Visual Analytics of Forest and other Roads Density

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Abstract. This paper compares the indicators of spatial development for the road network of Croatia towards chosen countries in Europe and on a county level in Croatia. It also shows the number of traffic accidents per counties and links it with indicators of spatial development. The paper presents the results of the research of spatial distribution of traffic accidents in Croatia by counties. An example of a hazardous site identification on the A6 motorway is provided by the accident data report. All the comparisons and analyzes are presented graphically in the form of charts and cartography-related views in the MapViewer 7 program. From the results it can be seen that there are significant differences between the counties and it is often the case that similar values for the counties derived from similar level of development and similar number of population. From the results it is concluded that the number of traffic accidents is more dependent on the population than the length of the road network in relation to the surface of the county. To invest in remediation of hazardous sites, it is necessary to consider more factors than repeated traffic accidents.

1. Introduction
This paper presents indicators of development for the road network and presents their value in Europe and Croatia. It will also be linked to the density of traffic and road safety in Croatia. It will define the place of reduced traffic safety and explain the possible causes of accidents in these areas and propose remedial measures. Croatia has the most developed road traffic. Traffic is a result of society's needs and is inevitably linked to many other factors that serve society and we can define their dependence. This paper will show an example of the correlation between highway conditions in hazardous areas and traffic accidents over a period of five years. A section to observe the A6 motorway from Bosiljevo 2 to Kikovica. Information obtained by data analysis will be compared numerically and graphically. Temporary cartography is the main means of describing the interdependence of the data. Cartographic representations to the user in a convenient way represent the information obtained and allow them to be easier to understand.

One of the unwanted consequences of increased motorization and road development is the increase in traffic accidents. These are the most common causes of deaths in the age group of 15 to 29 years and according to World Health Organization (WHO) data, around 140,000 people worldwide on the world's roads average daily, of whom more than 3 400 deaths. Spatial and demographic density are indicators of development for the road network and their comparison with the number of accidents can determine the correlation between the length of the road network, the population living in the area and the number of traffic accidents. In 2007, 61 020 road accidents occurred on Croatian roads, which is also the largest in the period from 2006 to 2015. The same year, on the A6 8 motorway accident, there was a consequent death of people. On the highway in the period from 2006 to 2016 21 traffic
accidents occurred with the injured and 312 traffic accidents with injured persons. 1 053 traffic accidents resulted in material damage. That is why more attention needs to be paid to ways of reducing or preventing many victims. This can be achieved through the improvement of basic elements: man, vehicle and road, and regulations, controls and sanctions. One of the projects that assess the road safety is the EuroRAP (European road assessment program) project. State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Highways are the best means of connecting big cities and are very important for the carriage of more passengers by buses and freight transport by trucks and other means of transport for economic purposes. Cars and other means of transportation are more and more financially available over time, affecting the increase in traffic, but also the increase in traffic accidents and the question of traffic safety. Human life is in the first place, and it strives to establish safer traffic. As part of the EuroRAP project, road hazards are reported.

2. Literature review
In Croatia there are many publications, scientific papers and articles on the density of traffic in the Republic of Croatia and road safety in the Republic of Croatia, but are rarely related to the analysis of traffic accidents in terms of spatial distribution and most publications relate to traffic accidents at the state level. Within the National Road Safety Program of the Republic of Croatia, EuroRAP analyzed traffic safety on state roads D8, D27, D30, D36, D50, D54 and A1 and A3 motorways. This paper analyzes the development of the road network and dangerous sites on the A6 motorway and the aforementioned publications serve as a model.

Publications on the topic of road network development in Croatia and traffic density are [1] and the work of [2]. Current works related to road network safety are [3] and [4], following by the work [5] of Anese Husić with explantion of improvement of the safety situation on the Rijeka - Zagreb motorway. Improved signage for roads are proposed in publication [6] of the European Road Safety Federation. Work from Yongjun Shen, Elke Hermans, Qiong Bao, Tom Brijs and Geert Wets [7] contains results which indicate that the fatality risk rather than the number has been halved. The fact that simply considering the fatality reduction may not reflect the real improvement is verified in the same work. The Mapping Natural Hazard Impacts on Road Infrastructure [8] examines the precipitation occurrence and road infrastructure impact characteristics in Baden-Württemberg and identifies spatiotemporal hazard patterns. The article suggests further research needs and fields of application for risk mapping in climate change adaptation. Recent work [9] containing mapping data, spatial distribution and mapping of related displays are with thematic map design. Research in Germany. by of HF Kern and H. Morhard- [10] in which computerized maps of density of traffic of the federal province located in the southwestern part of Germany were designed to inspect the current state and planning of the future.

Eurostat has data on the total length of motorways in each of the NUTS level 2 regions in Europe including Croatia. This can be shown with a cartogram (Figure 1), and the data refer to the year of one’s choice. The database contains data from 2004 to 2015.
Motorways network by NUTS 2 regions

2015

Kilometre

Legend

0.0 - 63.0
63.0 - 154.0
154.0 - 257.0
227.0 - 454.0
454.0 - 2585.0
Not available

Minimum value: 0.0
Maximum value: 2585.0

Figure 1. Cartographic network of highway networks by NUTS 2 levels for 2015 [11]

The number of people killed in traffic accidents in 2015 is shown by signs of proportional data (Figure 2). In addition to the year to which the data relates, the EuroStat interface allows for changing the color scale, changing the type of chart - a chart, a display of signatures or a combination of the mentioned, in which case the number of variables is represented by a different colour of equal circles for each country. Show, add additional elements on the map like rivers, relief lines, labels, and names of major cities and optional balloons.
Apart from the above-mentioned interface, there are several simple comparisons with the reference data. The reference data may be the data of a state and then the values in other countries will be displayed in relation to one selected (Figure 3). In this case, in addition to the value of the second state, each reference value of the selected Republic of Croatia is shown. The second case is a comparison with one of the offered years (2004 to 2015) and the third comparison with an arbitrarily selected value that can be entered in the foreseen location. The A3 road risk assessment was analyzed for the purpose of the EuroRAP project. Numerous cartographic illustrations are available in the publication, where the degree of risk from traffic accidents is indicated by different colors along the analyzed road. In addition, it contains the spatial definition of the node along the roadway (Figure 4) with marked node names. In this diploma work, motorway A6 will be processed and Figure 4 is a good example of a node display. EuroRap maps on the pages of the Croatian Autoclaves [14] (Figure 5) show colours categorizing the risk of roads from "green" to the least risky to "black" along which the risk is greatest. Dangerous places or black spots are not uniformly defined at the level of Europe or the world. Given that the number of accidents mentioned above does not meet the conditions for the identification of dangerous places by number of traffic accidents, there will be places where data is bounded by the definition of dangerous places. On the A6 motorway there are 11 places where eight or more traffic accidents occurred within 300 meters in five years or in the period between 2012 and 2016. Most of the traffic accidents did not cause the injured person, or as a result there is only material damage to the vehicle and infrastructure of the road. The current law requires that the site be identified as dangerous if at least 15 accidents occurred at the site, regardless of the consequences of the previous three years or 12 of the injured. Data required for processing and analysing the spatial distribution of traffic accidents on the A6 motorway are traffic density, technical characteristics and categorization of the stock, location and consequences of traffic accidents.
Figure 4. Cartographic display of highway A3 (Zagreb East - Lipovac) analyzed on the basis of EuroRAP methodology [15].

Figure 5. Road risk assessment for the period from 2010 to 2012, [16]
3. Hazard Identification on Highway A6

The data are downloaded from the Croatian Roads d.o.o., Google Maps Street View web pages and obtained from the Ministry of the Interior of the Republic of Croatia. Hrvatske ceste d.o.o. each year they publish the turnover data in a table 1 and in the form of a written publication with analyzes, graphs and summaries for the year concerned. The Google Maps Street View browser defines the characteristics of the stock (slope, limit, sun exposure, number of bars, fence, etc.). Data on distribution of traffic accidents on the A6 motorway were requested via electronic mail. The data are not published publicly on the Ministry of Foreign Affairs, but each person has the right to ask for them and ultimately have access. The data was obtained in the form of a text file and contained information on the police administration and the station within whose area of accident occurred, the date and time in the hours and minutes when the accident occurred and the accident location information expressed by the station in meters. The motorway station is defined by the traffic sign "kilometric mark for highways or highways. The sign is set every 1.0 km, and the numbers grow from the beginning to the end of the highway. The highway starts and ends: 1. on the state border or 2. at the junction, at the point of connection with the other highway. For one and the second direction of the motorway, the same station is valid, so the number on the kilometre mark is equal to the same cross section for both directions. The motorway station is growing from north to south or west to east, according to the description of the highway [17].

Table 1. Average Annual and Average Daily Traffic with General Data on Counter Stations on Roads of the Republic of Croatia for Year 2015 [18]

| Station | Brosačko mjesto | Promet | Hodište i nacionalna željeznička stanica | Brosački odjeljak |
|---------|-----------------|--------|------------------------------------------|-------------------|
| | | | | |

The text file also contains information on the consequences of a traffic accident and the type of traffic accident. The consequences are divided into three categories, where number 1 indicates accidents with the injured, 2 injured and 3 with material damage. The section of the type of traffic accident is divided into the category of "Collision between vehicles on the move and collision on the animal". Table 2 shows the way of marking depending on the type of accident.
Table 2. Categorization of a Type of Traffic Accident (Ministry of the Interior)

| TYPE OF TRAFFIC ACCIDENT                      |   |
|-----------------------------------------------|---|
| INTERIOR JUNCTION OF THE VEHICLE ON THE MOVE |   |
| from the opposite directions                  | 1 |
| side collision                                | 2 |
| parallel driving                              | 3 |
| driving in sequence                           | 4 |
| backward drive                                | 5 |
| collision with a parked vehicle               | 6 |
| landing a road vehicle                        | 8 |
| bicycle collision                             | 9 |
| pedestrian collision                          | 10|
| collision on a motorcycle or a moped           | 11|
| collision with a railway vehicle              | 12|
| other                                          | 14|
| collision on a road vehicle                   | 15|
| collision in the roadside object              | 16|
| COLLISION ON THE ANIMALS                      |   |
| domestic animals                              | 17|
| wild animals                                  | 18|
| birds                                         | 19|

Hazardous areas were defined by data analysis by grouping those where a repeat of a traffic accident at a distance of three feet was established and where at least eight accidents occurred.

The first such location is located at an 11th kilometre mark between Bosiljevo 2 and Vrbovsko highway exits (Figure 6). The location is located directly in front of the entrance or exit of the Veliki Gložac tunnel in the middle of the rocks and coniferous trees. The traffic takes place in three bars without stopping. Exit from the tunnel or tunnel input is unlikely to change brightness and may cause dazzle in the driver and impede driving. In the same way they affect the "thick" shadows of coniferous forests when moving from the sunny area. The road is five percent sloping and the speed limit in that area is one hundred kilometres per hour and there is a possibility of an unsuitable driving speed since the usual limit on highways is one hundred thirty miles an hour. Two accidents were caused by a parallel run and two due to a run in sequence. Part of the road in front of the tunnel has no protective fence and there is a danger of landing from the road. Of ten traffic accidents, eight of them are landing vehicles off the road. Another dangerous place is the twenty-first kilometre (Figure 24). Location features are six percent slope and speed limit of one hundred and ten kilometres per hour. The section is located between the rocks and the extension of the road from two to three strips without stopping strips. Due to the tilt the drivers often "cling" and achieving speeds higher than allowed. By accident type, three are landing vehicles from the road, two caused by an animal stroke, and one case of a vehicle strike in the roadside object, one in the road, one caused by a collision and one case categorized as the other. There were nine accidents at the site, of which only one injured person was injured while the remaining damages were material.

In the third location, twenty-three kilometres, there were a total of eight accidents, six with material damage and two with injured persons. In this area, one lane is lost or the traffic from the three bars without stop is directed to the two strips with the stop bar in both directions, which requires additional attention from the driver when shifting. As can be seen in, a dangerous location is located near the entrance or exit of the tunnel on a flat section after a long sloping section that can affect the speed of driving of the driver. This section prohibits the overtaking of trucks and the limit for all types of vehicles is 100 kilometres per hour. Of the eight accidents in two cases there was a landing of vehicles
from the road, in two stroke of the vehicle on the road, and the other four were categorized into the other.

![Dangerous place on 11th kilometre of highway A6, [19].](image)

**Figure 6.** Dangerous place on 11th kilometre of highway A6, [19].

4. Conclusions
An indirect increase in security can be achieved by more precisely defining the location of the hazardous site and the characteristics of that stock so that in the future in case of recognizing the dangers of the stake could be able to remedy the deficiencies. Also, improvements are needed in educating police officers who will use the system. Traffic-technical measures can be directly affected by the remediation of a hazardous site by recognizing the disadvantages of achieving safe traffic.

In addition to the above-mentioned proposals, an important factor in traffic safety is man. Traffic education and training contributes to increased safety as well as the surrender of generational generation traffic culture through educational institutions, special seminars, public presentations and all kinds of media. The paper presents the results of the research of spatial distribution of traffic accidents in Croatia by counties. Calculations of the values of development indicators for the road network were also calculated and compared with the distribution of traffic accidents by counties. Graphic shows and comparable rates of traffic accidents per 1000 inhabitants, 1000 registered drivers and 1000 registered vehicles per county. The position of Croatia in Europe in terms of spatial and demographic density was also presented.

By spatial density, Croatian values are three times less than the average. Less populated areas, with high levels of development and population, have a lean transport infrastructure. As spatial density expresses the number of kilometres of road network per 100 kilometres of square meters, countries such as the Netherlands, Denmark and Switzerland have a leading position in this segment. Spatial density of Croatia is most similar to Slovakia. Looking at the demographic density, Croatia is in line with the UK and Germany per kilometer of the road network per inhabitant. In Germany, however, the length of the road network and population is larger than almost twenty times, and the area is seven.

In Croatia, the counties have the largest spatial density in Varaždin, Međimurje and Krapina Zagorje County. These counties are one of the smaller ones on the surface and have a favorable position along the border with Slovenia and Hungary near the main Slovenian city of Ljubljana and
Zagreb and have a long road network in relation to the surface. Demographic density denotes the length of the road network per inhabitant of the county and the highest values will be attributed to the least inhabited counties with the most road network. As the road networks developed, the characteristics of the more developed and developed areas have been the most important factor, with the population being Lika - Senj, Šibenik - Knin and Požega - Slavonia County.

Distribution of traffic accidents by counties is best suited to demographic data, which concludes that more populated areas are responsible for a greater number of traffic accidents. These are the County of Zagreb and the City of Zagreb, Splitsko - dalmatinska and Primorsko - Goranska counties. Correlation between spatial density and traffic accidents is very weak. Although the correlation is weak, it exists. Hundreds of square miles of land in counties with more traffic accidents mostly correspond to several kilometers of road network. It is concluded that the number of traffic accidents is more dependent on the population than the length of the road network in relation to the surface of the county.

Tracking of traffic loads can define stocks that require higher quality, especially if identifying a dangerous place on those shares. To invest in remediation of hazardous sites, it is necessary to consider multiple factors of repeated traffic accidents. Current law needs to be replaced with new ones and apply new methods for identifying hazardous sites. Greater data usefulness requires uniformly filling in questionnaires on traffic accidents and location determination as well as good communication and data exchange between vehicle accident recording bodies and bodies for the identification and rehabilitation of dangerous sites.

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