

TRAFFIC RISK MAPPING – RISK DISTRIBUTION AMONG THE MUNICIPALITIES IN MONTENEGRO

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Abstract: Accident analysis plays an important part in the strategy to reduce road accidents. To significantly reduce traffic fatalities and serious injuries on public roads, there is need to review the characteristics of motor vehicle accidents and identify the hidden patterns behind the accidents. Identifying traffic accident concentration area is important for road safety improvements. Determining the risk rate in road traffic and its spatial distribution may indicate the areas that are more at risk in traffic in proportion to others. Beside, such analysis can identify differences in the nature of the problem among spatial units on the territory of a country. An analysis of spatial traffic risk distribution among the municipalities on the territory of the Montenegro has been conducted. The results of the study indicate that there is a significant difference in the amount of traffic risk among the municipalities.

Keywords: TRAFFIC SAFETY, MOTOR VEHICLE ACCIDENTS, RISK MAPPING

1. Introduction

In Montenegro in the last ten years, the number of persons killed in road traffic is reduced. However, it is still not enough to be compared with the developed countries of the European Union. According to EU statistics, the rate in terms of fatalities per 100,000 populations in Montenegro in 2012 was 29.6; while in EU countries this indicator varies from 2.5 to 18.7, /1/. As well, Montenegro's road network is high risk, including those segments with a high traffic volume, /2/. Many road crashes are preventable and history provides evidence that the right intervention can make a significant positive impact. In order to make progress in road safety, comprehensive data collection and in-depth data analysis are essential in terms of designing effective safety strategies, setting challenging targets, determining intervention priorities and monitoring program effectiveness. In May 2011, the United Nations launched a Decade of Action for Road Safety. The goal of the Decade (2011–2020) is to stabilize and reduce the increasing trend in road traffic fatalities, saving an estimated 5 million lives over the period. This report builds on the 2009 report, and provides additional data in a number of important areas. It is supported by a Global Plan for Road Safety, /3/. In Montenegro, National Coordination Board was established to monitor road safety parameters. In addition, government adopted Strategy for efficient traffic (2008), /4/, Strategy for improvement of road traffic safety 2010-2019, /5/, and Action plan for Strategy for improvement of road traffic safety implementation (2011), /6/. The main goal of this strategy is to reduce number of fatalities by 30% and injuries by 20% before 2014 (compared to 2007). The long-term goal is to reduce these figures by 50% and 30% respectively by 2019, compared to the same year.

To significantly reduce traffic fatalities and serious injuries on public roads, we need to review the characteristics of motor vehicle accidents and identify the hidden patterns behind the accidents' records, referring mainly to the actual knowledge contained in the collision data rather than the raw data records themselves. Thus, identifying traffic accident concentration area is important for road safety improvements. The main objective of road safety ranking is to identify sections that carry the highest individual risk, i.e. where the probability of a fatal road accident is the highest, and sections that carry the highest societal risk and offer strong potential for reducing accident costs as a result of treatment undertaken by road managers.

2. Risk mapping

Risk maps are colour-coded maps showing the relative risk to an individual road-user of being involved in fatal and serious crashes or relative risk of fatal and serious injury on individual road sections across a road network. Risk maps are statistically

designed to support national road safety strategies and add an extra layer of information alongside existing approaches. These maps each gave useful information in building up the overall picture of safety performance of the network. It was concluded that accident databases could be established that enabled comparative risk maps to be drawn for different municipalities, and provided useful information on the difference in risk rate. Focus of the risk mapping is to inform the road user how and where he needs to modify his behaviour to minimize risk – i.e. to enable him to recognize the sources of risk on different types of road. Alongside this should be the recognition that risk cannot be eliminated on all roads through infrastructure changes, and that the road user must take a share in the responsibility for a safe road system.

There is variation in methodology for identification of critical zones or black spots and checking road safety level, such as: road safety impact assessment, road safety audit, road safety inspection (periodic road safety inspection, night-time road safety inspection, railway crossing inspection, tunnel inspection, destination-sign inspection, inspection of other road signs and traffic devices, ad-hoc road safety inspection), in-depth studies, black spot management, network safety management, etc.

In the last few decades, road safety has become a high priority in many governments' policy-making. During 2001, a process of risk rate mapping was developed by TRL for the European Road Assessment Programme, /7/, to enable the risk of fatal and serious injury accidents occurring on different parts of the British primary road network to be compared. As a second stage of risk comparison, a risk rating system was developed which ranked road sections according to their road design features. This rating process was first used extensively in Sweden and Germany, but was subsequently applied in other European countries including the United Kingdom, /8/.

As critical zones were defined as an area or location where there is a higher likelihood for an accident to occur based on historical data and spatial dependency, /9/, within this area it is possible to determine micro location – an accident-prone spot (black spot) – place with a higher number of accidents compared to other similar spots due to local risk factors. The definition of black spot is different from country to country. Many definitions of accident-prone spots are available through research emphasizes that there is no comprehensive definition of what is accepted as a hazard, /10/.

Montenegro has started a Black spot management with risk mapping in 2007 under the responsibility of Road Directorate and there are proposals under discussion to add a special department for road safety issues (road safety unit) in the level of the Ministry of Transport. Neighbor countries, Serbia and Croatia, are also adopting programs for black spot management.

From 2011 to 2013 Serbia realized project "Consulting services for road safety – technical support", /11/. Project complied report about identification and black spots recovery. Collecting, sorting and analyzing traffic accident data, identification of dangerous locations, ranging, analyzing causes of accidents, planning recovery measures of black spots, implementation and assessment are in detail explained in report. Also, the most frequent contra-measures are presented. Alike action were undertaken in Croatia: Government of Croatia adopted Strategy of traffic development of the Republic of Croatia 2014-2030, /12/, where was implemented "Black spots recovery programme".

3. Methodology

Many countries and cities have applied various methods to identify dangerous locations with the real situation of road traffic. Currently the main form of numerically risk assessment in road transport area is usually defined by recorded numbers of fatalities (or casualties) and some measures of exposure. A researchers may use different indicator of exposure (e.g. size of population, time in traffic, traffic density) to describe traffic risk. International Traffic Safety Data and Analysis Group (IRTAD) pointed out that the three most frequently used measures of exposure to risk are: population size, the number of registered vehicles, and the distance travelled, /13/. Rates expressed as density or total number of crashes on a road over a given travelled distance and the traffic flow can show more real situation on roads than those mentioned earlier.

The crash data in Montenegro is collected by police officers as an adjudication record. Vital information on exact crash location, road geometry and condition, etc. is missing from the data and thus incomplete for any scientific crash investigation. Also, the management and mechanism to share the available data with other stakeholders, as well as a reliable data of traffic flow, is also missing. Accordingly, in this paper only demographic (by population size) and traffic risk (by registered vehicles) are observed.

Table 1 Demographic and accidents data, Montenegro 2013 –2014

Municipalities	Inhabitants	2013									2014								
		Registered vehicles	Accidents			Injuries			Registered vehicles	Accidents			Injuries						
			1	2	3	I	II	III		1	2	3	I	II	III				
1	Podgorica	186290	69318	1455	434	9	648	83	10	65892	1546	446	14	627	96	17			
11	Cetinje	16689	6283	83	47	4	74	15	4	6207	82	46	1	77	19	1			
13	Kolasin	8396	1815	74	15	5	44	26	22	1724	69	30	3	58	13	4			
12	Danilovgrad	18507	4881	111	24	0	40	7	0	4445	78	39	1	54	9	1			
2	Niksic	72581	19589	486	151	4	239	52	4	18269	475	155	7	210	43	7			
16	Pluzine	3252	512	12	5	2	13	5	2	483	9	3	2	7	3	3			
14	Savnik	2074	332	15	2	1	5	1	4	6448	12	5	0	10	3	0			
3	Bijelo Polje	46138	9232	101	66	3	98	20	3	9475	100	71	1	104	16	2			
17	Mojkovac	8638	1686	43	24	0	36	4	0	1512	38	18	1	29	2	1			
18	Berane	34035	6713	29	16	3	20	6	4	6489	27	12	0	17	7	0			
19	Rozaje	23008	5092	39	26	0	36	6	0	5013	32	33	3	53	5	4			
20	Plav	13133	2378	10	5	1	8	3	1	2305	5	8	2	20	6	3			
21	Andrijevica	5081	1021	5	2	1	4	1	1	943	13	4	1	6	2	1			
4	Pljevlja	30844	7186	63	27	1	46	11	1	7284	58	30	2	45	8	2			
15	Zabljak	3576	772	13	6	0	8	4	0	839	13	6	1	11	5	1			
7	Herceg Novi	30923	12746	232	62	1	77	19	1	12251	267	51	4	58	7	4			
6	Kotor	22644	10647	297	44	5	55	27	6	10167	362	50	2	57	20	2			
5	Tivat	14058	6592	138	24	1	28	9	1	6756	158	41	2	46	6	2			
8	Budva	19255	11283	249	69	4	110	26	5	11913	278	86	4	113	22	5			
9	Bar	42128	17566	366	100	3	135	20	3	17456	418	92	5	171	48	5			
10	Ulcinj	19959	7399	177	67	2	88	15	2	7213	157	52	0	62	10	0			

1 = accidents only with damage; 2 = injury accidents; 3 = fatal accidents; I = slight injuries; II = serious injuries; III = fatal injuries

In road accidents statistics in Montenegro, accidents were categorized in: fatal accidents, serious injury accidents, slight injury accidents and damage only accidents, /15/. Both, number of accidents and injuries are weighted with following coefficients recommended by British ministry of transport:

- Accidents:
 - 1 = accidents only with damage
 - 20=50 = injury accidents
 - 150 = fatal accidents;
- Injuries:
 - 1 = slight injuries
 - 5 = serious injuries
 - 50 = fatal injuries.

The road safety ranking is based on a methodology used in the EuroRAP Programme, /7/. In order to show the varying levels of risk across municipalities, individual sections are allocated into one of five colour coded risk bandings, which represent standard RAP Road Risk Mapping colour palette. The colour palette has been designed to meet the following criteria:

- ✓ Achieves international consensus;
- ✓ Is based on the significance of particular colors (such as black and red to signify danger) in different countries and is therefore meaningful to a wide audience;
- ✓ Adjoining colors are easily distinguishable from one another;
- ✓ Ensures that the information is clear and distinguishable when presented in a variety of media (online, print, high resolution, low resolution).

Additionally, in this paper, because of wide dispersion of extreme data, median (Me) as a measure of central tendency was used to obtain the thresholds for each risk banding.

4. Results and discussion

Table 1 shows basic data for Montenegro for 2013 and 2014. Number of inhabitant is based on population census from 2011.

Annual average values for demographic risk rang thresholds (Me for accidents and injuries retrospectively: $Me_{ac}=619.91$; $Me_{in}=103.94$) and traffic risk rang ($Me_{ac} =195.18$; $Me_{in} =37.64$) for two-years data period is presented in Table 2. Demographic risk was shown as weighted number of accidents and injuries per 100,000 inhabitants; while traffic risk was shown as weighted accidents and injuries per 10,000 registered vehicles. Risk rate maps for those are presented on Fig. 1 and Fig. 2.

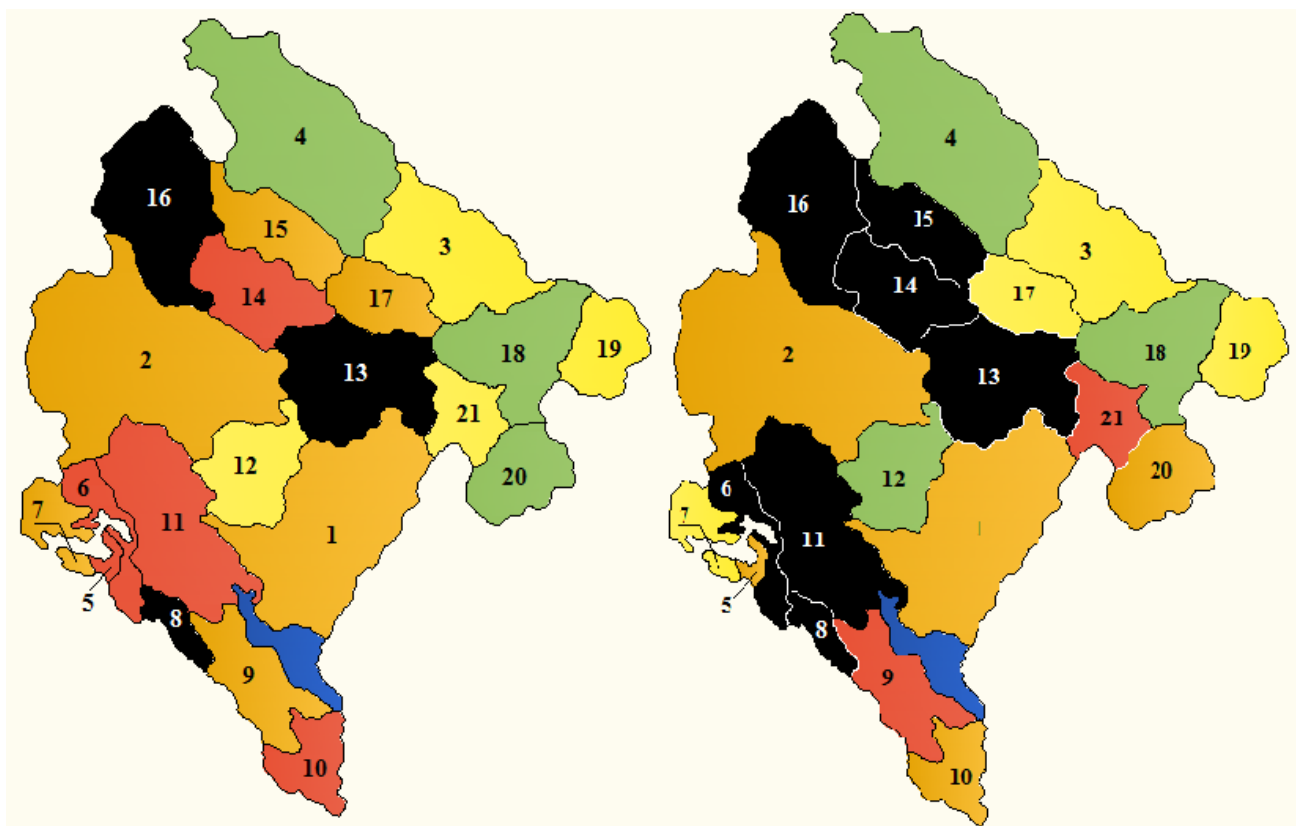
Table 2 Risk band thresholds (2 years assessment period)

Risk level	Demographic risk		Traffic risk		Range (color)
	Accidents	Injured	Accidents	Injured	
2013-2014					
Low	< 247.96	< 41.57	< 78.07	< 15.05	
Low-medium	247.96 to 495.93	41.57 to 83.15	78.07 to 156.14	15.05 to 30.10	
Medium	495.93 to 743.89	83.15 to 124.73	156.14 to 234.21	30.10 to 45.15	
Medium-high	743.89 to 991.85	124.73 to 166.30	234.21 to 312.29	45.15 to 60.20	
High	> 991.85	> 166.30	> 312.29	> 60.20	

Critical zones were north and central municipalities, especially 13 (Kolasin) and 16 (Pluzine) where both, demographic and traffic risk were twice as high as average. High risk rates are also recorded in municipalities: 8, 14, 15, 16, 17, and 21. The lowest risk of being involved in accidents or injured in it, were in municipalities 4 (Pljevlja) and 18 (Berane). It can be observed that there are a large number of municipalities defined as 'high risk'. Therefore, it's not surprising that on Montenegro roads 75 black spots have been identified during Black Spot Management programme, where 18 have been alarming, mostly in municipalities

identified as very risky. To understand picture of road safety in Montenegro it should be noted that the large number of tourists' vehicles were involved in traffic flow during summer season. That's reason why smaller municipalities (with small number of registered vehicles: municipalities N° 14, 15, 20, 21 on figs) were with 'high' rang when observing traffic risk. Also, those were municipalities with main and regional roads. One of the reasons for bad road safety situation in Montenegro is inapproachable (rough) terrain. Main road, from north border (with Serbia) to capital city (Podgorica) and seaside, is through canyon. The quality of road network in Montenegro, as well as transport safety will be enhanced with the construction of two highways Bar-Boljare and Jadransko-Jonski highway, in accordance with Transport Strategy of Montenegro.

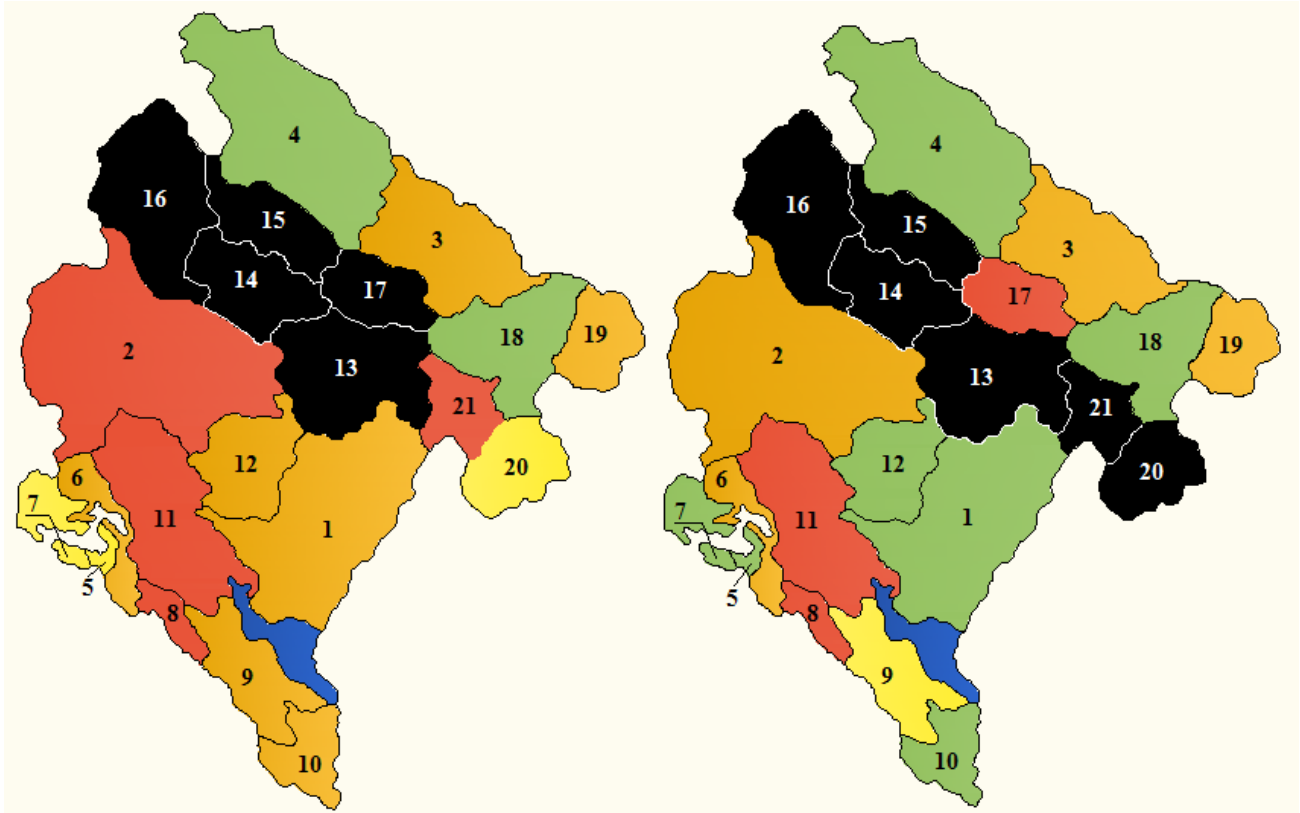
Figure 3 and figure 4 presents change of demographic and traffic risk from 2013 to 2014. Risk for 2013 is presented on the left side of contour of municipality and risk for 2014 on the right side of municipality. It can be observed that in most cases there was impairment of road safety. Like in following municipalities: 5, 7, 12, 15, 19, and 20. In few municipalities improvement of road safety has been recorded: 6, 10, and 11. However, this was more a coincidence rather than progress due to undertaken measures. The most critical zones stayed critical during both years



Accidents per 100,000 inhabitants

Injuries per 100,000 inhabitants

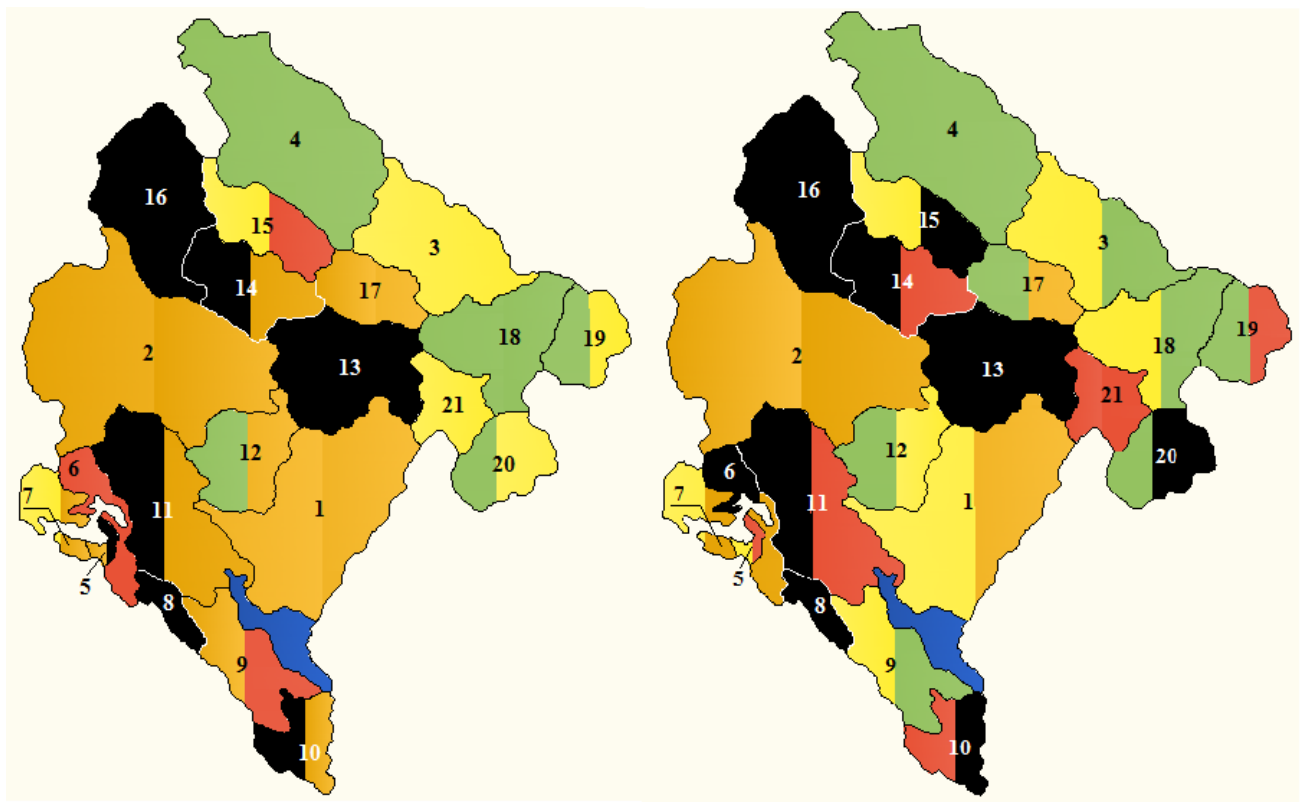
Figure 1 Demographic risk rate for assessment period



Accidents per 10,000 vehicles

Injuries per 10,000 vehicles

Figure 2 Traffic risk rate for assessment period



Accidents per 100,000 inhabitants

Injuries per 100,000 inhabitants

Figure 3 Demographic risks changing in Montenegro from 2013 (left side of contours) to 2014 (right side of contours)

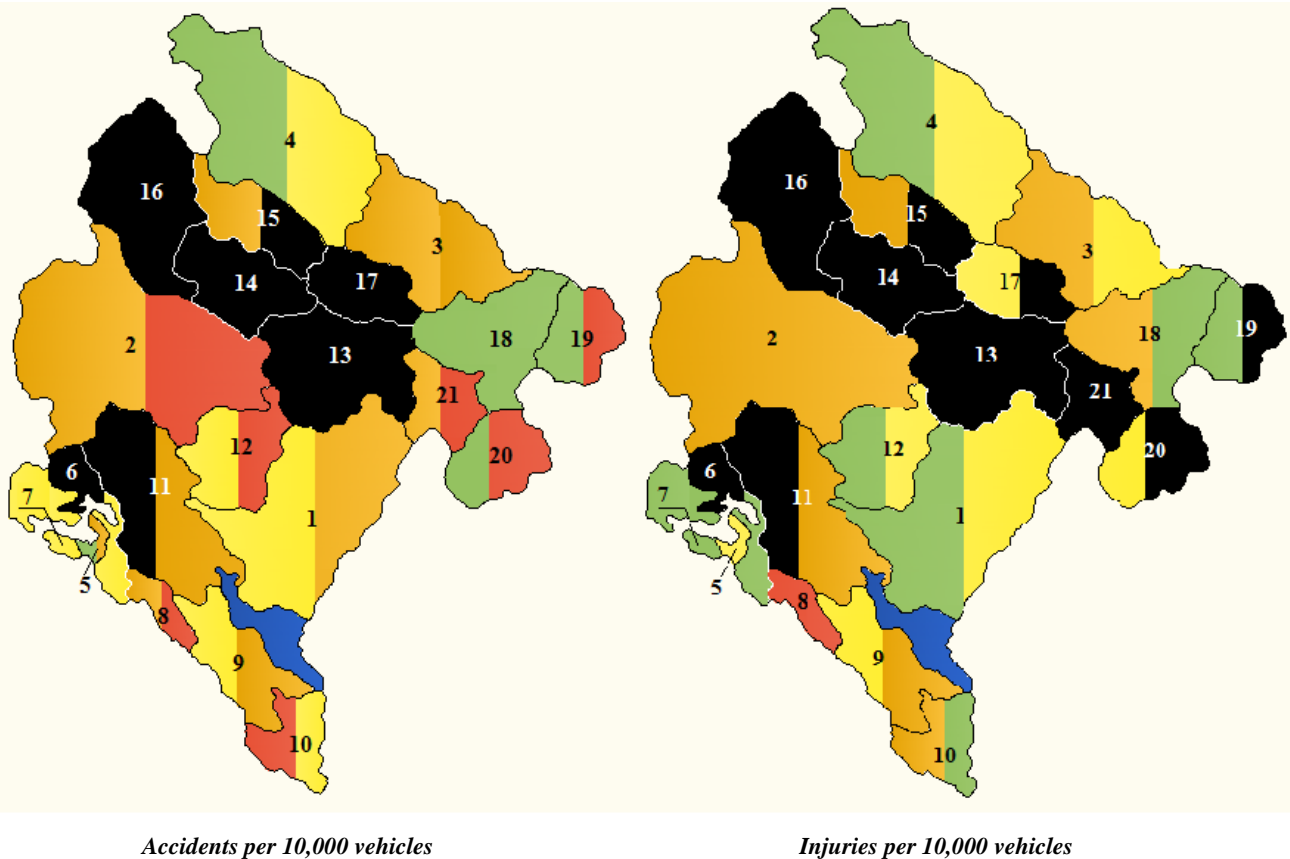


Figure 4 Traffic risks changing in Montenegro from 2013 (left side of contours) to 2014 (right side of contours)

5. Conclusion

In the last few decades, road safety has become a high priority in many governments' policy-making, and is now a critical item on the political agenda. On the developing countries, such as Montenegro, the problem is even greater due to the growing number of cars, the poor quality of road projects and the lack of legislation related to driving and safety. As the absolute number of accidents cannot well reflect the road safety, the concept of relative risk indicator is proposed. Risk mapping, by its very nature, relies on the use of historic crash and/or traffic flow data, and shows the combined influence of behavior, road and vehicle. Here, analyses have been made of fatal and serious accidents occurring on the Montenegro road network during 2013 and 2014. Mapping the risk occurs there is high difference in risk values between roads/municipalities which may reproduce false road safety picture. For the individual road user, it is important to understand both the role of the infrastructure and the role of their own behaviour in determining the risk they face on the road. It is important to recognize that not all roads can be managed to the same risk level, but at the same time to seek to keep the risk within acceptable bounds for those roads with the highest levels of risk. For the road provider, the most immediate need is to decide how best to improve the collective risk across the network, primarily in terms of how to spend available budgets most effectively.

References

- /1/ Organization for Economic Co-operation and Development/ International Transport Forum (OECD/ITF), *Trends in the Transport Sector 1970–2010*, 2012.
- /2/ COWIS A/S, *World Bank – Road Safety Survey Montenegro, Final Report*, 2008.
- /3/ European Commission, Directorate General for Mobility and Transport, *Road safety evolution in EU*, 2012.
- /4/ Ministry of transport and maritime affairs, *Strategy for efficient traffic in Montenegro*, Podgorica, 2008.
- /5/ Ministry of interior, *Strategy for improvement of road traffic safety 2010-2019*, Podgorica, 2009.
- /6/ Government of Montenegro, *Action plan for Strategy for improvement of road traffic safety implementation*, 2011.
- /7/ RAP Road Risk Mapping Manual: *Technical Specification*, Available in: http://downloads.irap.org/docs/RAP-RM-2-1_Risk_Mapping_technical_specification.pdf
- /8/ Lynam D., TRL, *Development of risk models for the road assessment programme*, 2012.
- /9/ Wang J., *A traffic accident risk mapping framework*, UCGE Reports N° 20353, 2012.
- /10/ Sadeghi A. et al, *Identification and prioritization of hazardous road locations by segmentation and data envelopment analysis approach*, Promet – Traffic&Transportation, Vol. 25, N° 2, pp. 127-136, 2013.
- /11/ Louis Berger SAS, *Consulting services for road safety – technical support*, Beograd, 2013.
- /12/ Government of Croatia, *Strategy of traffic development of the Republic of Croatia 2014-2030*, Zagreb, 2014.
- /13/ Organization for Economic Co-operation and Development/ International Transport Forum (OECD/ITF), *International Traffic Safety Data and Analysis Group: IRTAD Annual Report 2011*, Paris, 2012.
- /14/ RAP Road Risk Mapping Manual: *Design Specification*, Available in: http://downloads.irap.org/docs/RAP-RM-3-1_Risk_Mapping_design_specification.pdf
- /15/ Monstat, *Accident research methodology*, Available in: <http://www.monstat.org/>
- /16/ Pajkovic V., Grdinic M., *Road safety – performance and perception, Montenegro case study*, International Conference on Traffic and Transport Engineering, Belgrade, 2014.
- /17/ Grdinic M., Pajkovic V., *Traffic risk mapping (in Serbian)*, Symposium on Traffic Accidents, Zlatibor, Serbia, 2016.