FIRE OCCURRENCE MAPPING FOR PROVIDING THE RISK ANALYSES AND FIRE INVESTIGATION PURPOSES

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ABSTRACT

In the paper, there are introduced the results of analysis of fire occurrence data and a map of spatial distribution of fire occurrence in the territory of Presov region in period 2004 - 2013. To provide the analysis was necessary to build a fire geodatabase, which contained the data that are collected at the Fire Research Institute since 1996. To visualize the data on fire occurrence we used the cartogram built in the ArcGIS environment. The results of such analysis are necessary as for providing the fire risk analyses as for fire investigation purposes.

ARTICLE INFO

INTRODUCTION

The data on fire occurrence have been collected, summarized and evaluated at the Fire Research Institute of the Ministry of Interior of the Slovak Republic since 1996. There are collected and summarized the data coming from all the Local and Regional Headquarters of the Fire and Rescue Corps of the Slovak Republic. Those data represent of type of input data required to complete the form on the fire brigade intervention in the CoordCom environment used for operational management fire and rescue activities. The data, after collecting at the Fire Research Institute, are processed and analyzed in STAT ZPP software environment. The core of this program is a database of fire occurrence, the analyses and the functions to be used are the same as in many others database systems. This program is mostly used to produce the fire statistics, which are annually published by the Institute in the form of print publication.

In this paper we introduce an approach to processing the data on fire occurrence in GIS environment. For this purpose we applied the professional ArcGIS 10 Desktop environment. To visualize the data on fire occurrence in the particular districts of the Presov region in period 2000 – 2013 we used the cartograms. This is the first time we used the GIS to process and visualize these data this way

PROBLEM

Geographical information system (GIS) is a comprehensive tool to process and visualize spatial data. To its basic functions belong: input data from different sources including the GNSS devices, data pre-processing The Analytical and Expertise Department of Fire Research Institute of the Ministry of Interior in Bratislava ensures the performance of state administration in identifying the causes of fires: manages from a professional point of view the activity of state fire supervision in the field of investigation of the causes of fires, statistical monitoring and creating the analyzes on fire occurrence; plays a role in collecting statistics on fires and expertizes on the causes of fires in the Slovak Republic; and processes the analyzes on the development of fires. The purpose of processing the fire analyzes is the concentration and analysis of data and knowledge on fires and their use in management, preventive-educational, inspection and operational and technical activities. District Directorate and the Regional Directorate of the Fire and Rescue Corps use in the processing of fire analyzes in particular the knowledge gained in investigating the causes of fires, enforcing the state fire supervision and activities related to fire-fighting. To process analyzes, the organizational departments of the directorate are involved, which are applying the knowledge from their own activities. Analyzes are intended only for official use. About the provision of data from analyzes decides the President, Vice president, Director of the Institute or Director of the Regional Directorate or District Directorate of the Fire and Rescue Corps.

Fire Analysis contains basic information about fires, in particular: the number of fires, direct damages, consequential damages, saved values, the number of injured people, the number of dead people; overview on fires, with which was the number of persons injured or killed or amount of direct damage fundamentally influenced; evaluation of the fire safety situation in the sectors of the economy; evaluation of the activities of the Fire and Rescue Corps members who were involved in investigating the causes of fires, evaluating the survey results of the causes of fires from the success of clarification, the organization of activities in the field of investigation of the causes of fires and the appropriateness and comprehensiveness of material-technical equipment of the department point of view (conversion of formats, transformation of reference systems, setting projection, georeferencing, selecting the area of interest), processing the database records (updating, filtering, etc.), data analyzes applying the spatial analyst tools, map algebra tools, distance analyzes tools or geostatistical and network analyzes tools, and creating the output in the form of maps or web map services.

To visualize the results of analyzes on fire occurrence we used the cartograms.

Cartogram can be described as a map, in which represent the statistical data for particular territorial units in the form of chart. The values which are expressed in the map are always absolute. The chart is commonly placed in the center of the polygon. Current GIS systems offer different types of charts to select: bar/column, pie or stacked [1].

EXPERIMENTAL PART

To analyze the data on fire occurrence, which occurred in Presov region in period 2004–2013, we used the tools and functions provided by the ArcGIS 10 environment.

The data on fire occurrence were exported from the STAT ZPP program in database format. In the database were introduced data on the date of fire ignition, number of fire, the place and environment of fire ignition, the reason of fire ignition, the damage calculated in EUR currency and the extent of the fire damaged area.

In the analyses we consider only the number of fires per district in each year in the time period observed, the reason of fire ignition classified to the following categories: carelessness of children up to 15 years, setting fire at waste dumps, manipulation with open fire, grass burning, arson and electrical shock; and the fire damage expressed in EUR.

These data were analyzed, processed to the form suitable to be used in ArcGIS environment. The numbers of fires, classified by the reason of fire ignition were extracted for each district existing within the Presov region. Totally, there are 13 districts: Presov, Poprad, Kezmarok, Stara Lubovna, Sabinov, Levoca, Bardejov, Svidnik, Stropkov, Vranov nad Toplou, Medzilaborce, Humenne, Snina. To visualize the results of analyses we used the cartograms.

We also processed the data on the fire damage expressed in EUR currency in GIS.

Results

Here we introduce the results of data on fire occurrence processing in GIS in graphical and also in tabular form.

From the results of fire number analysis in period 2004 – 2008 figures the fact that the highest number of fires occurred in 2007. It was totally 2,337 fires. The highest number of fires that year occurred in Stropkov and Presov districts. Year 2007 belonged to the most dry years in period analyzed. The total number of fires that occurred in this period was 8,977.

In Fig. 1 we introduce the results of survey related to the number of fire occurrence in particular years of the period analyzed (2004 – 2008) in form of cartogram produced in ArcGIS. In Tab. 1 we introduce the overview on the fire number in period 2004 - 2008 in tabular form.
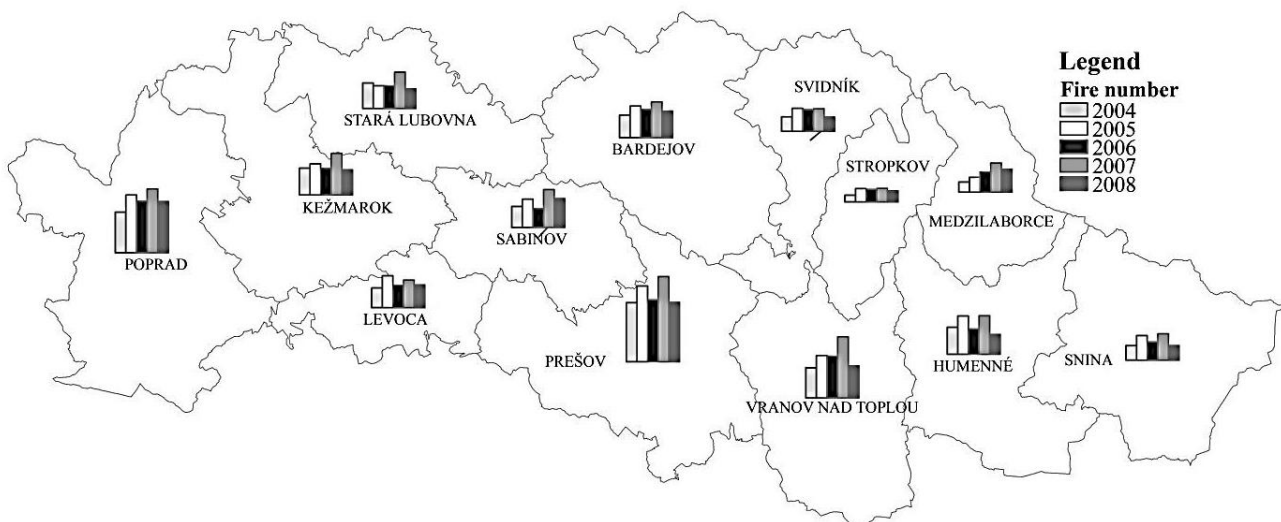

Fig. 1 Results of survey related to the number of fires in period 2004 – 2008

DISTRICT/YEAR	NUMBER OF FIRES					
	2004	**2005**	**2006**	**2007**	**2008**	**Total**
Bardejov	102	143	128	161	120	654
Humenne	65	103	97	101	64	430
Kezmarok	115	102	102	164	89	572
Levoca	46	67	91	132	104	440
Medzilaborce	120	139	119	186	113	677
Poprad	31	60	56	61	50	258
Presov	183	260	233	287	231	1,194
Sabinov	94	127	85	170	130	606
Snina	122	172	114	173	89	670
Stara Lubovna	66	111	82	119	66	444
Stropkov	266	341	278	383	267	1,535
Svidnik	135	191	188	275	145	934
Vranov nad Toplou	89	144	102	125	103	563
Total	1,434	1,960	1,675	2,337	1,571	8,977

Tab. 1 Overview on the fire number in period 2004 - 2008

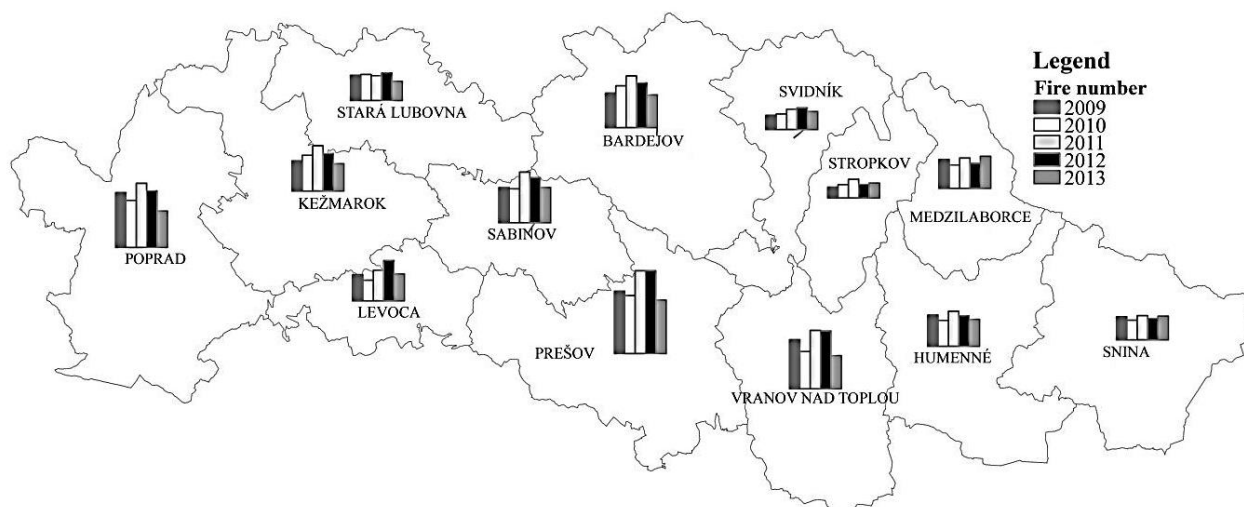Fig. 2 and Tab. 2 present results survey related to the number of fire occurrence in period 2009 – 2013.

Fig. 2 Results of survey related to the number of fires in period 2009 – 2013

District/Year	Number of fires					
	2009	2010	2011	2012	2013	Total
Bardejov	148	179	222	192	140	881
Humenne	61	66	87	93	77	384
Kezmarok	108	112	106	118	82	526
Levoca	125	101	131	108	138	603
Medzilaborce	130	154	195	161	117	757
Poprad	46	57	80	58	64	305
Presov	236	202	276	243	157	1,114
Sabinov	151	146	218	194	151	860
Snina	134	111	150	131	116	642
Stara Lubovna	99	84	104	91	102	480
Stropkov	268	249	356	356	229	1,458
Svidnik	211	161	251	249	143	1,015
Vranov nad Toplou	113	89	132	174	116	624
Total	1,830	1,711	2,308	2,168	1,632	9,649

Tab. 2 Overview on the fire occurrence number in period 2009 - 2013

The highest number of fires in period 2009 – 2013 was observed in 2011 (2,308 fires). On the other hand, the lowest number of fires was observed in 2013. From the districts point of view the highest number of fires occurred in Stropkov district. The total number of fires was 9,649, what represents the increase by 7.49 % in comparison to previous period.

Further we introduce the results of fire damage analysis (Tab. 3, Fig. 3) that are classified by the district and expressed in EUR currency.

District/ Year	Fire damage in thousands of EUR										
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Bardejov	136.4	118.7	129.7	168.4	193.9	255.2	182.4	116.0	1050.2	151.8	2502.7
Humenne	34.6	90.7	228.4	50.6	31.5	221.4	47.1	83.1	145.2	216.6	1149.0
Kezmarok	251.6	262.1	176.1	249.1	296.4	128.6	105.9	115.0	175.6	54.3	1814.9
Levoca	42.8	27.6	133.2	50.1	23.7	20.0	32.3	52.9	123.3	471.2	977.1
Medzilaborce	41.0	185.7	192.7	410.7	314.2	279.7	323.2	67.9	586.1	400.9	2802.1
Poprad	33.4	79.0	18.5	51.6	88.9	56.2	64.6	47.8	32.4	215.3	687.8
Presov	1525.7	927.0	1733.0	4149.8	1070.2	704.2	221.7	577.7	332.0	2485.4	13726.6
Sabinov	101.1	239.4	115.9	215.0	192.6	280.4	59.3	74.1	450.8	115.1	1843.7
Snina	194.4	101.6	136.8	635.8	525.2	209.1	64.5	861.5	130.1	587.5	3446.5
Stara Lubovna	57.6	257.2	255.6	204.5	43.2	372.0	110.1	117.7	106.8	232.0	1756.6
Stropkov	390.4	784.5	220.3	5045.5	1012.7	192.6	311.1	275.7	574.0	371.6	9178.5
Svidnik	61.4	131.0	153.7	164.6	56.5	571.1	146.2	628.8	159.1	96.2	2168.6
Vranov n. Toplou	114.9	101.3	119.8	98.7	141.4	236.4	94.0	84.1	116.3	134.2	1241.3
Total	2985.3	3305.9	3613.7	11494.3	3990.6	3527.1	1762.4	3102.5	3981.8	5532.0	43295.5

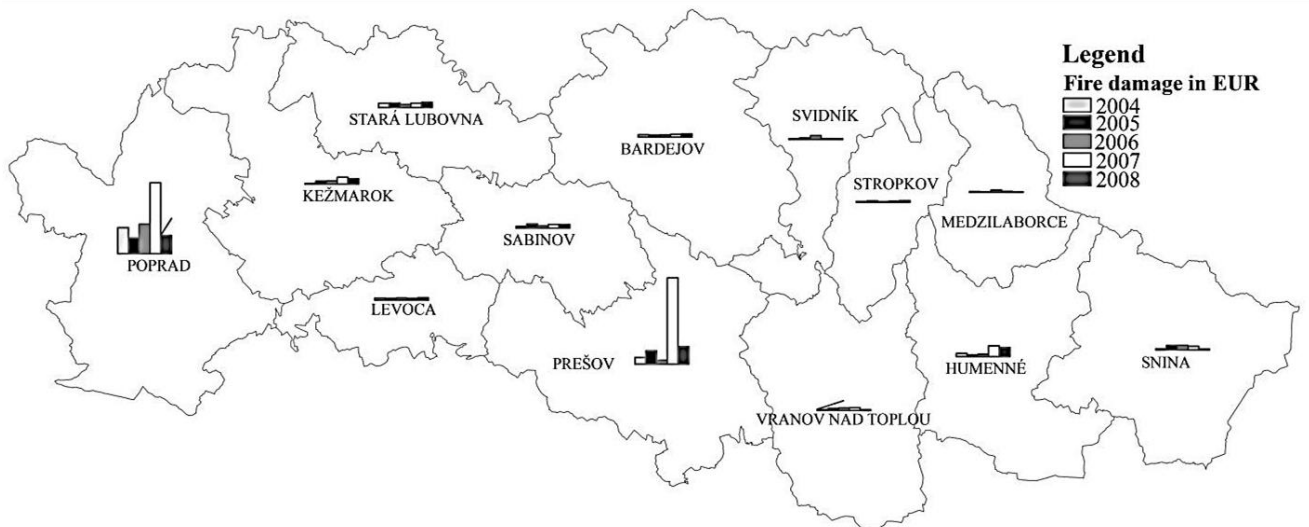**Tab. 4** Results of fire damage analysis in period 2004 - 2013

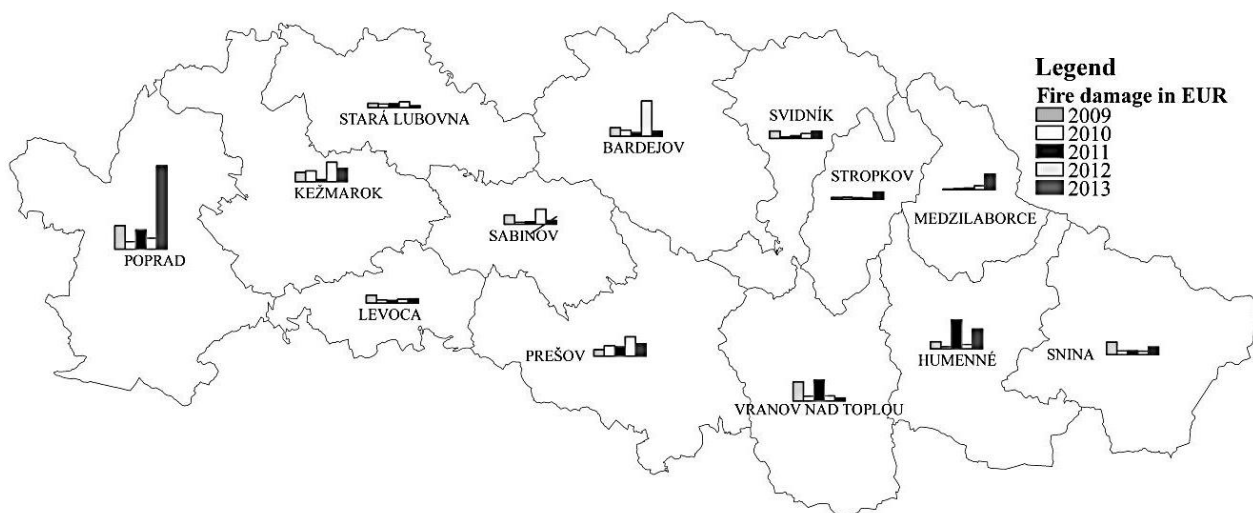**Fig. 3** Results of fire damage analysis in period 2004 – 2008

Fig. 4 Results of fire damage analysis in period 2009 – 2013

The total height of fire damaged, expressed in EUR, was more than 43 million EUR. The highest damages were observed in 2007 (very dry period from the weather point of view), especially in Presov and Stropkov districts.

The results of fire reasons analysis for period 2004 – 2008 and 2009 – 2013 are also introduced in Fig. 5, 6 and Tab. 5, 6.
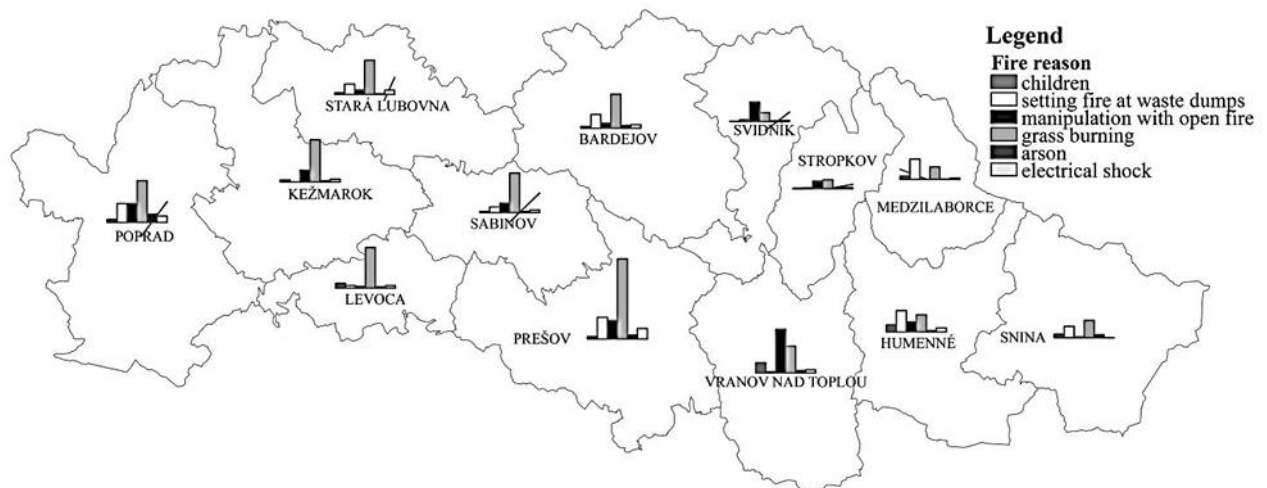
Fig. 5 Results of fire reason analysis in period 2004 – 2008

District	Fire reason						
	Children	Setting fire at dumps	Manipulation with open fire.	Grass burning	Arson	Electrical shock	Total
Bardejov	14	107	40	267	22	29	479
Humenne	3	14	152	70	6	9	254
Kezmarok	14	80	35	268	5	33	435
Levoca	27	161	0	100	4	12	304
Medzilaborce	16	0	93	330	11	22	472
Poprad	3	6	59	70	6	9	153
Presov	26	150	148	328	66	51	769
Sabinov	9	45	75	310	9	20	468
Snina	56	167	81	137	12	33	486
Stara Lubovna	26	87	4	134	23	0	274
Stropkov	20	171	145	627	31	83	1077
Svidnik	82	12	344	212	21	27	698
Vranov nad Toplou	38	20	15	318	11	20	422
Total	334	1,020	1,191	3,171	227	348	6,291

Tab. 5 Results of fire reason analysis in period 2004 – 2008

In period 2004 – 2008, there was observed the most often occurring reason of fires the grass burning. The total number of grass burning fires was 3,171 what represents 50 % share of the total number of fires that occurred in this period. The highest number of grass burning fires occurred in Stropkov district (626 fires), lower number of grass burning fires

occurred in Medzilaborce (330 fires), Presov (328 fires), Vranov nad Toplou (318 fires) and Sabinov (310 fires) districts.

Among the other often occurring reasons of fire ignition belonged manipulation with open fire (1,191 fires) and setting fire at dumps (1,020 fires).
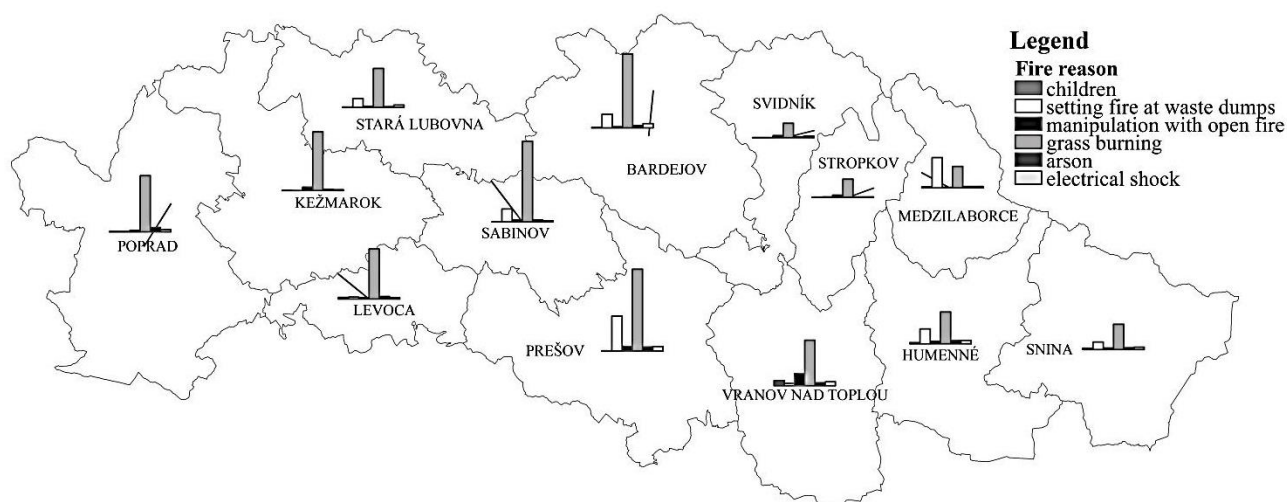

Fig. 6 Results of fire reason analysis in period 2009 - 2013

District	Fire reason						
	Children	Setting fire at dumps	Manipulation with open fire.	Grass burning	Arson	Electrical shock	Total
Bardejov	3	90	7	487	15	28	630
Humenne	1	1	14	95	7	10	128
Kezmarok	2	59	8	258	6	16	349
Levoca	7	200	5	142	10	10	374
Medzilaborce	1	0	22	387	7	5	422
Poprad	1	2	15	120	3	2	143
Presov	3	3	11	372	30	15	434
Sabinov	0	85	13	532	13	6	649
Snina	8	98	16	211	21	23	377
Stara Lubovna	10	50	11	167	12	16	266
Stropkov	1	230	30	540	27	29	857
Svidnik	36	17	81	302	21	27	484
Vranov nad Toplou	11	14	9	331	18	9	392
Total	84	849	242	3,944	190	196	5,505

Tab. 6 Results of fire reason analysis in period 2009 – 2013

Analyzing the data on fire reasons in period 2009 – 2013 we found out that the most occurring reason of fire ignition was grass burning (3,944 fires) like in the previous period. In comparison to the previous period we found out that the number of grass burning fires increased by 24 %. The most risky region from grass burning point of view was Stropkov again. To the other fire risky districts belong Sabinov (532 fires), Bardejov (487 fires), Medzilaborce (387 fires) and Presov (372 fires) district.

The second most frequently occurring reason of fire ignition was setting fire at dumps. From this reason point of view, the most fire risky district was identified Stropkov district again.

Fire reason	Children	Setting fire at dumps	Manipulation with open fire	Grass burning	Arson	Electrical shock	Total
Total	418	1,869	1,433	7,115	417	544	11,796

Tab. 7 Total number of fires classified by reason of fire ignition (period 2004 – 2013)

In both periods (Tab. 7) the most dominant reason of fire ignition was grass burning. The most risky district from grass burning point of view was identified Stropkov district (totally 1934 fires).

Among the other often occurring reasons of fire ignition belonged setting fire at dumps (1,869 fires) and manipulation with open fire (1,433 fires).

CONCLUSIONS

Here introduced approach to analyze the data on fire occurrence in GIS represents a new way of evaluation the data on fire occurrence in Slovak conditions. Having the information on specific position of fire occurrence could improve the complexity of the analysis and enable to use more sophisticated methods of statistical data processing, e.g. to provide the Kernel analysis. Results of such analysis can be useful for risk assessment purposes as well as for fire investigation purposes.

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