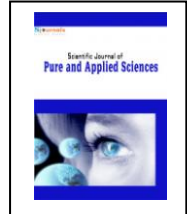


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**Original article**

**Analyzing the role of climatic factors on road accidents (case study: ardabil-parsabad road in Ardabil province, Iran)**

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**ABSTRACT**

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Road accidents and their fatalities are among the current challenges human society facing, which in turn resulting in huge social and economic costs on the countries. The developing countries are the biggest victims of the road accidents such that in these countries, road accidents are considered as the major cause of death. Unfortunately, Iran is among the countries in which the rate of road accidents is high. Among the driving factors that affect road safety and transport is climate. Ardabil-Parsabad road in Ardabil province is one of the roads many accidents have been occurred during years, and this trend began when the number of cars increased resulted in huge road deaths in 1990s. In this study, data has been used from four meteorological stations in Ardabil, Samian, Meshkin-Shahr and Parsabad, over a period of 5 years (2008-2012). For this purpose, several climatic elements were collected including the average daily temperature, average of minimum temperatures, average of maximum temperatures, the number of snowy days, the number of frost days, starting glacial period, duration of the snowfall, duration of the glacial period, total average humidity and moderate precipitation, average of sunny hours, average number of foggy days, the average number of windy days. This analysis is provided using Excel software in the Arc GIS environment of continuous levels of these parameters in the

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region.

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## **1. Introduction**

Today, transportation is one of the important components of the national economy, which is due to its infrastructural role. This section is largely encompasses activities in all areas of production, distribution and consumption of goods and services; and has an undeniable role in the economic activities. Without the transportation networks and appropriate auxiliary installations, the concept of public development seems impossible. Primarily in the development of global trade and growth in the current period, one cannot deny the role of transportation systems, transportation velocity, and safety and service levels. Meanwhile, the role of climate cannot be ignored. Climate means the weather including cold days and frost, sunny days, dust, rain and other climatic parameters. With the creation of the first human communities and population growth, road was introduced as a factor for the development of communication in order to satisfy human needs. Road can be as old as human history. Civil engineering may be considered in road construction, however without regard to the geological and climatic characteristics of the road, the lifeline of the road will be lower than the standards, therefore, it is of great importance to consider climatic measures to minimize accidents.

We can say that climatic parameters pale a major role in road transportation. Understanding these elements (temperature, precipitation, frost, cloudy, smog and other factors) could help authorities and experts to improve the safety and security of roads.

## **2. Problem description**

Since the advent of vehicles, mankind has faced with a serious issue, i.e., the road accident, taking attention of human societies. Road accidents are among the factors behind mortality and severe injuries of human and financial implications; in turn, threatening the economic, social and cultural aspects. The number of mortalities and damages resulting from road accidents is higher in the developing countries than in the developing countries.

Climatic and environmental factors are important factors behind the accidents in Ardabil-Parsabad road. Although these factors are out of control, but ways are available to reduce it. Road size and the number of vehicles as well as the impact of climatic phenomena on road accidents in Ardabil-Parsabad road are the main issues of investigation in this research.

As this road is in the mountainous areas, and its condition is also very poor, therefore, it is always criticized. The road is an arrow two-way road, and because much of it is in the mountainous regions, in the case of critical conditions, drivers cannot escape from the accidents. Since Moghan Plain is located along the border of Iran-Azerbaijan and also due to being stripped away from the center of the province of Ardabil, Ardabil-Parsabad road is the only one. Indeed, in terms of road traffic vehicles, Moghan Plain is remote; therefore, all vehicles go to Moghan should also return using the same road, and the road traffic in turn is increased.

## **3. Research highlights and objectives**

Conducting such research is obviously needed, because road accidents nowadays are great dangers toward public health and large costs are imposed on the societies both economically and socially. Roads have a clear impact on transportation in the province and in turn on road accidents, because there are no railroads or airways between the cities and towns in Ardabil province. Thus, according to the topographic and various climatic conditions and the possible influence of them on road accidents, it is required to research widely on safety of transportation in Ardabil province. The purpose of this study was to identify the relationship between climatic variables and mortality resulting from road accidents.

#### **4. Methodology**

To investigate the impact of climatic parameters on road safety, statistics and data of climatic factors (average of daily temperature, average of minimum temperatures, average of maximum temperatures, snowy days, the number of frost days, duration of the snowfall, duration of the glacial period, total average humidity and moderate precipitation, average of sunny hours, average number of foggy days, the average number of windy days) corresponding to Weather Stations along Ardabil-Parsabad road (Ardebil, Samian, Meshkin-Shahr and Parsabad) are gathered for the statistical years (2008-2012). Excel software was used to produce charts and tables, while GIS software Arc GIS was used for mapping. In addition, the statistics of the days the accidents occurred, were extracted and analyzed with the weather, and the relationships between them were investigated.

#### **6. Research questions**

1. What are the main climatic factors involving on road accidents in Ardabil-Parsabad road?
2. What are the most important of human factors on road accidents in Ardabil-Parsabad road?
3. Which months have the highest frequency of accidents throughout the year and what is the reason for?
4. Which months have the lowest frequency of accidents throughout the year and what is the reason for?

#### **7. History and literature review**

One of the greatest risks and impacts of any transportation system is car accident. Therefore, various specialists, including geologists, geo morphologists, civil engineers, economists, mechanical engineers, industrial designers and etc., have been studied and discussed this problem according to their expertise and perspective. Many works have been conducted on the road accidents throughout the universities and institutions to reduce the number of accidents and increase safety issues. However, considering less to no recorded data in Iran, research on this issue is restricted in Iran compared to the other countries. Regarding road safety issues, not much research has been done in Iran and even internationally. In this paper, it is tried to show the impact of climatic and non-climatic factors on road accidents. Moreover, Ardabil-Parsabad road is investigated for the first time from this viewpoint.

##### **A) External literature (outside of Iran)**

Moore and Cooper (1972), showed that dense fog with visibility less than 150 meters is the onset of the serious accidents. Under such circumstances, due to issues such as speeding or ignoring traffic laws or not complying with the permitted distance between vehicles lead to accidents.

Larson and Brad (1973, 1977), analyzed a road accident index for the number of snowy roads in which the variables of temperature, precipitation, snow depth and its variations in month, year, day, week, and even in holidays are taken into consideration. In 1981, they reported a correlation between weather conditions, road conditions and road accidents in the winter, provided that they were based on data from the years 1977 to 1973. According to this data, roads are divided into three groups: Group A, Salt sprayed roads in the winter, and Group B, Salt sprayed roads in the spring and fall, and group C, roads that are not salt sprayed. Roads in icy (glacial) condition which are salt sprayed are twice more accident-prone compared to the other roads, as the drivers do not perceive the icy condition and in turn do not regulate their driving in this condition. Overall, accidents in March and April are less than those of in September, October, November, December, and February (reported by Kamaliet al.).

Smith and Coodling (1982-1974) concluded that accidents on rainy days are more than the days without rain by 30%.

Wafen et al., (2002) reached considerable results in a research using multi-spectral satellite data. To reduce the fog impact on land transportation system, they also required changes in strategic policies related to the transportation.

Jean Andre (2001) has done several studies in the field of road weather. Interestingly, most of his studies have focused on accidents caused by rainfall. In one of his studies, he has come to some interesting conclusions which are outlined below:

A) The risk of accidents during the rainfall increases usually from low to large amounts.

B) There is considerable evidence that suggests snow affects accidents more than rain. However, it should be noted that the severity of accidents caused by snow is less than those of by rain.

C) Strong winds combined with rain increase the accidents.

D) The brightness of the sun, stress as a result of heat and air pressure influence the occurrence of road accidents. But, the evidence is so dispersed that it is not possible to reach a logical conclusion in this case.

### **B) Internal literature (inside of Iran)**

The first research in this field was performed by No-khandan (1999) in cold period of year on Haraz road. It was implied that 237 accidents in March, 206 accidents in December and 170 accidents in January were due to the icy roads, while the total number of accidents was at 931.

Ghatreh Samani (1999) conducted a research on the effect of weather on accidents in Chaharmahal and Bakhtiary province. It was revealed that when the weather is great without any climatic phenomena, the number of accidents decreased considerably. On the other hand, in the case of climatic condition such as rainy days the number of accidents increased (24%). Other climatic factors are also effective as follows; snowy condition (34%), foggy days (20%), cloudy days (22%) and windy days (5%).

Habibi No-Khandan (2004) performed a research using data collected from 120 synoptic stations in a static period of 10 years and presented the results in the form of figures and tables. In addition, for investigation of the relationship between climatic condition and road accidents, he analyzed the results and concluded the followings:

A) Most drivers, especially young drivers have a little knowledge of driving in unfavorable weather conditions.

B) The slope of the road causes the accident rate to be increased in unfavorable weather conditions.

C) In the fall months, as the winter maintenance operations are not performed in mountainous areas, with the first snowfall and icy roads drivers are more susceptible to road accidents.

D) Accidents caused by rainfall in days are more than in nights, because of the faster cars and more inexperienced drivers are in roads in daylong.

E) The number of accidents in spring and summer are more than in fall and winter, however, considering the number of accidents per traffic in roads revealed that the ratio of accidents are high in cold seasons.

Karami (2002) studied Firouzkouh to Sari road as the case study. He investigated the impact of climatic parameters on accidents and traffic safety and the results achieved as follows: February is the month with the highest number of frost days during which 115 accidents have been reported. While, January has the maximum frequency in rainy days during which 35 accidents were reported.

Mahmoodi (2005) studied Sanandaj-Hamedan road as a case study. He found interesting results after analyzing accidents in 7 months of cold period.

Aghae et al. (2007) concluded that, November has the highest climatic impacts on road accidents.

## **8. Fundamental information of research**

For the purpose of studying climatic conditions on road safety, data were collected from Ardabil stations in a period of 5 years. In addition, data related to accidents in Ardabil-Parsabad road was taken from the department of road police. The gathered information were prepared in the form of figure and tables using Excel software. Afterwards, maps were provided using Arc GIS software. Further, accidents were simultaneously analyzed with weather condition. Finally, synoptic and topographical maps were used for road analysis.

## **9. Relationship between accidents and weather conditions**

Based on the analysis of road accidents in Ardabil-Parsabad road, for each of the weather conditions, the contribution of each of the constituent elements in the accident was identified. It can be concluded that:

1. There is proportionality between road accidents in Ardabil-Parsabad road and climatic factors.
2. Temperature in sunny days and cloudy conditions has an important role in increasing the frequency and severity of accidents.
3. Most accidents reported when the temperature is high.
4. Least accidents happened when the weather was foggy.

Obviously, one can say that many factors dealing with the accidents including human factors, road and weather factors and etc., but it must be said that the weather conditions are not a major factor in accident, but they exacerbate the risk of a car crash.

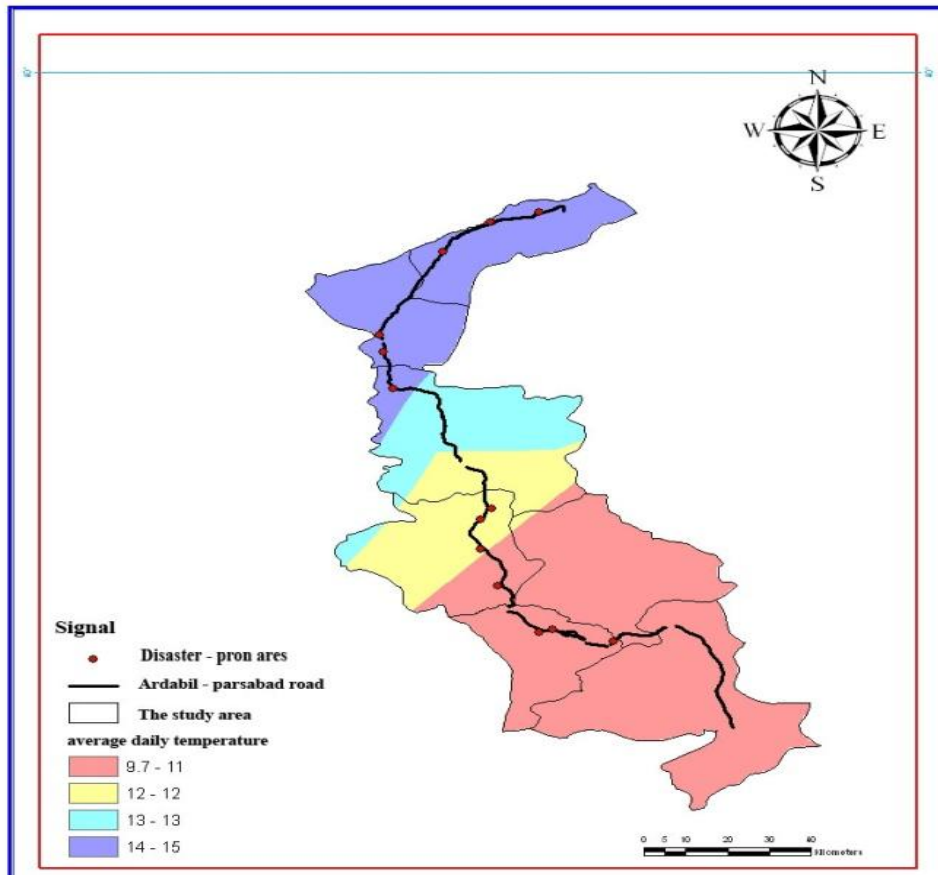


Fig. 1. Distribution of average daily temperature for the case study.

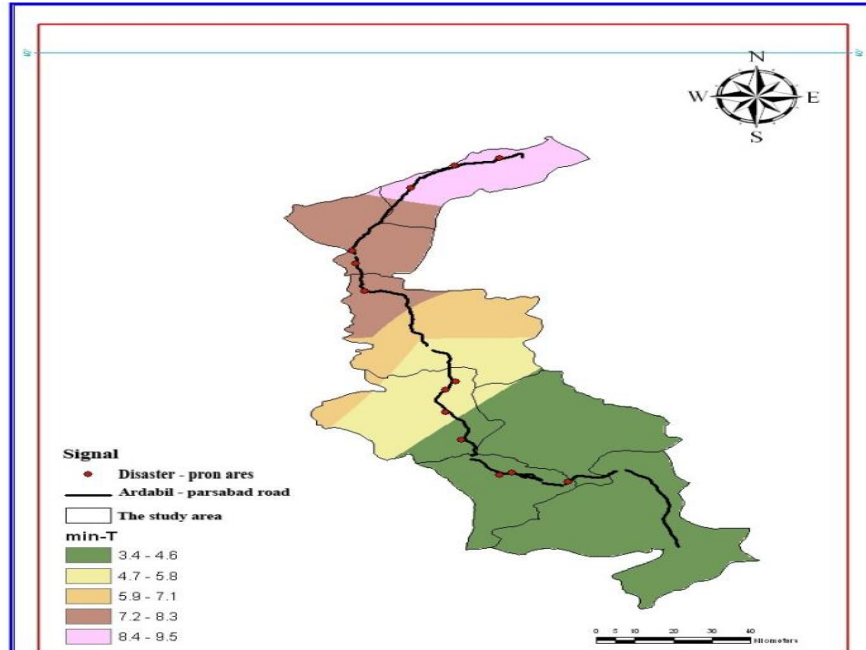


Fig. 2. Distribution for the minimum temperature for the case.

### 10. Analysis of accidents and their relation with the climatic condition

The accidents occurred in the course of the study are given in Table 1. Among the unstable weather condition, the highest accident occurred in the sunny days. This can be due to the temperature increase resulting in sleepy drivers and in turn the drivers lose the control of the cars. Cloudiness, rainy and foggy conditions are the other significant factors influencing the accidents.

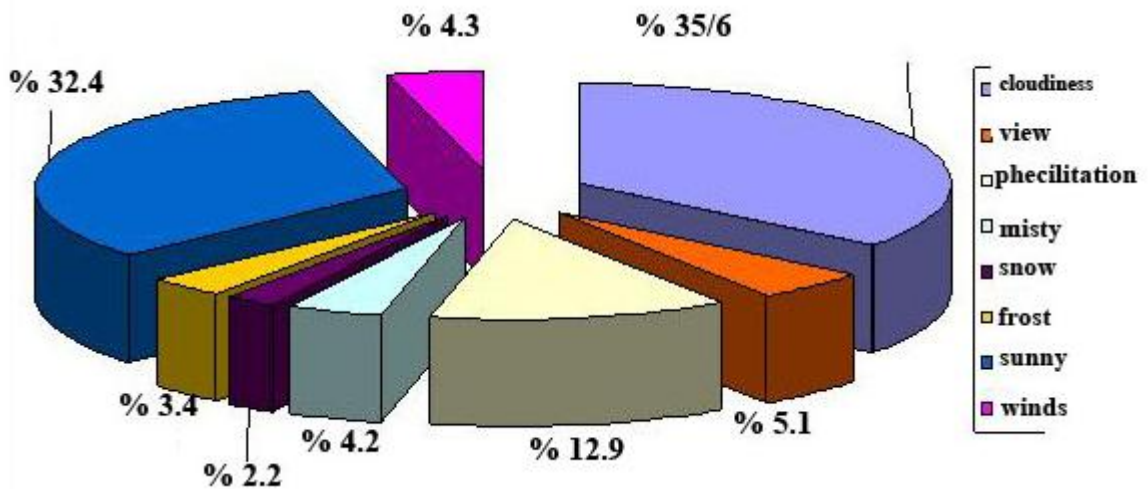


Fig. 3. Relative comparison of climatic factors impact on accidents in Ardabil-Parsabad road.

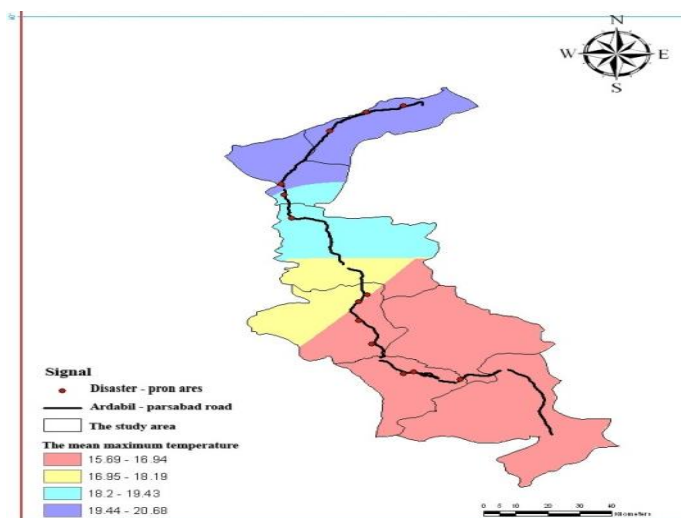
**Table 1**

Important factors of in the occurrence of accidents in Ardabil-Parsabad road caused by human behavior.

Month	Foggy	Rainy	Cloudy	Sunny	rural	Lateral road	Main road	Other reasons	Sudden change of direction	Violation of priority	Violation of permission distance between	Inattention to the front	Fatigue and drowsiness	Deviation to the left	Inability to control the vehicle	Speed violation	Exceed the speed regulation
March-April	3	7	16	71	5	26	66	13	0	18	3	5	3	12	11	16	16
April-May	0	10	17	45	2	22	48	11	0	13	4	4	3	13	16	3	5
May-June	3	9	26	55	0	30	63	6	1	14	3	9	6	25	12	5	12
June-July	3	8	35	84	4	39	87	27	0	31	4	3	2	27	9	14	13
July-August	1	4	24	78	2	21	84	8	5	24	16	8	5	20	10	3	8
August-September	2	8	30	60	9	18	73	7	2	15	10	6	6	20	14	12	8
September-October	4	17	38	58	9	28	80	15	0	24	6	10	0	30	13	2	17
October-November	17	24	57	55	4	27	122	20	0	36	8	11	2	36	10	11	19
November - December	11	18	45	35	0	33	76	21	0	21	9	2	3	28	8	4	13
December-January	6	19	22	29	2	21	53	0	0	13	6	6	3	17	9	14	8
January -February	13	21	20	35	5	18	66	8	0	10	9	8	0	22	6	8	18
February-March	5	9	27	31	3	14	55	4	0	13	3	10	1	10	10	14	7
Total	68	154	357	636	45	297	873	140	5	232	81	82	34	260	128	106	144

**11. Analysis of accidents on sunny days**

During the 5-year statistic data (from the years 2008 to 2012), a total of 1215 accidents reported in Ardabil-Parsabad road. Among which 636 cases have been in sunny days. Daily analysis shows that most accidents reported between July-August in 2011 and 2012. However, the highest average accidents reported in June-July.



**Fig. 4.** Distribution of total precipitation for the case study.



### 12. Analysis of accidents on cloudy days

During the 5-year statistic data (from the years 2008 to 2012), a total of 1215 accidents reported in Ardabil-Parsabad road. Among which 357 cases have been in cloudy days.

### 13. Accident analysis in foggy days

During the 5-year statistic data (from the years 2008 to 2012), a total of 1215 accidents reported in Ardabil-Parsabad road. Among which 154 cases have been in rainy days.

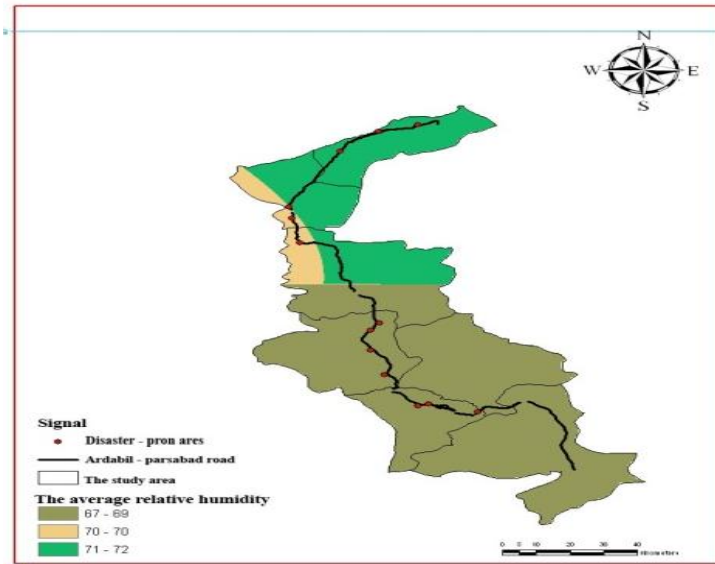


Fig. 5. Distribution of the average humidity for the case study.

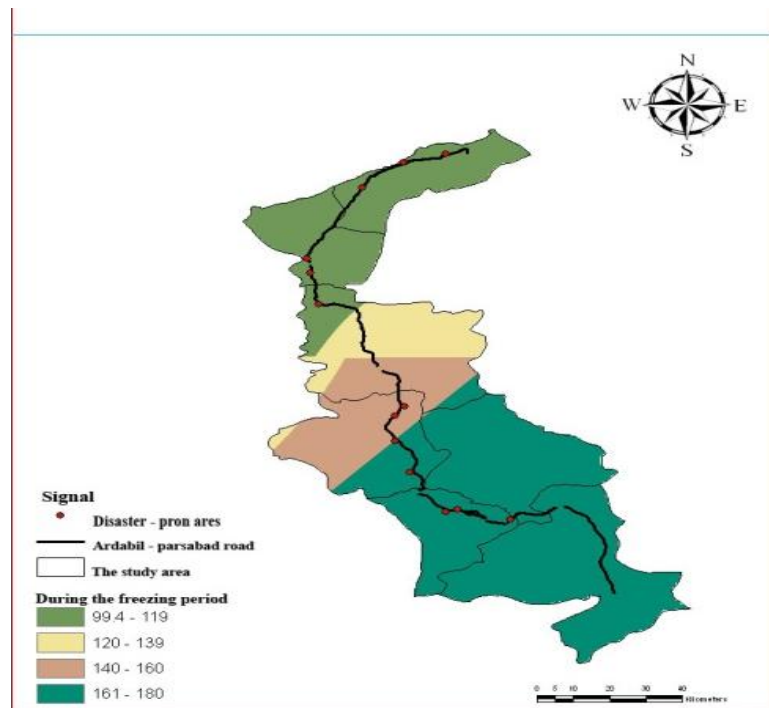


Fig. 6. Distribution of the average icy days for the case study.



During the 5-year statistic data (from the years 2008 to 2012), a total of 1215 accidents reported in Ardabil-Parsabad road. Among which 68 cases have been in foggy days mostly during October-November and February-March months.

#### 14. Analysis of accidents on snowy and icy days

In this research, days in which the snow is falling and the temperature was below freezing were considered as the snowy and icy days. As we know, in the case of snowfall, by the reduction of the horizontal visual acuity, accidents are occurred.

5.6% of accidents in Ardabil-Parsabad road were in snowy and icy days. The related figure illustrates the distribution of this information. November-December and March-April has the highest rate of accidents from this viewpoint.

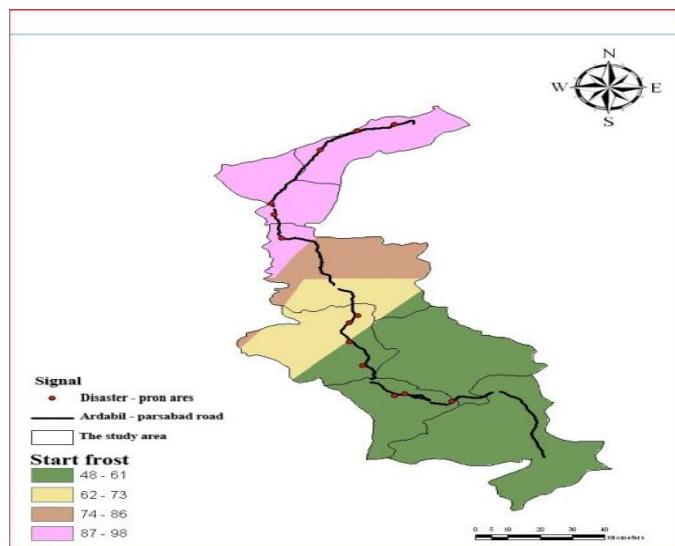


Fig. 7. Distribution of the onset.

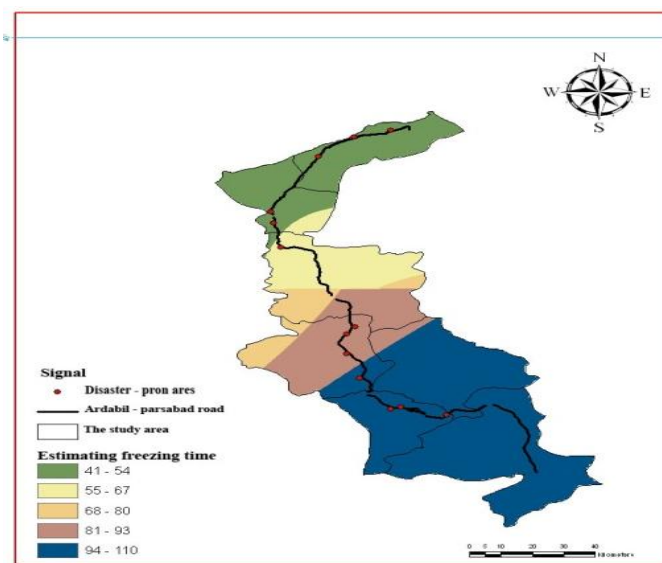


Fig. 8. Distribution of the icy duration for the case.

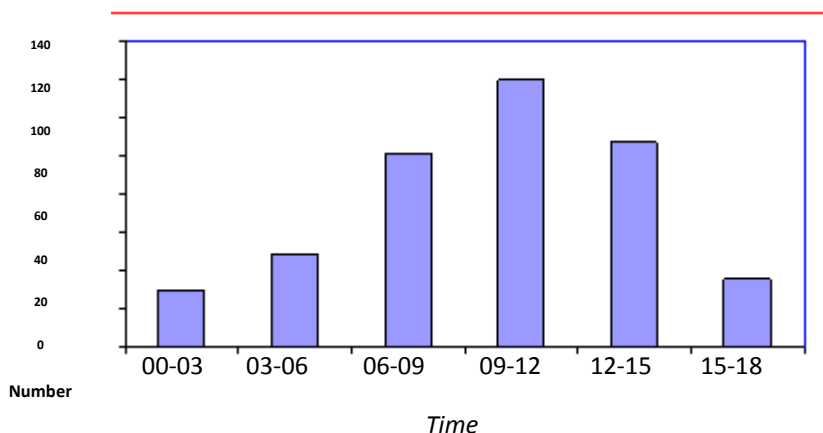
### 15. Hourly analysis of accidents in Ardabil-Parsabad road

It was revealed that most of the accidents occurred in daylong. Because much of the transportation is done during day. According to the collected data, most of the accidents have occurred between the hours 12 and 15 and the least between 3 and 6. (Table 4-3, figure 4-15).

**Table 2**

The annual frequency of accidents in Ardabil–Parsabad road in daylight hours during the statistical period.

Hourly accidents in Ardabil-Parsabad road between 2008 and 2009						
months	00 - 03	03-06	06-09	09-12	12-15	15-18
March-April	1	3	4	8	6	0
April-May	3	4	6	8	8	3
May-June	2	2	6	11	10	3
June-July	5	7	12	11	9	4
July-August	1	5	6	8	15	1
August-September	0	2	3	8	17	2
September-October	3	8	9	18	13	2
October- November	4	6	13	29	9	9
November - December	5	2	6	17	10	8
December-January	1	2	15	8	3	1
January -February	4	6	11	6	2	3
February-March	1	2	10	7	5	0
Total	30	49	101	139	107	36



Shaft accident Ardabil – Parsabad in 1387 – 1391 years each time  
**Fig. 9.** Hourly comparison of accidents in Ardabil-Parsabad road.

### 16. Analysis of the accidents in different months of the year in ardabil-parsabad road

#### In 2008

The most of the accidents were reported for November-December. Total 23 accidents were reported which were mainly due to the cloudy condition, and the deviation to the left and reversal of the vehicle.

The lowest of accidents were reported in March-April (5 accidents) which were mainly due to high temperature and the inability to control the vehicle and violating the right priority.

**In 2009**

The most of the accidents were reported for June-July (32 accidents) which were mainly due to the high temperature, the deviation to the left, and violating the right priority led to reversal of the vehicle.

The lowest of accidents were reported in March-April (7 accidents) which were mainly due to high temperature and violating the right priority led to reversal of the vehicle.

**In 2010:**

The most of the accidents were reported for June-July (35 accidents), while the lowest of accidents were reported in May-June (12 accidents) which were mainly due to high temperature and speed violation led to reversal of the vehicle.

**In 2011**

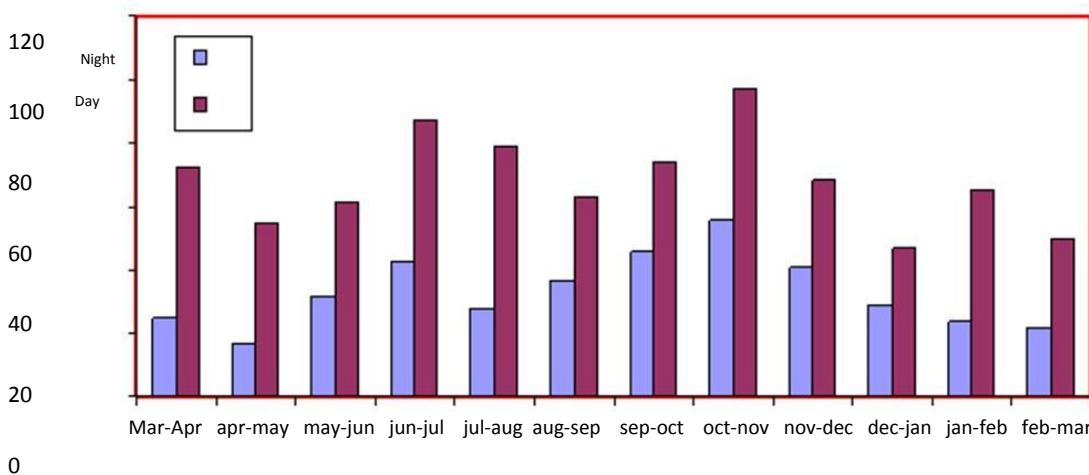
The most of the accidents were reported for March-April (30 accidents) mainly due to high temperature and speeding, while the lowest of accidents were reported in June-July (8 accidents) which were mainly due to high temperature and inattention to the front led to hit with a pedestrian.

**In 2012**

The most of the accidents were reported for October-November (30 accidents) mainly due to cloudy and foggy conditions and inattention to the front, while the lowest of accidents were reported in April-May (10 accidents) which were mainly due to high temperature and speeding and deviation to left led to reversal of the vehicle.

**17. Statistical evaluation of the total number of accidents during the 5-year statistical period in ardabil-parsabad road**

During the 5-year statistic data (from the years 2008 to 2012), a total of 1215 accidents reported in Ardabil-Parsabad road. Among which 815 and 400 accidents were reported in day and night, respectively.



**Fig. 10.** Comparing of accidents in day and night in Ardabil-Parsabad road.

**18. Analyzing the minimum and maximum number of accidents in ardabil-parsabad road**

The most frequent accident statistics over 5 years was reported in November-December, with 153 cases, which were mainly due to the cloudy condition, and diversion to left, and violating right priority causing the vehicle to overturn.

The lowest frequency of accidents was reported for the months of May and June, with 72 cases, which were mainly due to the high temperature, and the inability to control the vehicle and speed violation led to the overturning vehicles.

### 19. Analyzing parts of road with the maximum number of accidents in ardabil-parsabad road

After obtaining the data of the accidents in Ardabil-Parsabad road from the department of road Police, the accidents' location were mapped (videotaped) then by using Arc GIS software they have been mapped into a map.

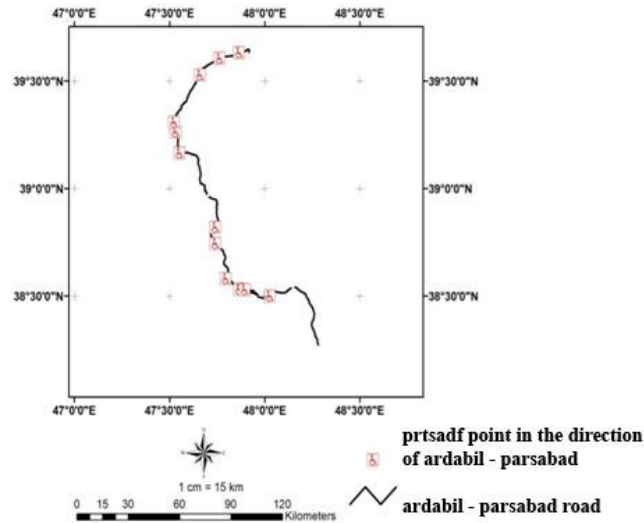


Fig. 11. the accidents in Ardabil-Parsabad.

### 20. Conclusion

According to the accident analysis for each of the studied weather conditions, sunny, cloudy, rainy and foggy area, the contribution of each of the phenomena based on the accident in Ardabil-Parsabad road were revealed. In general it was concluded that:

1. There is a direct correlation between the accident and the climatic conditions.
2. Temperature of the area and the sunny and cloudy conditions hasan important role in increasing the frequency and severity of accidents.
3. Most accidents were occurred when the weather was sunny.
4. The lowest accidents were occurred in foggy condition

Thus, it should be noted that there are many factors involving in road accidents. In fact, in most of cases road geometrical shape has effect on accidents and this is worsen when the weather condition is unfavorable.

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