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Investigating the effect of climatic factors on road accidents applying hierarchical analysis method (Case Study: Kermanshah province roads in Iran)

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Abstract

In the present study, the relationship between climatic parameters and road accidents in the road network of Kermanshah province is investigated. Because, studying road accidents, as the most important dilemma for transportation and communication networks, has the highest contrast considering human and environment. Therefore, the required data, including the data related to the accidents, accident-prone regions, statistics and effective parametric information (sunny weather, rainfall, snow, glacial, and horizontal view) during the existing statistical periods were gathered from synoptic stations and file shapes of the province. At first, applying interpolation methods, the measured point values of synoptic stations were distributed through the study area. Using reclassification procedure, the maps were classified into four groups ranging from the least dangerous to the most dangerous. They were saved as a raster. Then, multi-critical decision making method of hierarchical analysis was applied to determine the importance coefficient of each parameter. It was characterized by gathering the ideas of the experts, making the matrix of pairwise comparison, and analyzing these comparisons in Expert Choice software. At the end, the zoning of the province roads according to the effects of weather factors on the road accidents was done by applying weighted sum function by GIS software. Based on the results, it was found that sunny weather has the highest effect on road accidents in

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Kermanshah province, and precipitation, frost, horizontal visibility and air temperature are in the next ranks, respectively.

Keywords: Climatic Parameters; Hierarchical Analysis; Kermanshah province; GIS; Road Accidents.

1. Introduction

In recent years, the role of weather conditions, as the most essential factor in the accidents, have attracted the attention of most researchers. In fact, meteorological services, and informant weather services in transportation system not only increase the awareness of the travelers from road conditions but also are considered so important for the managers and tolls. Fortunately, there was a considerable development in applying road- meteorology for more safety, economic efficiency, and optimal use of the roads (Asyaei and Samadineghab, 2006). Although weather conditions may not be considered as the main reason of the accidents, they are undoubtedly one of the major environmental components (Habibi Nokhandan, 2005).

The occurrence of accidents among the vehicles is one of the effects of road transportation network accompanying by majority of problems, like damages, crowd, waste of time and fight (Ahmadinezhad *et al*., 2008). The accidents mostly take place when the vehicle cannot be coordinated with the surrounding area. Lack of coordination may be the result of human mistakes, road, vehicle and environment, although the environmental factor has been ignored replaced by the other factors. Except for human, vehicle, and road, any factor, which affects the action of the driver, vehicle, and car control leading to accident is called environmental factor. As a matter of fact, climatic factors are considered as the most effective environmental ones in which rainfall and snowfall, especially in winter, have more crucial role in the occurrence of accidents (Sadredini Mehrjordi, 2005).

Unfortunately, road accidents are introduced as the main reason of early death after heart disease in Iran. According to the latest accident statistic, it turns out that 26888 people have been killed and 12000 ones injured in road accidents which is 45 times more than the injuries of driving accidents in industrial countries revealing a terrible event which is repeated every year without any solution.

Due to the increasing development in scientific experiences about road-meteorology, there are regional, national, and international conferences in different parts of the world every year. For the first time, studying the role of climate in road accident was presented in transit road of Liverpool-Hall, England, in 1960. Besides, the effect of geographical factors on road networks has been investigated in which climatic factors have been strictly regarded as one of the main parameters (Falahtabar, 2000).

Jahanbakhshasl *et al*. (2009) tried to investigate the road accidents of Tabriz-Miyaneh road in snowy, rainy, and icy weather and the average temperature during a three-year statistical

period (2003-2005). They used the hourly data of Tabriz-Miyaneh meteorology stations to find the role of this phenomenon in the occurrence of road accidents. Moreover, the data from the stations were compared with weather reports of police in the time of the accidents. Out of 3960 accidents of the road, the highest number was recorded in icy weather (1112), snow (1036), rainfall (935) respectively and the average temperature (877). Pirouti (2010) investigated the effects of climatic parameters on road accidents of Sardasht-Orumiye road. He analyzed the data related to the accidents and climatic hourly data of the aforesaid roads during a 2-year period (2005-2007) by applying regression and interpolation analysis. Climatic parameters, namely, temperature, glacial, snow, rain, cloudiness, precipitation, horizontal view, relative moisture, and sunny hours were regarded as the independent variants while the occurred accidents in the area as the dependent variant. The findings show that precipitation parameter has the highest effect on the accidents. Moreover, it turned out that the accidents mostly occurred in sunny days.

FarajzadehAsl *et al*. (2011) studied the effect of weather conditions on road accidents of Karaj-Chaloos road. Applying topography map 1:250000 and accident reports of the checkpoint, the hazardous accident-prone points were analyzed in each weather conditions (sunny, cloudy, etc.). The findings revealed that the points in the kilometers of 17, 20, and 41 in sunny weather, the kilometer of 62 in cloudy weather, the kilometers of 40 and 70 in rainy weather, the kilometers of 40, 60 and 62 in snowy weather and the kilometers of 60, 62 and 65 in foggy weather have the highest frequency of the accidents regarded as the most dangerous points. In a study, Asakareh (2010) analyzed the road accidents taking climatic attitude to investigate the relationship between spatial distribution of the accidents and climatic phenomena like rainfall, fog, dust, temperature, moisture and wind. Therefore, he applied the hourly data of meteorological stations of Ahvaz, Abadan, Bostan, and Hamidiye extracting weather conditions in the time of accident occurrance. Mahinfar (2011) studied the effects of climatic factors on road accidents in Esfehan-Samiram. Making a spatial data base of the road by the statistics, he investigated hazardous points. It was concluded that the accidents are likely to be increased in higher regions facing more severe climatic conditions like rainfall and glacial. Totally, the role of severe conditions is less than sunny weather.

Shahabi *et al*. (2011) investigated the role of climatic conditions on the road accidents of Saghez-Sanandaj providing distribution map of the accidents and the possible risk of accident for each climatic condition (snow, rain, fog and sunny). Applying descriptive-analytic method during a 15-year period, Kamyabi *et al*. (2013) focused on the relationship between the possible risk of accident and glacial in the main roads of Semnan to recognize the network roads of Semnan and the effect of glacial on the accident occurrence. Moreover, he tried to demonstrate the hazardous points according to ground reference statistics in geographical information networks to present management strategies

decreasing the risk. The findings indicated the time and spatial distribution of the glacial beginning and end.

Ghafari *et al*. (2013) aimed at finding the impacts of meteorological phenomena on the number of the accident occurrences in Sanandaj-Marivan roads, so he gathered the statistic during a 3-year period and hourly data from synoptic stations of the province. Using 90-meter DEM of the region, topographic maps, height level maps, direction map and slope map were drawn. The related level to the studied region and road level were added in the next step. Then, the risk map of accident occurrence was drawn for each weather condition in the environment of GIS by applying correlation, linear regression, multiple regression, and Spline interpolation method. Teymouri (2014) investigated the role of cold weather and glacial on road accidents of Tehran-Fasham. Therefore, he analyzed the road accidents of Tehran-Fasham in rainy, snowy, foggy, cloudy and sunny weather during a 5-year period (2008-2012). It turned out that sunny weather had the highest number of accidents, while the other weather conditions had the same role. He believed that inappropriate weather factors have increasing effects on road accidents.

Andrey *et al*. (2002) analyzed the risk of the accidents from weather conditions in Ottawa-Canada. They found that rainfall and snowfall have considerably increased the risk of death and property damage accidents, although the role of rainy weather was greater than snowy weather. Moreover, he concluded that the accident rate on the weekend is higher than weekdays, especially in winter. As a matter of fact, early precipitations on winter made more accident risk than natural seasonal precipitations. Keay and Simononds (2006) studied the relationship between precipitation and other climatic variants and road traffic volume in Melbourne-Australia concluding that the risk of accident occurrence increased during humid periods and the period after the precipitation. Furthermore, rainfall was considered as the most important factor having the highest influence on decreasing traffic volume in rainy days during winter and spring.

Hermans *et al*. (2006) explored the effect of different weather conditions on road safety analying 17 climatic parameters in Netherlands. He found out that the increase of wind speed led to the increase of accident occurrence. Moreover, radiation has negative effect on road safety, while cloudiness had a positive effect. Although rainfall had the highest influence on the road safety, the length of precipitation had more effect than the precipitation volume. Cools *et al*. (2010) also tried to investigate the effects of weather conditions on the intensity of traffic and daily accidents in Belgium. The findings revealed that rainfall, snow and wind speed decrease the traffic intensity, while high temperature increases traffic intensity. Jaroszweski and McNamara (2015) presented a new method to analyze the effect of rainfall amount on road accidents applying radar data in meteorological prediction and weather parameter estimation during a 3-year period (2008-2011) in Manchester and London. They argued that the aforesaid method is able to analyze the events from weather phenomena.

Previous studies prove that weather conditions are one of the most essential natural factors affecting road transportations and accidents which threat the properties and lives of people. The findings reveal that some of these occurrences can be controlled provided that the effect of climatic parameters and factors are recognized and managed appropriately. Therefore, property and death damages from these occurrences can be prevented. The present study aims at analyzing the accident zoning of accident risk hierarchically in Kermanshah roads applying meteorological data, interpolation methods, and multi criteria decision making method.

2. Martials and methods

Kermanshah province with the approximate area of 24434 km^2, 1.5 percent of the country area, is located in the western side of Iran, from 33° 42' to 35° 17' northern latitude and 45° 24' to 48° 6' eastern longitude from prime meridian. Kermanshah, as a western province, shares border with Iraq in the west, Kurdistan in the north, Lorestan and Ilam in the south, and Hamedan in the east. The capital is Kermanshah. According to the last country division, the province includes 14 cities, 31 sections, 86 rural districts, and 31 towns in which 69.7 percent and 30.3 percent of the population are living in urban and rural areas respectively. The cities are Kermanshah, Islamabad, Paveh, Javanrood, Songhor, Sarpol-e-Zahab, Kangavar, Gilan-e-Gharb, Harsin, Sahneh, Ghasr-e-Shirin, Dalahoo, Salas-e-Babajani, and Ravansar. The province is presented in Figure 1.

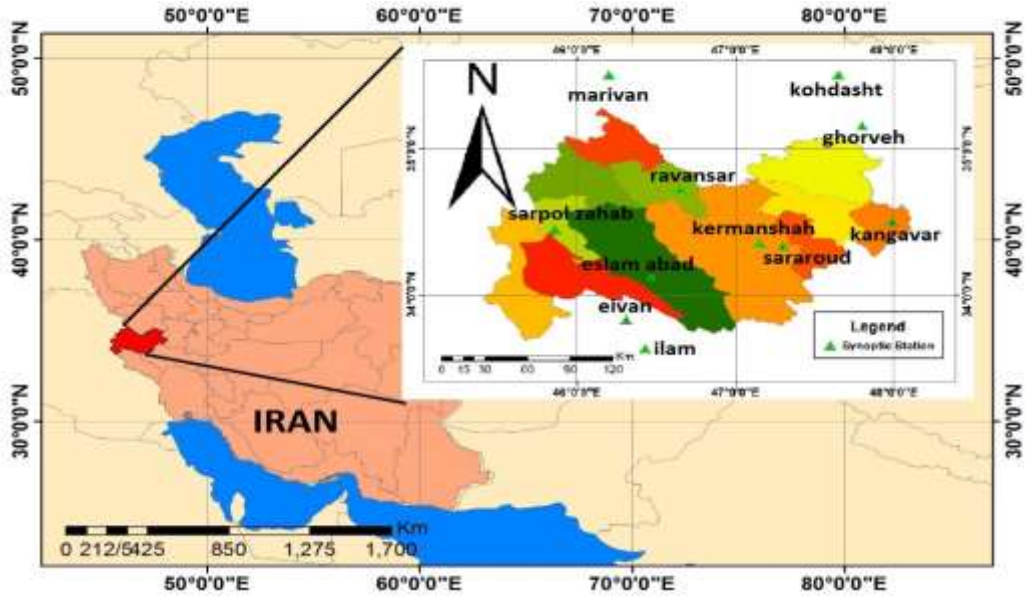

Figure.1. The study area of Kermanshah province (using GIS Software)

The province climate is affected by humid Mediterranean regime and has annual rainfall average of 300 to 800 mm. Kermanshah province has different climates: cold semi-arid, cold Mediterranean, hot semi-arid, dry and hot, moderately humid, and moderately humid (Kermanshah province Textbook database, 2011).

The data used in the present study include long-term monthly average of climatic parameters of the province synoptic stations (sunny hours during a day, the amount of precipitation, snow, glacial, horizontal vision distance and air temperature), related statistic to road accidents of the province in 2015 which was recorded in special forms called death and injury reports of the roads by traffic police, location information including descriptive tables of accident-prone regions of the province from 2013 to 2015, and digital maps of the province limits, cities, the roads, urbane points, and etc.

Kermanshah has six synoptic meteorological stations which measure, record and gather climatic data. Besides, the meteorological data of neighboring provinces were used to increase the accuracy and decrease the errors of the computations. As a result, not only is geographical distribution of the area extended, but also the accuracy of the computations in interpolation increases. Table 1 presents the information of the stations and length of statistic period.

Table 1. Applied information of synoptic stations in Kermanshah province (Iran Meteorological Organization- https://www.irimo.ir/eng/index.php)

Station name	Longitude	Latitude	Height (m)	Statistical Period
Kermanshah	47° 09´	34°21´	1318.6	2015-1951
Ravansar	46° 39´	34° 43´	1380	2015-1998
Sarpol-e-Zahab	45° 52´	34° 27´	545	2015-1986
Islamabad	46° 28´	34° 07´	1349	2010-1987
Kangavar	47° 59´	34° 30´	1468	2015-1987
Sararoud	47° 15´	34° 20´	1361.7	2010-1989
Ghorveh	47° 48´	35° 10´	1906	2015-1989
Marivan	46° 12´	35° 31´	1286.8	2015-1992
Towiserkan	48°26´	34° 33´	1783.2	2015-2003
Malayer	48°51´	34° 15´	1777.8	2015-1992
Kouhdasht	47°39´	33° 31´	1197.8	2010-1997
Ilam	46° 26´	33° 38´	1337	2015-1986
Ivan	46°19´	33° 50´	1170	2010-1999

The six effective climatic parameters on road accident occurrences are used herein including air temperature, precipitation, horizontal view, ice and glacial and sunny weather.

Heat and cold are regarded as the effective parameters in the accident occurrences. Heat can relatively make danger for the drivers, although cold is one of the most dangerous disasters which influence transportation making an icy layer on the roads. Long-term average of the days with maximum temperature of 30 °C and more was applied to investigate the role of heat in road accidents. The findings indicate that the most and the

least hot days are recorded for Sarpol-e-Zahab station and Kangavar station respectively. Besides, the days with minus temperature were used to study the effect of cold.

Precipitation is one of the essential and effective factors in the transportation and traffic of the roads which has always been making problems for drivers. It leads to slow motion, slippery roads, loss of vision, road closure, and etc. The days with precipitation more than zero was used as precipitation parameters. It turned out that Sararoud station, with annual long-term average of 81.6 days, and Sarpol-e-Zahab, with annual long-term average of 65.9 days, have the highest and lowest amount of precipitation, respectively.

Since, high height of mountainous roads and climatic differences cause numerous problems for road users in cold months along the roads, the accidents affected by sudden decrease of temperature and cold make a lot of property and death damages (Dolatimehr and Samadzade, 2008). This phenomenon, which is caused by dramatic decrease of energy through the region, has more frequency in cold months. Therefore, the days with maximum zero or less temperature were used to investigate this parameter. Accordingly, Sarpol-e-Zahab station with no days with zero or less temperature and Sararoud with annual average of 9.5 had the least and the iciest days respectively.

Snow is one of the climatic phenomena which play an important role in the occurrence of road accident and disorder in road transportation. In fact, snowfall leads to extreme slippery roads, so the cars are out of control. Therefore, the average of snowy days or the ones with slush were calculated during the statistic period revealing that Ravansar station with the average day of 20.9 and Sarpol-e-Zahab with the average day of 1.4 days had the most and the least snowy days respectively.

Driver's view during driving is one of the most effective elements in road accident occurrence. In other words, if the driver's view decreases due to the factors like fog, dust, and snowfall, the accident occurrences will increase. Therefore, long-term average of the days with the view less than two km was prepared indicating that Kangavar station with 32 days and Sararoud stations with 12 days had the most and the least days with the view less than two km respectively.

Furthermore, mild and cloudy sky is the other condition which can be considered as a factor in accident occurrence. It is recorded in the accident reports by accident experts. Accordingly, the mild and cloudy days for the province synoptic stations were extracted revealing that Sarpol-e-Zahab station had the mildest days while Kermanshah and Sararoud stations had the cloudiest days. Furthermore, Kermanshah station had the least mild day while Islamabad had the least cloudy days. Sunny hours are the other effective climatic factor in road accidents. This factor, especially in hot regions or summer, makes the drivers too tired which not only remotes them from the ideal condition, but distracts them leading to accident occurrence. Besides, driving in the direction of sun sometimes causes accident. Long-term average of sunny hours of the province synoptic stations was used to find the

effect of sun. The results showed that the sunniest hours were recorded for Islamabad, more than 3068 hours, and the least for Sararoud station, 2820 hours.

Gathering weather data from synoptic stations of the studying area, they were entered to Excel environment and making a location data base. Entering them to GIS environment, the related statistic to the stations was generalized to the whole region by applying geo-statistical interpolation methods.

Since the meteorological data are continuous, they are not measurable in all levels. As a result, they are gathered mostly as point samples which have to be generalized to the surface. Therefore, it is necessary to rebuild the meteorological data of neighboring regions based on the data collected from the synoptic stations of the Iranian meteorological organization in Kermanshah province (https://www.irimo.ir/eng/index.php).

The process of information estimation based on the sample data for the regions with no meteorological information is called spatial interpolation. Interpolation methods are a collection of different mathematical and statistical models used for non-finite values. In the present study, two famous interpolation methods, IDW (for the parameters affected by distance like temperature and precipitation) and Kriging (for the phenomena like horizontal view and sunny hours) were applied (FarajzadehAsl *et al*., 2011).

As there was no complete information about climatic conditions in accident occurrence available, the importance of each parameter was specified applying hierarchical analysis and Expert Choice software (Saaty, 1980).

In the science of decision-making, in which the choice of a solution among the existing solutions or the prioritization of solutions is discussed, the methods with Multiple Attribute Decision-Making (MADM) have been proposed in scientific studies. Among these, Analytical Hierarchy Process (AHP) method has been used more than the other methods in management science (Saaty,1980). This process is considered as the most famous method of multi-object decision making which was invented by Saaty in 1980s. Besides, Hieratical Analysis is used when decision making is facing some rival options and decision making criterion. It is basically dependent on pairwise comparison. The decision maker starts by providing hieratical tree which shows the stage of decision, comparison elements and evaluated rival options in decision. Then some pairwise comparison is done indicating the weight of each factor to the evaluated rival options in decision (Saaty, 2008). The comparisons are presented in Table 2.

In fact, the logic of hierarchy analysis combines the matrix from pairwise comparison in a way leading to optimal decision. Finally, arranging the layers in GIS software, the zoning map of the accident risk in the roads and climatic conditions are made. In the present study, weighted sum method is used for overlay layers, although it can be done in GIS software with different functions. In this method, necessary calculations can be done on various raster layers according to optional coefficient (the criterion value). This method provides

the advantages in which not only does it not need to convert the coefficient scales (converting to percentage), but also decimal data and coefficients can be used.

Table 2. The values of the indices regarding each other

Explanation	Comparison of i and j	Preference Value
i scale equals j scale.	Equal importance	1
i scale is a little more important than j scale.	Rather more important	3
i scale is more important than j scale.	More important	5
i scale is much more important than j scale.	Very important	7
i scale is really much more important than j scale, and cannot be compared at all.	Completely important	9
It shows intermediate values, for instance, 8 has more value than 7 and less than 9 for i.	-	2,4,6,8

3. Findings and Discussion

Interpolating the aforesaid climatic factors according to the data from synoptic stations (Table 1), the layers were reclassified in order to smooth out the data in a raster layer, applying equal interval method. The maps were classified into four classes including too much danger, much danger, average danger, and little danger. Based on the implementation of the model by GIS, the interpolation maps calculated for each parameter are shown in Figures 2 to 7.

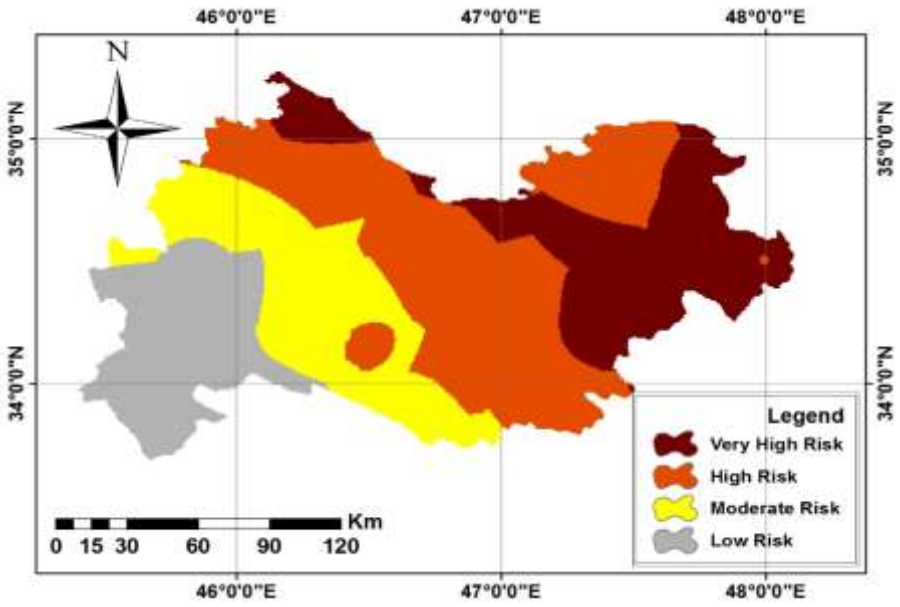

Figure 2. Classified map of rainy day average in Kermanshah Province

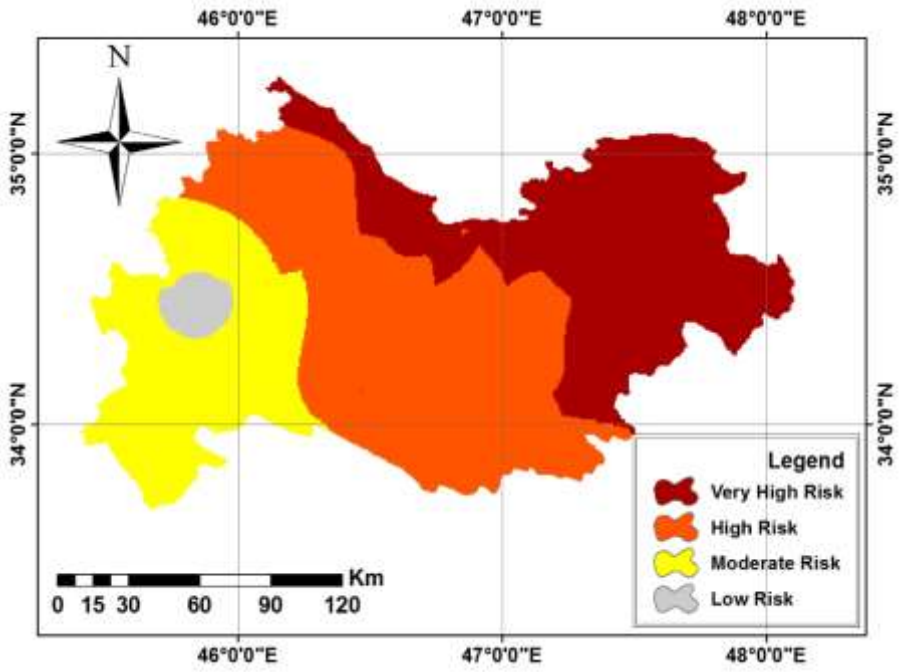

Figure 3. Classified map of snowy days in Kermanshah Province

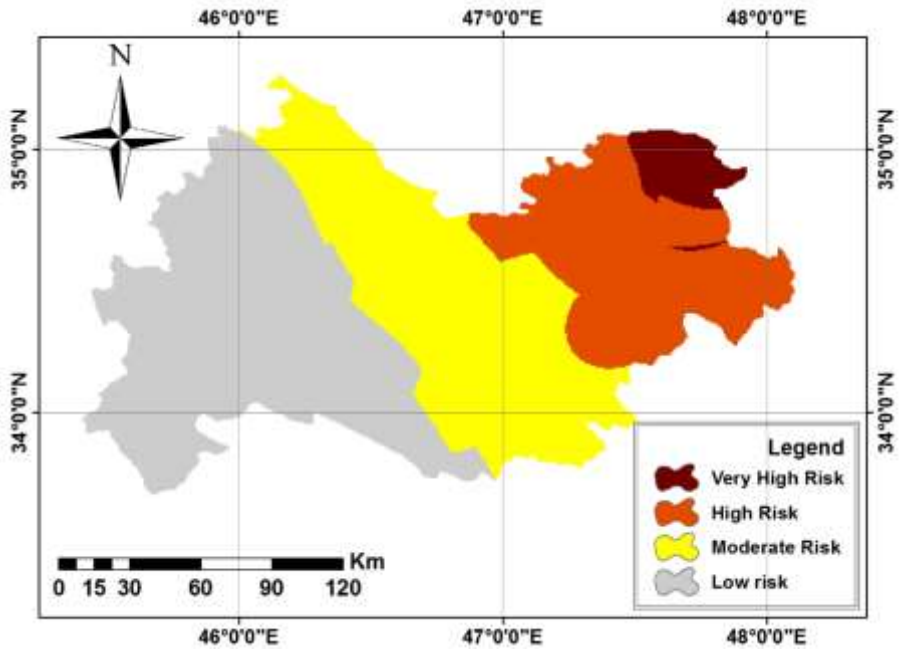

Figure 4. Classified map of glacial days in Kermanshah Province

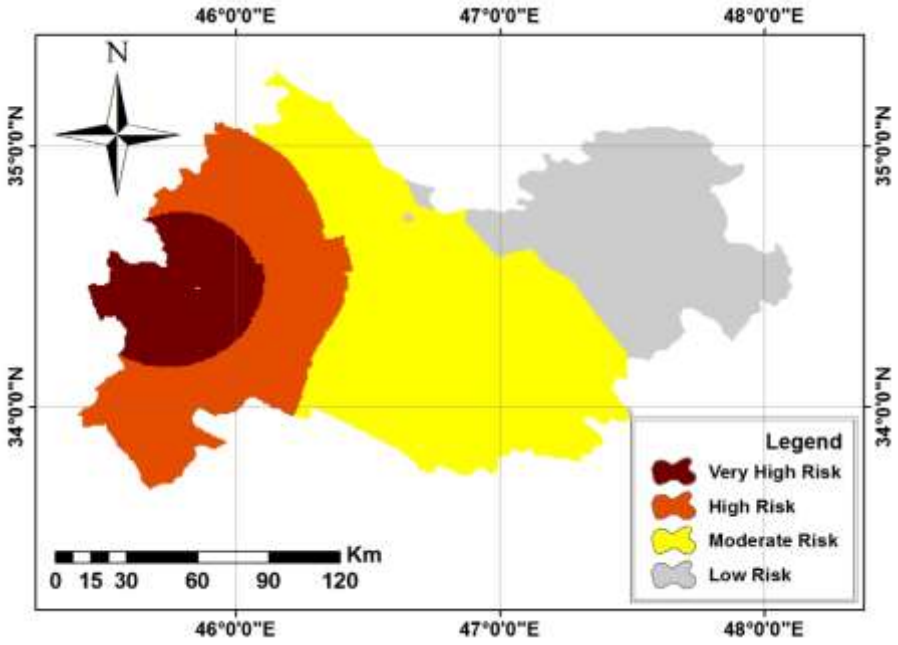

Figure 5. Classified map of the view less than 2 Km in Kermanshah Province

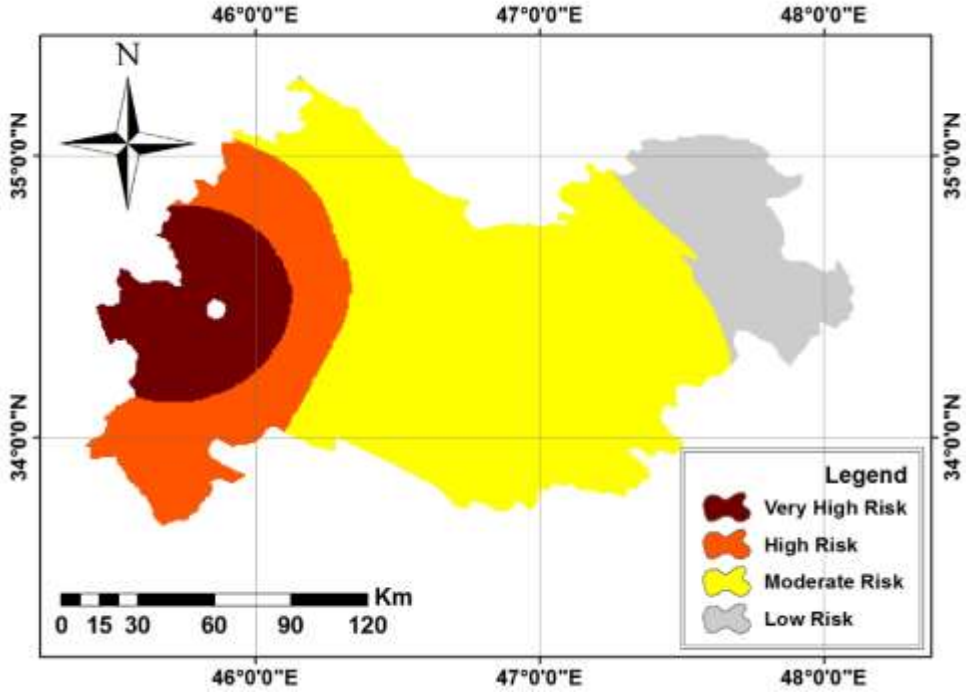

Figure 6. Classified map of sunny hours

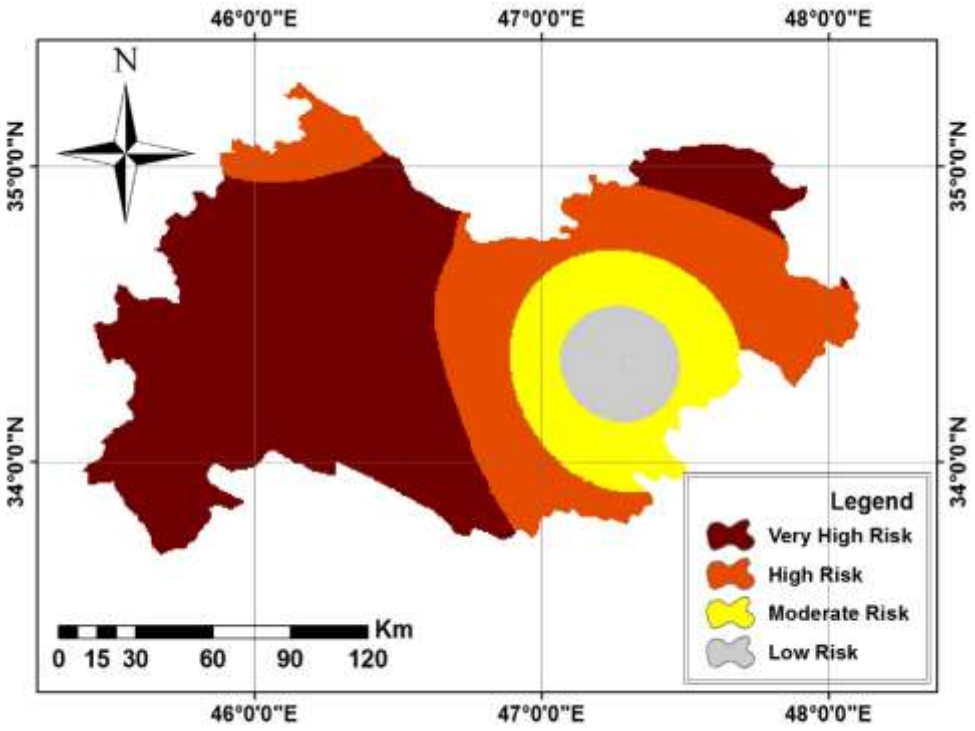

Figure 7. Classified map of the days with 300C or more in Kermanshah province

Applying parameter pairwise comparison questionnaire, the experts' attitudes about the importance of each parameter were gathered to determine the importance coefficient of each criterion. The matrix for each criterion is presented in Table 3.

Table 3. Matrix of the criterion pairwise comparison

	Clean air	Rainfall	Snow	Glacial	Horizontal view	Heat
Sunny	1	5	4	5	6	6
Rainfall	0.2	1	0.5	0.5	3	3
Snow	0.25	2	1	2	4	2
Glacial	0.2	2	0.5	1	3	0.5
Horizontal view	0.16	0.33	0.25	0.33	1	0.5
Temperature	0.16	0.33	0.5	2	2	1

The final score is achieved by mixing the importance coefficients in Expert Choice 11 software (Saaty, 1980), shown in Table 4.

Table 4. Calculated weight for each criterion

Criterion	Sunny	Rainfall	Snow	Glacial	Horizontal view	Temperature (°C)
Importance percentage	0.473	0.116	0.168	0.107	0.044	0.092

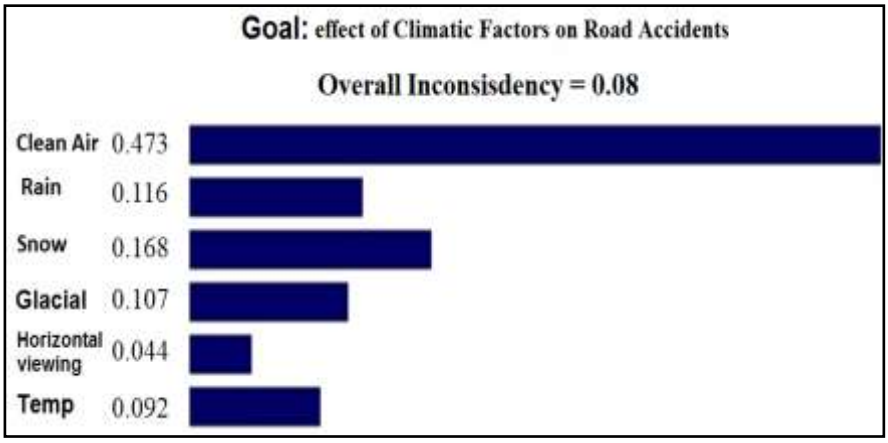

Figure 8. The coefficient for each criterion and inconsistency rate (study results)

In hierarchical analysis, inconsistency rate is considered less than 0.10 (Saaty, 2003), otherwise they should be reconsidered. According to the calculations by the software, the inconsistency rate of the comparisons is 0.08 proving that they are trustworthy.

When the criteria, information layers in GIS, are prepared, overlaying of the layers is done by the coefficients. These criteria are used as raster in making decision. Therefore, the aforesaid 6 layers, which were classified in previous steps, are entered the software. Zoning map of the region about the effect of weather elements on accident occurrence is made. Figure 9 shows the findings from the calculations.

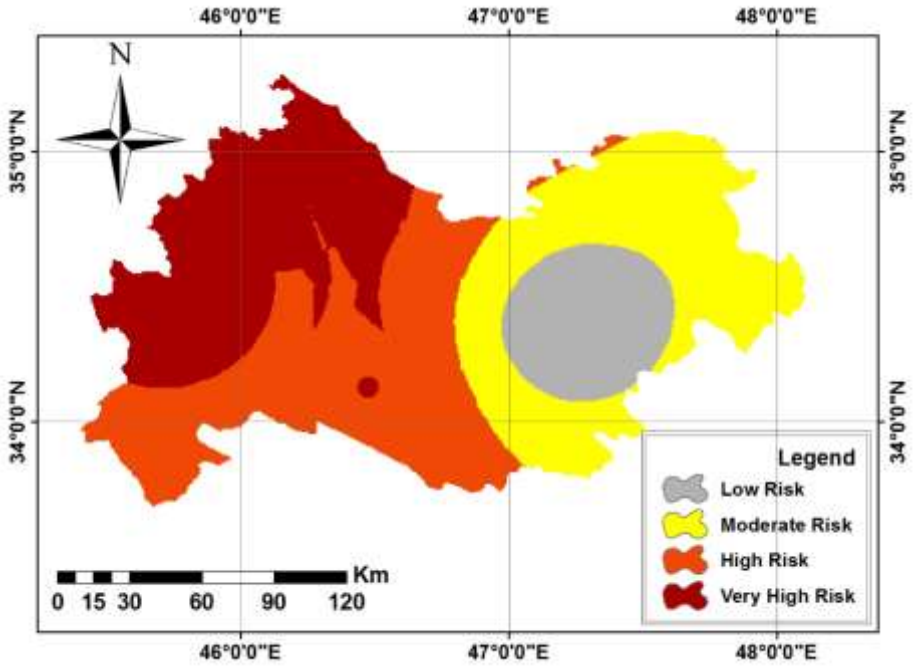

Figure 9. Zoning map of Kermanshah province according to the effect of weather elements on the road accidents

As can be seen, by GIS software zoning map of the region is made by applying the coefficients on the layers and reclassifying the map into 4 levels. Locating 260 accident-prone points obtained from the road accident reports, it turns out that most of accident-prone regions are located in the regions with too much danger, presented in Table 5.

Table 5. The area percentage of each danger zone of accident by GIS sof ware in Kermanshah province

Danger rate	Little danger	Average danger	Much danger	Too much danger
Area percentage	3.1	33.9	33.7	29.3
Accident-prone percentage	3	31.2	21.2	44.6

According to Table 5, the regions with little danger covers a small part of the studying region. In contrast, the regions with too much danger, occupying less area than the other two regions, include more accident-prone regions significantly. The regions with average and much danger, covering 67% of the region area, include a half of the accident-prone regions (Table 5). Therefore, the findings from the calculations and the comparison of the accident-prone regions prove the accuracy of the results. Hosseini (2011) reported 44% of the accidents in sunny weather for Baneh-Saghez road; Sari Sarraf *et al*. (2012) showed 43% of the accidents in sunny conditions for Tabriz-Jolfa road, Pirouti (2010) indicated 46% of the accidents in sunny weather and 19% for cloudy weather for Sardasht-Orumiye road. To justify, it is supposed that this weather condition leads to more travels and traffic in which the drivers drive in maximum speed and do not observe the driving rules. Unlike the eastern part of the province, the western half has less sunny days and cloudier and semi-cloudy days due to more height. Therefore, the roads located in eastern half face more accidents. On the word, the zoning map of the road danger about the effect of weather elements on road accident of Kermanshah province, it is revealed that the roads with average danger are located in western half of the province in Islamabad, Kermanshah, Harsin, Sahneh, Songhor, and Kangavar. Besides, the roads with much danger are found in western cities like Ghasr-e-Shirin, Gilan-e-Gharb, Sarpol-e-Zahab, Islamabad, and Kermanshah and partly in eastern cities. In contrast, the roads with too much danger are mostly located to the north of the province including Javanrood, Sala-e-Babajani, Paveh, Ravansar, and Islamabad. The map is presented in Figure 10.

Conclusions

The relationship between the climatic parameters and road accidents of Kermanshah province has been studied by AHP method. The data included road accident reports, accident prone points and effective weather parameters from the province and neighboring synoptic stations it was gathered. The distribution of the measured point value was determined through the region by applying reverse interpolation of weight distance and Kriging methods. Then each map was classified into four classes from little danger to too much danger saved as a raster. Since the data about the accident occurrence in different weather conditions and the number of effective parameters on accidents were not complete, multi criteria decision making method of hierarchal analysis was applied to determine the

importance coefficient of each parameter. It was done by Expert Choice software. At the end, using weighted sum function in GIS software, the zoning map of the province roads according to the effect of weather elements on road accidents was prepared.

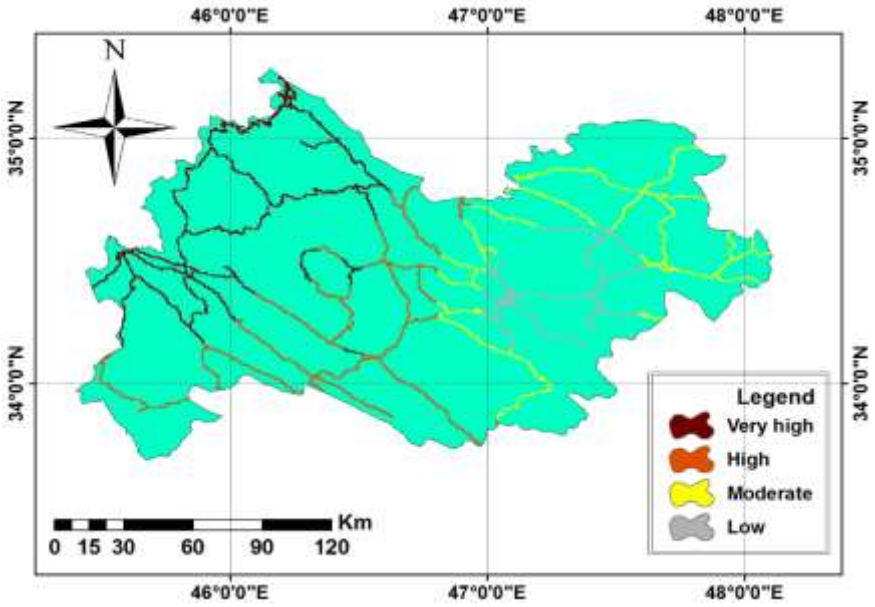

Figure 10. Zoning map of the province roads according to the effect of weather elements on accidents

When the elements were compared by pairwise comparison and the comparison matrix was analyzed, it turned out that the highest coefficient, approximately 0.44, is related to mild days and sunny hours. The snowy and rainy days are in the second and third place. These factors not only make the road slippery and out of control for the drivers, but also affect the horizontal view of them, especially at nights, leading to accidents. The related maps reveal that western half face more accidents due to more precipitations.

Glacial is also considered as another weather element in the occurrence of the accidents, locating in the 4th stage. Like precipitation, this factor is influenced by height making more accidents in high regions.

Air temperature is the 5th factor which make the drivers tired and sleepy increasing the risk of accident. Unlike glacial, this element affects low lands, so makes more accidents in eastern half.

Last climatic parameter, horizontal view, has the least importance coefficient. Since the drivers do not have enough view, they drive in safe speed. It was revealed that eastern roads of the province are more in the risk of accident. The findings from road zoning, based on the effect of weather elements on road accidents, are presented in four levels in Figure 10. Generally, it can be said that the roads of the province can be divided into two parts, eastern and western, according to the role weather elements in road accidents. Western half often

covers the roads with little and average danger. In other words, considering weather conditions, the roads with less risk of accident are mostly ended to Kermanshah. On the contrary, according to the effect of climatic elements, the roads with much danger are located in southeast half, and the roads with too much danger are located in northeast half. Accordingly, 126 km of the roads are in less dangerous, 727km in mid dangerous, 370 km upper-mid dangerous and 928 km in the most dangerous regions

Furthermore, there is a high convergence in the regions with high density of risky points and the roads with too much and much danger proving the accuracy of the calculations. Considering the heavy losses and casualties of road accidents, as well as the climatic diversity of Kermanshah province, it is suggested to establish road weather stations along the routes, especially in high and very high risk areas.

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