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A Prioritization Model for the Immunization of Accident Prone Using Multi-criteria Decision Methods and Fuzzy Hierarchy Algorithm

Hasan Ziari*, Amir Amini, Amir Saadatjoo, Sayyed Mohsen Hosseini, Vahid Najafi Moghaddam Gilani

School of Civil Engineering, Iran University of Science and Technology (IUST), Tehran, 16846-13114, Iran

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Fuzzy hierarchy algorithm.

Abstract

Suburban accidents are more significant than intercity accidents in terms of both material and spiritual damages due to the vehicle's high velocity. Based on the statistics, the mortality rate in suburban routes accounts for more than 69% of total casualties caused by accidents in Iran. In this study, it has been attempted to determine a model for assessing and prioritizing the immunization of accident prone sections of Qazvin-Abyek-Zanjan highway using various methods such as economic analysis, accidents intensity (RSI), Bayesian probability in accident prediction, AHP-GIS and AHP-Fuzzy. The results showed that the ranking of the accident prone sections' correction is affected by the type of pattern and indicators used to assess the safety of the sections. Finally, with the implementation of fuzzy hierarchy algorithm, using the survey of safty specialists and determining the weights of input factors to the model by the expert choice (EC) software and fuzzy function, a comprehensive model is presented for assessing and prioritizing the correction of incidental events. According to the model's acheivements, Buin Zahra-Rahim Abad three way with BSIP index of 0.596 meets the highest correction prioritization among the different sections, while Qazvin-Buin Zahra section has the lowest one with the BSIP index value of 0.148.

1. Introduction

During the recent years, due to the inappropriate status of road accidents in Iran, many actions have been carried out to ensure the safety of traffic and improve the performance of the transportation industry. The average annual cost of road accidents and their damages is estimated as 1% of the gross national product for the low income countries. This value is calculated as 1.5% for the medium income countries and 2% for rich ones and those with high incomes. The annual cost of the accidents is estimated over than 518 billion US dollars around the glob from which nearly 65 billion dollars is the portion of low income and medium income countries [1].

Based on the available statistics, the mortality rate in suburban routes constitudes more than 69% of the total casualties due to the accidents of Iran. Although suburban accidents due to the high velocity and collision's intensity are less in terms of the number of accidents than the intercity ones, they are more important from the aspects of the material and spiritual damages. As illustrated by several researches, the ratio of the number of suburban accidents to the urban ones was estimated as 0.5 in 1997. However, the damages cost ratio of the suburban crashes to urban ones was about 3.5. Based upon these statistics and the relation between the cost and accidents intensity. suburban accidents meet the intensity of 6.5 times than the urban collisions [2].

During the recent years, various studies have been carried out on the subject area of traffic safety and prioritization correction of the accident prone sections in the world and in Iran.

In 2007, Moreno and his coassociates investigated and identified the incidental points by implementing Bayesian multi-criteria methods. The aim of that study was to rank the specified areas and determine the place or point of danger in detaile as well as accurate review as the first step in improving the transportation safety. In this research, two methods of Bayesian structure are imployed including the Bayesian test with weights (BTW) and Bayesian test controlling for the posterior false discovery rate (FDR) or false negative rate (FNR). The hypotheses tests are implemented on the basis of two random effect or Bayesian models, namely, the hierarchical Poisson-Gamma or negative binomial model and the hierarchical Poisson model. Present acheivements showed that using the hierarchical Poisson structure is more effective for modelling the accidents data and the model selection has a considerable impact on the results [3].

* Corresponding Author:
E-mail address: h.ziari@iust.ac.ir – Tel, (+98) 2177243100 – Fax, (+98) 2177240398

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Agrawal et al. introduced the ranking method for the hazardous places of the road based on the safety index and using the AHP [4]. They used a four-step hirerchical structure for identifying and ranking the hazardouse locations in the straight sections of the highways, curves and intersections. Washington and co-authors in a study in 2013 identified the accident prone sections using the equivalent property damage only (EPDO). They have attempted to introduce a simple as well as effective method of determining the damages caused by the accidents and the incidental points of the roads by means of mixing the costs in terms of the developed EPDO criteria. The results of the study which carried out on the local roads of South Korea illustrated that using the developed criteria EPDO has a suitable ability for determining the high-risk locations and correcting them with regard to the productive costs [5].

Using the generalized pareto distribution (discontinuous model with three parameters), Perito et al. [6] suggested a model for determining the accident prone points of road incidents. They have attempted to clarify that the occurences of the road traffic network for the specific accidents, named as the adventurous points, may be determined by the use of the simple probabilistic distribution models. They used the accidents data of Spain between 2003 and 2007 and the data collection were simulated by implementing the generalized pareto distribution models and lumax discrete distribution. The results further show that the probabilistic models are capable of detrmining and analyzing the incidental points of road accidents [6].

In a study in 2015, Fancello et al. investigated the safety condition of road transportation using quantitative and qualitative data. In their study, the number of accidents, traffic flow rate, lane width, shoulder width, road curvature, access-point density, and signs and marks beside the road have been considered as the effective parameters on the safety. The appropriate points of correction have also been determined by analyzing the roads specifications under the effect of these parameters. Furthermore, it has been attempted to examine road's safety condition by multi-criteria analyzing process and determine a simple as well as appropriate model based on the case studies for assessing the safety index [7].

Due to the high importance of the safety in road transportation, several other studies can be found in the literature dealing with this subject. From the applied methods for the determination of the road safety index, various models can be found including the generalized predictive [8], mixed regression [9], three-step counting [10], random effects [11], random parameters [12], Bayesian hierarchical [13], artificial neural network [14] and zero-inflated Poisson [15] models.

The main impetus of the present study is to determine an assessment model and correction prioritization for accident prone section based on the inclusive safety index for Qazvin-Abyek-Zanjan highway as one of the most prominent connective highway of Iran. To do this, first, the classical prioritization methods of accident prone sections such as the economical analysis of profit to cost (B/C), RSI, statistics and Bayesian probability in accidents prediction, AHP and the combined method of AHP-Arc GIS will be used. Next, a comprehensive model based on the factors affecting the strategic performance of the traffic safety is presented by combining the different analyses within the frame of the AHP-Fuzzy combined method. In addition, the presented model, provided that the necessary data is available, is capable of prioritizing and evaluating all the roads in the country and improving the safety of the accident prone sections.

2. Research Methodology

With respect to the fact that the goals considered in this study include more than one indicator and each indicator more than one sub-indicator, weighing and valuing the goals and indicators accounts for the design necessities of the safety prioritization pattern. Several approaches are available for weighing to the under studed y indexes. which The weightings are mainly based on the specialists's opinions and each one has their its own advantages and disadvantages. In the present current study, weighing the goals and indexes in the field of safety is also performed using the experts' opinions as well. Using an appropriate method for weighing the experts' opininions is of a high importance. Otherwise, the final model is inable of presenting satisfactory results. It has been efforted in this study to use different approaches for the correction as well as betterment prioritization of the accident prone sections. The dDifferent implemented methods are described in the following sections.

2.1. RSI

In this criteria, the classified model of the traffic safety index in is defined considering the three indexes associated with the accidents intensity. These indexes include the accidents intensity recommended by Portugal's association of the roads (IG), EPDO index recommended by the global association of the roads (PIARC), and the intensity index (SI) which stands for the ratio of the type to the number of accidents. and itThe latter is was recommended by the transportation center of Alabama University (UTCA) [16].

The three mentioned intensity indexes describing the effect of accidents on different sections of the road network are based on the variaous principles. The IG parameter only determines the safety index based on the relative severity level of the accidents . The EPDO parameter solely defines the safety index according to the financial damage caused by the accident, while, SI evaluates the intensity based upon the injuries and financial losses considering the accident cost and according to each section's accidents rate [17]. The IG parameter is has been definedgiven by Portugal's association of the road as in Eq. (1)

$$\mathrm{IG} = (100T_A + 10T_B + 3\, T_C) \qquad (1)$$

In this relation, IG is the intensity index, TA, TB and TC stand for the number of fatal, with severe injury, and damage accidents, respectively. To define the importance level of each criteria, it is necessary to specify a weight to each severity index regarding to its relative prominence in comparison with the partial index. The AHP is implemented based on a mutual comparison in order to arrive at each index's weight [17]. Therefore, RSI is defined as follows in Eq. (2)

$$\mathrm{RSI} = (\mathrm{f(IG)} \times \mathrm{W_{IG}}) + (\mathrm{g(EPDO)} \times \mathrm{W_{EPDO)}} + (\mathrm{h(SI)} \times \mathrm{W_{SI}}) \qquad (2)$$

In the above equation above, RSI describes the final index of the accidents severity. Furthermore, f(IG), g(EPDO) and h(SI) are the normalized indexes of the accidents intensity, financial damage and cost losses, respectively. Furthermore, W_{IG}, W_{SI} and W_{EPDO} stand for each index's weight.

In this method, after preparing the certified questionnaire, 5 traffic safety specialists were surveyed for the hierarchical analyses and multi-criteria decision makings. After collecting the surveys and evaluating the scores in the discussion of the mutual comparison of the indexes, the weight of each index is given in Table 1 in order to use in RSI.

Table1. Each index's weight for using in RSI

SI	IG	EPDO	index
0.144	0.482	0.374	weight

2.2. AHP-GIS Analysis

In this approach, first, a hierarchical structure wass formed, then, the safety indexes corresponding to each point were mutually compared and their relative importance were identified. The results of these comparisons forms the input of EC software . This software has a high capability for the hierarchical analyses. The output of this software is each index's weight in different buffers and their combination, i.e., the final weight of each criteria. One of the capabilities of this software is the possibility of comparing and determining the importance of the bufferes relative to each other. in such a way that similar to the criteria, iIt mutually compares the buffers and enters the software and calculates each buffer's weight. Then, it combines the buffers' weight and indexes' weight in each buffer in order to estimate the final weight. As the final step, the acheivements of EC software are used as the inputs of ArcGIS. Then using ArcGIS, the accident prone sections of the under study highway were determined for the prioritization, a node was created at the center of them and the weights corresponding to each index were imported and proved.

2.3. Fuzzy-AHP Analysis

Reviewing the available resources in the filed of pattern presentation and evaluating the weaknesses and strengths of the assessment models, a combined fuzzy-AHP model is implemented in this study. The classical AHP model is based on judging and choosing a 9-degree value and in pairs. However, the use of expert opinions alone can not compare the criteria well and with high confidence [18]. So, using the fuzzy numbers with an uncertainty approach can increase the efficiency and validity of the proposed model. The fuzzy-AHP model was firstly suggested by Sati in late 1970 with the aim of determining the importance coefficient of an option according to the multiple criteria. From the significant advantages of this technique, one can say the combinative usage of the qualitative and quantitative data for creating a rational approach [19].

$$BSIP = \sum_{J=1}^{m} \sum_{I=1}^{n} W_J \left(F(x) \times W_I\right) \quad (3)$$

3. Study Area

The under study area in this research is the connective highway of Abyek-Qazvin-Zanjan. Qazvin province has a special position in the road transportation system due to its location in the communication network of eleven north and northwest provinces of the country to the center and Eastern Europe as a bridge. According to the report of Iranian legal medicine organization, regarding the comparison of the provinces in terms of the number of deaths due to the traffic accidents in terms of population (per 100 thousand people), Qazvin province has been among the first three provinces with a ratio of about 50 in 2008 .

In this research, 17 accident proneal areas designated by the road'sIran Traffic Ppolice and general directorate of railroad services of Qazvin province in 2013 were selected for the correction prioritization. The accident data related to the years 2011, 2012 and first 9 months of 2013 have been selected based on the report of the road'sIran Traffic police, general directorate of railroad services of Qazvin province and also transportation organization of Qazvin province. Also, the traffic information used in this research is collected based on the statistical yearbook of road maintenance and transportation organization in 2013 and the comprehensive system of this organization. The specifications corresponding to the considered route is given in Table 2. Also, Figures 1 and 2 show the geographical location, annual average daily traffic (AADT) and the traffic accident status of the accident proneal sections of the studied highway. In Table 3, the status of the studied sections is shown in terms of the highway name, predicted actions for the correction purpose, technical correction's cost and the approximate time of the correction.

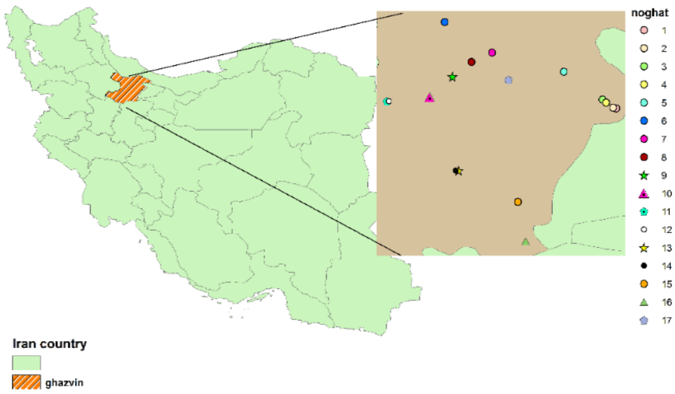

Figure 1. Geographical location of studied highway

4. Results and Discussion

After the analysis and assessment of the accident prone sections of the study highway, the results of the prioritization and ranking of the ways have been extracted by using various approaches and illustrated in the following subsections.

Table 2. Specifications corresponding to the considered highway

V/C	30th Peak Hour Traffic	Average Speed (Km/h)	AADT (Went route)	AADT (Return route)	Highway Name
0.48-0.64	501-1000	111-113	37248	37080	Abyek-Qazvin
0.1-0.27	1500-2000	80-90	12504	13725	Qazvin-Zanjan

Table 3. The status of the studied sections

Time of the Correction	Technical Correction's Cost (million rials)	Predicted Actions for the Correction Purpose	Highway Name	Section Number
6	5000	Sign installation - Guerrillas installation - Slab Reinforcement	Qazvin-Abyek	1
2	3000	Slab Reinforcement	Qazvin-Abyek	2
4	2000	Slab Reinforcement - Sign installation	Qazvin-Abyek	3
6	5000	Sign installation - Guerrillas installation - Slab Reinforcement	Qazvin-Abyek	4
3	2000	Sign installation Eliminate - Dropping shoulder - Guerrillas installation	Qazvin-Abyek	5
2	1500	Middle fencings	Qazvin-Abyek	6
2	4000	Collection and disposal of surface waters – Geometric correction - Pavement operation	Qazvin-Eghbalieh	7
3	1500	Slab Reinforcement - Guerrillas installation	Qazvin-Zanjan	8
3	1500	Slab Reinforcement - Guerrillas installation	Qazvin-Zanjan	9
3	3000	Sign installation - Guerrillas installation - Slab Reinforcement	Qazvin-Zanjan	10
1	1000	Sign installation - Modification of ramp entry and exit	Qazvin-Zanjan	11
1	1000	Sign installation - Modification of ramp entry and exit	Qazvin-Zanjan	12
1	500	Complete the bridge shield - Guerrillas installation	Buin zahra-Rahim Abad	13
15	100000	Sign installation	Buin zahra-Rahim Abad	14
12	50000	Marking - Sign installation- Guerrillas installation	Buin zahra-Saveh	15
4	35000	Sign installation	Buin zahra-Saveh	16
2	2000	Obstruction Level Intersection- sign installation - Construction of two J-Turn	Qazvin-Buin zahra	17

Table 4. Results of the benefit to cost analysis associated with the accident prone sections

B/C	Total Cost of Accidents	Costs Due to the Accidents (million rials)			Type of Accident			Section Number
		Damage	Injury	Fatal	Damage	Injury	Fatal	
90.7	453250	1100	2150	450000	55	43	9	1
34.3	103020	1020	2000	100000	51	40	2	2
125.8	251660	1160	500	250000	58	10	5	3
70.7	353900	1400	2500	350000	70	50	7	4
50.9	101840	840	1000	100000	42	20	2	5
135.3	203020	1020	2000	200000	51	40	4	6
75.9	303740	1240	2500	300000	62	50	6	7
101.6	152500	900	1600	150000	45	32	3	8
135.2	202800	900	1900	200000	45	38	4	9
234.6	703900	900	3000	700000	45	60	14	10
502.8	502820	920	1900	500000	46	38	10	11
352.6	352610	1160	1450	350000	58	29	7	12
1908	954090	1240	2850	950000	62	57	19	13
9.0	902800	900	1900	900000	45	38	18	14
13.0	652000	500	1500	650000	25	30	13	15
25.7	901200	500	700	900000	25	14	18	16
50.9	101940	640	1300	100000	32	26	2	17
3918	7197090	16340	30750	7150000	817	615	143	Totla
-	-	-	-	-	51.87	39.06	9.07	Percent
230	423358	961	1809	420588	48	36	8	Average

Table 5. Results of accidents intensity related indexes

RSI Index	IG Index	EPDO Index	SI Index	Section Number
0.34	1495	291	2.72	1
0.12	753	210	2.26	2
0.05	774	141	1.92	3
0.33	1410	312	2.45	4
0.00	526	131	2.05	5
0.18	953	229	2.41	6
0.29	1286	294	2.49	7
0.10	755	186	2.32	8
0.16	915	216	2.48	9
0.55	2135	388	3.26	10
0.33	1518	274	2.91	11
0.21	1164	226	2.40	12
0.69	2656	442	3.20	13
0.56	2315	349	3.46	14
0.37	1675	254	3.73	15
0.45	2015	245	4.30	16
0.03	556	142	2.37	17

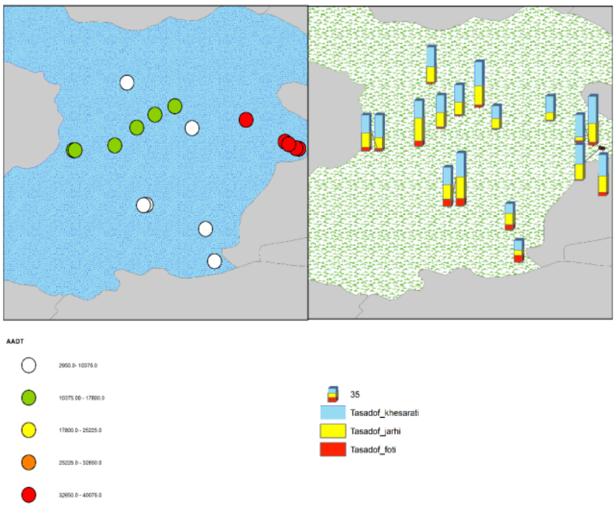

Figure 2. AADT and the traffic accident status of the accident proneal sections

4.1. Analysis of the Results Based on the Cost-benefit Index

In Table 4, the results of the benefit to cost analysis associated with the accident prone sections of Abyek-Qazvin-Zanjan highway are given according to each accident's type and cost, total costs due to the accidents, and B/C ratio. Regarding to the accidents' costs, section numbers 13, 14 and 16 have been placed in the first, second and third rank, respectively. However, the obtained results via B/C analysis for various sections illustrate that the section numbers 13, 11 and 12 are accordingly in the highest priority for reform based on the economic analysis. A remarkable point in this analysis is related to sections 14 and 16. So that, in section 14, despite being in the second level in terms of the accidents' costs, it was ranked in the last level in B/C analysis, which is also true for the section number 16. In other words, the highe cost of modifying in sections 14 and 16 has reduced the priority of the correction of these sections.

4.2. Results Analysis Based on the Accident Intensity Index

Table 5 lists accidents intensity related indexes related to different sections. In this table, the SI index referres to the accident intensity, EPDO is the accident intensity equivalent to the property damage accident and IG stands for Portugal's accident intensity. Based on the measured index in this table, section 13, which is related to the Buin Zahra-Rahim Abad three way, with a RSI of about 0.7, has the highest risk among the studied axes. In other words, in terms of improving and reforming the section during a budget constraint, this section has a higher value than other levels. Also, sections 13, 14 and 10 ranked first to third, respectively. Furthermore, sections 16, 15, 1, 11, 4, and 7 have RSI values greater than 0.281, which are more than the mean value. In addition, sections 5, 17 and 3 with the least amount of RSI have the least risk and correction potential among all sections.

4.3. Results Analysis Based on the Accidents Predictive and Bayesian Models

Table 6 lists the PI indexes via the accident predictive model and the Bayesian model related to the modification and ranking of the accident prone sections. According to the improvement potential index of the prediction model of the accidents, sections 13, 4 and 10 with PI values of 50.4, 33.39 and 29.66, respectively, have been ranked first to third among all sections. This means that these sections have met higher modification and improvement potential rather than the others. Also, the investigation of the improvement potential of different sections from the perspective of the Bayesian model clarifies that sections 13, 4, and 10, with PI values of 43.1, 27.86 and 25.55, respectively, have the highest improvement potential. In terms of this indicator, sections 5, 16 and 17 have the least improvement potential and the lowest correction priority. Figure 3 shows the status of the different sections in terms of the improvement potential based upon the accidents predictive and Bayesian models and also the accidents' costs in the Arc GIS environment.

4.4. Ranking Results of the Incidental Sections Using AHP-GIS Analysis

In this method, a combination of AHP and Arc GIS environment is implemented for determining the priority in the correction and improvement of the accident prone sections. To this end, first, using the hierarchical method and applying EC software, the weight of the prioritization and correction indexes of the incidental sections were determined and then these weights were integrated into the Arc GIS and combined with the layers and eventually the ranking map and the correction assessment of the incidental sections are determined. In order to determine the final ranking model for Arc GIS, methods for estimating and evaluating the unknown variables and interpolation technique are used. The IDW method is implemented in this section. This method is applied for areas with ups and downs. In this method, the calculation of the unknown sections is obtained by means of averaging the specified sections, and each section is weighed in the calculation.

Figure 4 illustrates the Arc GIS environment's layout maps for prioritizating the accident prone sections. In this figure, different sections are graded with a score from 1 to 10 based on several indexes such as AADT, the ratio of the number of accidents to AADT, EPDO, correction costs, costs of accidents, number of accidents, and correction time. Figure 5 exhibits the final results of the accident prone points.

Prioritization are accordingly given according to the AHP scores and in Arc GIS environment.

4.5. Ranking Results of the Accidental Prone Using AHP-fuzzy Analysis

After analyzing and comparing the objectives for evaluating the safety of different sections, a linear AHP-fuzzy method has been used to provide a comprehensive model for evaluating and prioritizating the correction of the incidental points. In this regard, at first, using the expert opinions, the coefficients of importance for the goals, indexes and sub-indexes were determined. In this step and after preparing the desired forms using AHP, a survey was conducted from 30 transport and safety specialists. After analyzing the expert opinions using EC software, the importance coefficients for goals, indexes and sub-indicators are obtained as given in Table 7.

Table 6. PI indexes via the accident predictive model and the Bayesian model

Ranking	PI Index- Bayesian Model	Ranking	PI Index- Bayesian Model	Ranking	PI Index- Accident predictive Model	Section Number
6	11.1	5	14.4	6	13.4	1
10	-0.9	10	0.4	10	-0.9	2
14	-17.4	13	-19.6	14	-20.6	3
2	27.9	2	34.4	2	33.4	4
17	-25.0	15	-28.6	17	-29.6	5
7	9.9	7	2.4	7	-10.3	6
4	24.6	4	25.4	4	28.7	7
12	-7.4	12	-12.6	12	-9.4	8
11	-1.5	11	-5.6	11	-2.4	9
3	25.4	3	26.4	3	29.6	10
٨	4.4	8	1.4	8	4.6	11
9	4.1	8	1.4	9	4.3	12
1	43.1	1	45.4	1	50.4	13
5	12.1	6	8.4	5	13.4	14
13	-14.3	14	-24.6	13	-18.3	15
16	-23.6	17	-35.6	16	-29.3	16
15	-23.1	16	-32.6	15	-28.3	17

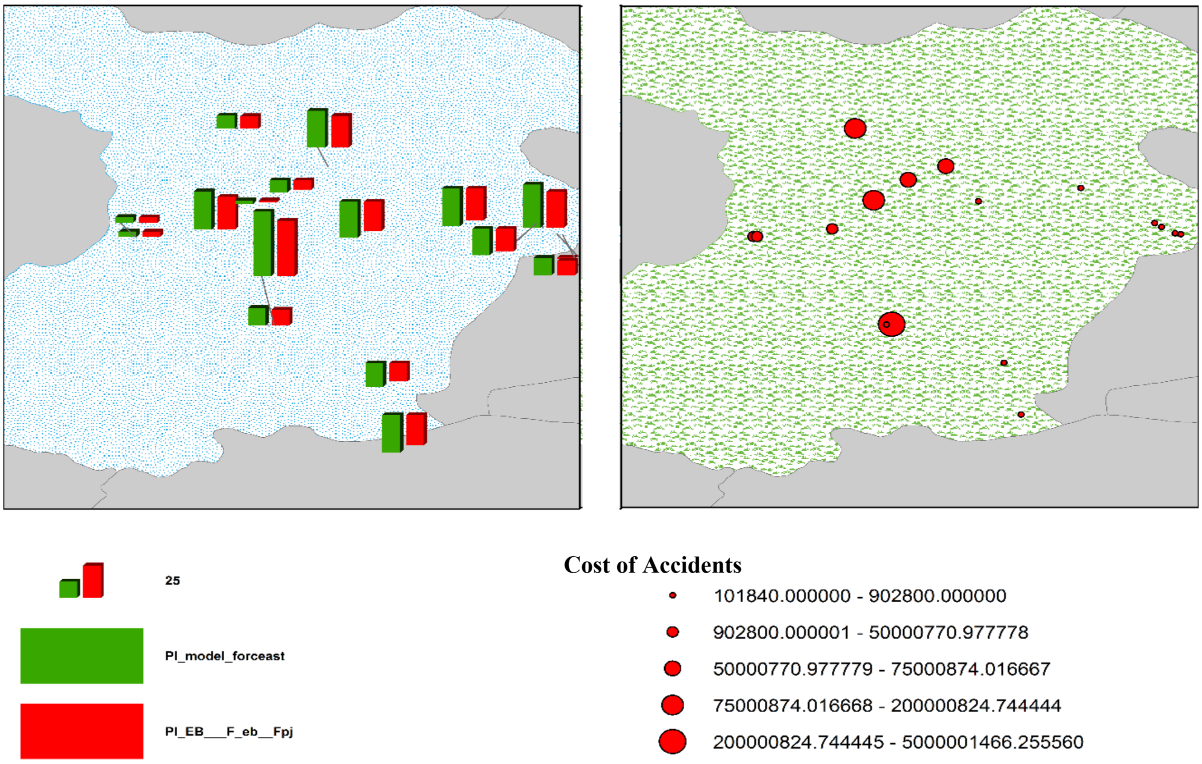

Figure 3. Status of the different sections in terms of the improvement potential based upon the accidents predictive and Bayesian models

Table 7. Output of EC software, the importance coefficients for goals, indexes and sub-indicators

Sub-Indicator Score	Sub-Indicator	Index Score	Index	Goal Score	Goal
0.32	Cost of Accident	0.544	Cost of Accident	0.551	Accident prone
0.68	Cost of Accident/AADT				
0.38	Number of Accidents	0.164	Number Of Accidents		
0.62	Number of Accidents/AADT				
0.19	EPDO	0.292	Severity of Accidents		
0.29	EPDO/AADT				
0.52	SI				
0.46	Cost of Correction	1	Cost of Correction	0.277	Cost of Correcting accidental prone
0.64	Cost of Correction/AADT				
0.28	Time of Correction	1	Time of Correction	0.18	Time of Correction
0.72	Time of Correction/AADT				

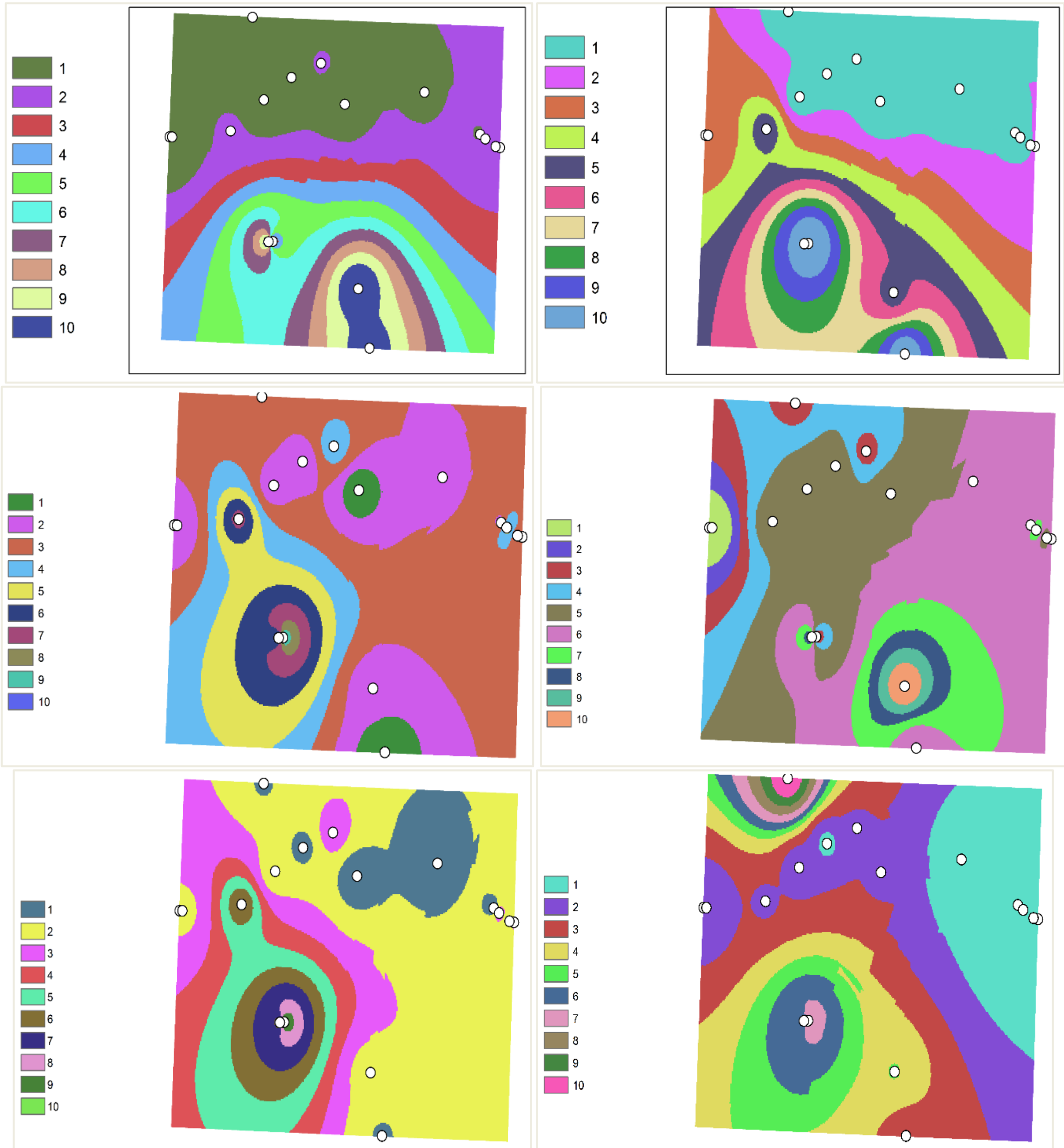

Figure 4. Arc GIS environment's layout maps for prioritizating the accident prone sections

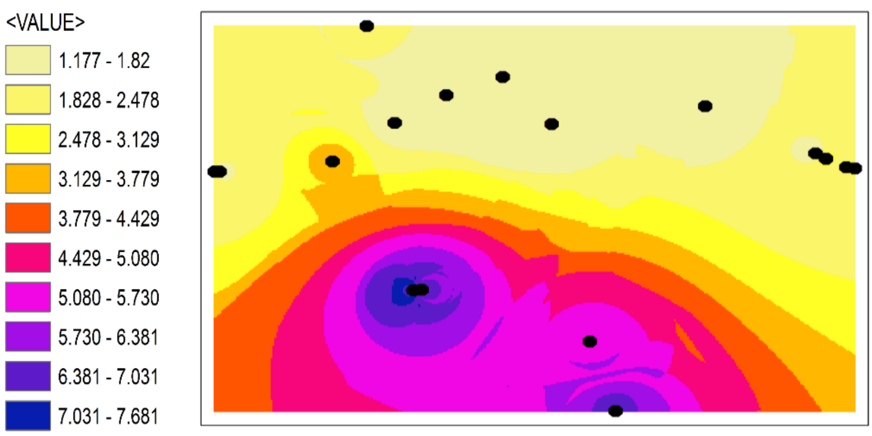

Figure 5. Final results of the accident prone points according to the AHP scores and in Arc GIS environment

After determining the importance coefficients using the hierarchical method and the sub-indexes values by the linear fuzzy function, the safety status is specified in the determined goals. The correction priority indexes are scored in the range of 1-0, from which score 1 indicates the highest priority and score 0 represents a lower priority.

Finally, after examining and evaluating the safety indexes for different sections, final result via the evaluation and prioritization pattern of the sections (BSIP) is shown in Figure 6. Section 13, section 11 with the index value of 0.384 and section 12 with that of 0.365 are placed in the second and third levels, respectively. The results clarify that there is a significant difference between the prioritization values of section 13 and the others; which means the correction as well as improvement priority of this section compared to other under assessment sections. After the above three sections, sections 16, 2, 5 and 3 are accordingly located in the fourth to seventh places and their BSIP indexes are higher than the average value. Also, section 17 with BSIP index value of 0.148 meets the lowest correction priority among the different sections.

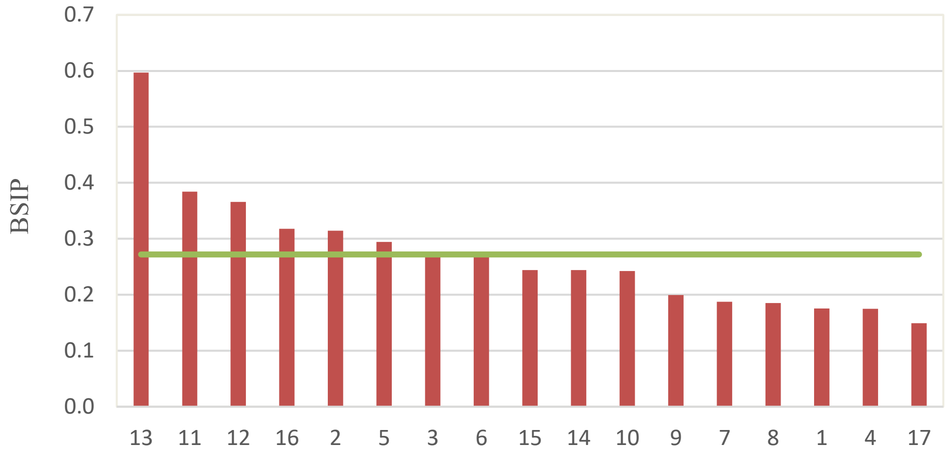

Figure 6. Final result via the evaluation and prioritization pattern of the sections (BSIP)

Table 8. Results of the correction prioritization of the accident prone

AHP- Fuzzy Model	Bayesian Model	Accident Predictive Model	RSI Index	Economic Analysis	Section Number
15	5	6	6	9	1
5	10	10	13	14	2
7	13	14	15	7	3
16	2	2	8	11	4
6	15	17	17	13	5
8	7	7	11	5	6
13	4	4	9	10	7
14	12	12	14	8	8
12	11	11	12	6	9
11	3	3	3	4	10
2	8	8	7	2	11
3	8	9	10	3	12
1	1	1	1	1	13
10	6	5	2	17	14
9	14	13	5	16	15
4	17	16	4	15	16
17	16	15	16	12	17

In Table 8, the results of the correction prioritization of the accident prone sections are given according to different methods. Also, Table 9 illustrates the relationship between the effective indexes in determining the correction prioritization of the incidental prones.

Table 9. Relationship between the effective indexes in determining the correction prioritization of the incidental prone

Cost of Accidents	Number of Accidents	EPDO	EPDO/ AADT	SI Index	Correction Cost	Correction Time	Correction Prioritization	Index
						1	-0.301	Correction Time
					1	0.896	-0.087	Correction Cost
				1	0.617	0.453	0.234	SI Index
			1	0.635	0.412	0.224	0.388	EPDO/AADT
		1	0.491	0.547	0.252	0.200	0.392	EPDO
	1	0.819	0.149	-0.008	-0.137	-0.082	0.265	Number of Accidents
1	0.307	0.771	0.614	0.878	0.584	0.429	0.466	Cost of Accidents

5. Conclusions

The aim of this study was to propose an evaluation and prioritization model for correcting the accident prone sections of Qazvin-Abik-Zanjan highway as one of the most important connective axes of Iran based on the comprehensive safety index. To this aim, first, the classical methods of prioritization were used and next, a comprehensive model based on the effective factors influencing the traffic safety strategic performance has been presented using a combinative technique of hierarchy-fuzzy. After investigating and analyzing the safety status of the accident prone sections, the following results were obtained:

•The obtained results via B/C analysis for various sections illustrated that sections 13, 11 and 12 are accordingly of highest correction priority based on the economic analysis.

•The results of RSI accident analysis show that Section 13 associated with Boein Zahra- Rahim Abad's three-way, having an RSI value of about 0.7, has the highest risk. sections 14 and 10 are in the second and third place, respectively.

•The results of the improvement potential index of the accidents' prediction model showed that sections 13, 14 and 10, with PI values of 50.4, 33.39 and 29.66, ranked first to third among the total sections and based on the improvement potential of different sections. In terms of the the Bayesian model, the above-mentioned sections with PI values of 43.1, 27.86 and 25.35, accordingly, meet the highest improvement potential.

•The results of the assessment and prioritization model of the sections (BSIP) expressed that the correction priority of section 13 with an index of about 0.596, is the highest priority of reform, and sections 11 and 12 with index values of 0.384 and 0.365, are in the second and third place, respectively. Further to these, section 17 with the BSIP index equal to 0.148 has the least correction priority among the different sections.

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