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ARTICLE

STUDYING THE ROLE OF CLIMATIC PHENOMENA IN ROAD ACCIDENTS IN YAZD PROVINCE

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ABSTRACT

This study has been conducted aimed to investigate the role of climate phenomena in road accidents in Yazd in 2015-2016. This study is a descriptive-quantitative one conducted in documents or descriptive-analytic method. Research population consisted of all statistics and documents related to road accident of Yazd. In this research, the statistics of road accidents of Yazd due to dust from 2010 to 2014 were considered as the study sample. The data was obtained from records and statistics provided by the meteorological organization, traffic police, Department of Transportation and Terminals, and Urban Development Department of Yazd. Inferential statistics indices chi-square test, Friedman test, Pearson correlation and regression were used to analyze data. The results showed that the increase in the frequency of dust is correlated with an increase of accidents in Yazd (correlation coefficient 0.75). In the study period, 55.6 percent of accidents have been due to dust and 44.4 percent have been due to other climatic factors. Moreover, the results showed that the most accidents caused by dust have been in the spring and then in winter. Finally, road accidents caused by dust from 2010 to 2014 have had an increasing trend in a varying form. As a result, the climatic factor dust has a greater role in road accidents compared to other climatic factors, and this phenomenon increases with the annual increase in the number of vehicles present in roads of this province and increase in intercity trips in the intended seasons.

KEY WORDS
climatic factors, the role of dust, road accidents

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INTRODUCTION

One of the study cores of human and environment relations is addressing the environmental hazards. Environmental hazards may be man-induced or natural and no matter whatever the results, they return to man or the environment. Human hazards include excessive levels of crime, war, economic depression, weakness, a variety of illnesses, and pollution, and natural hazards refer to incidents such as earthquakes, volcanoes, droughts, floods and storms. With different level of strength, in all places and at all times, natural hazards threaten human existence, always lead to destruction, and create huge damages to human life and property.

In general, four main factors are involved in accidents: natural factors or environmental factors, human factors, management factors, and vehicles .[1] In addition to incidents in which human is involved, natural disasters such as floods, earthquakes, hurricanes, cyclones, and dust have had a significant role in the escalation of events, especially car accidents over the past decades. Road accidents and their fatalities are one of the current challenges of human societies that impose enormous costs on the economy of countries and pose a big problem to general health. [2]

Several factors may contribute to the occurrence of road accidents, among which the geometric design problems, environmental conditions, and human factor could be noted. Among natural factors (that affect safety and sustainability of transportation) climatic factors can be pointed out, whose effects on road accidents are identified in a documented and logical way. It can be stated that, although very few studies have been done in this area, abundant evidence of the effects of climatic factors such as dust, dust, rain, snow, and frost as important and influential factors in road accidents is found.

Among the important consequences of dust are cutting off roads, limiting visibility for drivers, and trapping them that in some cases besides causing significant economic damage, cause much human injury . In substantial parts of Iran, including deserts and arid and semi-arid regions, such as East and Southeast of the country, part of the Central Plateau and East Esfahan (Nain, Ardestaan, Kashan), Yazd, Kerman, Sistan and Baluchestan, Fars, some parts of Khuzestan and southern parts of Khorasan, Markazi, and Hormozgan, climatic conditions is favorable for dust. In these areas, on the one hand, due to dry land, there is not enough vegetation, and on the other hand, the hot weather of spring and summer has dried the soil and turned it into powder. [3]

Every year, dust imposes great damage to the residential areas and roads, we always witness the decline of many cities and villages of the country, especially in desert areas, and the residents of these areas flee from their homes and turn to larger cities, which threats normal life in urban and rural communities. Health can also be affected by dust. Dust particles can cause respiratory problems, especially asthma. In addition, viruses and germs in the dust can cause various diseases .[4]

In a comparison between countries in terms of development, the most victims of this crisis are in developing countries, so that road traffic accidents are known as one of the major causes of death in these countries. Dust imposes irreparable damage to the earth every year, and not only in Iran but also in other Asian, African, and American countries, it causes frequent physical and financial damages. Each year, dust destroys human life, challenges sustainable urban and rural life, and has a devastating impact

on road transport, agriculture, crops and livestock, trade, and public health and welfare of the people in the affected areas and nature .
Studies concerning the impact of climatic factors on the occurrence of road accidents and controlling strategies in developed countries have had significant progress hence; these countries have become a good role model in minimizing damage from road accidents incurred by climatic factors. However, unfortunately, due to the lack of studies on the role of climatic factors (especially dust) in road accidents in Iran, insufficient information of toll officials of these factors, lack of preventive measures in this regard, and poor performance of officials, every year we witness tragic events that can be minimized with some management and research .

Doaguyan et al. conducted a study titled "Analysis of the role of dust storms in occurrence of road accidents (Case Study of Minab-Jask road). The aim of this study was to evaluate the effects of dust storms on the number of road accidents of Minab-Jask road. The results showed that the highest number of road accidents in Minab has happened in spring in April, when dust storms have often occurred due to dry air. By identifying the characteristics and predicting this type of climatic disaster one day before, while traffic management, road safety, and informing roadside assistance databases, EMS, police, and warning drivers, one can reduce the damage of this climatic disaster. Exploring and identifying the role of climatic factors of road accidents are important in terms of offering management solution. Management of accidents and or accident scene management is one of the effective strategies that can reduce the consequences, including reducing mortality, and preventing new accidents by controlling climatic factors. This study is conducted aimed to investigate the role of dust in the road accidents in Yazd. [5]

Moreover, as road-accidents caused by dust are not fully covered by financial and life insurance in Yazd, most perpetrators escape from the scene, and this has created a kind crime and has exacerbated insecurity in the province. Thus, in addition to loss of life and property that road accidents incur in Yazd, they have numerous cultural problems ranging from failure to comply with traffic laws, civil rights, culture, traffic, lack of cooperation and partnership in crisis management, etc. [6]
Accordingly, main research question or problem will: what role does the climatic factor dust have in the occurrence of road accidents in Yazd? These questions in detail are:
- How much is the role of dust compared to other climatic factors in road accidents in Yazd?
- In which season of the year has dust caused the most road accidents in Yazd?
- How are the process and developments of road accidents due to dust in Yazd?

MATERIALS AND METHODS

In general, the dominant approach of this paper is applied-developmental and its analysis method is descriptive-analytic. The population is the number of traffic accidents of Yazd and the required information is collected from statistical yearbooks, Meteorological Organization in Yazd, traffic police of Yazd, Department of Urban Planning, Department of Transportation and Terminals of Yazd, and Governor of Yazd. The changes and development of road accidents are studied with developing questionnaires and their completion to obtain field information with respect to documents available with the use of data and statistics related to accidents in the past 5 years. Therefore, methods of accidents mean, accidents type, and causes of accidents were used for analyzing accidents, because the technique of assessing and analyzing the past years can provide good information about the causes and contributing factors in the accidents. Moreover, it may be used to manage accidents and changes that will befall in the future. All data and documents related to road accidents in Yazd from 2010 to 2014 formed the study population. [7]
In this method, the researcher has collected the needed data and information from authoritative sources. The researchers has received data from the records and statistics provided by the Meteorological Agency, the traffic police, and the Roads and Urban Development of Yazd, and by developing a questionnaire and completing it and by turning data into usable data, he has analyzed the statistics.
In order to analyze the data from the study, the indices of descriptive and inferential statistics are used. SPSS software is used whenever necessary. The indices of frequency, percentage, and so on are used to describe data (drawing tables was used for data classification). In order to test research hypotheses, nonparametric chi-square test (significance test) through spss is used. For inferential analysis of the data, chi-square test, Friedman test, Pearson correlation coefficient, and regression are used. [8]

RESULTS

In order to show the frequency of occurrence of storms in Yazd, the statistics of synoptic stations of this province during 2010-2014 are used. The results show that the highest frequency of storms in the study period is related to 2014 with 47 times. Moreover, in terms of frequency in month, May with 53 times has the highest frequency during the statistical period. Displaying the influence of each climatic factor on the accidents in this province indicates that during the entire statistical period studied, the phenomenon of dust has caused accidents more than any other phenomenon. In this period, the phenomenon of dust has caused 1948 accidents and storm has caused 913 accidents.

Examining the relationship between dust and accidents in Yazd

In [Table 1]n order to evaluate the extent and the nature of the relationship between the independent variable (the phenomenon of dust) and the dependent variable (accidents), Pearson correlation coefficient is used. The results of this coefficient at 99% confidence level show a significant relationship between the variables: according to this output, the increase in the frequency of dust has increased the total accidents in Yazd. This coefficient is obtained as 0.745 indicating the strength of the relationship between variables.

Table 1: Analysis of the relationship between the phenomenon of dust and accidents in Yazd

Pearson coefficient		Dust	Accidents
Dust	Pearson coefficient	1	0.745**
	Significance level		0.005
	Frequency (per month)	12	12
Accidents	Pearson coefficient	0.745**	1
	Significance level	0.005	
	Frequency (per month)	12	12
** Significance level 99% (0.01)			

Moreover, to determine the effect of dust on accidents, the coefficient of determination (beta) in regression test is used. The results of coefficient of determination of regression analysis show that in the studied period, due to the intercorrelation of variables, 55.6% of the accidents are due to dust and 44.4% are due to the other factors. Moreover, regression analysis shows that the dependence of the dependent variable accidents is equal to 0.745 [Table 2].

Table 2: Regression coefficients of accidents and dust

Variable		Correlation coefficient	The coefficient of determination	Adjusted coefficient of determination	Estimation error	Significance
1	Value	0.745	0.556	0.511	13.40308	0.005

Resource: research findings, 2015

The impact of dust on accidents compared to other climate factors

In Table 3 order to investigate the role of dust in road accidents in Yazd compared to other climatic factors, chi-square test was used. The results are presented in the following. As indicated in Table 3, the observed chi-square value is 816.137, and its significance level is smaller than 0.01. Accordingly, it can be argued that that there is a significant difference between the accidents occurred due to different climatic factors. According to the results, it is observed that amongst climatic factors, dust has the most important role in road accidents.

In addition, in order to determine the impact of each factor on the accidents, the coefficient of determination (beta) regression test is used. According to coefficient of determination regression test, dust is the cause of 55.6% of the accidents, storms, rain, and snow and ice are the cause of 0.167 of the accidents in Yazd.

Table 3: Results of chi-square test to compare the role of dust and other climatic factors in accidents

	Climatic variables				Chi-square test	Degree of freedom	Level of significance
	Storm	Dust	Rain	Snow and ice			
The number of accidents	913	1948	541	409	816.137**	3	0.000

** Significance level 99% (0.01)

Seasonal relationship of dust and accidents in Yazd

In [Table 4] In order to assess, in what season of the year the accidents and dust have happened more and the fact that whether the frequency of dust and accidents in a particular season is consistent or not, while using chi-square test, Friedman test is used. Chi-square values observed is equal to 1137.492 and its significance level is smaller than 0.05. Accordingly, we can argue that there is a significant difference in different between the accident occurred due to the dust in different seasons. Thus, most accidents caused by dust are in the spring and then winter.

Table 4: Freedman statistics of the dependent and independent variables separately for seasons in the investigation period

	Freedman statistics dust	Freedman statistics accidents
Spring	3.67	3.33
Summer	2.33	3
Fall	1.17	1
Winter	2.83	2.67

The process of road accidents in Yazd during the period

InTable 5: order to show the process of road accidents of Yazd due to dust during the period, while using chi-square test, Friedman test was used to show the frequency. Chi-square value is equal to 124.627 and its significance level is smaller than 0.05. Accordingly, it can be argued that there are significant differences between the road accidents caused by dust in different years. According to information obtained, it is understood that the road accidents caused by dust in Yazd have increased from 2010 to 2014, so that in 2010, the number of accidents caused by dust was 1432, which has reached 1542 in 2014. It should be noted that the variability of this increase for this period is because in some years due to a higher frequency of dust phenomenon, for example, in 2013 more accident have occurred than a year after.

Freedman's test results at 99% confidence level also show that the highest frequency of accidents is for the year 2013. Friedman statistics for accidents are 2.25 for 2010, equal to 1.42 for 2011, equal to 2.88 for 2012, equal to 4.83 for 2013, and 3.63 for 2014.

Table 5: Friedman test values for accidents caused by dust in Yazd

	Statistical Profile	Friedman statistic	Friedman statistic
Frequency	12	2.25	2.25
Chi-square statistic	32.954	1.42	1.42
Degrees of freedom	4	2.88	2.88
Significance level	0.000	4.83	4.83
		2014	3.63

Resource: research findings, 2015

Ordinal assessment of the impact of climate conditions on road accidents

In [Table 6] order to assess the fact that from among the studied climatic conditions which one has a greater impact on road accidents, W. Kendall ordinal test is used. The results of this test at 95% confidence level show that from among the climatic conditions, dust has the most effect on road accidents of the studied route. W. Kendall statistic was obtained as 4.08 for this phenomenon. The results of this

test show that, like descriptive findings, cloudy sky has minimal impact on road accidents among the different climatic conditions with 2.23.

Table 6: Ordinal assessment of the impact of climatic conditions on road accidents

Rank	W. Kendall statistics	Climatic condition
6	2.23	Cloudy
3	3.90	rainy
4	3.55	Snowy
2	4.00	Misty (of moisture)
5	3.25	Clear (direct sunlight)
1	408	Dust (Storm)

Resource: research findings, 2016

Inferential assessment of the impact of dust on road accidents

In order to assess whether or not dust has a role in road accidents, univarite t-test is used. The results of the test at 95% confidence level, taking into account the spectral range of Likert, and utility of the number three show that dust has affected road accidents. This is because all the items are at significant level, the mean observed is larger than expected, and the statistics have positively been assessed. As the test results show, the highest test statistic with a value of 3.684 is for the overall impact of dust on road accidents.

In [Table 7] according to test results, three variables of the impact of dust on reducing visibility, the impact of dust on the main route deviation of drivers, and its overall impact on road accidents have been assessed as strong, and only the item of the impact of dust on the road facilities and consequently accidents is estimated at an average level. This shows the high relationship between dust and road accidents, especially in the studied route.

Table 7: Inferential assessment of the impact of dust on road accidents

Components	Number utility test 3					
	Test statistics	Degree of freedom	significance	Mean difference	99 level of confidence	
					Minimum	Maximum
Loss of vision	2.904	19	0.009	0.85000	0.2347	1.4626
Deviation from	3.387	19	0.003	0.80000	0.3056	1.2944
Destruction of	1.756	19	0.04	0.45000	-0.0863	0.9863
The overall impact	3.684	19	0.002	1.00000	-.4319	1.5681

Resource: research findings, 2016

Assessing the factors affecting the reduction of road accidents caused by dust

In order to identify and assess the factors affecting the reduction of the role of dust in road accidents, five variables were selected. The results show that from among the studied variables, facilities with an average of 3.86 is at the highest level of effectiveness in reducing road accidents due to dust and the performance of other organizations with an average of 3.48 is at the lowest level of effectiveness. Among the items examined, quantitative and qualitative improvement of crisis information-equipment with an average of

4.15 has the highest impact and interaction and consultation with other relevant bodies before and after the crisis with an average of 3.20 is at the lowest level of effect. [Fig. 1]

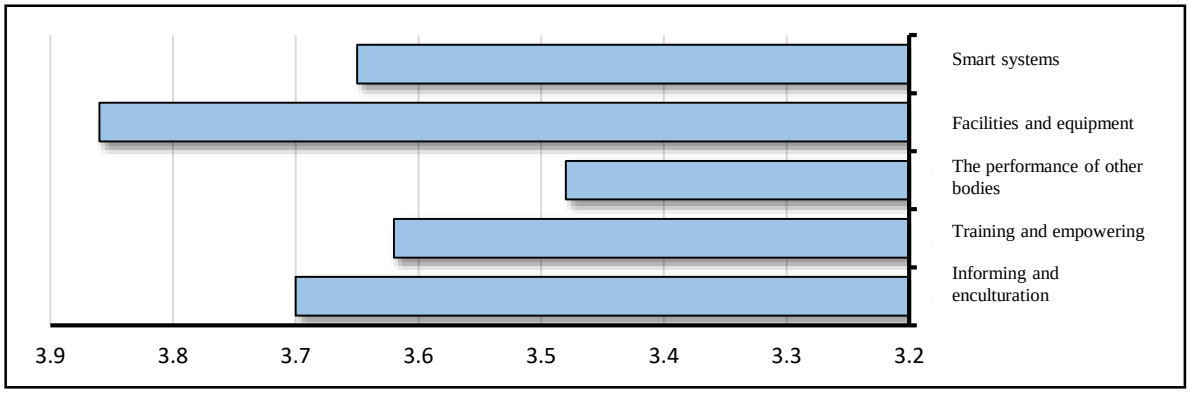

Fig. 1: Assessing factors affecting reduction of road accidents caused by dust.

CONCLUSION

1. The role of dust compared to other climatic factors is more in road accidents in Yazd.

Data analysis in Chapter 4 showed that there is a significant positive relationship between the climatic variable dust and road accidents in Yazd with 99% level of confidence (with a correlation coefficient of 0.74), so that the increased incidence of dust has increased road accidents in Yazd. This correlation between the two variables is maintained from 2010 to 2014. Thus, 55.6 percent of accidents have been due to dust, and 44.4 percent have been due to other climatic factors. Thus, dust has had a greater role in the occurrence of road accidents in Yazd compared to other climatic factors.
These findings are consistent with the results of some research done in this area. The results of the study Omidvar (2006) and Doaguyan et al. (2014) showed that most of dusty storms have occurred because of the dryness of the air, in the event of road accidents. This means that in hot and dry areas of Yazd, climatic phenomena rainfall, snow and ice, sand storms, and foggy air occur less than dust and on the other hand, there is a strong positive correlation between road accidents and dust in this province.

2. Dust has caused the most road accidents in the early spring and autumn in Yazd.

Analysis of the results in Chapter 4 indicate that from 2010 to 2014, in addition to the fact that by reduction and increase in the occurrence of dust, road accidents have decreased and increased, respectively, in different seasons, this phenomenon has existed. Frequency of the phenomena dust and road accidents, respectively, in the winter and spring has the most consistency. Thus, one part of the hypothesis that most road accidents due to dust occur in the early autumn is rejected. According to the researchers, although dust and dust storm in warm and dry the area where autumn is associated with different winds have led to the reduction in the visibility of drivers and road accidents, the majority of road accidents in the winter and spring attributed to dust may be due to other factors. These factors are such as an increase in road travel before and after the Nowrouz. However, most road accidents in Yazd have happened in spring and winter simultaneous to the increase in the occurrence of dust.

3. Trends and developments in road accidents due to dust in Yazd are increasing.

The results showed that there are significant differences between frequencies of accidents due to dust in different years. The road accidents caused by dust in Yazd have increased from 2010 to 2014, so that in 2010, the number of accidents caused by dust was 1432, which has reached 1542 in 2014.
The variability of this increase in road accidents for this period is because in some years due to a higher frequency of dust phenomenon, for example, in 2013 more accident have occurred than a year after, as the occurrence of dust storms and dust also shows a relative increase during the studied years.
However, despite this other phenomena are also associated with the frequency of road accidents in the winter and spring. The number of cars in 2010 and 2013 is not the same. This is because car production and conditions for the people buying are facilitated, and thus it is likely that in 2013, the number of cars on the road is more than in 2010 in Yazd, and this has increased the number of road accidents.
According to the findings, the following recommendations are offered.
1. The use of sand-dune movement-control methods such as mechanical methods of creating natural windbreakers (hills, planting trees) and artificial ones (concrete walls)

2. Equipping and installation of safety signs, lighting equipment along the path, especially is the path of Yazd to Ardakan.
3. Identifying, prioritizing, and the reduction of black spots for optimum services of road rescue
4. The creation of roads management centers and equipping them with electronic and communication services
5. Increasing road cleaning speed in natural incidents and road accidents, especially in areas subject to sand storms
6. Installing online GPS and satellite to show how the driver is like Isfahan
7. The participation of private sector in investment in the development of road transport
8. Establishing road shoulders in some parts of Yazd to Ardakan route
9. The creation of roadside parking in the studied road and observing standard distance between the parking lots available, and creating numerous car parks, especially in high-risk pathways
10. Organizing black spots of Yazd, including Yazd-Ardakan, Yazd-Tabas, Khatam, and Ali Abbado Neck
11. The traffic culture training, this is suggested to be offered as a course in schools
12. Acceleration in the completion of two between-road complexes named Oghda and Oghda 2 complexes given that most accidents occur between these two complexes
13. The development of public transportation, so that the most cars with the least possible rate are in the roads of Iran
14. The selection of expert consultants and contractors in the field of design and construction of roads and highways
15. Increasing traffic pathways in high traffic paths

CONFLICT OF INTEREST
None

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