DEVELOPMENT OF ROAD ACCIDENT PREDICTION MODEL: A CASE STUDY AT BHUJ CITY

By

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The Master of Engineering Degree in Transportation Engineering

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This is to certify that research work embodied in this dissertation titled **"Development of Accident Prediction Model: A Case study At Bhuj City"** was carried out by **Ms. Shivani Ratandan Sindhiya** at **Atmiya Institute of Technology and Science, Rajkot (003)** for partial fulfillment of Master of Engineering degree in **Transportation Engineering** to be awarded by Gujarat Technological University. This research work has been carried out under my supervision and is to my satisfaction.

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ABSTRACT

The problem of accident is very acute in highway transportation due to complex flow patterns of vehicular traffic presence of mixed traffic and pedestrians. Traffic accidents may involve property damages, personal injuries or even causalities. One of the main objectives of traffic engineering is to provide safe traffic movements. Road accident cannot be totally prevented, but by suitable traffic engineering and management measure, the accident rate can be decreased considerably. Therefore to carry out systematic accident studies to investigate the causes of accidents and to take preventive measures in terms of design and control.

To develop road accident prediction model each and every parameter related with the accident is considered and a micro level analysis of road accident is performed. For micro level analysis road accident data of last eleven year (2010 to 2019) from different five police station is collected and a detailed analysis is performed on basis like Hour, year, location, type of collision, type of road, physical feature of road, age group, sex etc. On basis of these analysis effect of accident is identified. After analysis road accident prediction models is developed based on different parameter like Number of Vehicle and population ratio and vehicular composition. All the models are validate through F test and Chi Square test.

CHAPTER - 1

Introduction

1.1 General

India is a second largest populated country in the world. Transportation sector plays the important role in developing our country. Transportation sector of any country, acting as an indicator for the economic development of that nation. The hike in Industry, trade and commerce depends on the growth of transportation facility of a country. More the lengths of roads, more the safe, easy and comfort transportation facility and more the prosperity of the country. Roads are the foundations of any country, brightness of transportation but the dark side of transportation are pollution and accidents.

Accidents are still thought of by some persons as "ACT OF GOD" or the result of luck or chance (bad or good). An accident is consider as an unpleasant, undesirable event or damage that happens unexpectedly or by chance. In accident human, vehicle and environmental factors play important roles before, during and after event. An accident is occurring suddenly, unexpectedly and inadvertently event under unforeseen circumstance.

Road traffic accidents can be defined as "An accident include collision, overturning or slipping that occurred on a road open to a public traffic; resulting in personal injury, damages to the property and loss of life in which at least one moving vehicle was involved." Thus, road traffic accident is collisions between vehicles, between vehicles and pedestrians, between vehicles and animals, or between vehicles and other object. The accidents on highways are grievous and disastrous situation. Road accidents have Increase in the recent years due to several different reasons. The road accident is now well established condition because many developing countries face a serious problem Of road accident. Accident fatalities rate in developing countries like India is high in the comparison with that in the developed countries so, study for this subject is important.

1.1.1 History of Accident

Any accident that occurs on the road is the output of a series of events a generating process in which road elements and transport vehicles as well as transport systems are involved and have been interacting. The first accident injury recorded in road crash occurred on 30th May 1886 in New York on account of a collision between a bicycle and motorcar. The first road accident fatality was a pedestrian on 25th February 1899 in London. The first vehicles registration plates for motor vehicles were introduced by Paris Police in 1893, followed by New York State in 1901 and in Britain in 1903**.** In 1924 first time driving license system was introduced in the world for the first turn in Britain, and in the same year the development of traffic legislation commenced in USA.

1.1.2 Global Accident Scenario

International comparison of road accidents records has of great value but to be meaningful, it should be based on only agreed definitions of accidents, fatalities and injuries. Another difficulty in interpreting the results of road accident is the wide variation that existence in different countries as regards economic conditions, education and literacy, weather, types of vehicles, traffic conditions, legal measures in force, population density, degree of urbanization and value of vehicle kilometers to which the statistics are usually related. Caution is therefore important in drawing conclusion from such comparisons. Most of the countries maintain road accident statistics in some form. Some other organizations such as the World Health Organization and Economic Commission of Europe also publish statistics of accidents.

The Road Research Laboratory Unaided Kingdom (U.K.) has collected accident figures from a number of countries. One of the ways of comparing safety situation in a large number of countries is to examine the accident fatality rate. Fatality rate is the number of road accidents death per 10000 licensed vehicles.

Over 1.2 million people die each year on the world's roads accident, with millions more sustaining serious injuries and living with long-term adverse health consequences. Universally, road traffic injuries are a leading cause of death among young people, and the main cause of death among those aged 15–29 years (see Figure 1-1). Road traffic injuries are currently expected to be the ninth leading cause of death across all age groups globally, and current trends suggest that by 2030 road traffic deaths will become the seventh leading

cause of death unless urgent action is taken. The fig 1-2 below shows the accident scenario in future years with and without taking action to prevent it.

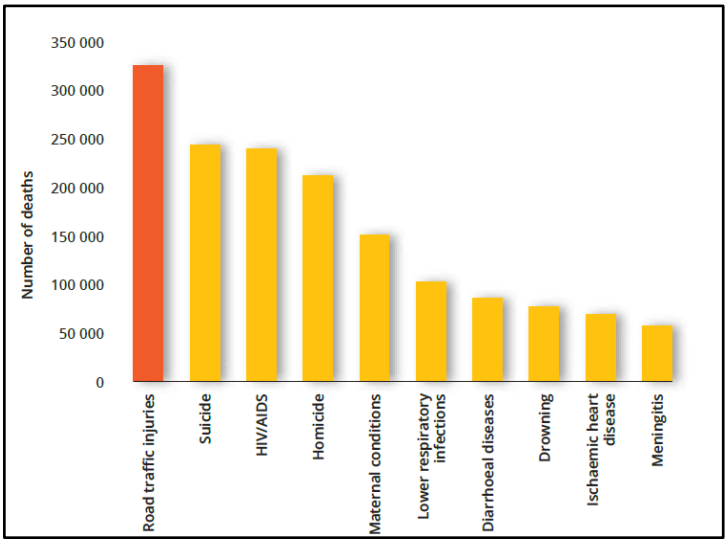

Fig. 1.1 Top ten causes of death among people aged 15–29 years, 2019

(Source: Global Safety Report on Road Safety, 2019 – WHO

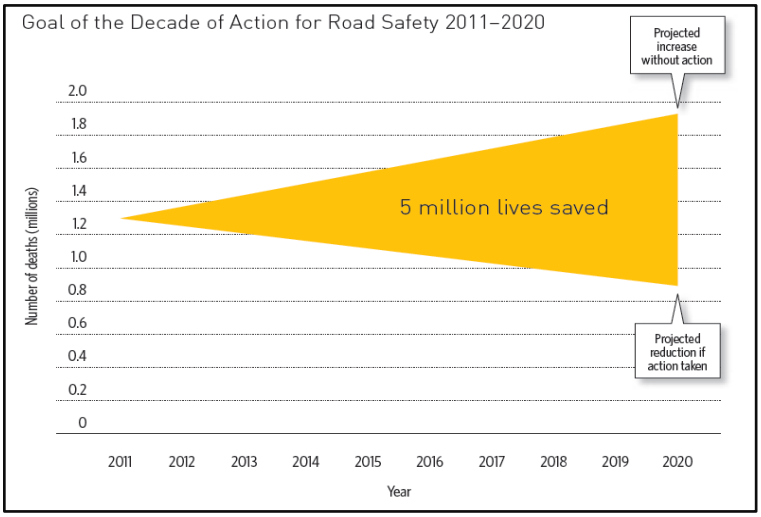

Fig. 1.2 Goal of the decade of action for road safety 2011-2020

(Source: World health organization, WHO)

Table 1-1

Fatality Rate of Different Countries

(Source: WHO Report)

Sr. No.	Country	Fatality rate
1	Ethiopia	191.5
2	Nepal	82.0
3	Bangladesh	76.8
4	Cameron	57.4
5	China	43.8
6	Botswana	40.3
7	Nigeria	36.1
8	Switzerland	35.7
9	India	29.5
10	Morocco	25.6
11	Pakistan	21.1
12	Cambodia	16.3
13	Srilanka	15.5
14	Indonesia	11.1
15	Hong Kong	7.1

Fig. 1.3 Number of Road Accident Death Worldwide – 2017

(Source: Global Safety Report on Road Safety, 2017 – WHO)

Accident Situation in India

India is one of the fastest growing automobile markets in the world, along with a rapidly expanding road and highway network than also spectacular increase in the number of motor vehicles. However, with more automobiles vehicles in all classes being introduced each month, the corresponding rate of accidents is also very high. The mixed traffic conditions Road traffic injuries are currently major problems in India. In our country India itself about eighty thousand people are killed in road accidents every year which are thirteen percent of the total fatality all over the world

total number of road traffic accidents increased by 2.5 per cent from 4,89,400 in 2014 to 5.01,423 in 2015. The total number of persons killed in accident increased by 4.6 per cent from 1, 39,671 in 2014 to 1, and 46,133 in 2015. Road traffic accident injuries have also increased by 1.4 per cent from 4, 93,474 in 2014 to 5, and 00,279 in 2015. Accident severity Index number of persons killed per 100 accidents has gone up from 28.5 in 2014 to 29.1 in 2015. The analysis of road traffic accident data 2015 reveals that about 1374 accidents and 400 deaths take place every day on Indian roads. It further reveals that 57 accidents take place and 17 lives are lost every hour on an average in road accidents injuries in our country.During 2015, a total of 5, 01,423 road accidents were reported by all States of these 26.3 per cent (1, 31,726) were fatal accidents. The number of persons killed in road accidents were 1, 46,133 i.e. an average of one fatality per 3.4 road accidents. The number of road accidents.

road accident fatalities and persons injured in road accidents in India during 2005 to 2015 shown in fig 1-4 and Table 1-2. [3]

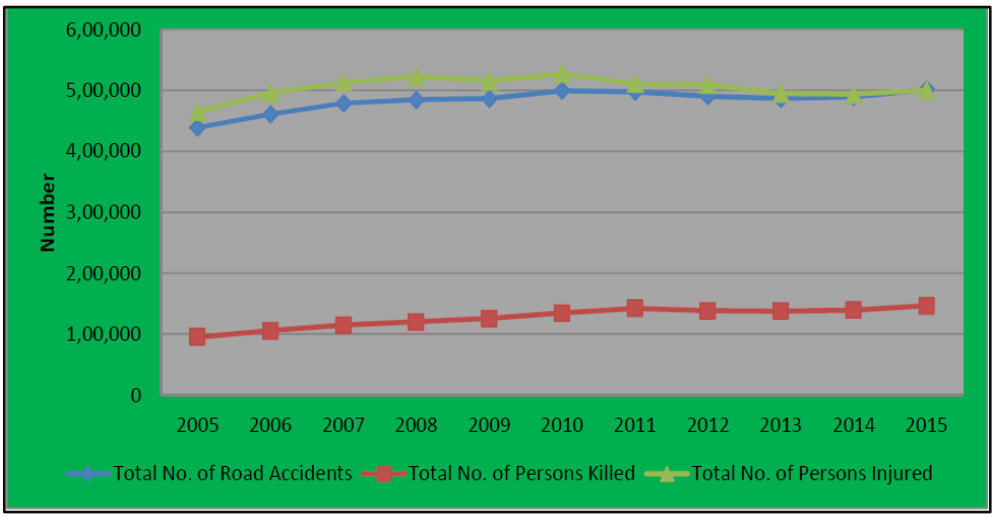

Fig. 1.4.1 Road Accident Statistics 2005– 2015

(Source: Road Accident in India, 2015, MORTH – India)

Table 1.2: Number of Road Accidents and Number of Persons affected: 2005-2015					
Year	Number of Accidents		Number of Persons		Accident Severity*
	Total	Fatal	Killed	Injured	
2005	4,39,255	83,491 (19.0)	94,968	465,282	21.6
2006	4,60,920	93,917 (20.4)	105,749	496,481	22.9
2007	4,79,216	1,01,161 (21.1)	114,444	513,340	23.9
2008	4,84,704	1,06,591 (22.0)	119,860	523,193	24.7
2009	4,86,384	1,10,993 (22.8)	125,660	515,458	25.8
2010	4,99,628	1,19,558 (23.9)	134,513	527,512	26.9
2011	4,97,686	1,21,618 (24.4)	1,42,485	5,11,394	28.6
2012	4,90,383	1,23,093 (25.1)	1,38,258	5,09,667	28.2
2013	4,86,476	1,22,589(25.2)	1,37,572	4,94,893	28.3
2014	4,89,400	1,25,828(25.7)	1,39,671	4,93,474	28.5
2015	5,01,423	1,31,726(26.3)	1,46,133	5,00,279	29.1

Source: Information supplied by States/UTs (Police Departments).
Figures within parentheses indicate share of fatal accidents to total accidents.
* Accident Severity : Number of persons killed per 100 accidents

Fig. 1.4.1 Road Accident Statistics 2005– 2015

(Source: Road Accident in India – 2015, MORTH Report)

Accident scenario at state level

Figure 1-5 shows the total number of fatalities by state and territory from 1971 to 2014. The states of Nagaland and Sikkim and Union Territories Lakshadweep, Daman & Diu, Andaman and Nicobar Islands and Dadra and Nagar Haveli have not been included in the chart as because they reported less than 100 fatalities in 2014. Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura are small hill states, and the union territories of Andaman and Nicobar Islands, Dadra and Nagar Haveli, Daman and Diu, Lakshadweep, Pondicherry, Chandigarh and Delhi union territories which are small and the last two are cities. Therefore, these regions can have different traffic and fatality patterns.

Andhra shows a decline in the number of fatalities between 2011 and 2014 because the state was divided in two states Andhra and Telangana in 2014. The total accident fatalities in Andhra and Telangana in 2014 was 1, 4814 as compared to 1,518 in undivided Andhra in 2011. In almost all the large states fatalities more than doubled between 1991 and 2014 show in fig 1-5. In Maharashtra, Orissa, Rajasthan, Tripura fatalities increased by 4 to 6 times, and in Gujarat, Punjab, Haryana and Assam 8 to 10 times during the same period.

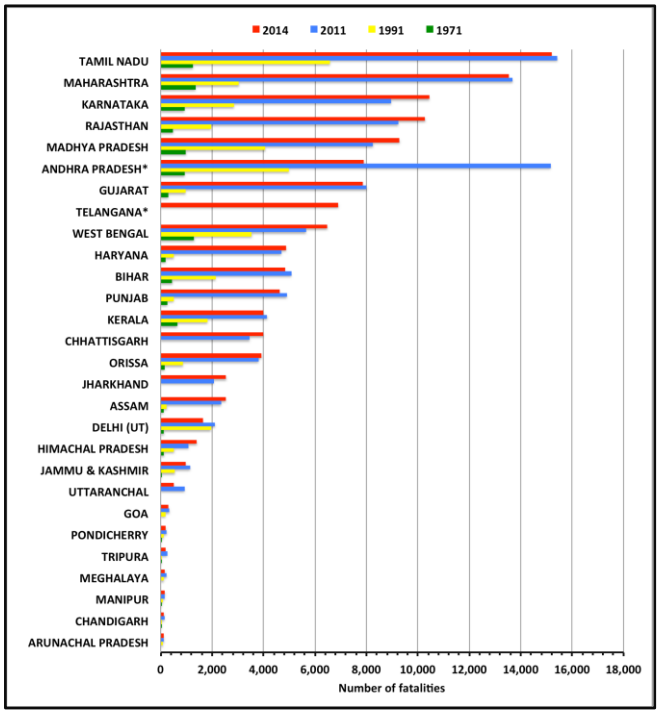

Fig. 1.5 Total number of RTI fatalities by state and union territory from 1971 to 2018

1.1.5 Accident scenario at Gujarat

Gujarat is first number of the most industrially developed and agriculturally advanced fertile state in India. Gujarat ranked the 7th highest in India in road accident. The population of Gujarat has increased from 4.13 cr. in 1991 to 5.06 crores in 2001, and 5.97 in 2010 to 6.49 in 2016. The road transport length in Gujarat has increased from 67065 km in 1991 to 73619 km. 2001 with increase in road length, the total no. of registered vehicles in Gujarat has increased from 675683 in 1981 to 850000 in 2010. Gujarat state transport is having a vehicle ownership rate of 100.6 motor vehicles per 1000 persons in 2010, as against average annual vehicles ownership 53.6 motor vehicles per 1000 person as per statistics pertaining to 2001. In Gujarat state Ahmadabad, Rajkot, Baroda is the largest

urban city then more number of accidents occurs in this type cities. There is an increase in number of road accidents from 2103 in the year 1961 to 32034 in year 2009. The rate of road accidents in Gujarat is 72.4 accidents per 10000 vehicles.

Table 1.3 Gujarat Road Accident Statistics, 2015 – 2019

Year	Total No. of Road Accident	No. of Person Killed in Road Accident	No. of Person Injured in Road Accident	Severity Index
2015	30114	7506	32449	24.9
2016	30205	8008	29744	26.5
2017	27949	7817	27650	28.0
2018	25391	7613	24836	30.0
2019	23712	7955	22392	33.5

Need of Study

The problem of road traffic accident is very acute in highway transportation due to complex flow patterns of the vehicular traffic presence of mixed traffic and pedestrians. In India there are over 100000 deaths occur on roads due to road accidents. The death include young and old people, people walking, people driving, people traveling in cars, buses, trucks, three wheelers, two wheelers and four wheelers. It also consider people on bicycles and people not traveling at all but simply passing the time of the day or night by the side of the road.

Given that the population is increasing every day by day and then the number of vehicles are coming on to the roads is increasing rapidly the future looks very black unless

something is done. Road accidents cannot be totally restricted but through scientific analysis and proper engineering measures their frequency and severity can be decreased. Therefore, traffic engineer has to identify systematic road accident studies to investigate the causes of accidents and to take preventive measures in terms of proper design and control. It is needed to analyze every individual accident and to keep zone wise road accident records. The statistical analysis of road traffic accidents carried out periodically at critical locations for the region or road stretches or zones will help to arrive at suitable improvements to decrease the accident rate effectively.

Objective of Study

- To perform a primary and micro level analysis of road accident.
- To develop road accident prediction model for road accidents by using statistical Analysis

Scope of Work

In this study road accident scenario of urban area is discussed. To limit the scope of this research, Bhavnagar city of Gujarat state is taken as study region. The data will be collected from police stations. The model will be developed from the data obtained using regression analysis and validated using statistics tests.

Important Theory

Definitions Related to Accident Study Road Accident:-An accident (collision, overturning or slipping) which occurred or originated on a road open to public traffic resulting in either injury or loss of life, or damage of property; in which at least one moving vehicle was involved.

The definitions of some of the terms used in accident study as given by **IRC 53- 1982** are given below.

Person Killed: -Any person who was killed outright on the spot in the accident or whose death could be directly traced to the injury received in the accident.

Fatal Accident: -An accident in which one or more persons were killed.

Grievously Injured Person: -A person who has received grievous injuries (in accident) such as fractures, concussions, internal lesions, crushing, severe cuts and lacerations, sever general shock requiring medical treatment and any other serious lesions requiring detention in hospital.

Grievous Injury Accident: -An accident in which one or more persons was grievously injured.

Minor Injury Accident: - An accident in which one or more persons received only minor injuries or bruises or sprains.

Non-Injury Accident: -An accident in which no one was killed or injured.

Pedestrian: -Any person other than a driver or passenger.

Driver: -Any person who drives a vehicle or rides a pack or saddle animal.

Passenger: -Any person, other than a driver, who is in or on a vehicle.

Motor Vehicle: -Mechanically propelled road vehicle including tractors and cycles fitted with auxiliary engines.

Cycle: -A two-wheeled or three-wheeled road vehicle fitted with pedals and using human energy as its sole means of propulsion.

Motor Cycle: -A motor operated vehicle with two wheels more than 450 mm in diameter without pedal operation.

Motor Car: -A free-wheeled self-propelled vehicle designed for the transportation of persons but limited in seating capacity to not more than 7 passengers.

Motor Car (Taxi): -A motor car constructed, adapted, or used to carry not more than six passengers excluding the driver for hire or reward.

Auto Rickshaw: - A motor operated vehicle with three wheels less than 450 mm in diameter without pedal operation.

Scooter: - A motor operated vehicle with two wheels less than 450 mm in diameter without pedal operations.

Articulated Vehicle: -A unit made up of a road motor vehicle and a semi-trailer.

Third Party: -For the purpose of reporting in this form, this category includes all types of insurance, other than comprehensive insurance.

1.5.2 Types of Accidents

Accident is an unfortunate incident that happens unexpectedly and unintentionally, typically resulting in injury or damage or in other words, it is an event that happens signified by chance or that is without apparent or deliberate cause. There are mainly four types of accidents based on the severity of it.

1. Fatal accident
2. Grievous injuries
3. Minor injuries
4. Property damage only (Non - Injury)

1.5.3 Cause of Accidents

The road users are generally responsible for the causes of accidents. The accident may be the driver of one or more vehicles are involved and pedestrians or passengers are also involved. The study of the various causes of accidents is very important for traffic safety and traffic engineering both.

Various causes of accidents may be listed as given below:

1. The driver
2. The vehicle
3. Pedestrians
4. Passengers
5. Road condition
6. Road design
7. Weather
8. Improper parking
9. Skidding
10. Other causes (animals, incorrect signs or signals)

1.5.4 Purpose of Accident Study

Road accident studies are usually for different purpose. Accident reports and statics of road accidents are importance of several bodies. Complete accident records are essential to identify high accident locations for detailed study and improve road safety. The traffic police are usually collecting the accident data and making original accident reports. They also help to make computation of financial losses in traffic accidents. Accident studies are used for planning of education and enforcement actions. The accident study has number of uses, enumerated below:

1. Engineering uses
2. Enforcement uses.
3. Educational uses.
4. Administrative and policy issues.
5. Uses for motor vehicle Administrator.

1.5.5 Classification of Accidents

The following classifications are usually characterizing the manner of occurrence may be done in following categories:

1. Running of the road
2. Non-collision

- Over-turning on road
- Other non-collision on road

3. Collision on road

- Head on Collision: Collision between vehicles traveling in oppose Site direction
- Rear - End Collision: A vehicle being hit from behind by another vehicle
- Brush / Side swipe: A vehicle being hit by another from the side while traveling in the same direction, or in opposite direction, usually in different lanes,
- Right Angle: Collision between vehicles when one vehicle moving right of the direction of travel,

➢ With pedestrian,
➢ With parked motor vehicle,
➢ With rail road train,
➢ With bicyclist,

- With animal,
- With fixed object

1.5.6 Accident Studies and Records

The various steps involved in traffic accident studies are collection of accident data, accident report and accident records. Accidents studies and the application of the above records for suggesting preventive measures.

(1) Accident data collection: The accident data collection is the first step in the accident study. The data to be collected should comprise all of these parameters:

1. General - Date, time, and person involved in accident, classification of accident like fatal, serious, and minor

2. Location - Description and detail of location of accident

3. Details of vehicle involved - Registration number, description of vehicle, loading detail, vehicular defects

4. Nature of accident - Details of collision, damages, injury and casualty

5. Road and traffic condition - Details of road geometry, surface characteristics, type of traffic, traffic density etc.

6. Primary causes of accident - Details of various possible cases (already mentioned) which are the main causes of accident.

7. Accident cost - Financial losses incurred due to property damage, personal injury and casualty.

(2) Accident Report: It involves basic data collection in form of two methods:

(a) Motorist accident report - It is filed by the involved motorist involved in all accidents fatal or injurious.

(b) Police accident report– It is filed by the attendant police officer for all accidents at which an officer is present. This generally includes fatal accidents or mostly accidents involving serious injury required emergency or hospital treatment or which have incurred heavy property damage.

(3) Accident records: The accident records are maintained giving all particulars of the accidents, location other details. The records may be maintained by means of location files, spot maps, collision diagrams and condition diagrams.

1.6 Summary

This chapter deals with the background of accident studies, global accident scenario, accident scenario of India and Gujarat, need for the study, objectives and scope of the study. Definitions and some well-known theories related to accident study are also explained in brief.

CHAPTER - 2

Literature Review

2.1 General

This chapter presents some basic information of the available literature related to the find black spot identification, accident rates, accident models and accident statistic databases. Review of literature is important in any research work. Many researchers have carried out research work in the area of road accidents till now. In accident analysis general trend is to perform analysis, accident prone stretches identification and prediction model generation.

2.2 Literature Review Study

Many researchers have studied collected past record of accidents in particular stretch of area. Many researchers have analyzed accident data in a different manner. Some of the literature in which analysis of accident data has been carried out is briefly discussed here.

1. **Sandip Chakraborty and Sudip K. Roy, (2005) "Traffic Accident Characteristics of Kolkata"**

Sandip Chakraborty and Sudip K. Roy assessment of the current level of road safety in Kolkata is made utilizing data obtained from secondary sources. The road safety level in Kolkata is assessed considering four parameters, namely, accident severity index, accident fatality rate, accident fatality risk and accident risk. The study is primarily confined to the accident characteristics of passenger vehicles in Kolkata. Models for the projection of future accidents in terms of total accidents and fatality and injury types of accidents have also been developed. These models can be used as tools to measure the effectiveness of future safety improvements implemented in the city.

2. **Ravi Shankar Raja Raman (2009) "Analysis of Road Traffic Accidents on NH45 Kanchipuram District (Tamil Nadu, India)**

Ravi Shankar Raja Raman conducted detail investigations of accidents occurring on the National Highway 45 over a 60 km stretch. The primary objective was to collect and

analyze India-based traffic crash data to begin to create a sound basis for decision making for improving safety on India's roadways. A secondary objective was to establish a standardized methodology for collecting and analyzing crash data, specific to Indian roads. For the 45 day study period, an accident intimation network was established between researchers and all police stations/highway patrols in the study area. On occurrence of an accident, police called a 24-hour contact number and researchers responded to the scene. On site, researchers used standardized reporting forms, methodologies, and equipment to perform accident scene examinations, accident vehicle examination, and AIS injury coding. The collected accident data was categorized first by single- or multiple-vehicle crash and next by accident type based on the first accident event. The data was then analyzed to identify accident (crash type, location time), vehicle (vehicle type, pre-crash condition), occupant (restraint use, gender, age) and other contributing factors, and environmental factors associated with injury severity. Findings show that front-to-rear collisions, mainly involving heavy trucks and buses, caused due to slowing down, stopping, breaking down or overtaking account for 59% of the accidents.[2]

3. **Ajit Goswami and Ripunjoy Sonowal, 2009 "A Statistical Analysis of Road Traffic Accidents in Dibrugarh City, Assam, India"**

   Ajit Goswami and Ripunjoy Sonowal analyzed Complete RTA data of the year 2009 from case dairies and police records of Dibrugarh Police station were studied. SPSS (13.0) and Ky-plot software with bivariate comparisons were used. Data interpretation was done using Degree of freedom, Chi–square test for goodness of fit, χ 2 – test for independence of attributes and Kruskal-Wallis test. Human characteristics (rush and negligence) make 95.38% of the total RTAs. 60% of the accidents were recorded during day time (6 AM to 6 PM). The peak time was between 12 PM to 6 PM (38.46%). The highest numbers of accidents (32.30%) were observed in the heavy rainy season during the months of July – September.[3]

4. **Gopala Raju et. Al., (2012) "Identification of Black Spots and Junction Improvements in Visakhapatnam City"**

   Gopala Raju et. Al. studied causes of accidents are studied and suggested different remedial measures to reduce number of accidents. The present work intended in

identifying various black spots (accident prone location) in Visakhapatnam city. Four locations have been identified as major accident prone areas namely, Gajuwaka junction, Venkojipalem junction, Spencers Junction and Hanumanthawaka junction. Most of the road accidents occur due to heavy vehicles and public utility vehicles like auto rickshaws and taxies. Accidents due to auto rickshaws may not be fatal but number of accidents is more, when compared to other mode of transportation.[4]

5. **R.R.Sorate ET. Al., (2015) "Identification of Accident Black Spots on National Highway 4 (New Katraj Tunnel to Chandani Chowk)**

   R.R.Sorate et. Al. analysed that the 34-km stretch of Mumbai-Bangalore highway in the Pune city limits has seen 110 fatal accidents in the last three years claiming 111 lives. Thus the primary aim of the project is to identify the accident black spots on National Highway-4 spanning 14.5Kms from New Katraj Tunnel to Chandani Chowk and to suggest remedial measures. Methodology adopted includes collecting the secondary data from respective authority, conducting physical survey (primary data) and analyzing them by method of ranking and severity index, accident density method, weighted severity index. Locations appearing in all the three methods were termed as black spots. Further corrective measures were suggested.

6. **Dr. NSSR Murthy and R. Srinivasan (2015) "Development of Model for Road Accidents Based On Intersection Parameters Using Regression Models"**

   Dr. NSSR Murthy and R. Srinivasa Rao carried out a detailed analysis through monthly, annual and hourly data and analyzed. A model was developed based on intersection parameters and no. of accidents by regression analysis. Using curve fitting technique & SPSS software package, curve fitting is done to test relation between road intersection parameters and accident rate by Microsoft excel. For each model, regression coefficients, variances were found. Based on statistical analysis of secondary data of road accidents, relation between accidents and intersection parameters was found .like Accidents /year vs

major road volume, minor road volume, turning traffic volume, pedestrian volume, approach width, turning radius , speed and no of legs. A model was developed between accident rate and intersection parameters using SPSS regression analysis. Scatter plots were drawn between accidents /year as a function of parameters major road volume, minor Volume, turning traffic volume, pedestrian volume, approach width, no. of legs, unpaved shoulder width and turning radius.

Regression correlation was found. From the above trend line approach, variation of accident rate with respect to intersection parameters is estimated and a model was developed.

Model form

Accident rate, Y = 5.0 E -04 MRV -3.86 E -03mrv – 6.91 E -01AW -2.17 E+01NL +

2.38 E+01UP + 1.04 E+0.00TR +6.79 E-01V + 187.235

Relation between accidents/year and various intersection parameters were found and a model was developed from regression analysis. As number of intersections increase, accident rate increases, major traffic, unpaved shoulder, speed and turning radius have positive relation with accident rate. Minor traffic shows negative relation with accident rate. [6]

7. **Rokade S.et. al. (2010) "Development of Accident Prediction Model" [7]**

Rokade S.et. al. developed Accident Prediction Model to take remedial measures in advance by studying future trends, to take mitigation measures to minimize the accident rates to certain extent and to take other safety measures. The dependent variable in an accident prediction model is the number of accidents, while the independent variables may be quantitative variables such as road cross-section dimensions, horizontal curvature, traffic volume, speed and qualitative variables such as type of terrain, road shoulder and median. The model is developed using Multiple Linear Regression Analysis as a modelling technique. The dependent variable used in the model is number of accidents, while independent variables used are road cross-section dimensions, traffic volume, speed, road shoulder width, lighting conditions, traffic signs and traffic signals. The errors are also calculated and the validity of the model is checked by finding the coefficient of determination and comparing the results with the help of graph. The results show that the coefficient of determination lies between 0 and 1 and therefore the model holds good fit.

The accident prediction model developed by them is as given below:

In (APW) 0.5 = 0.0212(AP) + 0.0007 (HTV 0.75 + GAP 1.25) + 0.0210 (85th PS)

Where,

APW = accident point weightage

AP = number of access points per kilometer

HTV = hourly traffic volume

Gap = amount of time, between the end of one vehicle and the beginning of the next in second.

85th PS = 85th percentile speed

The model has an R-square of 0.9987, which means that 99.87% of the variation in the number of accident has been explained the regression line. The T- test also indicates that the model is significant and can be used for the prediction of the number of accidents. Decrement of vehicle speed, access point, traffic volume and increment of gap are likely to have an influence effect of reduction on the road traffic accidents.

The research determined that number of accidents for study location (km 19, km 20, km 21, km 22, and km 23) at FT 050 has always increased. Accident data from year

2001 to 2007 have shown that the total is 1074 accident with 30 fatalities, 36 serious injury, 204 slight injury and 804 damage only.

Y=426.339+1707.9X1+922.208X2–524.83X3 +912.176X4+1552X5–1455.07 X6 + 1831.94 X7

CHAPTER - 3

Study Area Profile

3.1 General

The most of the accident is occurred urban area in large cities. The Ahmadabad, Rajkot, Surat, Baroda, Bhavnagar, Bhuj are largest cities in Gujarat state. Bhuj city is taken for case study. Bhuj is a city the Kutch region in the Gujarat state of India. It was founded by Shri.Rao hamirji. Bhuj is a famous destination for observing the historic craftsmanship of the Kutch region, including the textile crafts of bandhani, embroidery, and leatherwork. Artists of nearby villages bring their work artwork for sale in "Bhuj haat", which is situated near jubilee ground. Locals often visit Hamirsar Lake for relaxation in natural surroundings.

3.2 Geographic Location

Bhuj is located at a height of about 110m. It is located in center of the Kutch District. The location of Bhuj is strategic as it is having hills on its eastern side and a huge lake Hamirsar on the other side. The city has derived its name from this hill named "Bhujiyo Dungar" which also houses a fort on its top. This fort, Bhujia Fort, separates Madhapar Town and Bhuj City. Bhuj is located on 23.27 N Latitude and 60.67 E Longitude. Bhuj also houses many small and big lakes. Originally Bhuj City was surrounded by Bhujia Fort that had 5 major gates and a single small gate called Chathi Bari. Due to development and lots of constructions being done in the city, most part of the wall got destroyed. The wall was also destroyed due to 2001 earthquake.

3.3. Transportation Facility

Bhuj is an important city of Kutch District and is a significant place as it is the starting point for your journey of Rann of Kutch. Every year thousands of tourists including domestic and international ones reach Bhuj to visit the natural reserve, Rann of Kutch. During the Desert Festival, the numbers of tourists in Bhuj increase manifold and well management transport facilities in Bhuj ensure these visitors at no point of time have problems in reaching Bhuj and then visiting various places in and around Bhuj. To travel within and around the city, local transport facilities like auto-rickshaw and buses are used.

Fig. 3.1(a) Study Area

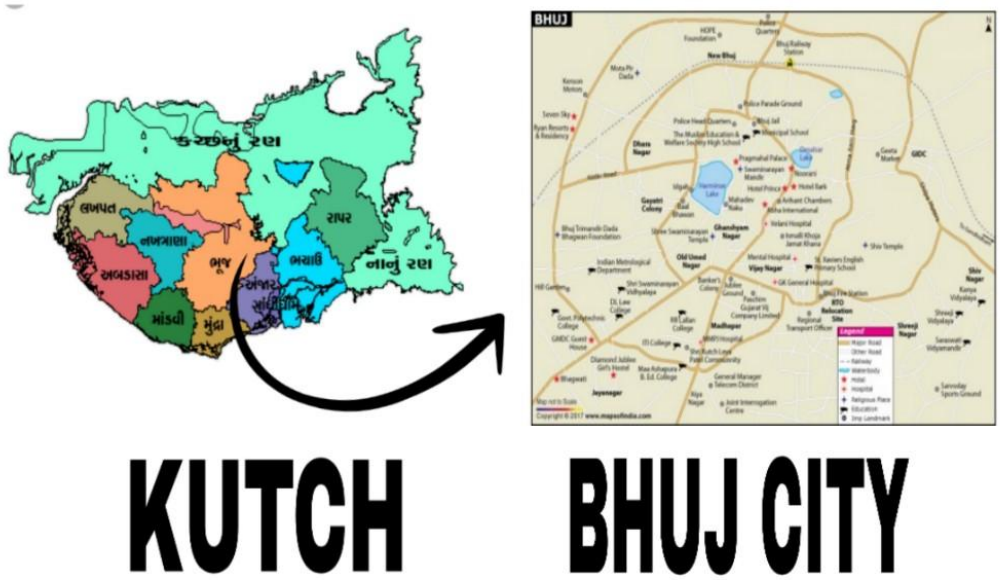

Figure 3.1(b) Study Area

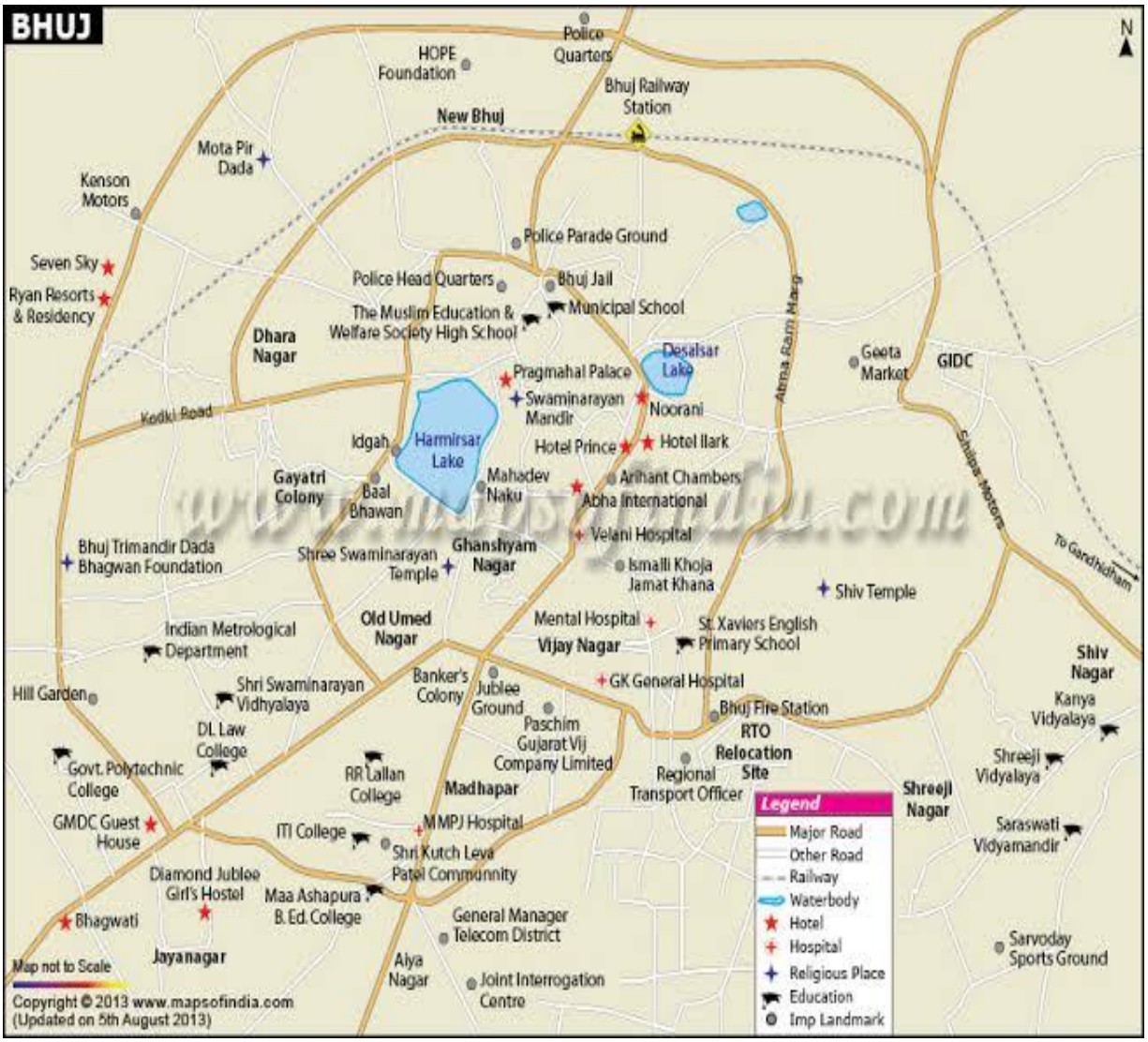

FIG 3.1 C BHUJ CITY MAP

3.4 Origin and Profile of City

The city of Bhuj was founded in 1510 by the local ruler Maharao Hamir. From the mid sixteenth century with the coming up of the Jadeja Rajput rulers Bhuj stood more important as a city than it was. Bhuj was made the capital during the reign of Rao Khengarji I in the year 1549.Bhuj derives its name from the Bhujia fortress, which overlooks the city from a nearby hill.

3.5 Climate

The climate in Bhuj is called a desert climate. During the year, there is virtually no rainfall.The average annual temperature in Bhuj is 26.3 °C. The rainfall here averages 358 mm. Bhuj has a borderline hot desert climate (Koppen *BWh*) just short of a hot semi-arid climate (*BSh*). Although annual rainfall "averages" around 330 millimetres or 13 inches the variability is among the highest in the world with coefficient of variation of around sixty per cent[6] – among the few comparably variable climates in the world being the Line Islands of Kiribati, the Pilbara coast of Western Australia, the sertão of Northeastern Brazil, and the Cape Verde islands.

3.6 Population

population of Bhuj in 2011 is 143,286; of which male and female are 75,914 and 67,372 respectively. Although Bhuj city has population of 143,286; its urban / metropolitan population is 188,236 of which 98,715 are males and 89,521 are females.

3.7 Number of Vehicle

The vehicle growth of Bhuj city is shown in Table and graphically in Fig. Total vehicles in Bhuj city is continuously increasing. It is surprisingly fact that in last two year vehicle growth is decreasing in the city. Almost two wheeler and four wheeler having a greater composition in the share of total vehicle. Following figure represent the vehicular growth of Bhuj city.

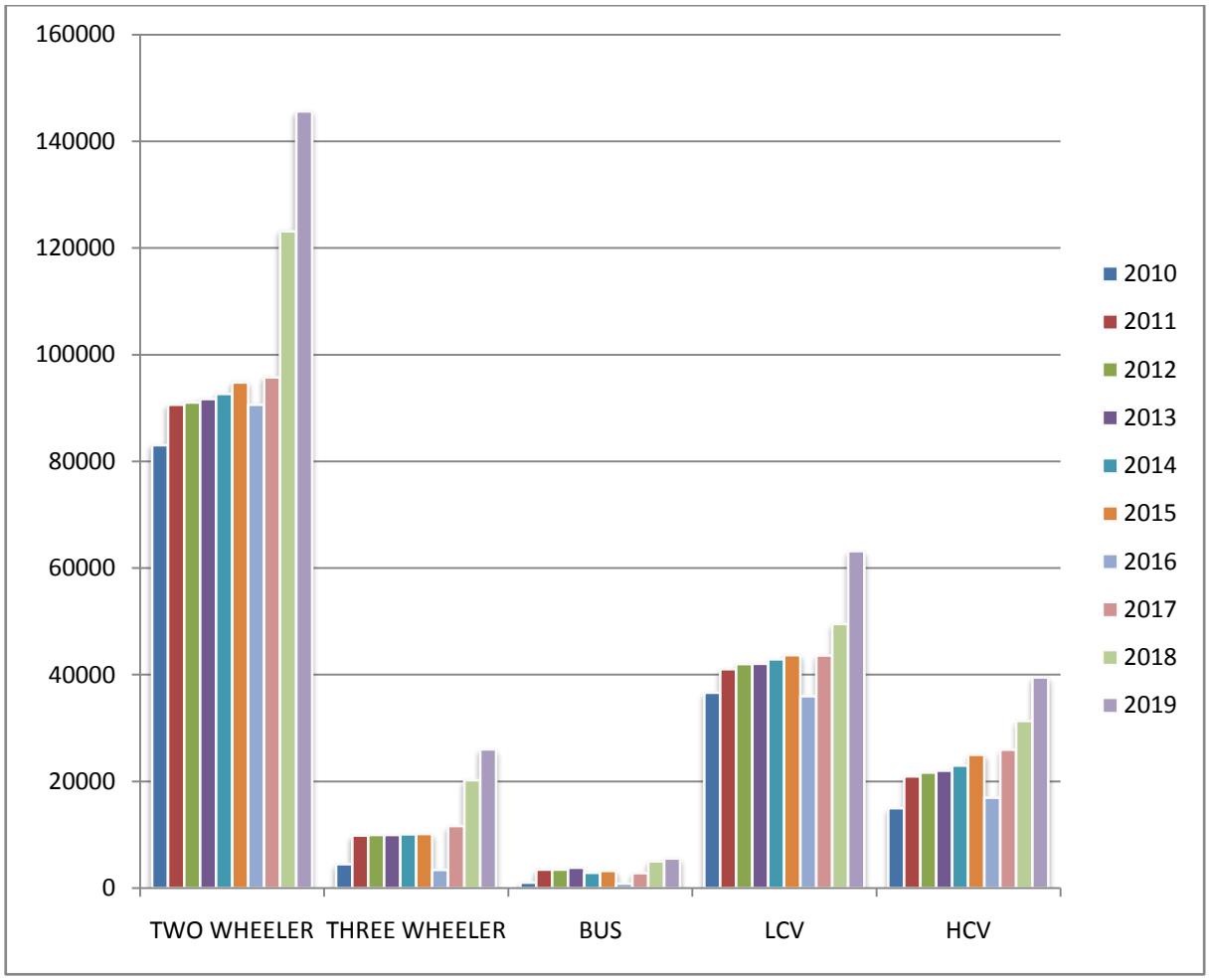

Fig. 3.2Number of vehicle 2010-2019
(Source: Regional Transport Office, Bhuj)

3.8 Summary

In this chapter area profile has been described in detail. Bhuj city is taken as study area and its basic details has been discussed.

CHAPTER - 4

Methodology

General

It is required to generate the methodology to be followed before starting the actual research work. For the accident study, data works as raw material for analyst, planner and decision maker. Without qualitative and detailed data, scientific analysis becomes difficult. For achieving objectives as mentioned in chapter 1, the work is to be done in various stages."

Methodology

To achieve the objectives a methodology is to be done. Main stretches of the study area are identified. Accident data is collected from different all police stations and accident prone stretches on the area. Accident models will be developed considering various factors. For this work study area is to be identified for collecting the required data**.**

Identificationof Data

Accident data is a very complex phenomenon. It is somehow much difficult to analyses as one factor or just one system. So that there is necessary to collect accident data and also need to be collected to analyze the accident phenomenon.

Following data is required to be collected from various organizations.

- Global level
- National level
- State level
- Study area level

Methodology

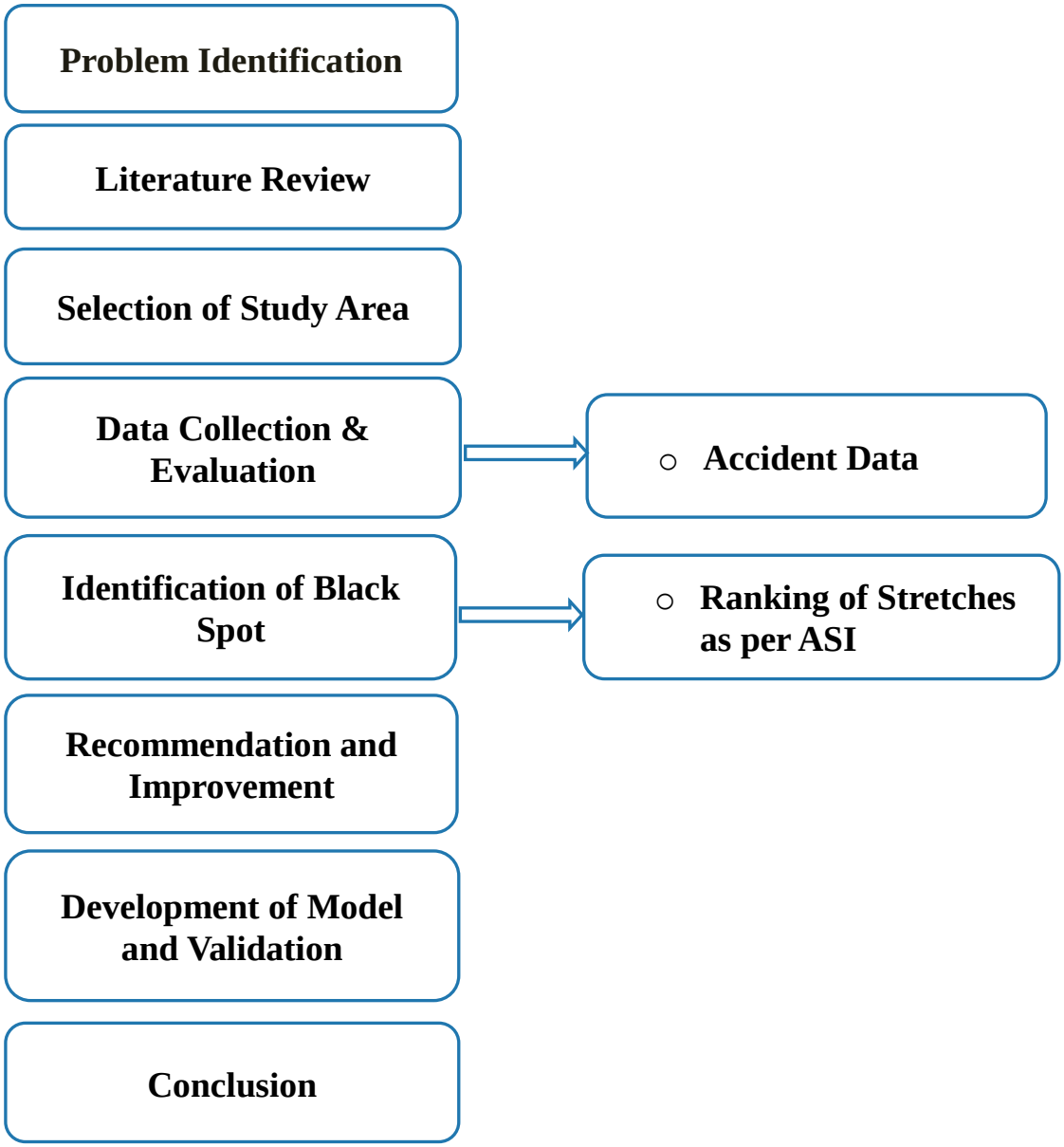

Table 4.1 Flow Chart of proposed Methodology

4.4 Collection of Data

For the present study accident data, vehicle registration data and other data of study area are required, which is a huge and tedious work. Global and national level data are obtained and from various websites, journals and technical published papers. State level data are collected and compiled from website of Gujarat government. Vehicle registration data is collected from Regional Transport Office of study area. The accident data of last ten years will be collected from police stations for the research work.

Analysis and Interpretation of Accident data

The collected data can be analyzed according to the following groups: (according Road safety manual IRC SP 088-2010)

1. Yearly variation of accidents
2. Road user type and fatalities
3. Accidents classified According to vehicle type
4. Accidents classified According to time
5. Accidents classified According to spot

In each group the percentage of accidents can be calculated as fatal, severe and minor.

Methodology for Model Development

In this study it is proposed to develop accident models with 5 % level of significance. These stages are explained as under:

- Data required for this are collected from various police stations, regional transport office and office of Municipal Corporation. Traffic volume data are collected from classified traffic volume count survey.
- Parameters are selected as independent variables (x) and dependent variable (y). Models are developed using Microsoft Excel. Model Properties are also noted.
- Models developed are validated for coefficient of determination (R^2). The coefficient of determination compares estimated and observed y-values, and ranges in value from 0 to 1.

If it is 1, it is a perfect correlation; there is no difference between the estimated y-value and the observed y-value. At the other extreme, if the coefficient of determination is 0, the regression equation is not helpful to predict y-value. The value of R^2 is not closer to one; it presented that there is not good relationship in between independent and dependent variables and therefore parameters selected are required to be changed. The value of R^2 is closer to one Means there is very good and linear relationship between dependent and independent variables.

- The F-statistics or the F-observed value is used to evaluate whether the observed relationship between the dependent and independent variables occurs by chance. F value is obtained from model properties which is given by Microsoft Excel. F-critical (Fcr) value is determined from the standard tables. If F< Fcr, parameters selected are required to be changed. If F > Fcr, the model is required to be validate with observed data and to check if Chi-square test is satisfied or not.
- Chi-square test is carried out by using Microsoft Excel Chi-square analysis tool pack. Chi-square test returns the probability that a value of Chi-square statistic at least as high as the value calculated could have happened by chance under the assumption of independence. If estimated value of Chi-square is less than Chi-square critical value, it can be said that the observed values are significant at 5 % level of significance.

CHAPTER - 5

Accident Data Analysis

5.1 General

Development of road transport in Bhuj city is very fast. There is also increase in vehicle ownership and population in the Bhuj city in last decade. The accident data has been collected from police commissioner office and various police stations of Bhuj city from the year 2010 to 2019 .This data has been extracted and analysed in this unit. Total number of vehicles on road has 16334 in 2010 and 63642 in 2019. The population in the year 2010 was 143286 and 2019 in 299983 has been collected from Bhuj Municipal Corporation. The population from the year 2010 to 2019 is found by interpolation. The population and number of vehicle from the year 2010 to 2019 is shown in the Table 5.1 and graphically in Fig. 5.1.

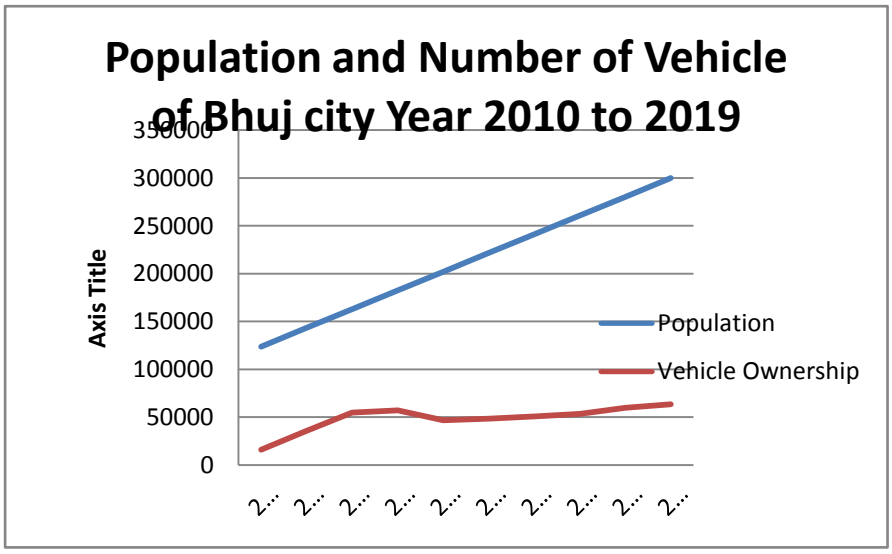

Fig. 5.1 Population and Number of Vehicle of Bhuj City from Year 2010 to 2019

Table 5.1 Population and Number of Vehicle of Bhuj City from the Year 2010 to 2019

(Source: Bhuj Municipal Corporation and Regional Tran-sport Office, Bhuj)

Year	Population	Number of Vehicle
2010	123699	140236
2011	143286	165989
2012	162873	168597
2013	182460	169586
2014	202047	171514
2015	221634	176895
2016	241221	147896
2017	260808	179856
2018	280395	225986
2019	299983	279898

5.2 Preliminary Analysis

Road accident statistics of Bhuj city from the year 2010 to 2019 is shown in Table 5.2 and graphically in Fig.5.2 to 5.4. Accidents are classified in fatal accidents, grievous injury accidents, minor injury accidents and non-injury accidents. In the year 2010 the total number of accidents was registered 683 and in the year 2019 the total number of accidents was 652. During these nine years the population and vehicle ownership have raised but the number of fatal accidents has remained approximately constant in the Bhuj city, but Number of Total accidents is decrease in city.

Table 5.2 Accidents Classified According to the Year from2010 to 2019
(Source: Police Commissioner Office, Bhuj City.)

Year	Type of accident				Total Accident	No. of person	
	Fatal (F)	Grievous Injury (GI)	Minor Injury (MI)	Non-Injury (NI)		Killed	Injured
2010	127	264	211	81	683	243	487
2011	140	283	152	164	739	178	452
2012	129	264	132	110	635	153	446
2013	148	236	111	84	579	174	402
2014	160	223	100	89	572	178	393
2015	168	228	94	87	557	191	444
2016	109	171	43	67	390	125	325
2017	140	141	40	115	436	155	310
2018	170	169	34	158	531	198	388
2019	124	140	33	355	652	143	293
Total	1415	2290	950	1310	5774	1738	3940

5.2.1 Accident Rate and Fatality Rate based on Population

Accidents in urban area are reported per 100000 population per year. This suggest the trend of the accident exposure of entire area. Year wise accident rate and fatality rate based on population of Bhuj city are calculated by the following formula.

AR = TA * 100000 / P

Where AR – Accident Rate per 100000 population

TA – Total Accident

P – Population

FR = FA * 100000 / P

Where FR –Fatality Rate per 100000 population

FA – Fatal Accident

P - Population

Accident rate and fatality rate based on population are represented in Table 5.3. From table it is seen that total number of accidents has decreasing continuously only in last year increases. Number of fatal accidents has been remained approximately constant.

Table 5.3 Accident Rate and Fatality Rate based on Population

Year	Population	Total Accident	Fatal Accident	Accident Rate	Fatality Rate
2010	123699	683	127	552.16	102.66
2011	143286	739	140	515.75	97.71
2012	162873	635	129	389.87	79.20
2013	182460	579	148	317.33	81.11
2014	202047	572	160	283.10	79.20
2015	221634	557	168	251.31	75.80
2016	241221	390	109	161.17	45.19
2017	260808	436	140	167.17	53.68
2018	280395	531	170	189.37	60.63
2019	299983	652	124	217.34	41.33

5.2.2 Accident Rate and Fatality Rate based on Number of Vehicle

Sometimes traffic accidents are expressed per 10000 motor vehicles registered. Year-wise accident rate and fatality rate based on motor vehicles registered are calculated by the following formula.

AR = TA * 10000 / V

Where AR – Accident Rate per 10000 Vehicle Registered

TA – Total Accident

V – Vehicle Registered

FR = FA * 10000 / V

Where AR – Accident Rate per 10000 Vehicle Registered

FA – Fatal Accident

Accident rate and fatality rate based on motor vehicles registered are represented in Table 5.4. From table it is seen that vehicle ownership is increasing at a faster rate but accident rate is decreasing continuously. Number of fatal accidents is approximately constant but fatality rate is decreasing.

Table 5.4 Accident Rate and Fatality Rate based on Number of Vehicle

Year	vehicle register	Total Accident	Fatal Accident	Accident Rate	Fatality Rate
2010	140236	683	127	48.70361	9.056162
2011	165989	739	140	44.52102	8.434294
2012	168597	635	129	37.66378	7.651382
2013	169586	579	148	34.14197	8.727135
2014	171514	572	160	33.35005	9.328685
2015	176895	557	168	31.48761	9.497159
2016	147896	390	109	26.36988	7.370044
2017	179856	436	140	24.24162	7.784005
2018	225986	531	170	23.49703	7.52259
2019	279898	652	124	23.29420	4.43018

5.3 Detailed (Micro Level) Analysis

Accident data can be analysis considering monthly distribution and hourly distribution of accidents. Accidents classified according to weather conditions, type of vehicle involved, age of vehicle, nature of accident, details of driver (age/sex of driver) may be taken into account for detailed analysis of accident data. Further it may also be analyzed according to classification of road, condition of road and geometric features of road. This Micro level analysis of accident data are described in the following sections.

5.3.1 Monthly Spectrum of Accidents

Month-wise details of accidents are collected and compiled in Table 5.5 to 5.16. It shows monthly spectrum of accidents for the 2010 to 2019. Fig.5.5 gives graphical representation of this. This shows that maximum number of total accidents is reported in the month of January followed by March, May and October. It is also seen that variation is not so considerable. Minimum number of total accidents and fatal accidents are observed in the monsoon months of July and August respectively. This is due to fewer trips of vehicles as well as cautious nature of driver in monsoon season. Maximum number of fatal accidents occurred in the month of March and December. Moreover in these months due to foggy weather the visibility becomes poor.

Table 5.5 Monthly Spectrum of Accidents for the Year 2010

(Source: Police Commissioner Office, Bhuj City.)

Month	Number of accidents					Number of persons	
	F	GI	MI	NI	TA	Killed	Injured
January	10	26	14	7	57	15	19
February	10	20	14	4	48	11	34
March	11	20	20	8	59	13	24
April	11	23	20	5	59	16	27
May	15	33	9	7	64	16	66
June	7	22	25	7	61	11	38
July	13	23	23	10	69	14	58
August	8	17	18	10	53	8	20
September	11	16	15	7	60	14	53
October	9	29	17	5	60	9	62
November	13	13	13	8	47	16	32
December	9	22	23	3	57	9	30
Total	127	264	211	81	683	143	487

Table 5.6 Monthly Spectrum of Accidents for the Year 2011

(Source: Police Commissioner Office, Bhuj City.)

Month	Number of accidents					Number of persons	
	F	GI	MI	NI	TA	Killed	Injured
January	9	22	10	12	53	11	19
February	16	23	15	9	63	21	36
March	11	26	11	7	55	27	47
April	11	21	14	16	62	12	25
May	12	17	13	19	61	12	46
June	17	30	17	26	90	25	40
July	7	25	12	17	61	7	30
August	12	18	17	14	61	13	24
September	9	29	9	10	57	10	55
October	12	30	12	10	64	13	47
November	8	19	12	10	49	10	29
December	16	23	10	14	63	17	39
Total	140	283	152	164	739	178	452

Table 5.7 Monthly Spectrum of Accidents for the Year 2012

(Source: Police Commissioner Office, Bhuj City.)

Month	Number of accidents					Number of persons	
	F	GI	MI	NI	TA	Killed	Injured
January	11	19	10	15	55	14	34
February	13	26	11	7	57	16	35
March	9	27	16	11	63	10	68
April	7	24	10	8	49	7	37
May	19	27	7	13	66	31	49
June	10	15	11	7	43	11	26
July	6	22	12	13	53	7	33
August	7	18	10	8	43	7	23
September	11	15	11	4	41	12	20
October	16	27	13	10	66	17	47
November	7	18	11	9	45	7	29
December	13	26	10	5	54	14	42
Total	129	264	132	110	635	153	446

Table 5.8 Monthly Spectrum of Accidents for the Year 2013

(Source: Police Commissioner Office, Bhuj City.)

Month	Number of accidents					Number of persons	
	F	GI	MI	NI	TA	Killed	Injured
January	9	22	12	8	51	12	39
February	5	14	10	5	34	5	31
March	15	18	13	5	51	17	28
April	9	30	8	14	61	11	56
May	13	19	12	6	50	20	37
June	15	26	8	5	54	19	49
July	11	14	10	4	39	13	19
August	16	18	8	8	50	17	28
September	12	14	4	7	37	16	18
October	13	23	9	12	57	13	32
November	19	19	10	6	54	19	26
December	11	19	7	4	41	12	39
Total	148	236	111	84	579	174	402

Table 5.8 Monthly Spectrum of Accidents for the Year 2013

(Source: Police Commissioner Office, Bhuj City.)

Month	Number of accidents					Number of persons	
	F	GI	MI	NI	TA	Killed	Injured
January	13	21	13	7	54	13	32
February	13	24	9	3	49	17	39
March	16	9	16	9	50	17	12
April	10	21	6	5	42	11	50
May	15	19	13	13	60	17	32
June	9	12	8	7	36	13	16
July	14	25	1	8	48	15	43
August	8	17	8	6	39	8	31
September	17	26	12	6	61	18	48
October	22	20	5	5	52	26	30
November	10	12	5	8	35	10	16
December	13	17	4	12	46	13	44
Total	160	223	100	89	572	178	393

Table 5.10 Monthly Spectrum of Accidents for the Year 2015

(Source: Police Commissioner Office, Bhuj City.)

Month	Number of accidents					Number of persons	
	FI	GI	MI	NI	TA	Killed	Injured
January	6	17	7	9	39	6	22
February	9	16	6	7	38	9	24
March	13	23	6	7	49	15	52
April	22	19	5	8	54	22	32
May	13	25	7	6	51	13	47
June	15	15	4	5	36	16	33
July	8	17	6	6	37	9	33
August	12	18	6	10	46	12	24
September	15	23	7	3	48	17	43
October	21	23	6	5	55	27	46
November	12	15	8	3	38	15	52
December	22	17	6	18	63	30	36
Total	168	228	74	87	557	191	444

Table 5.11 Monthly Spectrum of Accidents for the Year 2016

(Source: Police Commissioner Office, Bhuj City.)

Month	Number of accidents					Number of persons	
	F	GI	MI	NI	TA	Killed	Injured
January	14	21	6	2	43	15	50
February	14	24	1	7	46	14	43
March	9	16	5	11	41	10	32
April	12	26	6	11	55	18	48
May	16	20	5	9	50	17	46
June	9	17	7	6	39	10	23
July	14	18	3	8	43	20	35
August	9	13	6	8	36	9	20
September	12	16	4	5	37	12	28
October	1	11	4	8	24	1	16
November	2	15	4	5	26	2	20
December	1	12	3	1	17	1	13
Total	109	171	43	67	390	125	325

Table 5.12 Monthly Spectrum of Accidents for the Year 2017

(Source: Police Commissioner Office, Bhuj City

Month	Number of accidents					Number of persons	
	F	GI	MI	NI	TA	Killed	Injured
January	14	12	3	7	36	16	24
February	14	14	3	6	37	15	54
March	11	13	6	8	38	13	19
April	8	7	4	4	23	8	19
May	11	20	2	5	38	11	37
June	12	9	3	12	36	13	22
July	11	11	3	18	43	13	17
August	4	13	4	14	35	5	27
September	16	13	3	12	44	17	31
October	11	9	5	11	36	13	18
November	12	7	1	9	29	15	13
December	16	13	3	9	41	16	29
Total	140	141	40	115	436	155	310

Table 5.13 Monthly Spectrum of Accidents for the Year 2018

(Source: Police Commissioner Office, Bhuj City.)

Month	Number of accidents					Number of persons	
	F	GI	MI	NI	TA	Killed	Injured
January	14	17	5	11	47	25	41
February	10	11	1	11	33	11	35
March	16	13	4	15	48	16	28
April	15	14	5	14	48	15	39
May	19	14	0	10	43	24	32
June	12	13	3	15	43	12	24
July	16	11	4	13	44	16	26
August	11	17	0	17	45	17	38
September	16	12	5	9	46	17	39
October	16	16	5	9	46	17	34
November	11	14	1	15	41	12	26
December	14	17	1	16	48	16	26
Total	170	169	34	158	531	198	388

Table 5.14 Monthly Spectrum of Accidents for the Year 2019

(Source: Police Commissioner Office, Bhuj City

Month	Number of accidents					Number of persons	
	F	GI	MI	NI	TA	Killed	Injured
January	11	12	1	13	37	11	21
February	10	10	2	14	36	11	24
March	13	12	4	31	60	14	23
April	8	12	3	35	58	12	24
May	11	9	5	30	55	12	35
June	9	12	5	34	60	9	18
July	8	13	2	38	61	9	18
August	9	16	3	22	50	11	37
September	11	4	1	24	40	12	9
October	15	9	1	33	58	19	19
November	7	11	5	34	57	9	15
December	12	20	1	47	80	14	50
Total	124	140	33	355	652	143	293

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Table 5.15 Monthly Spectrum of Accidents for the Year 2010 to 2019

(Source: Police Commissioner Office, Bhuj City.)

Month	Number of accidents					Number of persons	
	F	GI	MI	NI	TA	Killed	Injured
January	111	189	81	91	472	134	331
February	114	182	72	73	441	129	361
March	124	173	101	108	506	152	333
April	113	197	81	120	511	128	360
May	144	203	73	118	538	173	427
June	115	171	91	124	501	139	289
July	108	179	76	135	498	107	315
August	96	165	80	117	458	107	272
September	130	168	71	78	447	145	344
October	135	186	73	100	494	154	335
November	99	128	66	102	395	113	238
December	126	174	65	128	493	141	335
Total	1415	2115	930	1294	5754	1622	3940

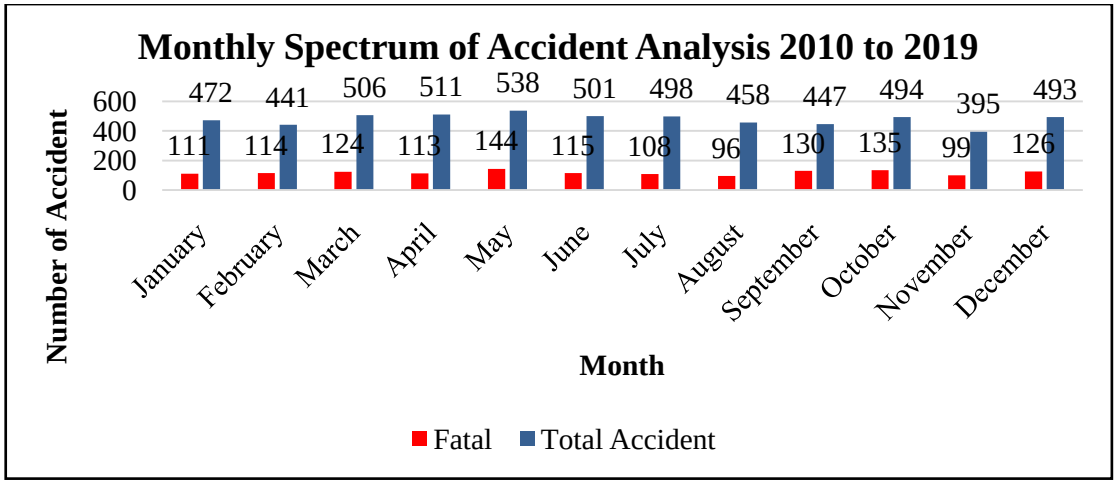

Figure 5.2 Monthly Spectrum of Accident Analysis

5.3.2 Hourly Spectrum of Accidents

When the time of accident is considered, most of the accidents are taking place during day time. Hour-wise analysis of accidents and the influence of traffic volume on accidents are important for the time series analysis of accidents. Table 5.17 shows hourly accident occurrence details for all the eleven years. Total number of accidents is highest during 11 to 12 hours and 17 to 18 hours. During peak hours traffic volume will be high and its effects on the chances of accidents. The evening hours are more prone to fatal accidents especially from 17 to 18 hours. The reasons may be attributed to poor visibility, absence of recto-reflective traffic signs/messages, traffic delineators, blinkers, road markings etc. on roads. Fig. 5.6 shows graphical representation for the same. Hourly trends of accidents show that during day hours, i.e. 7 to 22 hours, number of accidents is high compared to night hours.

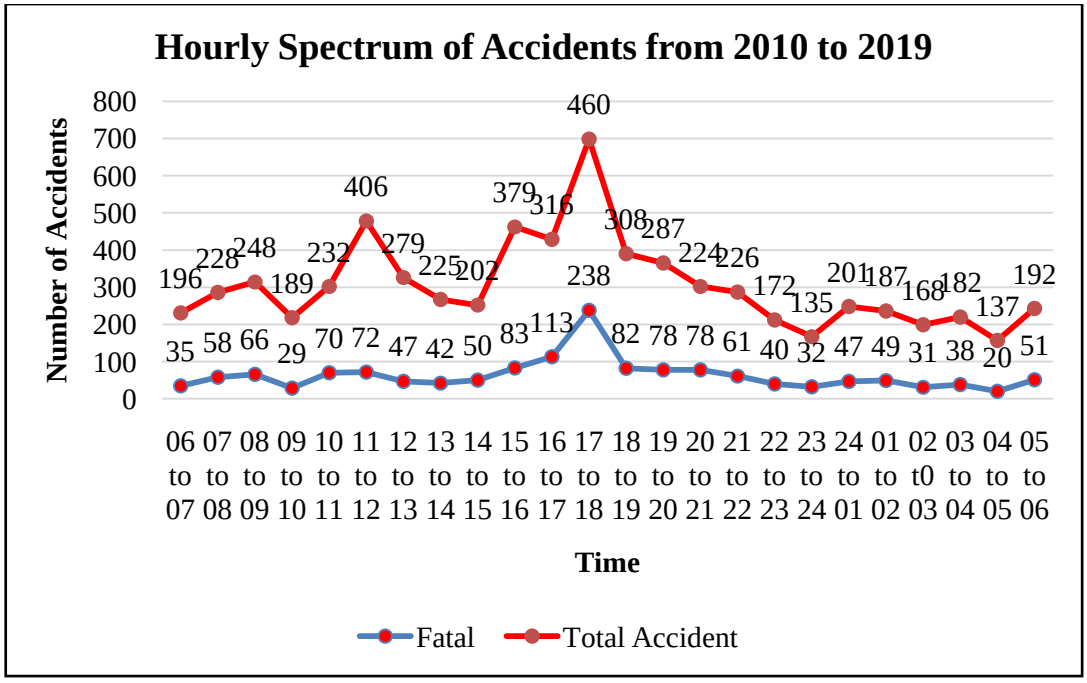

Figure 5.3 Hourly Spectrum of Accident From year 2010 to 2019

Table 5.16 Hourly Spectrum of Accidents for the Year 2010 to 2019

Hourly spectrum of accident 2010 to 2019																						
Hour Duration	**2010**		**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**		**2019**		**Total**	
	F	**TA**	**F**	**TA**	**F**	**TA**	**F**	**TA**	**F**	**TA**	**F**	**TA**	**F**	**TA**	**F**	**TA**	**F**	**TA**	**F**	**TA**	**F**	**TA**
06 to 07	3	22	4	26	3	18	4	22	4	21	5	19	1	15	4	22	5	13	2	18	35	196
07 to 08	5	25	6	30	5	20	7	26	6	26	8	23	3	18	6	20	8	20	4	20	58	228
08 to 09	6	30	6	32	6	31	6	22	7	20	9	21	6	20	6	23	9	15	5	34	66	248
09 to 10	2	20	2	25	2	26	3	19	4	18	5	20	2	10	2	13	5	12	2	26	29	189
10 to 11	5	26	6	32	5	20	8	26	9	25	10	18	5	19	6	21	11	26	5	24	70	232
11 to 12	7	42	6	47	8	40	6	42	8	40	8	36	7	40	6	43	9	32	7	44	72	406
12 to 13	5	30	5	34	5	25	5	27	4	26	5	25	3	29	5	31	5	25	5	27	47	279
13 to 14	4	26	4	30	4	26	4	21	5	22	4	20	5	14	4	18	4	20	4	28	42	225
14 to 15	3	25	4	32	2	25	5	17	6	18	7	19	3	10	4	11	7	18	3	27	50	202
15 to 16	8	44	7	34	10	42	9	41	10	40	9	35	6	29	7	35	9	35	8	44	83	379
16 to 17	6	35	5	39	6	32	6	30	7	29	6	27	6	29	5	36	6	27	6	32	113	316
17 to 18	15	56	21	61	14	52	22	40	26	41	28	43	8	35	21	37	28	43	15	52	238	460
18 to 19	6	32	9	35	7	29	10	31	11	33	10	31	4	27	9	30	10	31	6	29	82	308
19 to 20	7	35	8	38	6	30	7	29	8	27	9	28	9	20	8	22	9	28	7	30	78	287
20 to 21	7	29	9	36	8	24	8	22	7	21	8	20	7	15	9	13	8	20	7	24	78	224
21 to 22	8	32	6	30	9	33	7	20	6	22	5	21	1	5	6	9	5	21	8	33	61	226
22 to 23	4	20	4	26	3	16	4	18	5	16	4	17	4	15	4	11	4	17	4	16	40	172
23 to 24	3	17	3	16	3	15	3	15	3	14	4	15	3	9	3	4	4	15	3	15	32	135
24 to 01	4	26	5	31	3	23	5	21	5	22	6	21	4	5	5	8	6	21	4	23	47	201
01 to 02	4	23	5	27	5	21	6	19	6	20	5	22	4	6	5	6	5	22	4	21	49	187
02 t0 03	5	21	3	13	4	20	2	18	2	17	1	18	5	7	3	6	1	18	5	20	31	168
03 to 04	3	25	3	10	4	26	4	20	4	21	5	22	3	4	4	6	5	22	3	26	38	182
04 to 05	2	20	3	26	1	17	2	13	3	14	2	12	0	2	3	4	2	12	2	17	20	137
05 to 06	5	25	6	29	6	24	5	20	4	19	5	21	5	7	5	7	5	18	5	22	51	192
Total	127	683	140	739	129	635	148	579	160	572	168	557	109	390	140	436	170	531	124	652	1415	5774

5.3.3 Location-wise Analysis of Accidents

Location-wise analysis of accidents is shown in Table 5.30 to 5.41 and it is also graphically represented in Fig. 5.10 and 5.11.The accident data classified based to location shows that near religious places, near bus station, residential area, open space and bazaar are accident prone locations, with high accident frequency. This is due to the fact (that the risk goes up at) an uncontrolled junction located at above places. Over speeding by the driverplay an important role in such kind of accidents. Road user behaviour also play an important role in such kind of accidents. Minimum number of fatal accidents Near factory/industrial area This may be due to emotional and psychological effect on driver's mind.

Table 5.17 Accidents Details According to Location Year 2010

(Source: Police Commissioner Office, Bhuj City.)

Sr. No.	Location	Number of Accident				TA	Number of Person	
		F	GI	MI	NI		Killed	Injured
1	Near school/college	8	20	15	4	47	9	34
2	Near recreation place/cinema	9	20	16	6	51	11	30
3	Near religious place	7	23	13	7	50	8	38
4	Near factory/industrial area	6	13	10	3	32	7	33
5	At Junction	11	23	20	7	61	13	34
6	At pedestrian crossing	7	15	15	6	43	8	27
7	Near Hospital	10	17	16	5	48	11	40
8	Near bus stop	15	27	13	3	58	16	42
9	Near petrol pump	8	15	19	7	49	9	25
10	Near office complex	9	17	10	6	42	10	29
11	In bazaar	10	24	22	5	61	11	28
12	Residential area	8	15	9	8	40	9	42
13	Open space	7	15	17	8	47	8	40
14	Others	12	20	16	6	54	13	45
	Total	127	264	211	81	683	143	487

Table 5.18 Accidents Details According to Location Year 2011

(Source: Police Commissioner Office, Bhuj City.

Sr. No.	Location	Number of Accident				TA	Number of Person	
		F	GI	MI	NI		Killed	Injured
1	Near school/college	7	23	13	6	49	11	32
2	Near recreation place/cinema	11	22	11	6	50	13	28
3	Near religious place	8	26	16	9	59	10	36
4	Near factory/industrial area	7	14	10	7	38	9	31
5	At circle	12	24	32	8	76	15	32
6	At pedestrian crossing	8	16	5	8	37	10	25
7	Near Hospital	11	18	10	19	58	13	38
8	Near bus stop	16	28	11	26	81	19	39
9	Near petrol pump	9	16	9	17	51	12	22
10	Near office complex	10	18	4	14	46	13	26
11	In bazaar	11	25	8	10	54	14	25
12	Residential area	9	16	10	10	45	12	39
13	Open space	8	16	7	10	51	11	37
14	Others	13	21	6	14	54	16	42
	Total	140	283	152	164	739	178	452

Table 5.19 Accidents Details According to Location Year 2012

(Source: Police Commissioner Office, Bhuj City.)

Sr. No.	Location	Number of Accident				TA	Number of Person	
		F	GI	MI	NI		Killed	Injured
1	Near school/college	8	20	10	12	50	10	32
2	Near recreation place/cinema	9	20	6	12	47	12	27
3	Near religious place	7	23	5	11	46	9	35
4	Near factory/industrial area	6	13	7	10	36	8	30
5	At circle	11	23	9	13	56	14	31
6	At pedestrian crossing	7	15	10	9	41	9	24
7	Near Hospital	10	17	7	8	42	12	37
8	Near bus stop	15	27	11	9	62	17	39
9	Near petrol pump	8	15	12	3	38	10	22
10	Near office complex	9	17	10	3	39	11	26
11	In bazaar	10	24	11	5	50	11	25
12	Residential area	8	15	13	4	40	9	39
13	Open space	8	15	11	5	39	8	37
14	Others	13	20	10	6	49	13	42
	Total	129	264	132	110	635	153	446

Table 5.21 Accidents Details According to Location Year 2013

(Source: Police Commissioner Office, Bhuj City.)

Sr. No.	Location	Number of Accident				TA	Number of Person	
		F	GI	MI	NI		Killed	Injured
1	Near school/college	8	18	9	10	45	11	28
2	Near recreation place/cinema	12	18	10	8	48	13	24
3	Near religious place	9	21	13	11	54	10	32
4	Near factory/industrial area	8	11	7	7	33	9	27
5	At circle	13	21	18	9	61	15	28
6	At pedestrian crossing	9	13	4	5	31	10	21
7	Near Hospital	12	15	6	2	35	13	34
8	Near bus stop	17	25	9	5	56	19	35
9	Near petrol pump	9	13	5	6	33	12	19
10	Near office complex	10	15	2	5	32	12	23
11	In bazaar	11	22	3	2	38	14	22
12	Residential area	9	13	10	3	35	11	36
13	Open space	8	13	9	4	34	10	34
14	Others	13	18	6	7	44	15	39
	Total	148	236	111	84	579	174	402

Table 5.22 Accidents Details According to Location Year 2014

(Source: Police Commissioner Office, Bhuj City.)

Sr. No.	Location	Number of Accident				TA	Number of Person	
		F	GI	MI	NI		Killed	Injured
1	Near school/college	9	17	9	10	45	11	27
2	Near recreation place/cinema	13	17	10	8	48	13	23
3	Near religious place	10	20	13	11	54	10	31
4	Near factory/industrial area	9	10	6	7	32	9	26
5	At circle	14	20	17	9	60	15	27
6	At pedestrian crossing	10	12	3	5	30	10	20
7	Near Hospital	13	14	5	2	34	13	33
8	Near bus stop	18	24	8	5	55	19	34
9	Near petrol pump	10	12	4	6	32	12	18
10	Near office complex	11	14	1	6	32	13	23
11	In bazaar	12	21	2	3	38	14	22
12	Residential area	10	12	9	4	35	12	36
13	Open space	8	12	8	5	33	11	34
14	Others	13	18	5	8	44	16	39
	Total	160	223	100	89	572	178	393

Table 5.23 Accidents Details According to Location Year 2015

(Source: Police Commissioner Office, Bhuj City.)

Sr. No.	Location	Number of Accident				TA	Number of Person	
		F	GI	MI	NI		Killed	Injured
1	Near school/college	10	18	10	10	48	11	31
2	Near recreation place/cinema	14	18	8	8	48	12	27
3	Near religious place	11	21	11	11	54	14	35
4	Near factory/industrial area	10	11	7	7	35	10	30
5	At circle	15	21	8	9	53	16	31
6	At pedestrian crossing	11	12	4	5	32	11	24
7	Near Hospital	14	14	1	2	31	14	37
8	Near bus stop	19	24	4	5	52	20	38
9	Near petrol pump	10	12	5	6	33	13	22
10	Near office complex	11	14	4	5	34	14	26
11	In bazaar	12	21	1	2	36	15	25
12	Residential area	10	12	2	4	28	13	39
13	Open space	8	12	3	5	28	12	37
14	Others	13	18	6	8	45	16	42
	Total	168	228	74	87	557	191	444

Table 5.24 Accidents Details According to Location Year 2016

(Source: Police Commissioner Office, Bhuj City.)

Sr. No.	Location	Number of Accident				TA	Number of Person	
		F	GI	MI	NI		Killed	Injured
1	Near school/college	9	10	5	4	28	8	22
2	Near recreation place/cinema	10	12	1	3	26	7	18
3	Near religious place	12	9	2	6	29	7	26
4	Near factory/industrial area	6	8	3	5	22	6	22
5	At circle	17	14	6	10	47	11	15
6	At pedestrian crossing	3	10	1	4	18	7	28
7	Near Hospital	5	12	5	8	30	10	29
8	Near bus stop	8	18	6	9	41	15	13
9	Near petrol pump	4	12	3	3	22	8	11
10	Near office complex	1	13	1	2	17	9	18
11	In bazaar	2	14	3	4	23	10	31
12	Residential area	9	12	4	5	30	8	29
13	Open space	8	11	2	2	23	7	30
14	Others	5	16	1	2	24	12	33
	Total	109	171	43	67	390	125	325

Table 5.25 Accidents Details According to Location Year 2017

(Source: Police Commissioner Office, Bhuj City.)

Sr. No.	Location	Number of Accident				TA	Number of Person	
		F	GI	MI	NI		Killed	Injured
1	Near school/college	7	7	4	10	28	8	21
2	Near recreation place/cinema	11	8	0	11	30	12	17
3	Near religious place	8	11	1	13	33	9	25
4	Near factory/industrial area	7	7	3	8	25	8	21
5	At circle	12	8	6	19	45	13	14
6	At pedestrian crossing	8	12	1	5	26	10	27
7	Near Hospital	16	9	5	6	36	13	28
8	Near bus stop	9	16	6	9	40	18	12
9	Near petrol pump	10	10	3	5	28	10	10
10	Near office complex	11	11	1	3	26	11	17
11	In bazaar	9	8	3	3	23	12	30
12	Residential area	8	9	4	10	31	10	28
13	Open space	13	11	2	7	33	8	29
14	Others	11	14	1	6	32	13	31
	Total	140	141	40	115	436	155	310

Table 5.26 Accidents Details According to Location Year 2018

(Source: Police Commissioner Office, Bhuj City.)

Sr. No.	Location	Number of Accident				TA	Number of Person	
		F	GI	MI	NI		Killed	Injured
1	Near school/college	9	12	4	9	34	13	28
2	Near recreation place/cinema	12	9	0	13	34	15	26
3	Near religious place	9	8	1	10	28	12	29
4	Near factory/industrial area	8	9	2	9	28	11	22
5	At circle	14	10	5	14	43	17	47
6	At pedestrian crossing	10	14	0	10	34	12	18
7	Near Hospital	12	12	4	13	41	14	30
8	Near bus stop	18	12	5	18	53	20	41
9	Near petrol pump	12	18	2	10	42	13	22
10	Near office complex	13	14	1	11	39	14	17
11	In bazaar	14	13	3	12	42	14	23
12	Residential area	11	11	4	10	36	16	30
13	Open space	12	12	2	7	33	14	23
14	Others	16	15	1	12	44	13	22
	Total	170	169	34	158	531	198	388

Table 5.27 Accidents Details According to Location Year 2019

(Source: Police Commissioner Office, Bhuj City.)

Sr. No.	Location	Number of Accident				TA	Number of Person	
		F	GI	MI	NI		Killed	Injured
1	Near school/college	8	7	5	24	44	9	24
2	Near recreation place/cinema	7	11	2	20	40	11	23
3	Near religious place	7	8	2	28	45	8	27
4	Near factory/industrial area	6	7	1	23	37	7	15
5	At circle	11	12	8	24	55	13	25
6	At pedestrian crossing	7	8	1	17	33	8	17
7	Near Hospital	10	11	2	30	53	11	19
8	Near bus stop	15	16	1	31	63	16	29
9	Near petrol pump	8	9	2	15	34	9	17
10	Near office complex	9	10	1	20	40	10	19
11	In bazaar	10	11	1	20	42	11	25
12	Residential area	8	9	3	34	54	9	16
13	Open space	7	8	2	32	49	8	16
14	Others	11	13	2	37	63	13	21
	Total	124	140	33	355	652	143	293

Table 5.28 Accidents Details According to Location Year 2010 to 2019

Sr. No.	Location	Number of Accident				TA	Number of Person	
		F	GI	MI	NI		Killed	Injured
1	Near school/college	83	152	84	99	418	101	279
2	Near recreation place/cinema	103	155	64	95	417	119	243
3	Near religious place	88	170	77	117	452	97	314
4	Near factory/industrial area	78	103	56	86	323	84	257
5	At circle	130	176	129	122	557	142	274
6	At pedestrian crossing	80	127	44	74	325	95	231
7	Near Hospital	113	197	61	95	466	124	325
8	Near bus stop	143	207	74	120	544	160	322
9	Near petrol pump	88	132	64	78	362	108	188
10	Near office complex	104	143	35	72	354	117	224
11	In bazaar	101	183	57	69	410	126	256
12	Residential area	90	124	68	99	381	109	334
13	Open space	87	126	63	90	366	97	317
14	Others	120	173	54	105	452	140	356
	Total	1408	2168	930	1321	5827	1619	3920

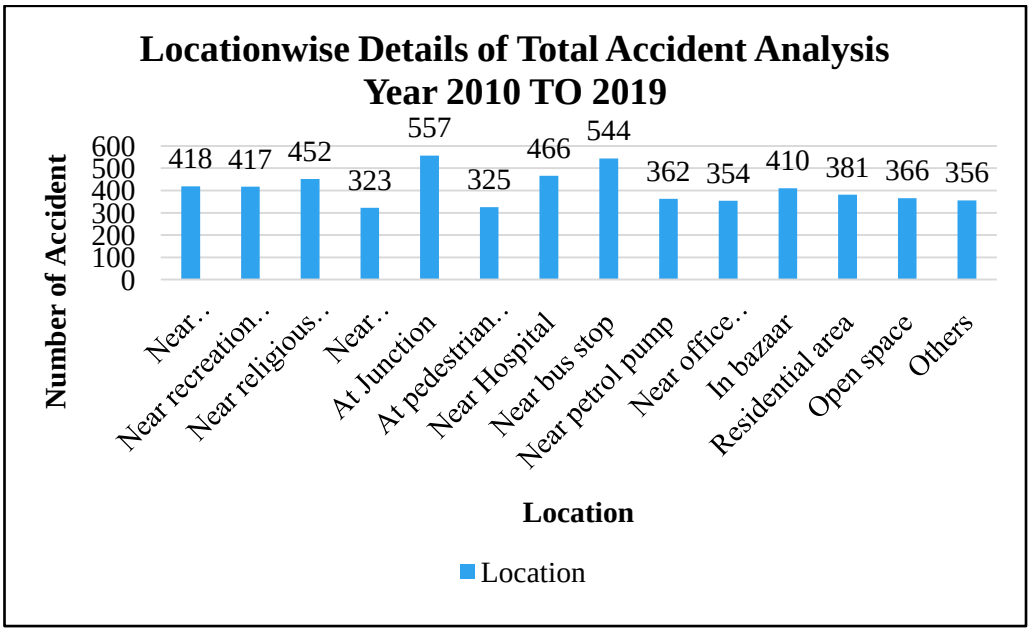

Fig. 5.4 Location wise Total Accident Analysis from Year 2010 to 2019

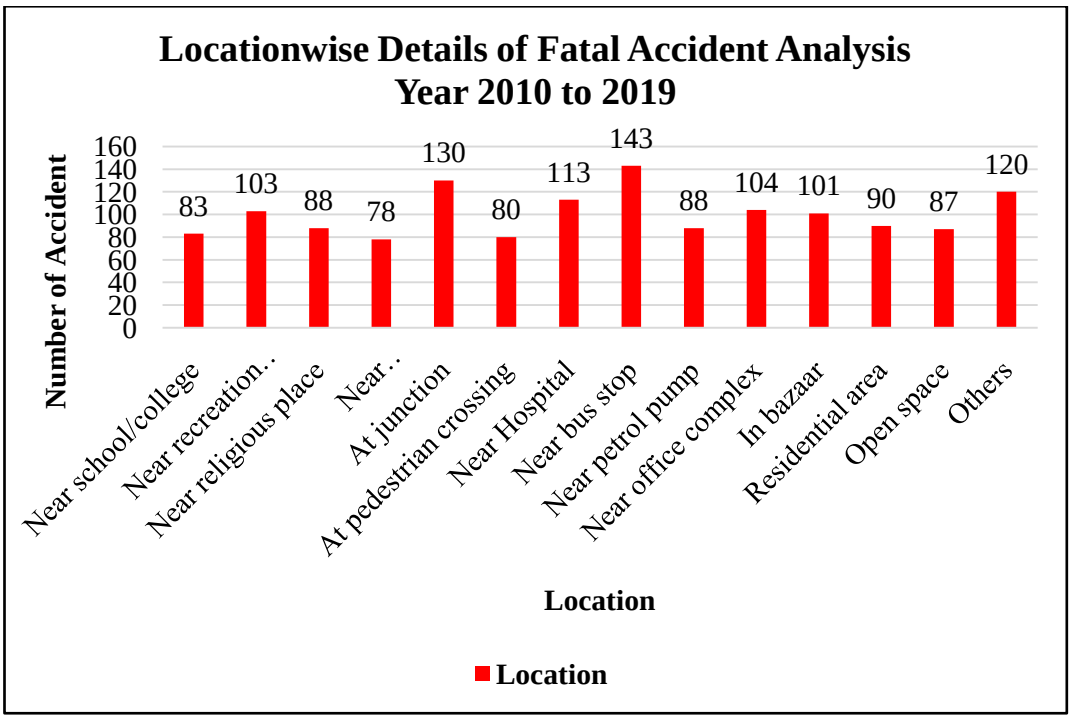

Fig. 5.5 Location wise Fatal Accident Analysis from Year 2010 to 2019

5.3.4 Vehicle-Wise Distribution of Accidents

The nature of traffic coupled with the characteristics of transport system governs the accident pattern. Table 5.54 to 5.65 gives compiled vehicle-wise distribution of accidents from the year 2010 to 2019. Fig.5.6 shows that two wheelers are involved in accidents in about 28% cases. Auto rickshaw followed it with 7% involvement and trucks followed them with 7 % involvement. It is also presented by a pi-chart in Fig. 5.16 and Fig 5.7. Some of the reasons for road accidents by these modes of transport may be attributed to high speed, rash driving, overloading of passengers or goods, drunken-driving and poor maintenance of vehicle. Fig. 5.4 and 5.5 reflects vehicle-wise distribution of accidents.

Table 5.29 Vehicle-wise Distribution of Accidents for the Year 2010

(Source: Regional Transport Office, Bhuj)

Type of Vehicle Primarily Responsible	Number of Accidents				
	F	GI	MI	NI	TA
Motor cycle/scooter	10	20	20	4	54
Moped	13	26	14	8	61
Auto rickshaw	11	20	14	7	52
Motor car	11	23	20	7	61
Truck	8	33	25	5	72
Taxi	9	23	9	7	48
Bus	8	22	23	3	56
Jeep	9	16	18	10	53
Tempo	11	17	17	7	52
LCV	16	13	15	10	54
Tractor	8	19	23	5	55
Others	13	22	13	8	56
Total	127	264	211	81	683

Table 5.31 Vehicle-wise Distribution of Accidents for the Year 2012

(Source: Regional Transport Office, Bhuj)

Type of Vehicle Primarily Responsible	Number of Accidents				
	F	GI	MI	NI	TA
Motor cycle/scooter	16	23	10	14	63
Moped	8	19	12	10	49
Auto rickshaw	12	30	12	10	64
Motor car	9	29	9	10	57
Truck	12	18	17	14	61
Taxi	7	25	12	17	61
Bus	17	30	17	26	90
Jeep	12	17	13	19	61
Tempo	11	21	14	16	62
LCV	11	26	11	7	55
Tractor	16	23	15	9	63
Others	9	22	10	12	53
Total	140	283	152	164	739

Table 5.31 Vehicle-wise Distribution of Accidents for the Year 2012

(Source: Regional Transport Office, Bhuj)

Type of Vehicle Primarily Responsible	Number of Accidents				
	F	GI	MI	NI	TA
Motor cycle/scooter	13	26	10	5	54
Moped	7	18	11	9	45
Auto rickshaw	16	27	13	10	66
Motor car	11	15	11	4	41
Truck	7	18	10	8	43
Taxi	6	22	12	13	53
Bus	10	15	11	7	43
Jeep	19	27	7	13	66
Tempo	7	24	10	8	49
LCV	9	27	16	11	63
Tractor	13	26	11	7	57
Others	11	19	10	15	55
Total	129	264	132	110	635

Table 5.32 Vehicle-wise Distribution of Accidents for the Year 2013

(Source: Regional Transport Office, Bhuj)

Type of Vehicle Primarily Responsible	Number of Accidents				
	F	GI	MI	NI	TA
Motor cycle/scooter	11	19	7	4	41
Moped	19	19	10	6	54
Auto rickshaw	13	23	9	12	57
Motor car	12	14	4	7	37
Truck	16	18	8	8	50
Taxi	11	14	10	4	39
Bus	15	26	8	5	54
Jeep	13	19	12	6	50
Tempo	9	30	8	14	61
LCV	15	18	13	5	51
Tractor	5	14	10	5	34
Others	9	22	12	8	51
Total	148	236	111	84	579

Table 5.33 Vehicle-wise Distribution of Accidents for the Year 2014

(Source: Regional Transport Office, Bhuj)

Type of Vehicle Primarily Responsible	Number of Accidents				
	F	GI	MI	NI	TA
Motor cycle/scooter	13	17	4	12	46
Moped	10	12	5	8	35
Auto rickshaw	22	20	5	5	52
Motor car	17	26	12	6	61
Truck	8	17	8	6	39
Taxi	14	25	1	8	48
Bus	9	12	8	7	36
Jeep	15	19	13	13	60
Tempo	10	21	6	5	42
LCV	16	9	16	9	50
Tractor	13	24	9	3	49
Others	13	21	13	7	54
Total	160	223	100	89	572

Table 5.34 Vehicle-wise Distribution of Accidents for the Year 2015

(Source: Regional Transport Office, Bhuj)

Type of Vehicle Primarily Responsible	Number of Accidents				
	F	GI	MI	NI	TA
Motor cycle/scooter	22	17	6	18	63
Moped	12	15	8	3	38
Auto rickshaw	21	23	6	5	55
Motor car	15	23	6	5	48
Truck	12	18	6	10	46
Taxi	8	17	6	6	37
Bus	15	15	4	5	39
Jeep	13	25	7	6	51
Tempo	22	19	5	8	54
LCV	13	23	6	7	49
Tractor	9	16	6	7	38
Others	6	17	7	9	39
Total	167	228	74	87	557

Table 5.35 Vehicle-wise Distribution of Accidents for the Year 2016

(Source: Regional Transport Office, Bhuj)

Type of Vehicle Primarily Responsible	Number of Accidents				
	F	GI	MI	NI	TA
Motor cycle/scooter	12	16	4	5	37
Moped	9	13	6	8	36
Auto rickshaw	14	18	3	8	43
Motor car	9	17	7	6	39
Truck	16	20	5	9	50
Taxi	12	26	6	11	55
Bus	9	16	5	11	41
Jeep	14	14	1	7	46
Tempo	14	21	6	2	43
LCV	2	1	2	4	9
Tractor	1	2	0	2	5
Others	0	1	2	3	6
Total	109	171	43	67	390

Table 5.36 Vehicle-wise Distribution of Accidents for the Year 2017

(Source: Regional Transport Office, Bhuj)

Type of Vehicle Primarily Responsible	Number of Accidents				
	F	GI	MI	NI	TA
Motor cycle/scooter	16	13	3	9	41
Moped	12	7	1	9	29
Auto rickshaw	11	9	5	11	36
Motor car	16	13	3	12	44
Truck	4	13	4	14	35
Taxi	11	11	3	18	43
Bus	12	9	3	12	36
Jeep	11	20	2	5	38
Tempo	8	7	4	4	23
LCV	11	13	6	8	38
Tractor	14	14	3	6	37
Others	14	12	3	7	36
Total	140	141	40	115	436

Table 5.37 Vehicle-wise Distribution of Accidents for the Year 2018

(Source: Regional Transport Office, Bhuj)

Type of Vehicle Primarily Responsible	Number of Accidents				
	F	GI	MI	NI	TA
Motor cycle/scooter	14	17	1	16	48
Moped	11	14	1	15	41
Auto rickshaw	16	16	5	9	46
Motor car	16	12	5	12	45
Truck	11	17	0	17	45
Taxi	16	11	4	13	44
Bus	12	13	3	15	43
Jeep	19	14	0	10	43
Tempo	15	14	5	14	48
LCV	16	13	4	14	48
Tractor	10	11	1	11	33
Others	14	17	5	11	47
Total	170	169	34	157	531

Table 5.38 Vehicle-wise Distribution of Accidents for the Year 2019

(Source: Regional Transport Office, Bhuj)

Type of Vehicle Primarily Responsible	Number of Accidents				
	F	GI	MI	NI	TA
Motor cycle/scooter	12	20	1	47	80
Moped	7	11	5	34	57
Auto rickshaw	15	9	1	33	58
Motor car	11	4	1	24	40
Truck	9	16	3	22	50
Taxi	8	13	2	38	61
Bus	9	12	5	34	60
Jeep	11	9	5	30	55
Tempo	8	12	3	35	58
LCV	13	12	4	31	60
Tractor	10	10	2	14	36
Others	11	12	1	13	37
Total	124	140	33	355	652

Table 5.39 Vehicle-wise Distribution of Accidents for the Year 2010 to 2019

(Source: Regional Transport Office, Bhuj)

Type of Vehicle Primarily Responsible	Number of Accidents				
	F	GI	MI	NI	TA
Motor cycle/scooter	852	172	62	129	1490
Moped	111	152	67	102	432
Auto rickshaw	137	177	70	102	486
Motor car	130	175	79	90	474
Truck	96	153	87	112	448
Taxi	104	115	56	134	409
Bus	115	171	89	120	495
Jeep	138	180	82	121	521
Tempo	113	191	78	122	504
LCV	129	170	92	114	505
Tractor	112	181	81	74	448
Others	114	185	80	92	471
Total	1426	2022	923	1312	5683

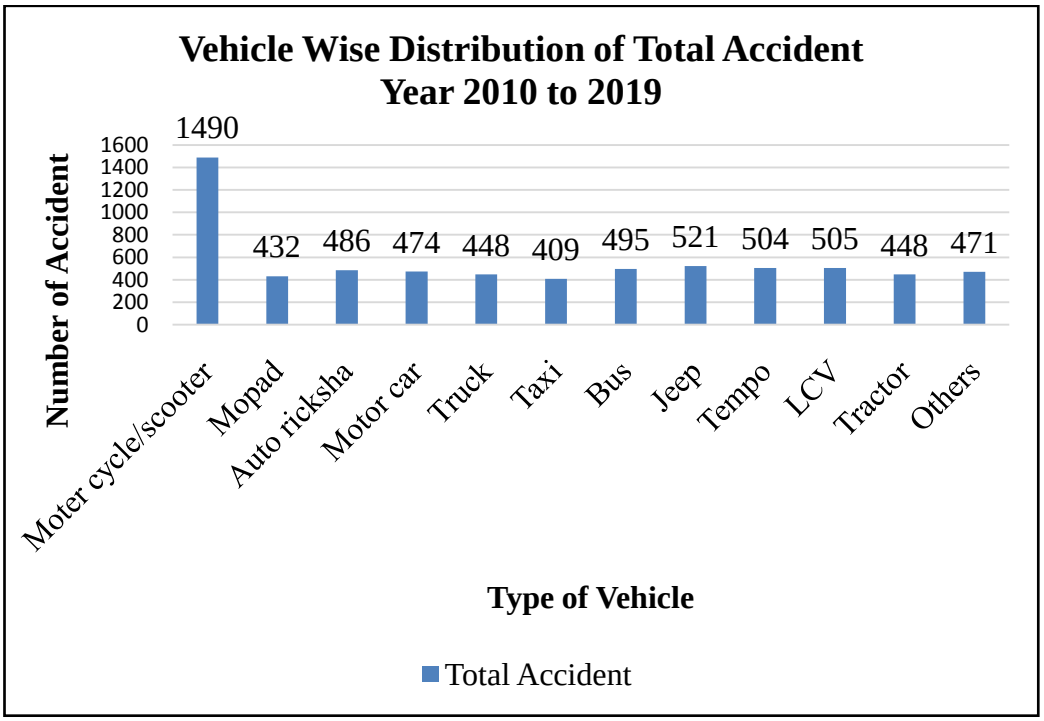

Fig. 5.6 Vehicle-Wise Distribution of Total Accidents from Year 2010 to 2019

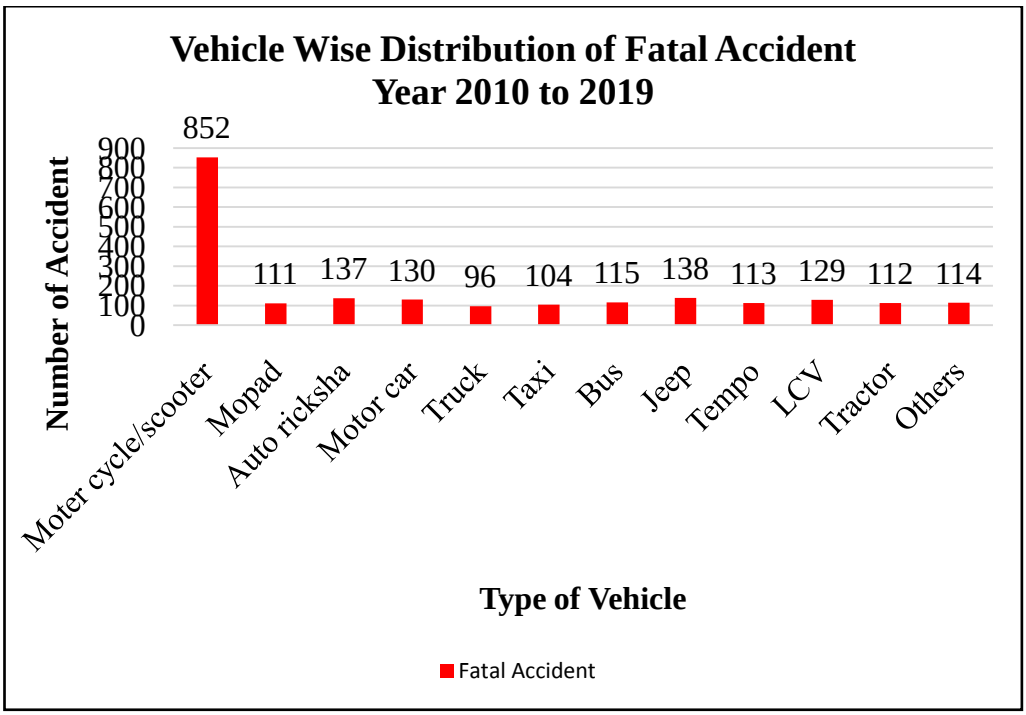

Fig. 5.7 Vehicle-Wise Distribution of Fatal Accidents from Year 2010 to 2019

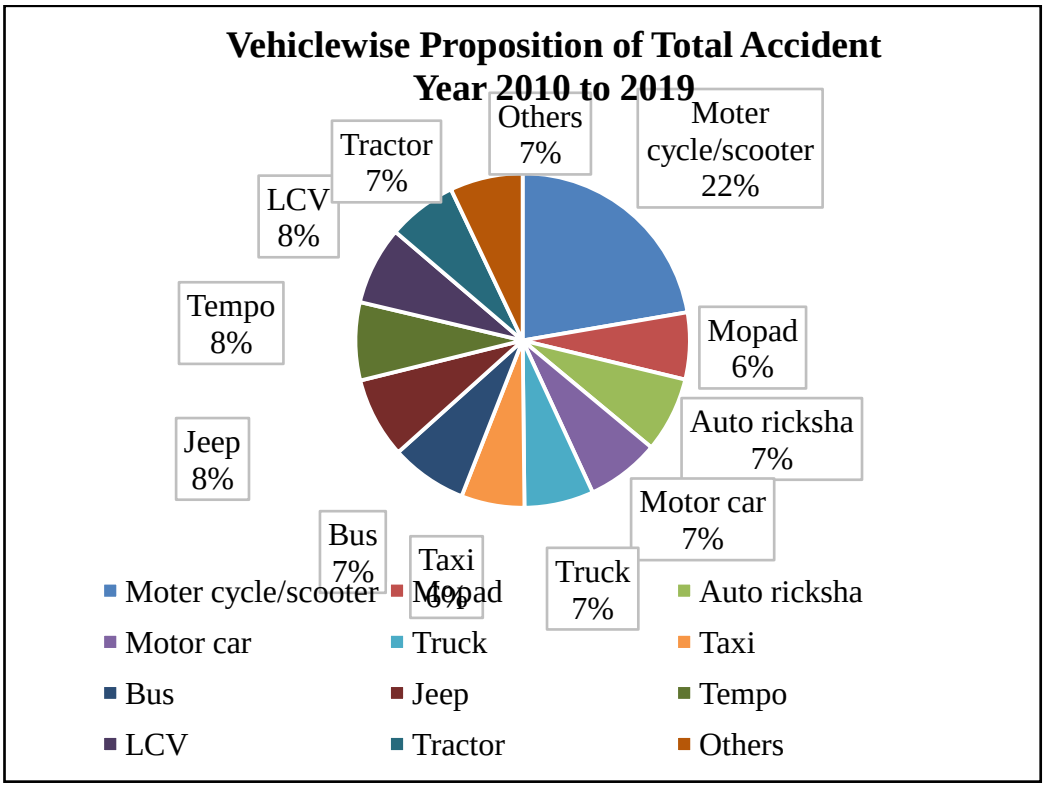

Fig. 5.8 Vehicle-wise Proportion of Total Accidents from the Year 2010 to 2019

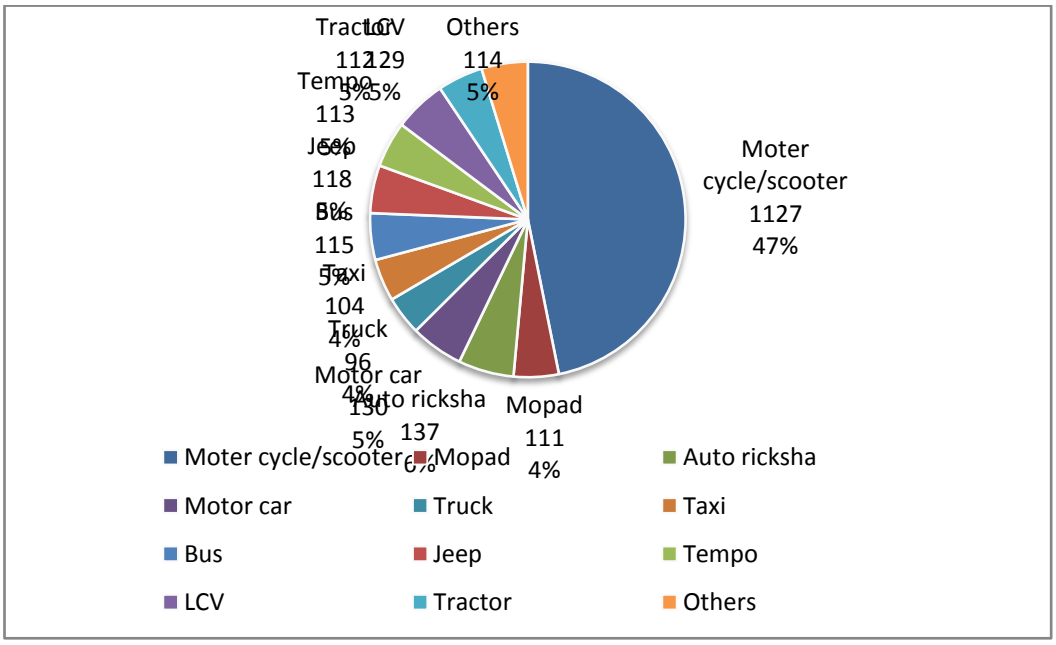

Fig. 5.9 Vehicle-wise Proportion of Fatal Accidents from the Year 2010 to 2019

CHAPTER-6

Accident Prediction Model

6.1 General

Generally, the cause of an accident may not be a single factor only, the combination or set of parameters may lead to an accident. Major effective parameters to accident are population, physical features of road, speed of vehicles, vehicular ownership, traffic volume of the road etc. In this research it is attempted to develop model which adopt parameter like vehicle-population ratio and vehicular growth of city.

6.2 Development of Prediction Model Based on Vehicle Ownership to Population (v/p) Ratio

The linear regression models are developed for prediction of total accidents and fatal accidents, considering number of total accidents or fatal accidents as dependent variable (Y) and vehicle ownership to population (V/P) ratio as independent variable(X). The models developed will take the following form:

$$y=mx+b$$

Where y = number of total accidents or fatal accidents per year

x = vehicle ownership to population ratio (for year 2010 to 2019)

m = Coefficient for Independent variable

b = Constant (Estimated parameter)

Model: 1 (For Total Accidents)

Y = 576.51*X+61.72

Model: 2 (For Fatal Accidents)

Y = 149.52*X+(-8.91)

Table 6.1 Model 1 & 2 Summary

Model	Parameter	Estimate	R^2	DOF	F-Statistic		Comments
					F	fcr	
Model 1 for **Total Accidents**	m	576.51	0.93	9	35.893	3.020	Fairly Accepted
	b	61.72					
Model 2 for **Fatal Accidents**	m	149.52	0.0064	9	1.585021	3.020	Rejected
	b	-8.91					

The fitness of models is proved on the basis of statistical test values i.e. R^2, F-statistics. The models developed on base f parameter estimation and different statistics are shown in Table 6-1 of model summary. It is explained from the table that for model 1 for total accidents, R^2value is near to 0.85 and F > Fcr. For model 1 of total, parameter are found significant and therefore it is statistically good it is proved. For model 2 of fatal accidents, R^2 value is observed to be less which is less than 0.85 standard value for significant. The observed values of accident data 2010 to 2019 and the estimated values of accident data from the accident prediction model are tested for comparability by Chi-square test. The result summary is too given in Table 6-2. It is found that the goodness observed from values are significant at 5 % level of significance. Table no 6-2 represent the validation summary of the model.

Table 6.2 Results and Validation of Linear regression model 1 and model 2 based on v/p ratio

V/P Ratio	Model 1 for Total Accident				Model 2 for Fatal Accident			
	Observed Values	Estimated Values (Y)	Chi-square (estimated)	Chi-square (critical)	Observed Values	Estimated Values (Y)	Chi-square (estimated)	Chi-square (critical)
1.133687419	683	715	13	3.325	127	161	121.61	3.325
1.158445347	739	730			140	164		
1.035143947	635	658			129	146		
0.929442069	579	598			148	130		
0.848881696	572	551			160	118		
0.798546252	557	522			168	110		
0.613114115	390	415			109	83		
0.689610748	436	459			140	94		
0.804928761	531	526			170	111		
0.933046206	652	600			124	131		

6.3 Development of Prediction Model Based on Vehicular Composition

The multiple linear regression models are developed for prediction of total accidents and fatal accidents considering number of total accidents or fatal accidents as dependent variable(Y) and vehicular composition as independent variable (X). Data for vehicular composition for last eleven year 2010 to 2019 from RTO is consider. 2W,3W,Bus,LCV,HCV is consider as a independent variable and the multiple linear regression is carried out.

The Models developed will take the following form:

Y = m1x1+m2x2+m3x3+m4x4+m5x5+m6x6+b

Where y = number of total accidents or fatal accidents per year

X_1 = Volume of Two wheeler

X_2 = Volume of Three wheeler

X_3 = Volume of Four wheeler

X_4 = Volume of LCV

X_5= Volume of HCV

m_1, m_2, m_3, m_4, m_5 are coefficient

b = Estimate Parameter = Constant

Model: 3 (For Total Accidents)

Y=-29.79443*2W+55.15913777*3W+-1.69*4W+ 55.85452449*LCV +-124.4219083*HCV+2150.578318

Model: 4 (For Fatal Accidents)

Y =-6.2097655*2W+-5.57784011*3W+-1.23*4W+ --2.62086518*LCV +2.2523374834*HCV+546.6334252

Table 6.3 Model 3 & 4 Summary

Model	Parameter	Estimate	R^2	DOF	F-Staticstic		Comments
					f	fcr	
Model 3 for **Total Accidents**	m_1	-29.79443794	0.83	9	5.81	3.020	Accepted
	m_2	55.15913777					
	m_3	1.69					
	m_4	55.85452449					
	m_5	-124.4219083					
	b	2150.578318					
Model 4 for **Fatal Accidents**	m1	-6.2097655	0.38	9	0.79	3.020	Rejected
	m2	-5.57784011					
	m3	1.23					
	m4	-2.62086518					
	m5	2.523374834					
	b	546.6334252					

The goodness of models is analyzed on the basis of statistical values i.e. coefficient of determination R^2, t-statistics. Model summary is given in Table 6.2. It is observed from the table that for model 3 and model 4, R2 value is 0.83 and 0.38 respectively, 0.83 is very near to 1. This indicates that there is near to perfect correlation ship between independent and dependent variables for total accidents and fair relationship for fatal accident. For both the models as F <Fcr.For these models parameters are found significant with 95 % confidence level and therefore they are statistically good.

Table 6.4 Results and Validation of Linear regression model 3 based on Vehicle Composition

Year	TWO WHEELARS	THREE WHEELARS	BUS	LCV	HCV	Total Accident	Estimated Total Accident	Chi square Estimated	Chi Square Critical
2010	59.23229	3.208876	0.731624	26.11598	10.71123	683	688.768	31.6761	3.325
2011	54.58073	5.951599	2.088693	24.73598	12.64301	739	661.2106		
2012	54.00986	5.923593	2.291856	24.90495	12.86974	635	657.9015		
2013	54.04868	5.894354	2.256672	24.82398	12.97631	579	637.3506		
2014	54.023	5.885817	1.673333	25.0102	13.40765	572	594.3775		
2015	53.58489	5.742955	1.834987	24.70279	14.13437	557	491.9598		
2016	61.25183	2.32934	0.601098	24.34481	11.47293	390	386.3833		
2017	53.2476	6.482408	1.571813	24.24996	14.44823	436	478.4541		
2018	53.17896	8.954095	2.081987	21.91552	13.86944	531	558.4595		
2019	52.01824	9.310177	2.000014	22.56322	14.10835	652	619.1352		

Table 6.5 Results and Validation of Linear regression model 4 based on Vehicle Composition

Year	TWO WHEELARS	THREE WHEELARS	BUS	LCV	HCV	Fatal Accident	Estimated Fatal Accident	Chi square Estimated	Chi Square Critical
2006	59.23229	3.208876	0.731624	26.11598	10.71123	127	119.4982	15.54428947	3. 325
2007	54.58073	5.951599	2.088693	24.73598	12.64301	140	141.5762		
2008	54.00986	5.923593	2.291856	24.90495	12.86974	129	145.4067		
2009	54.04868	5.894354	2.256672	24.82398	12.97631	148	145.8098		
2010	54.023	5.885817	1.673333	25.0102	13.40765	160	146.6173		
2011	53.58489	5.742955	1.834987	24.70279	14.13437	168	152.7741		
2012	61.25183	2.32934	0.601098	24.34481	11.47293	109	118.4273		
2013	53.2476	6.482408	1.571813	24.24996	14.44823	140	152.7229		
2014	53.17896	8.954095	2.081987	21.91552	13.86944	170	144.0202		
2015	52.01824	9.310177	2.000014	22.56322	14.10835	124	148.1472		

CHAPTER - 7

Result Discussion and Conclusion

7.1 General

It has been found immense growth of both road network and road traffic in Bhuj city. Many problem arises due to rapid growth in Population and Vehicular ownership and because of that now a day's road accidents has become the prime concern for the city.

7.2 Result Discussion

• During these ten years the population and vehicle ownership have raised but the number of total accidents and fatal accidents has remained approximately constant in the Bhuj city.

• Maximum number of total accidents is reported in the month of April, May and June. Minimum number of total accidents and fatal accidents are observed in November respectively

• Majority of accidents are being observed during high peak hours in morning (i.e. 11am to 12pm) and in evening it is in between 6pm to 7 pm. This may because of heavy traffic volume in said hours.

• Accident data based to location resulted that near bus stop , near at hamisar lake are having high accient.This is due to the fact that the accident goes up at an uncontrolled intersection/junction..

• It is seen that two wheelers contribute in total accidents is 28%. Maximum number of fatal accidents is also caused by two wheelers i.e. 51% and it is followed by four wheelers i.e. 16 %, though truck contributes only 4 % of traffic composition.

7.3 Conclusion

It is fact that traffic rules should be enforced to be scientific so that road users use the facility within the boundary of law, rules and regulation. This basic enforcement should be done on base of technical research and past data records.Following points has been concluded

1) Percentage of sharing of two wheelers is near about 75% and the involvement in fatality is nearly 51%. There is require to control the 2W traffic and also Awareness regarding use of public transport should be increased so that the accidents can be reduced.

2) For accident prediction models based on V/P (Number of Vehicle to Population) ratio , Model is Fairly accepted for total accident as R^2 is near to 0.85 for total accidents and it is model rejected for fatal accident, also F > Fcr for total accident and F<Fcr for fatal accident . These models satisfy the Chi-square test of validity. Models are proved to be significant at 5 % level ofsignificance.

3) For Accident prediction model based on vehicular composition R^2 value is near to 1 for total accident and it is failed for fatal accident as it is only 0.28. This indicate that there is good relationship. For these models F <Fcr. And also satisfy the Chi-square test. These parameters are proved significant with 95 % confidence level and statistically good and found to be significant at 5 % level of significance.

7.4 Scope of Future Work

In this study micro level analysis of accident data is carried out for Bhuj city. Identification and prioritization of accident prone stretches are being done. Road accident models are developed on base of three different parameters. In future following type of work can be carried out to improve road safety.

• Development of models can be done based on speed of vehicle and other road features like sign, signals etc.

• Development of models can be done based on Traffic volume.

• Development of model accident severity index can be done, so that the most accident prone stretches can be treat to reduce the accidents.

• Cost effective analysis and safety analysis can be done.

• Model for accident prone stretches can be done so that it can be used for the other study area having same pattern.

• Recommendation and Road Safety Policy can be suggest on base of this micro level analysis.

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