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MULTICRITERIA EVALUATION OF DANGEROUS SECTIONS FROM THE OCCURRENCE OF WILDLIFE ON STATE ROADS OF LIKA-SENJ COUNTY USING THE AHP METHOD

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Abstract

A trend of increasing traffic accidents involving vehicles has been observed, which requires proposed measures to prevent the occurrence of wildlife on risky sections of roads. Before implementing the relevant measures, it is necessary to rank the risk sections on the roads from the occurrence of wildlife. Roads pass through the natural habitats of wildlife, so with each kilometer of newly built roads and with each newly registered vehicle, the probability of a vehicle colliding with wildlife increases. The problem of increasing the number of encounters with game is expressed both at the global level and in the territory of the Republic of Croatia. Traffic accidents related to vehicle crashes into wildlife are a major problem of road safety on the road network. The paper presents an analytical hierarchical process of AHP methods, multi-criteria evaluation on the example of ranking dangerous sections from the occurrence of large game on state roads of Lika-Senj County. The AHP method is one of the most well-known methods of multicriteria analysis, which consists of goal, criteria and alternatives. The ranking of dangerous sections from the occurrence of large game on the state roads of Lika-Senj County by the AHP method includes qualitative and quantitative criteria. The AHP method of multi-criteria evaluation of dangerous stocks from the appearance of large game was presented with the software tool Expert Choice. The obtained results rank the dangerous sections from the occurrence of large game and define the priorities of their rehabilitation from the competent authorities.

Keywords: vehicle collision with game, AHP method, Lika-Senj County, traffic safety

1 Introduction

By monitoring and analyzing data on traffic accidents involving large game on the roads, from the point of view of traffic safety, it is possible to determine dangerous sections from the occurrence of game on the roads. The aim of this paper is to show that the quality of decision-making on the ranking of dangerous sections from the occurrence of game can be improved by multi-criteria decision-making, using the AHP method, on the example of a vehicle collision with large game on the state roads of Lika-Senj County. The paper deals with traffic accidents involving large animals on state roads of Lika-Senj County in the period 2012-2016, obtained from the Ministry of the Interior, Lika-Senj Police Administration [1].
On sections that are dangerous for road safety due to the possibility of wildlife on them, it is possible to increase traffic safety by applying certain measures of regular road maintenance. So far, apart from the installation of traffic signs (game on the road), no measures have been

taken to prevent the occurrence of game on the roads, nor have potential dangerous places from the occurrence of game on the roads been ranked. The paper ranks dangerous sections from the occurrence of wildlife on the state roads of Lika-Senj County, so that they can be rehabilitated through measures of regular or extraordinary road maintenance, all in order to increase road safety. The following criteria were applied: number of large game encounters in the period 2012-2016, section length, number of large game encounters per 100 kilometers and number of large game encounters per year, and they significantly influenced the ranking of variants.

2 Background AHP methods

Multicriteria decision making is a set of methods that allow the simultaneous use of several different criteria in order to select the optimal variant from a set of variants with respect to a given function of the goal [2].Due to the complexity of the transport system, the approach of evaluating the solution of traffic problems by applying several criteria is important. The application of several criteria is used in the evaluation of projects by multi-criteria decision-making methods. One of the most commonly used methods for evaluating projects in transport is the Analytical Hierarchical Process (AHP) method. The Analytical Hierarchical Process was founded by Thomas Saaty in the 1970s with the aim of solving complex decision-making problems, when there are a large number of decision-makers as well as criteria. It is one of the best known, most proven and most frequently used methods of decision making, ie methods for multicriteria analysis. Its main advantage is manifested in the ability to adapt the decision maker in terms of the number of attributes, or criteria and variants that are decided at the same time, and which can be described both quantitatively and qualitatively. Therefore, the AHP method allows for flexibility in the decision-making process and helps decision-makers to set priorities, and to make the best decision taking into account both the qualitative and quantitative aspects of the decision.
The application of AHP is significant in large investment projects that require significant capital investment, and have great social significance (eg investment projects in transport infrastructure), but is also important in the evaluation of other solutions to transport problems. Based on the research conducted so far, it can be concluded that the application of AHP in solving problems in the field of transport is extremely large. The analysis of relevant databases has shown that the AHP method is applied in scientific papers, scientific projects, diploma theses and doctoral dissertations [3]. The AHP method includes expert opinion and multi-criteria evaluations. Its popularity stems from the fact that it is very close to the way an individual solves complex problems, breaking them down into simpler components and that into goal, criteria and variants. These components are combined into a model in which the goal is at the highest level, the criteria are at the first lower level, their sub-criteria are at the second lower level, and variants (possibilities) are at the lowest level [2]. The AHP method converts estimates from the Saaty scale into numerical values that can be processed and compared over a whole range of problems. The stated priority weights are calculated for each criterion in the hierarchy, allowing a comparison of different and often immeasurable elements in a rational and consistent manner. This possibility distinguishes AHP from other decision-making techniques [4].
In the final stage of the process, priority weights are calculated for each variant. These numbers represent variants or their relative ability to achieve the goal, so that they allow direct observation of different modes of action. Instead of prescribing the right decision, the AHP method helps decision makers find the answer that best suits the goal and their understanding of the problem [4]. The method consists of four parts: structuring the problem, collecting data, estimating the relative weights and determining the solution to the problem. The method is intended for solving decision-making problems in which a larger number of

decision-makers participate, and a larger number of criteria and sub-criteria appear. The AHP method has its advantage in solving complicated problems in that it simplifies these problems to less complex situations. The method allows when considering problems to easily find the relationships between criteria and variants, in order to find the influence of one criterion in relation to another. After the problem structuring process, the decision maker assigns “ratings” to each individual pair of attributes at each hierarchical level. The most common rating scale is the so-called. Saaty scale of importance or evaluation (Table 1)

Table 1 Saaty evaluation scale, [5]

Intensity importance	Definition
1	Equally important
3	Moderately more important
5	Strictly important
7	Very strict, proven importance
9	Extreme importance
2,4,6,8	Among values
1.1-1.9.	Decimal values

The comparison of qualitatively expressed criteria, the scale of grades, is performed according to the description of the relationship of criteria from the so-called. Saaty scales (Table 1). Assigned grades are recorded in a matrix. This is how the so-called comparison matrix.As the method proved to be successful in solving multicriteria evaluations, the software tool “Expert Choice” [6] was developed for its application, which gave a significant impetus to the development and application of decision support systems and expert systems for solving multicriteria decision making. This tool is completely suitable for the application of the AHP method.

3 Application of AHP method for ranking dangerous sections since the occurrence of large game on state roads of Lika-Senj county

The paper investigates vehicle collisions with large game on the state roads of Lika-Senj County during the period from 2012 to 2016. The basic precondition for conducting the research is data that contain sufficient information on the basis of which dangerous sections from the occurrence of wildlife on the roads could be defined. Information on traffic accidents involving vehicles on game was taken over from the Ministry of the Interior, Lika-Senj Police Department [1]. In order to make a choice of variants, it is necessary to determine the criteria, based on which the solution will be chosen. The criteria involved can be evaluated, ie their data are available. The criteria are:

1. <u>Number of collisions</u>. The analysis of the number of vehicle collisions with game on the state roads of Lika-Senj County was conducted according to the data of the Ministry of the Interior, Lika-Senj Police Administration for the period 2012-2016. years [1]. The following data were used for each traffic accident: date of the accident, time of the accident, type, number and section of the road, consequences of the accident and species of wild animal.
2. <u>Length of section (km).</u> The lengths of the state road sections of Lika-Senj County were obtained from Hrvatske ceste d.o.o., Zadar business unit, Gospić technical branch [7].
3. <u>Number of collisions per 100 km.</u> The number of crashes per 100 km was obtained by dividing the number of crashes by the length of the section and by the number 5 (the observation period is 5 years) and multiplied by 100.

4. Number of collisions per 100 km per year. The number of raids per 100 km per year was obtained by dividing the number of raids per 100 km by the number 5 (the observation period is 5 years).

The choice of criteria is very important for the correct implementation of the AHP method, but it is also very important to determine the mutual values of the relationships of the selected criteria. By assigning weights to each criterion, the criteria were compared, and weights were added to all variants, ie dangerous sections, in relation to the number of collisions, section length in kilometers, number of collisions per 100 kilometers and number of collisions per 100 kilometers per year, ie in relation to each criterion. Table 2 and Figure 1 show the most dangerous sections of state roads in Lika-Senj County from vehicle collisions with large game in the studied period, and set the criteria for the implementation of the AHP method.

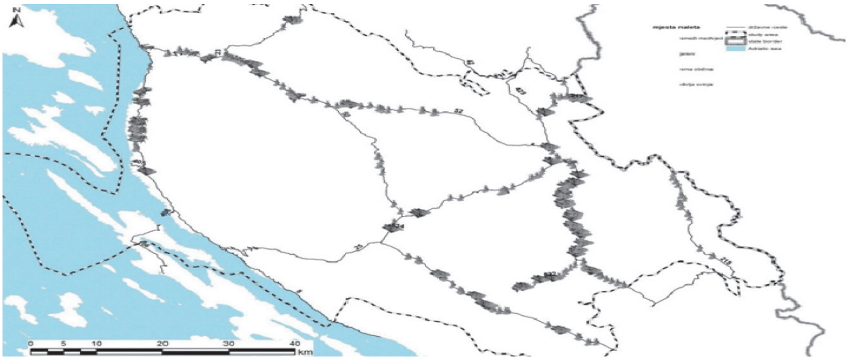

Figure 1 Location of the place of collision of vehicles with large game during the research period (2012-2016) on the state roads of Lika-Senj County

Before using the software tool Expert Choice [6], appropriate matrices were compared comparing the criteria with each one (subtracting the larger from the smaller) in relation to the given goal. Based on the comparison of criteria, we obtained that the lowest value is 0 and the highest value is 90. In the Saaty evaluation scale, the number 1 is always equal to 0. The other numbers on the Saaty scale are obtained by increasing each subsequent number in the scale by an equal number. We replaced the values obtained by comparing dangerous places in pairs with the ratings of the Saaty scale and we obtained a matrix of a certain criterion, and we do the same procedure for all criteria. We enter the results from the criteria matrices in the Expert Choice software tool.

Table 2 Number of collisions of large game vehicles on state roads of Lika-Senj County by sections during the period 2012-2016. and crash density [1] [6]

Dangerous stock N.	Road	Stock	Name	Number of flashes	Lenght of stock [km]	Number of flashes 100 km	Number of flashes 100 km per year
1	DC-1	12	Grabovac (DC42) – Vrelo Koreničko (DC52)	39	23,00	33,91	6,78
2	DC-1	13	Vrelo Koreničko (DC52) – Mutilić: čvorište Udbina (DC522)	91	33,17	54,87	10,97
3	DC-1	14	Mutilić: čvorište Udbina (DC522) – Gračac (DC27)	26	11,58	44,91	8,98
4	DC-8	7	Senj (DC23) – Stinica (DC405/LC59148)	32	36,67	17,45	3,49
5	DC-8	8	Jablanac (DC405) – Prizna (DC406)	2	13,00	3,08	0,62
6	DC-23	3	Jezerane (ŽC5191) – Žuta Lokva (DC50)	9	19,19	9,38	1,88
7	DC-23	4	Žuta Lokva (DC50) –Senj (DC8)	8	22,26	7,19	1,44
8	DC-25	1	Korenica (DC1) – Lički Osik (DC50)	9	36,57	4,92	0,98
9	DC-25	2	Lički Osik (DC50) – Karlobag (DC8)	7	47,26	2,96	0,59
10	DC-50	1	Žuta Lokva (DC23) – Špilnik (DC52)	27	21,47	25,15	5,03
11	DC-50	2	Špilnik (DC52) – Lički Osik (DC25)	8	34,37	4,66	0,93
12	DC-50	3	Gospić (DC25) – Lovinac (ŽC5165)	27	31,99	16,88	3,38
13	DC-50	4	Lovinac (ŽC5165) – Gračac (DC27)	12	15,19	15,80	3,16
14	DC-52	1	Špilnik (DC50) - Korenica (DC1)	31	41,11	15,08	3,02
15	DC-217	1	Ličko Petrovo Selo (DC1) – Novo Selo Koreničko: GP Ličko Petrovo Selo (granica RH/BIH)	14	2,97	94,28	18,86
16	DC-218	1	Nebljusi: GP Užljebić (Granica RH/BIH) –Dobroselo (Ž5203)	14	30,08	9,31	1,86
17	DC-218	2	Dobroselo (ŽC5203) – Bruvno (DC1)	1	8,70	2,30	0,46
18	DC-429	1	Selište Drežničko (DC42) – Prijeboj (DC1)	12	14,1	17,02	3,4
19	DC-522	1	Mutilić (DC1) – Gornja Ploča: čvor Gornja Ploča (A1)	21	13,19	31,84	6,37
20	DC-534	1	Gospić (DC25) –Lički Osik: čvorište Gospić (A1)	1	2,45	8,16	1,63

4 Results of multicriterion evaluation by AHP method

The Expert Choice software tool is suitable for the application of the AHP method as a method of multi-criteria evaluation, and allows direct entry of criterion values. The program models the hierarchical structure of the problem, and allows users to use their expertise. By entering values from the criteria matrices into the Expert Choice program, we obtain the following data below.

Of the 4 criteria (number of collisions, section length in kilometers, number of collisions per 100 kilometers and number of collisions per 100 kilometers per year), based on surveys and expert assessment, the most influential criterion, ie the criterion with the highest weight value was the section length in kilometers (Figure 2). it is followed by the criterion by weight criterion number of collisions per 100 kilometers per year, then the criterion number of collisions 2012-2016 and the last criterion by weight value is the criterion number of collisions per 100 kilometers. Figure 3 shows the ranking of the offered variants (dangerous shares) with a percentage.

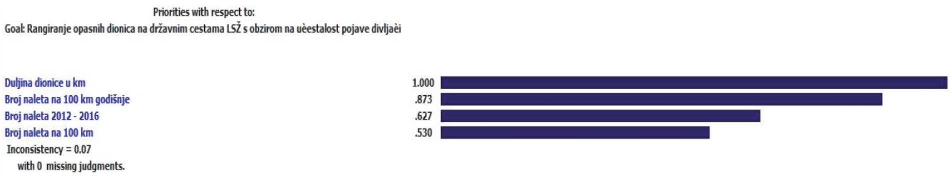

Figure 2 Weight values of the criteria

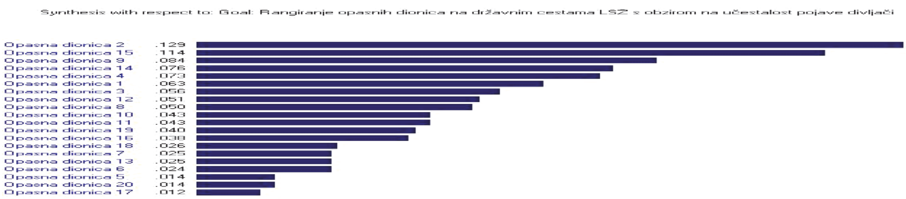

Figure 3 Ranking of dangerous sections from the smallest to the most dangerous section from the occurrence of game on the state roads of Lika-Senj County

It can be seen that the most dangerous section is section 2, followed by section 15, and measures to rehabilitate road sections from wildlife should be the first to be applied to them. Sensitivity analysis allows the determination of “critical” variables or model parameters, and its main goal is to assess the acceptability of the project if the values of critical project parameters are changed. Therefore, sensitivity analysis determines the reliability of the defined model, and it gives the possibility to make decisions to test different sets of alternative solutions. The Expert Choice software tool enables this analysis using three charts, namely the dynamics chart, the performance chart, and the gradient chart. Figures 4, 5, and 6 show the three graphs obtained with the Expert Choice software tool.

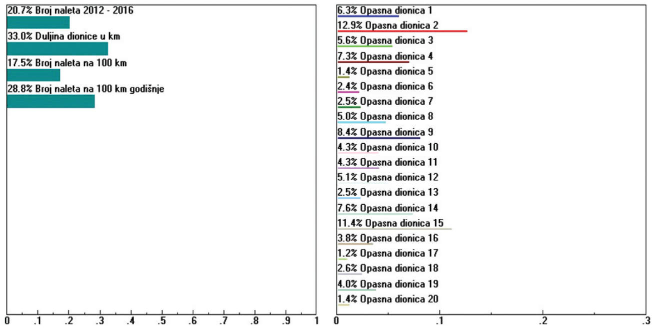

Figure 4 Dynamic chart

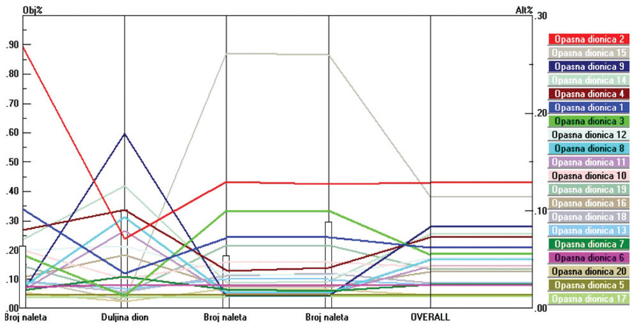

Figure 5 Performance chart

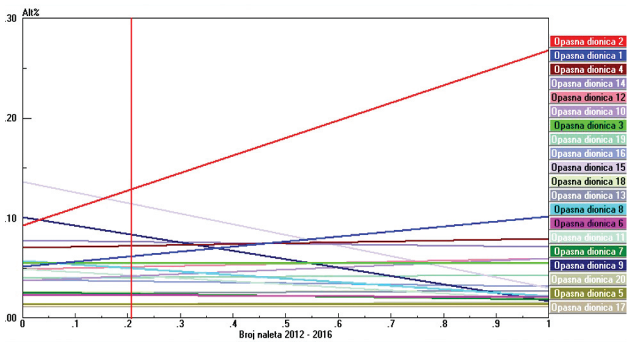

Figure 6 Gradient chart

Figure 4 shows the share of significance of individual criteria in the system of offered variants. Figure 5 shows the impact of individual criteria on the overall order of variants, while Figure 6 shows how changes in the weights of individual criteria affect the overall order of variants, and the graph provides an opportunity to analyze the impact of each individual criterion on the final solution.

5 Conclusion

Multicriteria evaluation is an extremely complex process, with the possibility of diverse applications in different spheres of activity. This paper presents a model for multi-criteria ranking of the most safety-critical sections on the state roads of Lika-Senj County since the appearance of large game on them. The AHP method was used for the valuation and ranking of dangerous stocks. Since the method proved to be successful in multicriteria decision-making, the Expert Choice program was developed for its application, which was also used in the paper. The most important result obtained during the research relates to the fact that thanks to a well-designed model of multi-criteria evaluation, it was possible, using the AHP method, to make an exact decision on the rank of risky road sections from the occurrence of wildlife. Multi-criteria evaluation by the AHP method gives us a good insight into the ranking of dangerous sections from the occurrence of large game on the state roads of Lika-Senj County. In this paper, the exact choice of the priority of the rehabilitation of dangerous sections from the occurrence of large game is obtained, which can signal the priorities of the rehabilitation of dangerous sections to the road infrastructure managers. In the end, it can be concluded that the multi-criteria evaluation by the AHP method proved to be a very good tool in the ranking of dangerous sections from the occurrence of large game on the state roads of Lika-Senj County.

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