by the following flow chart as shown in Figure 4.1.

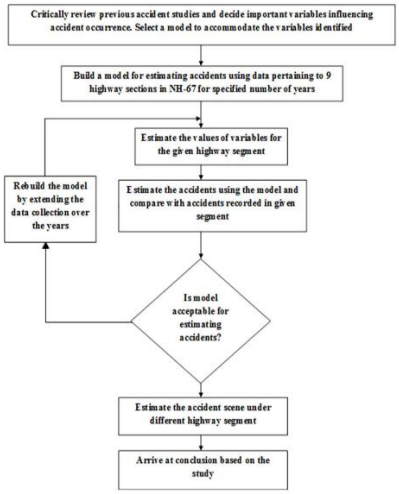

Figure 4.1 Basic Frame work of the Study

Highway accidents are primarily influenced by road, vehicle, road user and environment. The accidents occurring on highways are mostly contributed by traffic condition and road environment. Highways are not able to meet out the current status of traffic flow. Generally highways carry heavy vehicles like buses, Lorries, construction material trucks, and containers apart from light commercial vehicles and two-wheelers. Each category of vehicle has different static and dynamic characteristics and operates at various speeds.

4.1 Traffic Volume (Flow)

Indian traffic condition is mixed type consisting of various categories of vehicles like heavy vehicles, light commercial vehicles, two wheelers, autos, bullock carts etc. Each vehicle has different static and dynamic characteristics. Every year traffic volume through highways is getting increased due to infrastructure development and increasing population. At the same time the number of accidents also increases with traffic volume and positive correlation exists between traffic volume and accidents, (Do-Gyeong Kim, 2016). In general as VKT increases accidents increase and also vary with hourly, daily, monthly and seasonal variation of traffic flow.

4.2 Heavy Vehicles

Heavy vehicles include transport corporation buses, private buses, lorries, tractors and container trucks. Due to population increase and industrialization, major share of traffic flow through NH and SH is by heavy vehicles carrying passengers, sand, cement and other goods.

About 61% of accidents occur due to heavy vehicles in the state (Landge, 2016). Based on general accident report heavy vehicles versus light commercial vehicles accidents are the maximum. More number of accidents are caused due to the fact that fast moving vehicles overtake the slow moving vehicles, where inadequate overtaking sight distance is available. Parked heavy vehicles also contribute to road accidents.

4.3 Speed

Speed studies have always pointed to the fact that drivers adapt their speeds according to the highway ahead and may exceed both the speed limit and design speed. The operating speed is usually taken as 85th percentile speed, defined as the speed that 85% of the drivers do not exceed. Different highway elements are designed based on an arbitrary value of the design speed assumed by the designer. By setting a speed limit lower than the design speed, traffic safety is achieved assuming that drivers will not exceed the speed limit (Hassan, 2000).

The drivers tend to slow down on underdesigned curves with design speeds less than 96.5 kmph because of signing and visual perception and thus avoid severe accidents such as fixed object collision like parked vehicles. The drivers must continuously acquire information (detect hazard), make estimates of further development of traffic situations, and make decisions concerning their own acts in practice. All these phases take time. With increasing speed, the time available for the driver decrease. And when time for observation and decision making decreases, the chance for errors that can potentially lead to accidents increases. Furthermore, with increasing speed the time and distance available for evasive actions (e.g. braking or steering) decrease. Therefore drivers of slower vehicles can start braking further away from the hazard ahead than drivers of fast vehicles. The distance that faster vehicles have available for braking or steering maneuvers is short.

Higher speeds also increase the accident risk of other road users. Specifically road users tend to overestimate the distance and underestimate the speed of the approaching vehicle and these estimation errors and their variance increase with speed. Appropriate speed limits are necessary components to ensure a reasonable level of safe and efficient travel on highways and streets. The practice of speed control was found on the assumption that controlling speeds reduces accidents. (Kenneth,1997).

The current American Association of State Highway and Transportation Officials (AASHTO) definition for design speed is the maximum safe speed that can be maintained over a specified section of highway when conditions are so favourable that the design features of the highway govern. The AASHTO definition for operating speed is the highest overall speed at which a driver can travel on a given highway under favourable weather conditions under prevailing traffic conditions without any time delay. In general practice, the posted speed limit sets the maximum speed limit for a roadway such that the operating speed may be above the design speed for a particular location of the roadway. When this situation occurs, warning sign with advisory speeds may be used to warn drivers to reduce their speed to less than the posted speed limits

The 85th percentile speed is commonly used by highway agencies for describing actual operations speeds and establishing speed limits. This is the speed at or below which 85 percent of the traffic is traveling and is thought by many traffic engineers to reflect the safe speed for given road conditions. The 85th percentile speed is the speed range in which the accident involvement rate is lowest.

4.4 Segment Length

Segment length is the length of highway under the jurisdiction of respective police station. Segment length has number of straight stretches and horizontal curves. Straight segment has maximum visibility while curved sections are with (limited) restricted visibility. Segment length is exposed to variety of land use like residential, commercial, institutional and industrial activities. Presence of such zones is the main cause for accidents. For curves, crash frequency was found to increase with section length and for tangents the number of accidents per year increases with segment length. Generally, speed of vehicles in straight stretch is greater than the speed in other sections.

4.5 Access Roads

Access roads are like driveways and intersecting roads, which connect residential zones, commercial zones, agricultural zone and institutional zones with main highway. Driveways are positively correlated with road accidents. Access roads at unauthorized places are dangerous. As the land use activity along highway develops access roads at inappropriate places become very common and such roads connecting industries, institutions and financial institutions are the key factor for accidents during morning and evening peak times. In general, accident rate at horizontal curves is greater than accident rate at straight stretch with access roads, due to lack of visibility.

4.6 Curves

Generally highway curves are sharp and railway curves are larger. Many road crashes occur on bends in road and sharp bends are more likely to have crashes than gentle bends (Robin Hynes et al, 2018). Horizontal curves on highways are on average more hazardous than tangent sections. As their curvatures increase, horizontal curves tend to have higher accident rates (Feng Bor Lin, 1990). Areas with mostly curved roads had lower crash rates than areas with straight roads. The elements of simple curve involve curve length, radius, degree of curvature and tangent distance. As the number of road curvature over large area increases, it might be proactive. Reduction in speed increases driver vigilance and discouragement of risk-taking behaviour might be the possible mechanism for the effect on horizontal curve as the driver gets limited visibility. In general, the road alignment is decided with certain number of horizontal right turn and left turn curves, to avoid the driver being monotonous.

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5. RESULTS & SIMULATION

5.1 General

Road inventory details were collected and given below. For every 2 km in the study stretch 36 km of NH 19/44 from the chainage 220 km to 256 km. Accident details from nine police stations were collected for the years 2015-2020 and given in Table 6.2. Traffic flow surveys were conducted manually in all segments for six years from 2015-2020 and given in Appendix I. Speed surveys were also conducted manually in nine segments for five years. Using SPSS software a multiple linear regression model involving traffic volume, percentage of heavy vehicles, 85th percentile speed of LCVs, segment distance, access roads and horizontal curves is developed.

5.2 Road Inventory Details

Road inventory data like number of left side and right side access roads (like driveways, intersecting roads connecting fuel stations , service stations, residential zones, shopping centres etc., with main highway) and number of left turn and right curves were collected using GPS (Global Positioning System) instrument, which was kept by an observer in a car run throughout 36 Km. Mathura segment had maximum of 32 number of access roads and 38 number of horizontal curves while Mahuan had minimum of 18 number of access roads and 16 number of horizontal curves. There was maximum number of access roads and curves in the chainage from 242 to 244 km and from 246 to 248 km in Mathura segment. The road inventory details collected for 36 km are given in the Table 5.1.

Table 5.1
Road Inventory Details

Chainage (Km)	Access roads		Curves		Nature of the area
	L	R	L	R	
220-222	-	3	2	2	B
222-224	4	4	6	5	B
224-226	6	3	4	2	B&A
226-228	4	-	2	3	B
228-230	3	-	3	3	A
230-232	2	1	6	2	A
232-234	3	5	4	4	A
234-236	3	2	2	2	B
236-238	-	2	3	2	A
238-240	5	4	3	2	A
240-242	-	2	1	1	A
242-244	5	2	3	2	A
244-246	1	5	3	4	A
246-248	2	3	4	5	A
248-250	1	4	-	5	A
250-252	2	-	2	2	A
252-254	1	1	2	3	A
254-256	2	1	1	-	A

where, A - Agricultural areas, B- Built up

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A & B- Agricultural and built up, L-Left side, R-Right side

Figure 5.1 Presence of Horizontal Curve in Study Stretch

Figure 5.2 Vehicle from Access Road Merges with Main Traffic Flow

Figure 5.1 and 5.2 show the presence of horizontal curves and access roads

5.3 Accident Data

Accident data i.e., the number of accidents occurring every year, in the respective jurisdiction, was collected for the years 2015 to 2020 from 9 police stations along the study stretch and given in Table 5.2. Other details like location (near school, college, bus stop, hospital, village etc,), exact occurrence time, nature of accident (over turning, head-on-collision, rear-on-collision, side-hit, etc), driver details, age of vehicle, weather conditions etc were not available at all police stations. Distribution of accidents in segments is given in Figure 5.3. More information's related with accidents need to be collected in the standard forms as given in Appendix 2 and if uniformity in maintenance of records in all police stations is followed it would be useful for detailed analysis.

In Maholi segment, every year the number of accidents had been increasing on an average by 13.66%, except year 2017 where accident rate dropped to 115 from 118, a 2.5% decrease. At the same time, the number of two wheelers dropped to 5088 from 5136, a 1% decrease. In five years accident rate had increased to 167 from 92 resulting in 81.52% increase in number of accidents. On an average the number of accidents increased by 13.7% every year. Mahuan segment is familiar with Air Force activities and every year the number of accidents had been increasing on an average by 25 %, except year 2019 where accident rate dropped to 151 from 163, 7.4% decrease. The police enforcement could be the reason. In five years there was 150% increase in number of accidents. Mathura segment is busy with commercial and industrial activities. Every year the number of accidents had been increasing on an average by 4.6%, except year 2018 where accident rate dropped to 198 from 211, a 6.2% decrease. Road safety campaign programme could be the reason. In five years there was 17.18% increase in number of accidents. In Mathura segment every year the number of accidents had been increased on an average by 11.81%, except the year 2016 and 2018 where accident rate dropped to 73 from 84 and to 64 from 87, a 13% and 26.4% decrease respectively. In five years there was 9.52% increase in number of accidents.

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Table 5.2
Total Number of Accidents (2015-2020)

Segment	2015	2016	2017	2018	2019	2020
Maholi	92	118	115	138	155	167
Mahuan	74	136	148	163	151	185
Mathura	192	202	211	198	217	225

Source: From Police Records

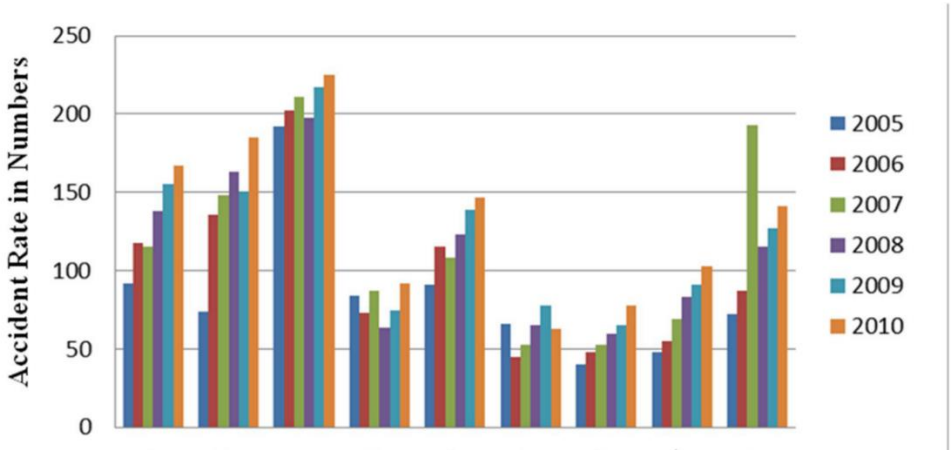

Figure 5.3 Distributions of Accidents

5.4 Traffic Volume Surveys

Twenty four hours traffic volume surveys in both directions were conducted every year, at every segment, at different months and week working days. Mostly the National Highway traffic composition was of heavy vehicles, light commercial vehicles and two wheelers as shown in Figure 5.4 For conducting traffic surveys 8 number of teams of 3 observers each (one each for heavy vehicles, light commercial vehicles and two wheelers), were formed. For day time surveys and night time surveys separately four teams were appointed. The hourly variation of traffic flow at each segment, the percentage of increase of traffic flow, heavy vehicles, light commercial vehicles and two wheelers, every year and in five years were analyzed, Every year, around 52 and 34 percent of traffic flow is contributed by light commercial vehicles and two wheelers in all segments. Generally accident rate increases with VKT which is equal to traffic volume multiplied by segment length. The values of traffic volume surveys for each segment are given in Appendix I. The consolidated values of traffic volume for each segment are given in Table 5.3 and hourly variations of traffic volumes are given in Figure 5.5 to 5.13.

Figure 5.4 Mixed Traffic flow in Industrial Area in NH-19

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Table 5.3
Consolidated Values of Traffic Volume (Average Volume/Day)

Maholi Segment				
Year	**Heavy Vehicles**	**LCVs**	**Two wheelers**	**Total**
2015	2849	7977	4999	15,825
2016	2777	8420	5136	16,333
2017	3337	9137	5088	17,562
2018	3759	9809	5224	18,792
2019	4227	10421	5477	20,125
2020	5472	10222	6191	21,885
MahuanSegment				
Year	**Heavy Vehicles**	**LCVs**	**Two wheelers**	**Total**
2015	2089	7020	4818	13,927
2016	2695	7492	4696	14,863
2017	3013	7995	4854	15,862
2018	3663	9233	5421	18,317
2019	4360	9990	5470	19,820
2020	5635	10144	4346	20,125
Mathura Segment				
Year	**Heavy Vehicles**	**LCVs**	**Two wheelers**	**Total**
2015	3752	9455	5549	18,756
2016	4369	9553	5029	18,951
2017	4787	9653	4708	19,148
2018	5113	10412	5453	20,978
2019	5544	10749	5784	22,077
2020	7060	11865	6880	25,805

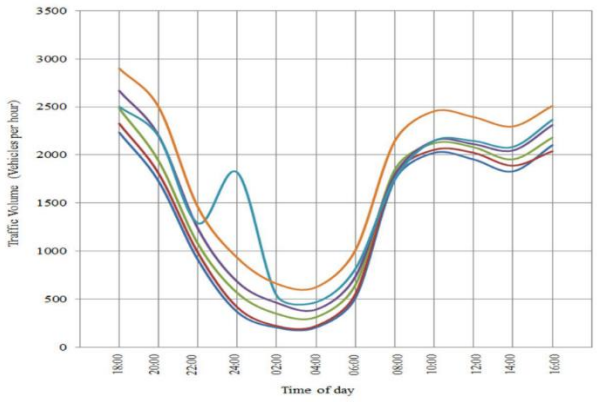

Figure 5.5 Hourly Variation of Traffic in Maholi

Traffic flow in the Maholi segment increased to 21885 in 2020 from 15825 in 2015, a 38 % increase in five years. On an average the traffic flow increased by 6.7% every year. Traffic is very low from midnight to morning 5:00 hours. After that traffic flow increased up to morning 9:00 hours and then decreased and became stable up to 20:00 hours, with minor variations. Finally

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the flow decreased up to mid-night. LCVs increased from 7977 in 2015 to 10222 in 2020, a 28 percent increase in five years. On an average the number of LCVs increased by 6.9 % every year. Two wheelers increased to 6191 in 2020 from 4999 in 2015, a 23.8% increase in five years. On an average the number of two wheelers increased by 5.8% every year. Heavy vehicles increased from 2849 in 2015 to 5472 in 2020, a 92% increase in five years. On an average the number of heavy vehicles increased by 11.5% every year.

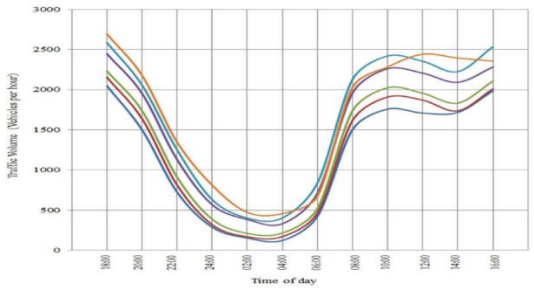

Figure 5.6 Hourly Variation of Traffic in Mahuan

Traffic flow in Mahuan segment increased to 20.125 in 2020 from 13927 in 2015, a 44.5% increase in five years. On an average the traffic flow increased by 7.7% every year. Traffic was very low from midnight to morning 5:00 hours. After that traffic flow increased up to morning 8:00 hours and then became stable up to evening 19:00 hours , with minor variations. Finally the flow decreased up to mid-night. LCVs increased from 7020 in 2015 to 10144 in 2020, a 44.5 % increase in five years. On an average the number ofLCVs increased by 7.7 % every year. Two wheelers increased to 5470 in 2019 from 4818 in 2015, a 13.5% increase in five years. On an average the number of two wheelers increased by 3.2% every year. Heavy vehicles increased from 2089 in 2015 to 5635 in 2020, a 169 % increase in five years. On an average the number of heavy vehicles increased by 17% every year.

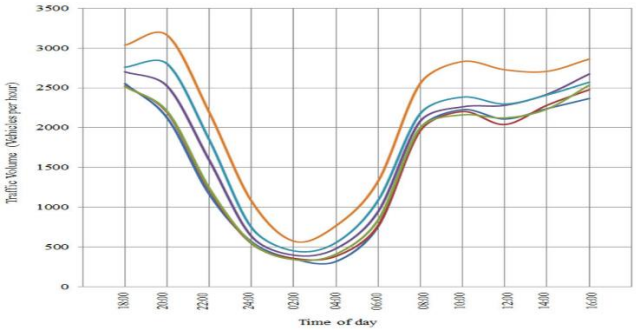

Figure 5.7 Hourly Variation of Traffic in Mathura

Traffic flow in Mathura segment increased to 25.805 in 2020 from 18756 in 2015, a 37.6 % increase in five years. On an average the traffic flow increased by 6.8% every year. Traffic was very low from midnight to morning 5:00 hours. After that traffic flow increased up to morning 9:00 hour and then decreases and became stable up to night 9:00 hours, with minor variations. Finally the flow decreased up to mid-night. LCVs increased from 9455 in 2015 to 11865 in 2020, a 25.5% increase in five years. On an average the number of LCVs increased by 4.7 % every year. Two wheelers increased to 6880 in 2020 from 5549 in 2015, a 24% increase in five years. On an average the number of two wheelers increased by 13.6% every year. Heavy vehicles increased to 7060 in 2020 from 3752 in 2015, a 88.2% increase in five years. On an average the number of heavy vehicles increased by 3.8% every year.

5.5 Speed Surveys

Light commercial vehicles normally travel at higher speeds than other categories of vehicles. Due to introduction of high power motor vehicles by automobile companies, the speed trend exceeds the safe speed limit. Here 85^{th} percentile speed of light

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commercial vehicles has been measured at all segments, every year, during morning 9.30 to11.30 hours. The 85th percentile speed is the speed below which 85 percent of all vehicles travel or only 15 percent of all vehicles travel above this speed and it is used for determining the speed limit for traffic regulation. For analysing the causes of accidents and identifying any relation between speed and accidents, spot speed is needed. So spot speed of light commercial vehicles had been measured at a place where the stretch was without curves, nearby intersections or built-up area so that real speed distribution could be measured. For conducting speed surveys two teams each of two observers, one for noting time of entry and other for vehicle number were formed and positioned at each end of 81m base length, with time of leaving and vehicle number having been noted by other team. Then by matching vehicle number observed by both teams and time taken by vehicle, the speed was calculated. For each segment 100 numbers of light commercial vehicles were observed and their speeds were calculated. In all segments generally the 85th percentile speed of LCVs increases and its distribution in all segments is given in Figures 5.8 to 5.11.The frequency distribution of speed in all segments is given in Tables 5.4 to 5.6 and Consolidated values of 85th percentile speed of LCVs is given in Table 5.7.

Table 5.4
Frequency Distribution of Speed in Maholi Segment

Speed (kmph)	Cumulative frequency (%)					
	2015	2016	2017	2018	2019	2020
0	0	0	0	0	0	0
10	7	4	0	3	0	0
20	13	12	5	8	4	7
30	31	28	17	21	10	14
40	54	54	46	43	35	35
50	87	87	74	73	64	65
60	100	98	96	91	82	81
70	100	100	98	95	95	93
80	100	100	100	100	100	100
90	100	100	100	100	100	100
100	100	100	100	100	100	100

Table 5.5
Frequency Distribution of Speed in Mahuan Segment

Speed (kmph)	Cumulative frequency (%)					
	2015	2016	2017	2018	2019	2020
0	0	0	0	0	0	0
10	4	3	10	0	6	0
20	13	14	15	4	11	8
30	29	30	25	10	26	16
40	57	68	51	35	46	33

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50	80	81	75	64	70	59
60	92	92	87	82	82	75
70	94	100	92	95	93	83
80	100	100	100	100	96	90
90	100	100	100	100	100	100
100	100	100	100	100	100	100

Table 5.6
Frequency Distribution of Speed in Mathura Segment

Speed (kmph)	Cumulative frequency (%)					
	2015	2016	2017	2018	2019	2020
0	0	0	0	0	0	0
10	4	4	0	3	4	5
20	12	13	5	10	8	13
30	28	29	17	22	22	29
40	54	57	46	42	44	51
50	87	80	74	73	75	72
60	98	92	96	92	90	89
70	100	94	98	95	98	98
80	100	100	100	100	100	100
90	100	100	100	100	100	100
100	100	100	100	100	100	100

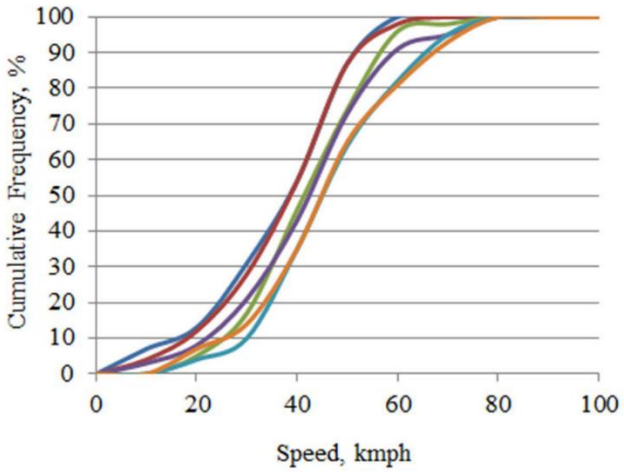

Figure 5.8 85th Percentile Speed in Maholi Segment

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In Maholi segment, the 85th percentile speed of LCVs increased to 64 kmph in 2020, from 48 kmph in 2015, 13 % increase in five years. On an average 85th percentile speed of LCVs increased by 5.9% every year.

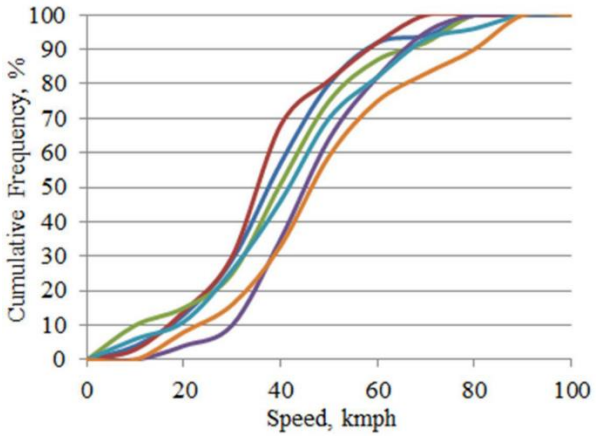

Figure 5.9 85th Percentile Speed in Mahuan Segment

In Mahuan segment, the 85th percentile speed of LCVs increased to 72 kmph in 2020, from 52 kmph in 2015, 18.5 % increase in five years. On an average 85th percentile speed of LCVs increased by 6.8% every year.

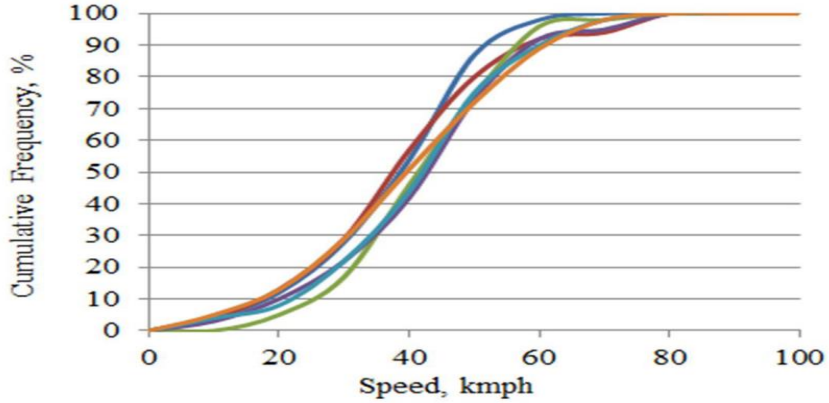

Figure 5.10 85th Percentile Speed in Mathura Segment

In Mathura segment, the 85th percentile speed of LCVs increased to 66 kmph in 2020, from 50 kmph in 2015, 32 % increase in five years. On an average 85th percentile speed of LCVs increased by 5.9% every year.

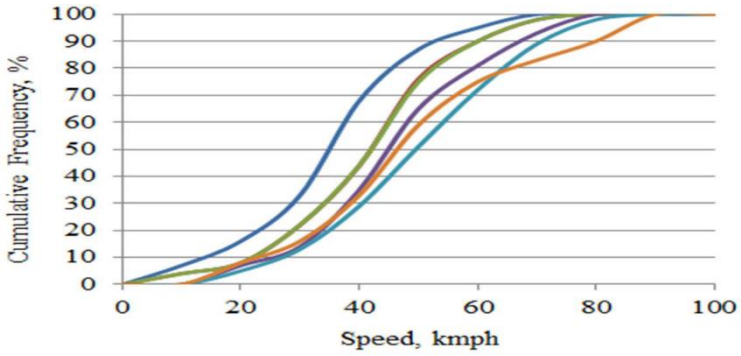

Figure 5.11 85th Percentile Speed in Mathura Segment

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Table 5.7
Consolidated values of 85th percentile speed of LCVs

Segment	Distribution of 85th percentile speed					
	2015	2016	2017	2018	2019	2020
Maholi	48	50	54	56	60	64
Mahuan	52	54	58	60	62	72
Mathura	50	52	54	55	57	66

5.6 Model Building

5.6.1 General

In multiple regression, objective is to build a probabilistic model that relate a dependent variable y to more than one independent variable. The general form of the multiple regression model is given by $Y= a_0+a_1x_1 +a_2x_2+\ldots+a_kx_k$ where Y is dependent variable, a_0 is intercept, x_i is independent variable, a_i is regression coefficient of x_i, and k is number of independent variables. In the above equation parameters $a_0,a_1\ldots a_k$ can be estimated by method of least squares. The analysis of variance approach is used to test the equation. The total sum of squares is split into the regression sum of squares and the error sum of squares. The total sum of squares (SST) = Regression sum of squares (SSR) + Error sum of squares (SSE) where $SST = \sum(Y_{ei} -Y_m)^2$, $SSE=\sum(Y_i – Y_{ei})^2$, Y_i=actual value, Y_{ei} =estimated value and Y_m= mean value of Y; the variance of errors given by s^2=SSE/ (n-m-1) where n is number of sets of data, m is number of independent variables and the standard error of estimate is given by the square root of variance of error. The coefficient of determination R^2 is another indicator of the strength of the relationship. Its value is given by R^2=SSR/SST, and it lies between 0 and 1, the closer it is to 1, the better is the relationship between the independent variables and dependent variable. The square root value of coefficient of determination is square root value of coefficient of determination is known as multiple correlation coefficients. The coefficient of determination is useful in judging the effectiveness of the model and hence future estimation can be made at reasonably an accurate level. When comparing regression analyses with different number of independent variables, adjusted R^2 to be calculated as $1-(1-R^2)$ (N-1)/ (N-K-1) where, N= number of observations and k= number of parameters in the model. The logical or theoretical relevance of the explanatory variables to the dependent variable and their statistical significance should be the prime concern. If in this process a high adjusted R^2 value is obtained it is good. The standard error of estimate measures the accuracy of the estimated values. The smaller the value of standard error of estimate, lesser will be the variation about the regression line. The standard error helps to ascertain how good and representative the regression line is as a description of the average relationship. The standard error gives an idea about the reliability and precision. The smaller the standard error, the greater the uniformity and hence greater is the reliability

5.6.2 Relationship between Traffic Flow and Accidents

Generally as the traffic flow increases, accident rate also increases. Following Figures show the relationship between traffic volume and number of accidents in all segments. Maholi segment is urban and built-up area adjacent to Coimbatore city, full of commercial and economic activities on both sides, in the form of shopping complex, market places, motor show room and dealers, hotels, financial institutions, bus terminal and recreation places. Traffic volume increased by 38% in five years. On an average the traffic volume increased by 6.7% every year. LCVs increased by 28% in five years. On an average the number of LCVs increased by 6.9% every year. Two wheelers increased by 23.8% in five years. But in the year 2017 the number of two wheelers dropped by 1% from previous year. On an average the number of two wheelers increased by 4.6% every year. Heavy vehicles increased by 92% in five years. On an average the number of heavy vehicles increased by 11.5% every year in this segment. In the segment the number of accidents increased on an average by 13.7% every year except year

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2017 where accident rate dropped by 2.5% decrease. In five years there was 81.5% increase in number of accidents. On an average the number of accidents increased by 13.7% every year.

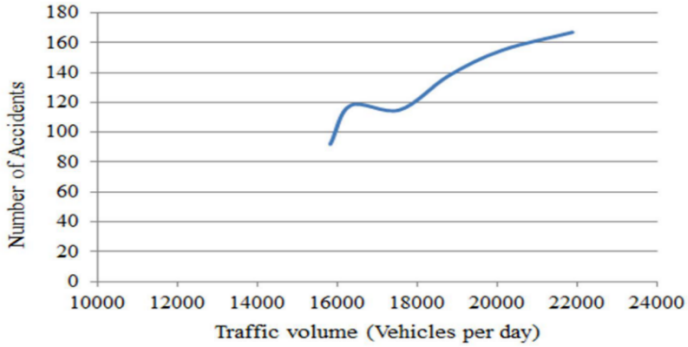

Figure 5.12 Number of Accidents versus Traffic Volume in Maholi Segment

Mahuan segment is semi urban area and Air force station is situated. On both sides vacant lands, teashops, hotels, medical centres, workshops, schools are available. Traffic volume increased by 44.5% in five years. On an average the traffic volume increased by 7.7% every year. LCVs increased by 44.4% in five years. On an average the number of LCVs increased by 7.7% every year. Two wheelers increased by 13.5% in five years. On an average the number of two wheelers increased by 3.2% every year. Heavy vehicles increased by 169% in five years. On an average the number of heavy vehicles increased by 17% every year in this segment. In the segment, every year the number of accidents had been increasing on an average by 25%, except year 2019 where accident rate dropped by 7.4% from previous year. In five years accident rate had increased by 150%.

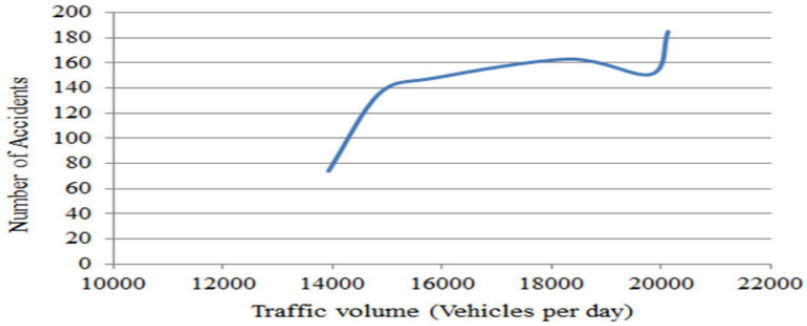

Figure 5.13 Number of Accidents versus Traffic volume in Mahuan segment

Mathura segment is a busy area with many commercial activities, market places, textile mills, foundry, workshops, hotels, medical centres and motor show rooms, theatres and this area had connectivity with other adjacent towns. Traffic flow in this segment increased by 37.6 % in five years. On an average the traffic flow increased by 6.8% every year. LCVs increased by 25.5% in five years. On an average the number of LCVs increased by 4.7 % every year. Two wheelers increased by 24% in five years. On an average the number of two wheelers increased by 13.6% every year. Heavy vehicles increased by 88.2% increase in five years. On an average the number of heavy vehicles increased by 3.8% every year.

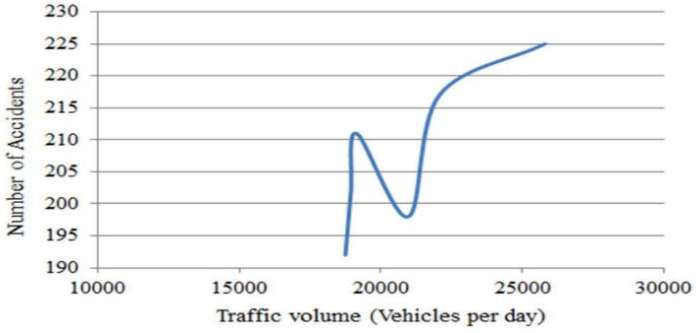

Figure 5.14 Number of Accidents versus Traffic volume in Mathura Segment

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5.6.3 Relationship between Accidents, VKT and Road Environment

The number of access roads and accidents are positively correlated. As the number of access roads due to increased land use activities, along a highway gets increased, proportionately accident rate also increases, and there is a positive relationship between access roads and segment distance. This relationship is shown in the Table 6.14 shows the consolidated values of accidents,VKT and road environment in various segments. Mathura segment of 16 km stretch with mean traffic volume of 20,952 vehicles/day and mean VKT of 3,35,232 had a maximum mean value of number of accidents of 207. Next to Mathura segment, Mahuan segment of 12 km stretch with mean traffic volume of 17,152 vehicles/day and mean VKT of 2, 05,824 had mean value of number of accidents of 143. Next to Mahuan segment, Maholi segment of 8 km stretch with mean traffic volume of 18,420 vehicles/day and mean VKT of 1,47,360 had mean value of number of accidents of 131. Next to Maholi segment, even though Gorakhpur segment was with maximum segment length of 24 km, mean traffic volume of 20,243 vehicles/day and mean VKT of 4,85,832 it had comparatively lower mean value of number of accidents of 122, than Mathura segment with higher number of accidents. Similarly the other segments Basti of 18 km stretch, Mathura of 10 km stretch, Sahjanwa of 12 km stretch, Vellakoi of 10 km stretch and Mahuan of 10 km stretch, with mean traffic volume of 18,105, 15,402, 16,917, 15,738 and 16,025 respectively, had mean VKT of 3,25,890, 1,54,020, 2,03,004, 1,57,380 and 1,60,250 and mean value of number of accidents of 120, 79, 75, 62 and 57 respectively. Table 5.8 shows the consolidated mean values of VKT, traffic volume and accidents in respective segments.

Table 5.8
Consolidated Mean Values of VKT, Traffic Volume and Accidents in Segments

S. No.	Segment	Traffic Volume	VKT	Road Environment		Accidents
				Access Roads	Curves	
1	Maholi	18,460	1,47,360	24	26	131
2	Mahuan	17,152	2,05,824	30	36	143
3	Mathura	20,952	3,35,232	32	38	207

Land use activities are commonly being developed along highways, in the form of commercial establishments, residential zones and industrial zones. These are the potential source for accidents. Variation of number of accidents with VKT is given in Figure 5.15.

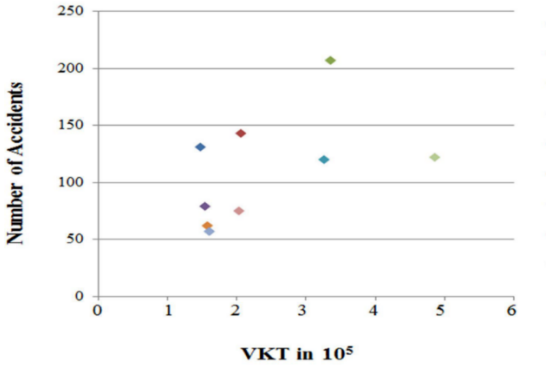

Figure 5.15 Number of Accidents versus VKT

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Table 5.9
Regression Model for Y (Accidents)

Variables	Regression Coefficient	Standard Error	t- value (d.f = 47)	Sig	R^2
Constant	-160.134	80.125	-1.999	0.051	0.86
X1-ADT	0.006	0.003	1.823	0.075	
X2-HV	2.296	1.369	1.678	0.100	
X3-Speed	0.001	0.848	0.001	0.999	
X4-Length	-1.123	0.938	-1.198	0.237	
X5-Acc.Roads	5.46	0.991	5.508	0.000	
X6-Curves	0.677	0.634	1.067	0.291	

The multiple linear regression equation fitted using SPSS is

$Y = 160.134+0.006 X_1 \pm 2.296 X_2+0.001 X_3 \quad 1.123 X_4+5.46 X_5+0.677 X -$

With an adjusted R^2=0.86, that is 86% of the variation in accidents has been explained by the variables as shown in the Table 5.9 (regression line).The independent variables were significant at 5% level of significance. Number of access roads was highly significant. The traffic volume, percentage of heavy vehicles and number of horizontal curves were significant. 85^{th} percentile speed of LCVs was less significant. Except segment distance all independent variables were positively correlated with number of accidents. As the calculated F value of 22.74 shown in Table 5 .10 is greater than tabulated value of 2.3 regression model is statistically significant.

Where, Y – Number of accidents per year in the given segment
X1 - Average Daily Traffic (ADT)
X2 - Percentage of heavy vehicle

X_4 – Length of segment (km)
X_5 – Number of access roads in the segment
X_6 – Number of horizontal curves in the segment

Table 5.10
Analysis of Variance for Regression

Source	S S	D F	M S	F
Regression	103257.6	6	17209.6	22.74
Residual	35561.17	47	756.6207	

5.7 Validation of Model

The multiple linear regression model generated is validated by comparing the accidents occurred in 2020 at all segments. The estimated values by the model and occurred values according to police record are in close relationships except Khalilabad and Mathura segments were the difference between estimated value and occurred value was considerable. Improper entry in police records and lack of precise data collection could be the reasons. So the model developed is useful for Civil and traffic engineers and planners to carry out further improvement in highway design for controlling accidents. Table 5.11 compares the estimated values and occurred values.

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Table 5.11
Comparison between Estimated Accident and Occurred Accident in the year 2020

S.L No.	Segment	Estimated accidents in numbers	Occurred accident in numbers	Error in %
1	Maholi	168	167	0.60
2	Mahuan	199	185	7.57
3	Mathura	239	225	6.22

6. CONCLUSIONS & FUTURE SCOPE

6.1 Conclusion

- For this study about 120km stretch of National Highway-19/44 between Mathura and Agra was selected. Road inventory survey was conducted throughout the length and for every 2 km road inventory details like number of access roads, horizontal curves and nature of areas were collected.
- Total length of study stretch was divided into three segments with different length ranging from 8 km to 24km, according to jurisdiction of the three police stations namely Maholi, Mahuan, Mathura, from where accident statistics were collected for the year 2015 to 2020.
- Traffic volume in Maholi segment increased by 38% in five years. On an average the traffic volume increased by 6.7% every year. The number of LCVs, two wheelers and heavy vehicles respectively increased by 28%, 23.8% and 92% in five years. On an average these vehicles increased by respectively 6.9%, 5.8% and 11.5% every year. The 85th percentile speed of LCVs increased by 13% in five years and on an average it increased by 5.86% every year. The number of accidents increased by 81.52% in five years and on an average it increased by 13.7% every year, except the year 2017 where the number of accidents reduced by 2.5% , while the number of two wheelers dropped by 1% in the same year.
- Traffic volume in Mahuan segment increased by 44.5% in five years. On an average the traffic volume increased by 7.7% every year. The number of LCVs, two wheelers and heavy vehicles respectively increased by 44.5% 13.5% and 169% in five years. On an average these vehicles increased by respectively 7.7%, 3.2% and 17% every year. The 85th percentile speed of LCVs increased by 18.46% in five years and on an average it increased by 6.76% every year. The number of accidents increased by 150% in five years and on an average it increased by 25% every year.
- Traffic volume in Mathura segment increased by 37.6% in five years. On an average the traffic volume increased by 6.8% every year. The number of LCVs, two wheelers and heavy vehicles respectively increased by 25.5%, 24% and 88.2% in five years. On an average these vehicles increased by respectively 4.7%, 13.6% and 3.8% every year. The 85th percentile speed of LCVs increased by 32% in five years and on an average it increased by 5.86% every year. The number of accidents increased by 17.18% in five years and on an average it increased by 4.6% every year.
- The Conclusions were reached from the highway traffic studies and analysis of accidents Traffic volume in the highway increased by 7.2% every year, out of which 6.6%, 6.8% and 15% were contributed by LCVs, two wheelers and heavy vehicles.
- Number of accidents in urban highway segment increased by 15.8% and in rural highway segment by 16% every year, respectively. A 1% decrease in number of two wheelers caused 2.5% reduction in number of accidents in urban segment while a 3.4% decrease in number of LCVs caused 6.1% reduction in number of accidents and a 12% decrease in number of heavy vehicles caused 40.4% reduction in number of accidents.
- In urban segment 50% of traffic volume was contributed by LCVs while 30% and 20% were contributed by two wheelers and heavy vehicles. In rural segment 50% of traffic volume was contributed by LCVs while 37% and 12% were contributed by two wheelers and heavy vehicles.

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- Traffic volume, Percentage of Heavy Vehicles, 85th Percentile Speed of LCV's, number of access roads and horizontal curves were positively correlated with number of accidents while segment distance was with negative correlation.
- There was minimum traffic flow of 5% of ADT in early morning from 2:00 to 6:00 hours, generally more number of accidents in highways likely to occur during this time.
- The multiple linear regression model built using six variables has been tested for traffic flow, 85th percentile speed of LCV's and road environment which normally represent the scene in Indian highways.
- The same model could also be studied and evaluated for Similar highways in developing Countries.

6.2 Future Scope

- The limited work in this study could be taken as the need of the hour towards highway accidents and thereby making the respective agencies to realize the importance of highway safety and to take the control measures to bring down the accident rate in National Highways and State Highways.
- In this work only limited number of traffic variables and road environment is taken. This work could be extended in the following ways.
- All road geometric variables could be involved Traffic flow and speed have been considered and traffic density not involved.
- This work has been attempted on undivided two-lane highway, other category of highways could be tried out.

REFERENCES

[1] Ashutosh Gupta and A.K. Gupta, "Analysis & Prediction of Road Accident Data for Indian States", International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 21 (2018) pp. 14841-14845.
[2] V.Sharmila , T.K.P. Rajagopal , S. Deva arasi , M. Ramani , and S.Karthick raja, "Traffic Accident Evaluation using MATlab", International Research Journal of Multidisciplinary Technovation, 2019, 1(2), 79-83.
[3] Daina, L, Tecsi, I, Chereji, A, Cioara, F & Laslau, C, "Road accidents-analysis, evolution causes and prevention measures", 2012, vol. 11, pp. 27-34.
[4] Daniel, "Brake Failure and its Effect on Road Traffic Accident in Metropolis", International Journal of Science and Technology, 2012, vol. 9.
[5] Garratt, BM, Johnson, M & Cubis, J, "An Amy Gillett Foundation report", 2015.
[6] Hana, A, Mahdi, Anwar, AA, Mohammad, TA, Alkhamisand, E, Fawaz, A & Alrashidi, "Road safety in Kuwait: Results from a Recent Survey", International Journal of Transportation, 2015, vol. 3, no. 2, pp. 65-72.
[7] Kahn, CA & Gotschall, CS, "The economic and societal impact of motor vehicle crashes (Revised)", Annals of Emergency Medicine, 2015, vol. 66, no. 2, pp. 194-196.
[8] Karimi Moonaghi, H, Ranjbar, H, Heydari, A & Scurlock-Evans, L, "Truck Drivers' Experiences and Perspectives Regarding Factors Influencing Traffic Accidents: A Qualitative Study", Workplace Health & Safety, 2015, vol. 63, no. 8, pp. 342-349.
[9] Kayvan Aghabayk, Majid Sarvi & William Young, "A Macroscopic Study of Heavy Vehicle Traffic Flow Characteristics", 25th ARRB Conference 2012 – Shaping the Future: Linking Policy, Research and Outcomes, Perth, Australia.
[10] Labana, AB, Parikh, VA & Parekh, VP, "Literature Review on Road Accident Analysis a Case Study on Dahod to Jhalod Section of N . H . 113", International Journal for Scientific Research & Development, 2015, vol. 3, no. 02, pp. 2338-2341.
[11] Linu, KJ, Minu, PK, Nithya, NP, Sajitha, S & Sreeshma, KP, "Road Safety awareness index and road user behavior – A case study at Kazhakkootam", International Journal of Innovative Research in Science, Engineering and Technology, 2013, pp. 270-276.
[12] Ponnaluri, R.V., 'Modeling road traffic fatalities in India: Smeed's law, time invariance and regional specificity', International Association of Traffic and Safety Science, 2012, vol. 36, pp. 75-82.
[13] Athipathi, G., Nagan, S. and Baskaran, T., "Accident Prediction on national highways in India", International Journal of Theoretical and Applied Mechanics, 2017, vol. 12, no. 1, pp. 153-165.

[14] Vijaya, R.B., "Analysis of road accidents of southern states in India using smeed's model", International journal of research in mathematics & computation, 2013, vol. 1, pp. 13-19.
[15] Goel, R., "Modelling of road traffic fatalities in India", Accident Analysis & Prevention, 2018, vol. 112, pp. 105-115
[16] Kanuganti, S., Agarwala, R., Dutta, B., Bhanegaonkar, P.N., Singh, A.P. and Sarkar, A.K., "Road safety analysis using multi criteria approach: A case study in India", Transportation Research Procedia, 2016, vol. 25, pp. 4649-4661.
[17] Singh, S.K., "Road Traffic Accidents in India: Issues and Challenges", Transportation Research Procedia, 2017, vol. 25, pp. 4708-4719.
[18] Naveen.N, and Satish Kumar.M., "Impacts of Roadway Condition, Traffic and Manmade Features on Road Safety", International Journal of Scientific & Engineering Research, 2016, vol. 7, pp.30-36.
[19] K. Moriya, S. Matsushima and K. Yamanishi, "Traffic Risk Mining From Heterogeneous Road Statistics," in IEEE Transactions on Intelligent Transportation Systems, vol. 19, no. 11, pp. 3662-3675, Nov. 2018, doi: 10.1109/TITS.2018.2856533.
[20] Nalini Ranjan Singh, Biswajit Mohanty, Pradyumna Sagar Sahoo Sagarika Panda, "Impacts Of Traffic, Manmade Features And Roadway Condition On Road Safety", Palarch's Journal Of Archaeology Of Egypt/Egyptology 17(9).ISSN1567-214x .
[21] Absar Alam, "Road Accidents in India: Need for Post-Accident Health Care Facilities", Transport and Communications Bulletin for Asia and the Pacific, No.-89, 2019.
[22] Tuhin Kanti Ray and Sukla Bhaduri, "Application of Road Traffic Accident Modelling for Future Prediction: A Case Study of Kolkata", IJCRR - Vol 09 Issue 05, March, 201, Pages: 01-08.