

Statistical Analysis of Traffic Accidents Locations Using Geographic Information System in Darbandikhan Town- Kurdistan Region of Iraq

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Abstract:

Road traffic accidents are a major cause of premature death and disabilities. Every year the lives of almost 1.24 million people are cut short as a result of a road traffic crash. Between 20 to 50 million more people suffer non-fatal injuries, with many incurring a disability as a result of their injury. Road traffic injuries cause considerable economic losses to victims, their families, and to nations as a whole. These losses arise from the cost of treatment (including rehabilitation and incident investigation) as well as reduced/lost productivity (e.g. in wages) for those killed or disabled by their injuries, and for family member who need to take time off work to care for the injured. The aim of the traffic accident analysis is to investigate the cause accidents, to determine hazardous locations and to determine to enhance road features, to evaluate traffic safety after enhancement. This kind of system often includes a database query tool to store and analysis information about accidents mainly to identify high crash locations, in other words hazardous locations along the road [2]. The advancements in using GIS and Remote Sensing techniques can be put to effective use in accident analysis. Although GIS has been used for over thirty years however it has only been recently used in the field of transportation. In addition, to promote linkage between various types of data for easy comprehension. This paper aims to observe and analyzed road accidents hazardous locations recognized according to accidents and traffic data and road information. The main purpose of this paper is to use Statistical GIS techniques, SPSS and high resolution imagery for detecting and determine the most critical accidents points along the external and internal roads of the study area. The study area for this research is Darbandikhan town and their surrounding landscape. Darbandikhan is one of the towns belong to Sulaimani Governance in Kurdistan Region at the northern part of Iraq.

Keywords: traffic accidents, hazardous locations, GIS, SPSS, frequency method, EPDO.

1. INTRODUCTION

Road traffic accidents are a major cause of premature death and disabilities. Every year the lives of almost 1.24 million people are cut short as a result of a road traffic crash. Between 20 to 50 million more people suffer non-fatal injuries, with many incurring a disability as a result of their injury. Road traffic injuries cause considerable economic losses to victims, their families, and to nations as a whole. These losses arise from the cost of treatment (including rehabilitation and incident investigation) as well as reduced/lost productivity (e.g. in wages) for those killed or disabled by their injuries, and for family member who need to take time off work to care for the injured. There are few estimates of the cost of injury, but an estimate carried out in 2000 suggest that the economic cost of road traffic crashes was approximately 518 billion \$. National estimates have illustrated that traffic crashes cost countries between 1-3% of their

gross national product, while the financial impact on individual families has been shown to result in

increased financial borrowing and debt, and even a decline in food consumption [1] thus to make road safer traffic accident analysis system is useful tool for highway agencies. The aim of the traffic accident analysis is to investigate the cause accidents, to determine hazardous locations and to determine to enhance road features, to evaluate traffic safety after enhancement. This kind of system often includes a database query tool to store and analyse information about accidents mainly to identify high crash locations, in other words hazardous locations along the road [2]. Classical database can also perform many queries such as crash statistics for locations during the specified time periods, types of accidents, drivers involving certain type of accidents etc. in addition to these output can be printed out [3].

The advancements in using GIS and GPS techniques can be put to effective use in accident analysis. Although GIS has been used for over thirty years however it has only been recently used in the field of transportation. GIS is a technology for managing, processing and analyzing locational and related information. It visually displays the results of analyses thus enabling sophisticated analysis and quick decision making. Development of a system that uses GIS to analyze traffic accidents has been pursued towards improving the efficiency and effectiveness of traffic accident countermeasure. Also GIS would make analysis less time consuming and less tedious which otherwise would become very labour sensitive. Thus GIS will offer a platform to maintain and update accident record database and use it for further analysis [4].

2. Study Area

The study area for this research is Darbandikhan town and their surrounding landscape. Darbandikhan is one of the towns belong to Sulaimani Governance in Kurdistan Region at the northern part of Iraq. It is mountainous region and it extends between latitude 35°09'09" north and longitude 45°47'42" east.

Darbandikhan town has an urban population of 45000. It is considered as an important region where contains Darbandikhan Dam, which was constructed in 1956 to 1961. The purpose of the dam is irrigation, flood control, hydroelectric power production and recreation. In addition, this town is considered as one of the important regions for tourist attractions, it is near the border with Iran, where witnesses a high traffic exposure because it is near of cross-border trade and it is the only communication link between the cities of Sulaimani and Kalar within Sulemani province .

3. The Methods of Selecting of Hazardous Locations in Road Accidents

It is very important that road accidents hazardous locations recognized according to accidents and traffic data and road information. There are many methods for this reason, but today five significant methods determine to identify accidents hazardous locations.

3.1 Frequency Method

It is the method used for analyzing hazardous locations and ranking them in order through the use of the number of accidents to determine and prioritize accident prone spots which were estimated by counting the reportable accidents occurred in each road segment simultaneous with making a list with descending order so, it means that higher crash frequency signifies the most hazardous location within the segment [5].

3.2 Rate Method

The accident rate method consists of simply dividing the accident frequency at a location by the vehicle exposure to determine the number of accidents per million vehicle-mile of travel at highway segment. Segments are priority ranked in order of descending accident rate [6].

3.3 Frequency- Rate Method (matrix method)

The frequency-rate method is a combination of three methods, the crash frequency, crash density and crash rate method. Locations are considered high-crash areas if they have a higher rate than predetermined crash frequency, crash density or crash rate. The method first finds crash frequency and crash densities on a highway segment and then uses the crash rate to reorder the final list.

The frequency-rate method provides a list of high-crash locations that are then evaluated using other methods. Sites that should be investigated using other methods. Sites that should be investigated further might not be and sites that should not be investigated might be, causing time to be wasted. This method does not take into account crash severity, such as fatalities and/or serious crashes [7].

3.4 Quality Control Method

The quality control methods consider various highway categories to rank high crash locations. The method compares site crash frequencies, densities, or rates against predetermined average values for sites with similar characteristics [7].

3.4.1 Number Quality Control Method

The number quality control method applies statistical analysis to find a particular crash site's frequency/density and compares it with the mean frequency/density for similar sites. The number quality control method is used on sites where crash density is much greater than other sites across the region. The formula to find the critical crash rate at a roadway location is as follows [7]:

$$F_c = F_a + k \sqrt{\frac{F_a}{M} + \frac{1}{2M}} \dots\dots\dots(1)$$

Where

F_c =critical rate for a particular location

F_a =average crash frequency/density for all road location of like characteristics.

k = probability factor determined by the level of statistical significance desired for F_c , and

M =number of vehicles traversing particular road section (millions of vehicle of vehicle-km) or number of vehicles entering particular intersection (millions of vehicles) during the analysis period.

3.4.2 Rate Quality Control Method

The rate quality method is used in the hazardous road locations by means of a statistical test which compares the traffic crashes rates for roadway segments and intersections with similar characteristics to determine if a site may have a higher rate of traffic crashes. The formula to find the critical crash rate at a roadway location is as follows [7]:

$$R_c = R_a + k \sqrt{\frac{R_a}{M} + \frac{1}{2M}} \dots\dots\dots(2)$$

Where

R_c : critical rate for a particular location (crashes per million vehicles or c crash per million vehicle-km)

R_a : average crashes rate for all road location of like characteristics (crashes per million vehicles or c crash per million vehicle-km).

k : probability factor determined to be the level of statistical significance desired for R_c , and

M : number of vehicles traversing particular road section (millions of vehicle-km) or number of vehicles entering particular intersection (million of vehicles) during the analysis period.

3.5. Crash Severity Method

The severity method is based on converting each crash to a "property damage only" (PDO) equivalency. The severity of a crash is determined by the most severe injured in the indicate regardless of the number of injuries.

The equivalent property damage only (EPDO) average crash frequency performance measure assigns weighting factors to crashes by severity (fatal, injury, property damage only) to develop a combined frequency and severity score per site. The weighting factors are often calculated relative to property damage only (PDO crash cost). The crash costs by severity are summarized yielding an EPDO value [8].

$$EPDO = 9.5K + 3.5B + PDO \dots\dots\dots(3)^{[9]}$$

Where

K : No. of fatal crashes

B : No. of injury crashes

PDO : No of property damage crashes.

4. Methodology

In order to determine hazardous locations in the geographical boundaries of Darbandikhan town and their surrounding landscape, accidents reports from 2010-2012 (where this period is long enough to limit random fluctuations in the accidents account and short enough to limit change in road and traffic conditions) collected from the traffic police office in Darbandikhan town. An integration of GIS techniques and statistical modeling using ArcGIS and SPSS software was applied to complete the research requirements. A brief description of the steps of work is shown in the figure (1) below.

Location	Date	Time	Day	Month	Year	Type of accident	Vehicle involved	Number of accidents
1. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
2. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
3. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
4. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
5. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
6. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
7. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
8. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
9. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
10. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
11. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
12. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
13. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
14. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
15. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
16. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
17. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
18. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
19. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
20. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
21. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
22. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
23. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
24. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
25. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
26. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
27. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
28. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
29. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
30. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
31. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
32. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
33. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
34. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
35. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
36. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
37. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
38. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
39. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
40. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
41. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
42. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
43. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
44. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
45. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
46. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
47. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
48. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
49. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1
50. Suburban city near road	2010	15	Wednesday	1	October	near-vehicle	near-vehicle	1

Fig. (3) :Database using Microsoft Excel

SSPS program was used to create charts that include number of accidents in each year, type of accidents, vehicles involved in accidents, time of accidents, accident's day and accident's month for the study area in general as shown in figures (7,8,10, 11 and 12).

Microsoft Excel software used to filter data and select a group of high-accident locations (which have five accidents or more in the specified section as shown in the figure (4) below.

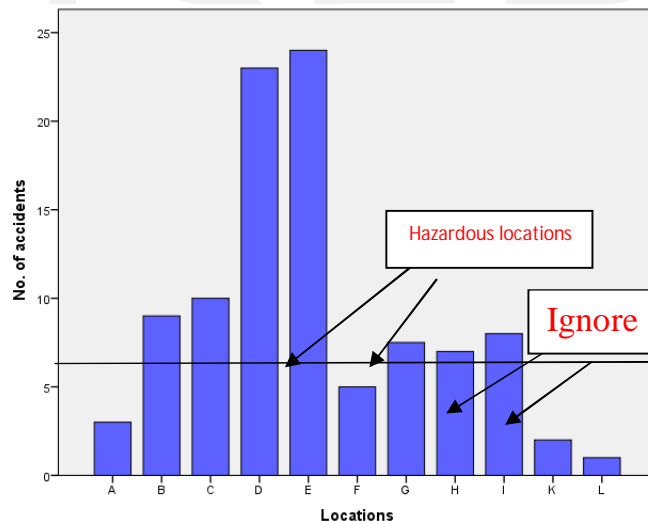


Fig. (4): Determining the hazardous locations by using Microsoft Excel software

Then these hazardous locations were visited and every section (which is defined in the study as 500 meters long). Each section has five accidents or more was considered as a hazardous location.

Although the traffic accidents data reports captured from the traffic police office at the study area contained a great details of information, at the same time, some information that are not available,

for this reason, in this paper the researchers arrived to the conclusion that there are only two methods that can be applied according to the quantity and quality of data available for the study area to determine the hazardous locations. In the beginning frequency method was used then the crash severity method used and (EPOD) calculated in these locations to rank the locations in order of priority.

As shown in figure (2) ArcGIS ESRI software was applied for editing, georeferencing and representing data to determine the location of twenty critical places with high risk and accidents along the main road which link Darbandikhan with other towns. In each section on the road network by using several colors according to the severity of these locations, as illustrated in the figures (5-12) below .

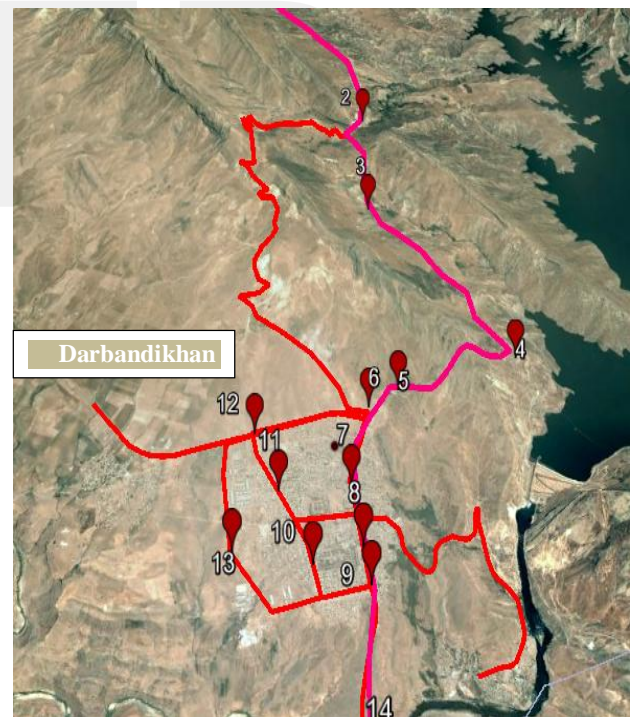
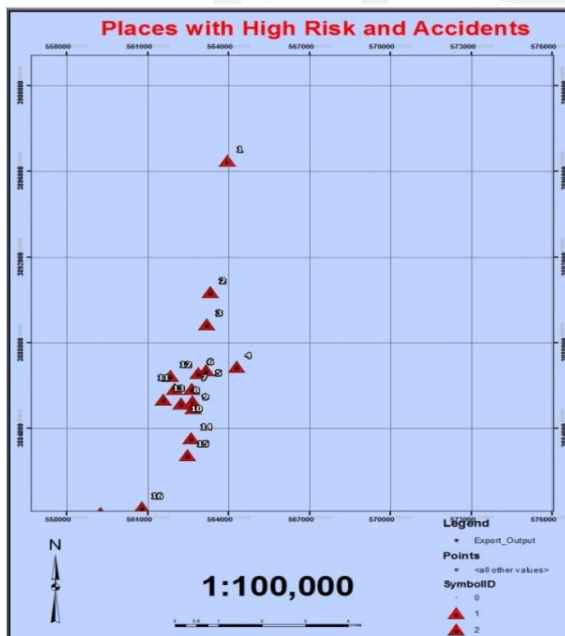


Fig (6) :Digital map of the places with high risk and accidents

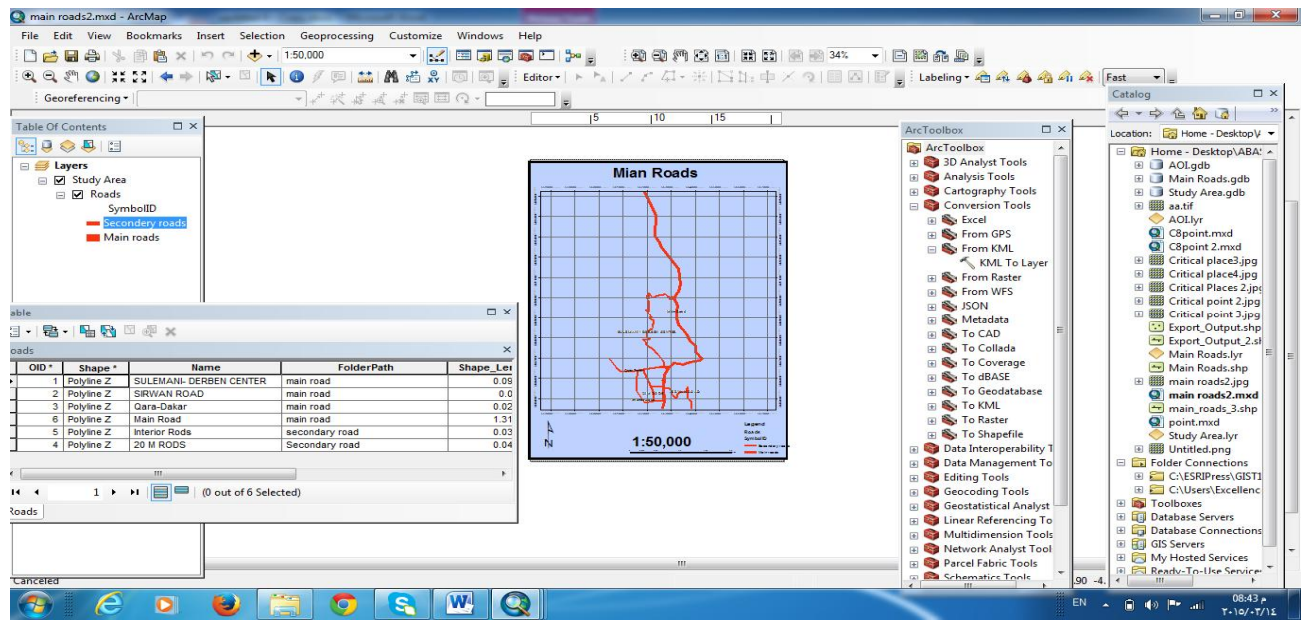


Fig (7): Determination of the main and secondary roads of the study area using ArcGIS

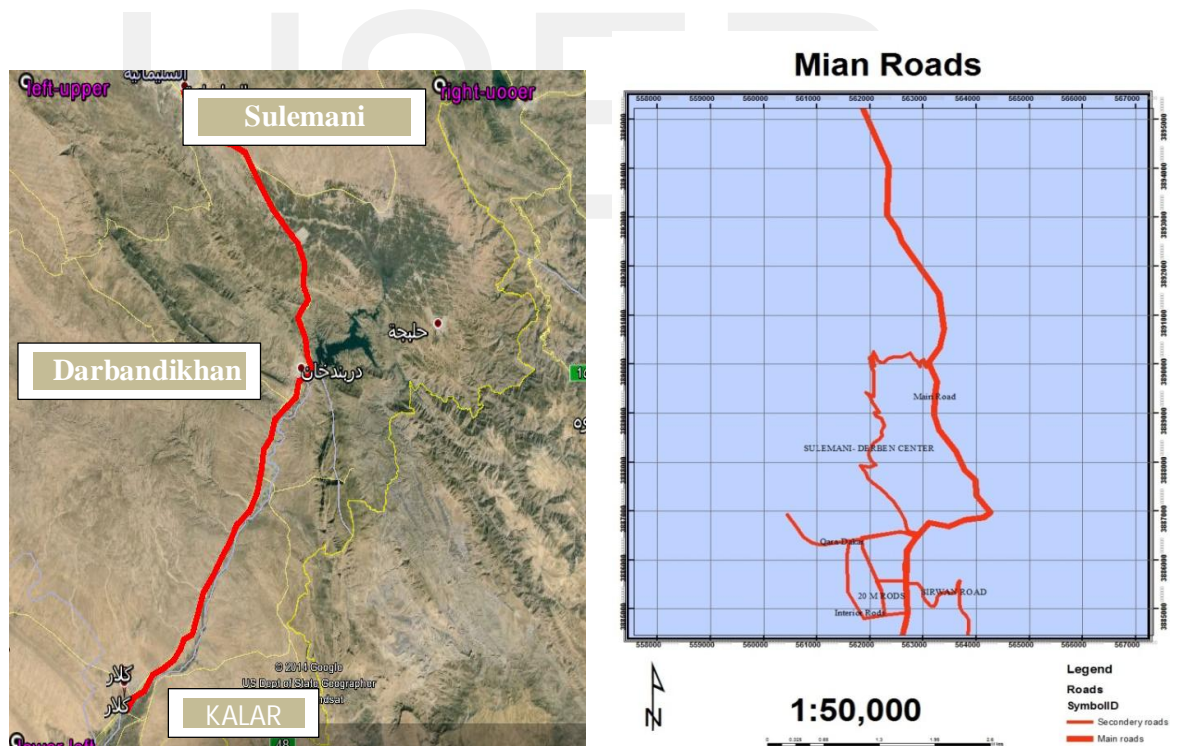


Fig (8): Digital map of Main & Secondary Roads of the Study Area and Neighborhoods

5. Results

Statistical analysis performed using SSPS 21 and ArcGIS 10.2 to analysis the data of 334 accident's reports. SSPS can quickly evaluate the accidents

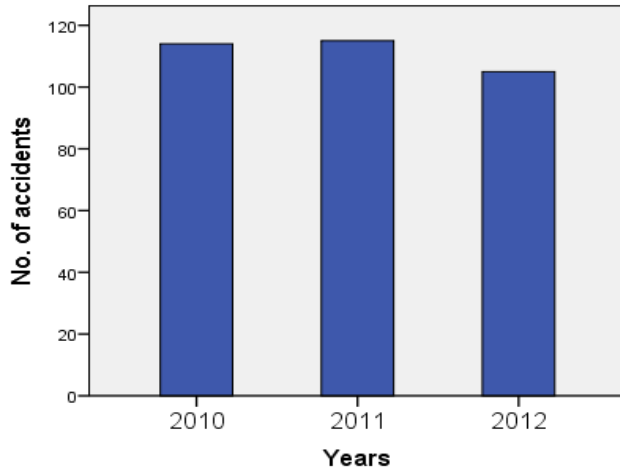


Fig. (9): Number of accidents in each year (2010-2012)

data and presents the general trends of the accidents data in the study region in general.

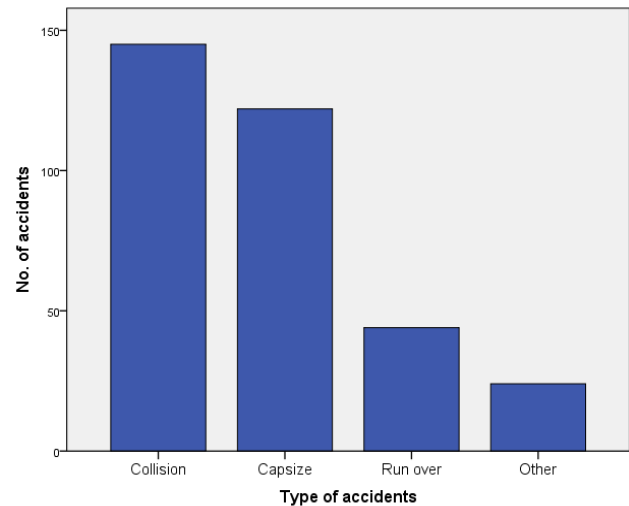


Fig.(10): Type of accidents

It can be seen from Fig. (9) that the number of accidents are nearly closed to each other's during the three years. Collisions, followed by capsizes accidents (36.42%). Meanwhile Fig. (10) Indicates occurrence of collisions

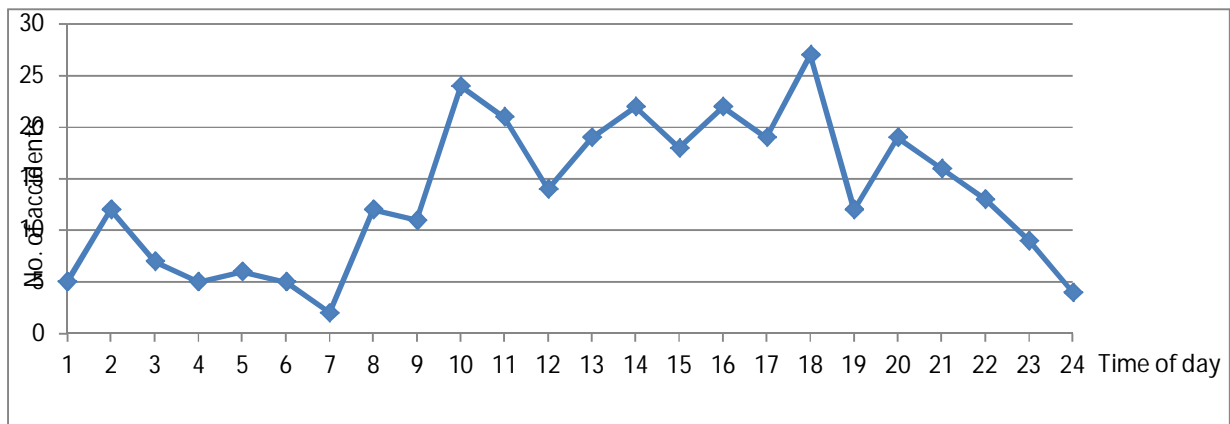


Fig.(11) :Variation of accidents with time of day

The graph above in Fig.(11) shows that frequency of accident is highest at 18 o'clock (8.33%); also it

shows frequency of accidents through the daytime (8-18) is (64.51%).

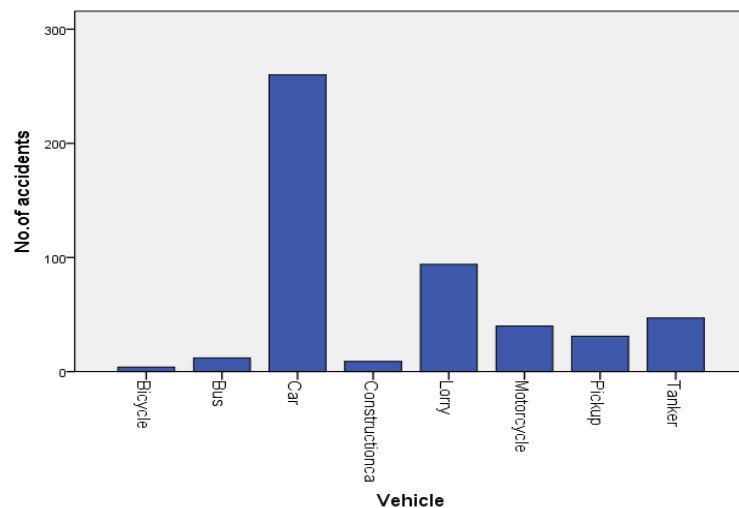


Fig. (12) : Distribution of vehicles involved in accident (2010-2012)

It can be clearly seen from Fig (12) that among various types of vehicles, the car is responsible for most

accidents of (52.3%) followed by lorry which is (18.9%) then tanker (9.5%).

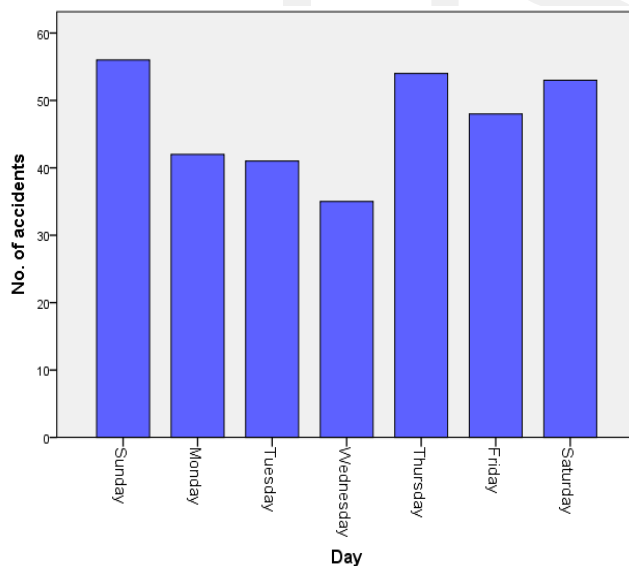


Fig.(13): Variation of accidents per days

Fig.(13) shows the occurrence of accidents from Thursday to Sunday is higher than (64.1%) compare with the other days.

Here, the chart in Fig.(14) illustrates frequency of

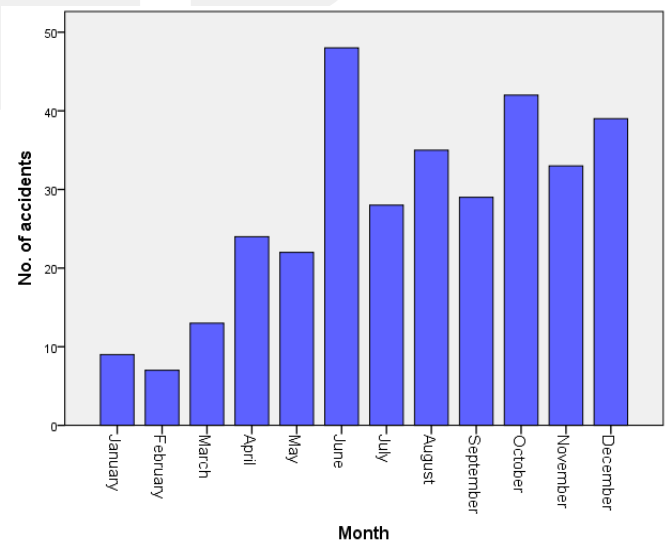


Fig.(14): Variation of accidents per months

accidents from June to December which are higher (77.2%) compare with the period from January to May.

From the table (1) and the figure (15) ,

it is clear to see that (Near village of Chinara)

and (The beginning of tunnel) locations

are the most vulnerable sites according to frequency method.

Table 1: Distribution of accidents at location (2010-2012)

Name of location	Fatal		Accident injury		Number property damage		Unknown		Total
	No.	%	No.	%	No.	%	No.	%	
Near village of Chanara	3	15.79	11	57.9	3	15.79	2	10.52	19
The beginning of tunnel	2	14.29	7	50	3	21.43	2	14.29	14
Near Katra region	4	33.77	8	61.54	1	7.69	-	-	13
Near Customs office	1	8.33	7	58.33	4	33.33	-	-	12
Katra bridge	3	27.27	6	54.55	2	18.18	-	-	11
Near village e of Banekelan	2	20	6	60	2	20	-	-	10
Near village of Bearky	1	10	6	60	3	30	-	-	10
Near industrial region (East)	-	-	5	50	5	50	-	-	10
Deoan bridge	-	-	4	44.44	4	44.44	1	11.11	9
Near village of Kashty	-	-	5	55.56	4	44.44	-	-	9
Near garage sulaimani	-	-	4	44.44	3	33.33	2	22.22	9
Near city game	-	-	8	88.89	1	11.11	-	-	9
Near industrial region (west)	1	11.11	7	77.78	1	11.11	-	-	9
The end of tunnel	2	25	5	62.5	1	12.5	-	-	8
Near the court	-	-	3	42.86	4	57.14	-	-	7
Near village of Dardaoean	-	-	3	50	2	33.33	1	16.67	6
Near Petrol station	2	33.33	2	33.33	2	33.33	-	-	6
Near village of Bonkla	-	-	4	80	-	-	1	20	5
Kanyard intersection	-	-	3	60	2	40	-	-	5
Near Saeedkaky building	-	-	2	40	1	20	2	40	5

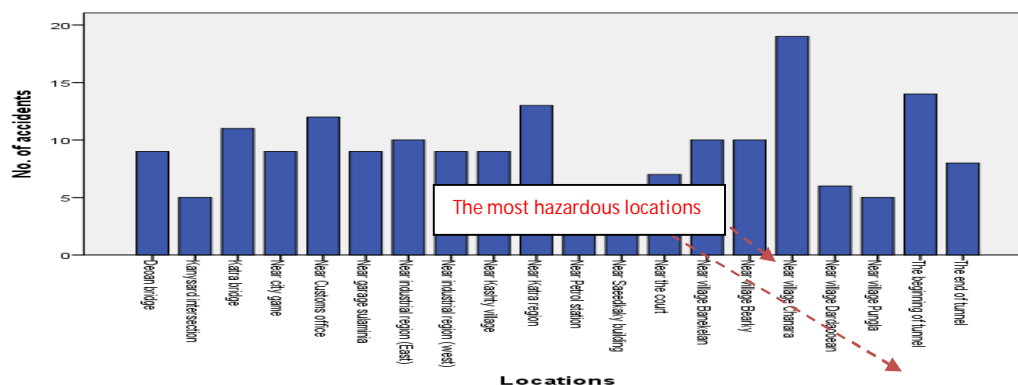


Fig. (15) : Ranking of hazardous locations according to the frequency method

However, the frequency method tends to rank high volume locations as high accidents locations, even if those locations have a relatively low number of accidents for the traffic volume. In addition accident severity has been neglected in this method. Therefore in this research the frequency method was used to select a group of high-accident locations and then accident severity method

(EPDO) was used to rank the locations in order of priority. Accident severity method is shown in table (2) and figure (16).

From the table (2) and the figure (16) it can see that (Near village Chanara) and (Near Katra region) locations are the most vulnerable sites according to severity.

Table 2: the value of EPDO at locations

Location	EPDO
Near village of Chanara	70
The beginning of tunnel	46.5
Near Katra region	67
Near Customs office	38
Katra bridge	51.5
Near village Banekelan	42
Near village of Bearky	33.5
Near industrial region (East)	22.5
Deoan bridge	18
Near village of Kashty	21.5
Near garage of suleman	17
Near fan fair	29
Near industrial region (west)	35
The end of tunnel	37.5
Near the court of Darbandikhan	14.5
Near village of Dardaoean	12.5
Near Petrol station	28
Near village of Bonkla	14
Kanysard intersection	12.5
Near Saeedkaky building	8

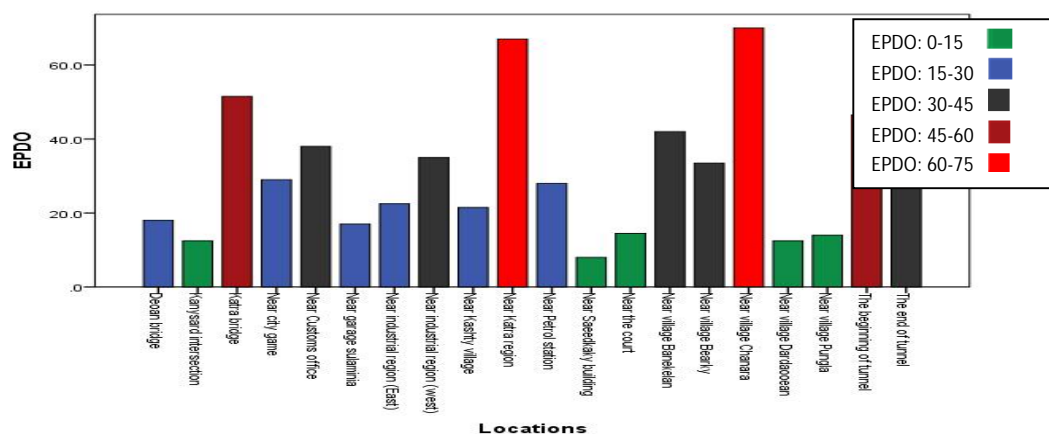


Fig. (16): The ranking of hazardous locations according to the EPDO method

6. Conclusions

The statistical analysis of road accidents has the purpose to characterize the main trends of data so in this paper the statistical analysis was performed by using SSPS program and several results were recorded. Application of accident frequency method might be easy to determine the hazardous locations but it neglects the accident severity. Hence in this paper EPDO was brought in to hazardous locations identification to rank the locations in order of priority. The use of GIS enables to display the hazardous location on the map and ranking these locations in order of priority by using several colors.

7. Recommendations

1. The most of traffic accidents occur at the daytime due to congestion caused by large transport vehicles, so must specify the hours of the passage of these vehicles during certain hours at the nighttime, with provide the better level of lighting in the critical regions.
2. Many of hazardous external sites suffer from lack of the sight distance because of the trees, so must minimize these natural obstacles.
3. Transport routes in this region are one lane so must set up a two lane road to reduce congestion and traffic accidents.
4. Most of accidents occur due to the excessive speed so should specify the speed by using the monitoring devices in critical areas and the imposition of fines on the offending cars.
5. Putting the warning signs in hazardous locations.

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