Technological Disasters

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Abstract. **Accidents or disasters can be the result of natural or man-made disasters. Technological disasters, civil commotion, terror acts and armed conflicts are regarded as man-made disasters. [1] In their turn, technogenic disasters include fires, transport accidents, accidents in manufacturing facilities, explosions, chemical substance leaks, etc. One of the most serious problems is connected with fires. Density of population in populated areas and welfare growing, fire risks also grow, including the risk of being injured or killed during fire. Threat to human life and health, possible damage to property and environment caused by fire are considered to be fire risk. [2]**

Keywords: **technological disasters, risk, fire, fire risk, killed in fires, injured in fires.**

I. Introduction

Centre for Research on the Epidemiology of Disasters (CRED) has formed disaster data base during several decades. Statistics show that the number of technological disasters has begun to grow rapidly since 1970 (Fig.1). [3]

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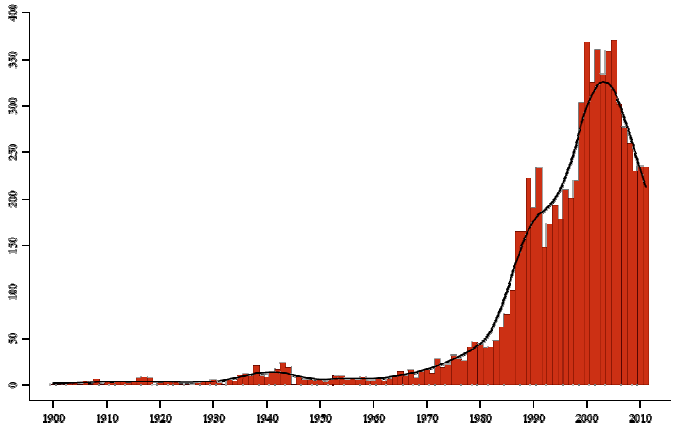

Fig. 1. Technogenic disasters

The number of transport disasters on rivers and seas has especially increased. Irrespective of the fact that North American and European countries have significantly greater transport and production infrastructure density in comparison with other continents, the biggest number of killed in such disasters is in Africa and Asia (Fig.2 and 3). [1] [4]

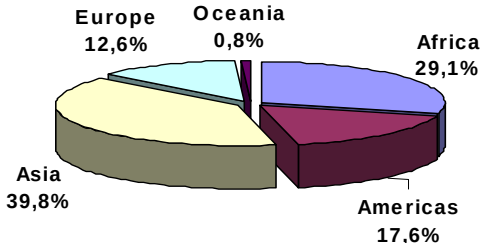

Fig.2. Transport accidents

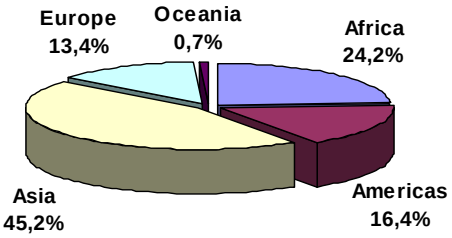

Fig.3. Number of killed

The aim of CRED databases is to provide humanitarian aid on the national and international levels. This initiative is directed at rationalising the decisions made, preparing for emergency situations duly and correctly, as well as at objective evaluation of possible weak spots and performing the definition of priorities.

Database of emergency situations summarizes and stores the information about more than 16,000 of different world's disasters starting with 1900. This summary is gathered from different sources including:

UN agency;
Nongovernmental organisations;
Insurance companies;
Scientific research institutes;
Mass media.

CRED recognizes an event as a disaster, if the event corresponds to at least one of four criteria:

10 or more people were killed;
100 or more people were injured;
Local authorities have issued an alarm in connection with emergency situation;
The state affected seeks for international help. [5]

UN data, as well as CRED data show, that technological disasters take the third place out of all disasters in the number of killed. In the first place there are hydrometeorological disasters, for example, flood and tsunami, in the second place – geological disasters (earthquakes, volcanic eruptiions, etc.).[6]

Technogenic disasters in Europe make one third, two thirds of which are transport disasters. (Fig.4). The Baltic Sea has the most loaded shipping routes in the world (Fig.5). Every moment there are about 2,000 vessels of different size in the Baltic Sea, including big oil tankers, as well as vessels transporting other kinds of cargo, big passenger vessels, fishing vessels, etc. [7] The calculations made in Estonia confirm that the possibility of a disaster taking place near the shores of Estonia, resulting in oil outflow, is 9 times a year. [8]

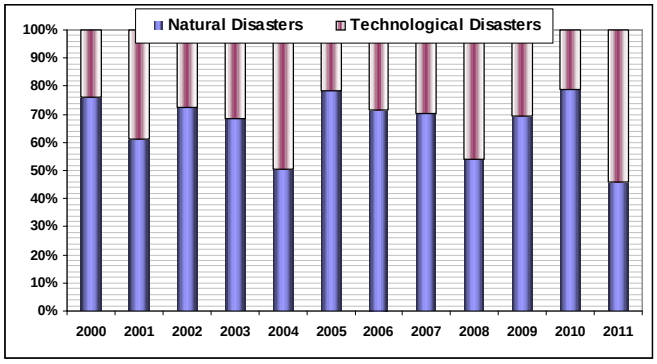

Fig.4. Division of technological and natural disasters in Europe

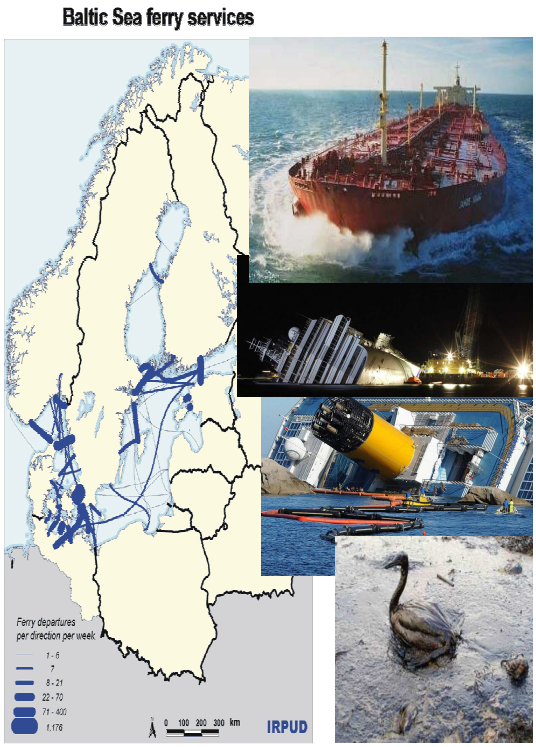

Fig.5. Load of the Baltic Sea

According to HELCOM (Helsinki Commission) data, in 2011 there took place 121 sea accidents in the Baltic Sea, 11 cases of which resulted in oil outflow, and there is no information about 38 cases (Fig.6). [8]

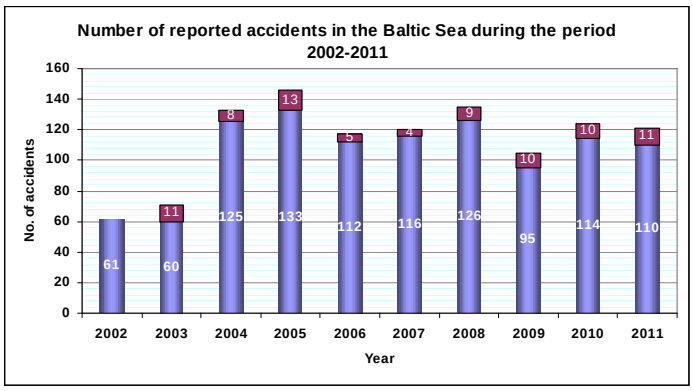

Fig.6. Accidents in the Baltic Sea, incl. with pollution

Barry Turner and Nick Pidgeon have analysed the reasons of technological disasters for the last decade and laid out their conclusions in their book „Man-Made Disasters". [9] Their opinion is that similar disaster can happen practically anywhere and there exist no „absolute weapon" to avert it. They also think there are some factors that allow prolonging the time till a disaster and minimising the consequences. Mainly these are high educational level of the inhabitants and their active civil position. If the attitude of the inhabitants of one or another country towards their job responsibilities is more professional and if the society controls it better, the level of technological disaster probability is lower. The preparedness of separate companies and state structures for actions in emergency situations plays a great role.

Each technological disaster is unique by its essence. However, there are also common reasons for such kind of disasters. American researcher Lee Davis, the author of a hand-book „Man-Made Disasters", names them in such sequence: foolishness, neglect and desire. Davis thinks that exactly „human factor" leads to technological disasters. [9]

Evaluating the greatest CRED technological disasters, one can define the cases, when the greatest number of people were killed (from 1900 to 2012, excluding transport accidents). See table 1.

TABLE 1

THE GREATEST NUMBER OF KILLED IN TECHNOLOGICAL DISASTERS

Country	Date	No Killed
Japan, Fire	1-Sep-1923	3,800
Colombia, Explosion	7-Aug-1956	2,700
Turkey, Fire	27-Nov-1954	2,000
India, Gas Leak	3-Dec-1984	2,500
China P Rep, Fire	2-Sep-1949	1,700
China P Rep, Other	26-Apr-1942	1,549
Japan, Fire	22-Mar-1934	1,500
Saudi Arabia, Other	3-Jul-1990	1,426
India, Collapse	11-Aug-1979	1,335
Iraq, Other	31-Aug-2005	1,199

II. GENERAL CHARACTERISTICS OF EMERGENCY SITUATIONS IN LATVIA

According to the statistics data of Central Statistics Board for 2009, the territory of Latvia is 64,559 km^2. The length of border is 1866 km (sea border - 498 km, land border – 1368 km), common border with Estonia is 343 km long, with Russia – 276 km long, with Byelorussia – 161 km long, with Lithuania – 588 km long. The number of inhabitants (in 2012) is 2,041,763 people, but the population density for 1 km^2 is 31.6 people. [10]

Latvia is exposed to the danger of natural disasters, as well as of technological disasters in the state itself and also from other countries. According to the statistic data of CRED, there happened 7 disasters in the territory of the Republic of Latvia from 1990 to 2011 (Fig. 7).

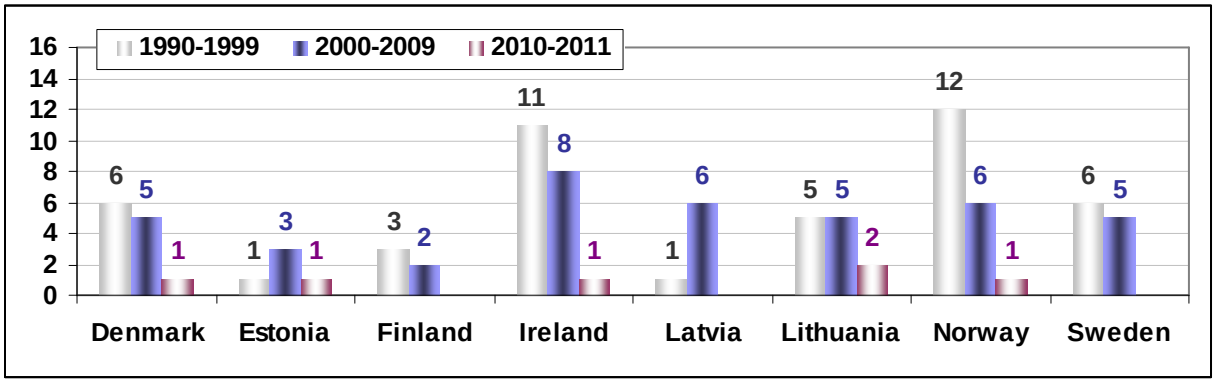

Fig.7. The number of disasters registered from1990 to 2011

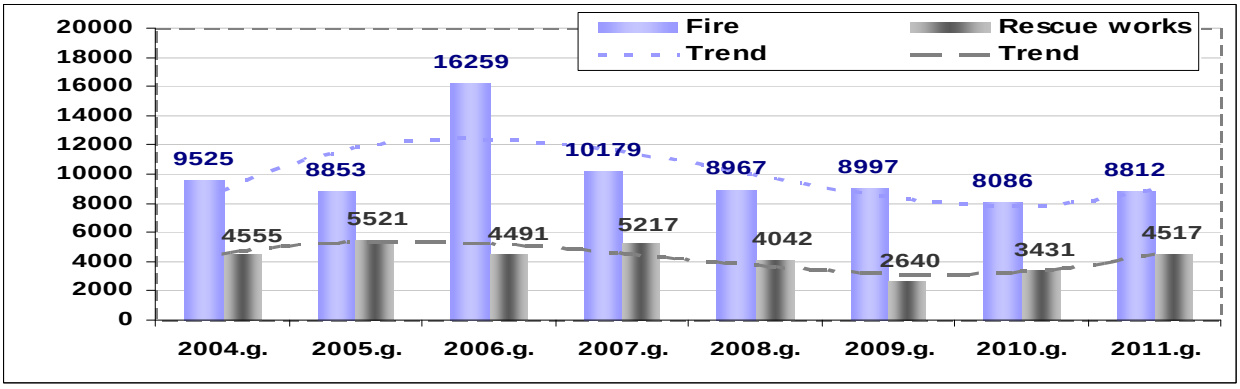

Fig.8. Dynamics of fires and rescue works

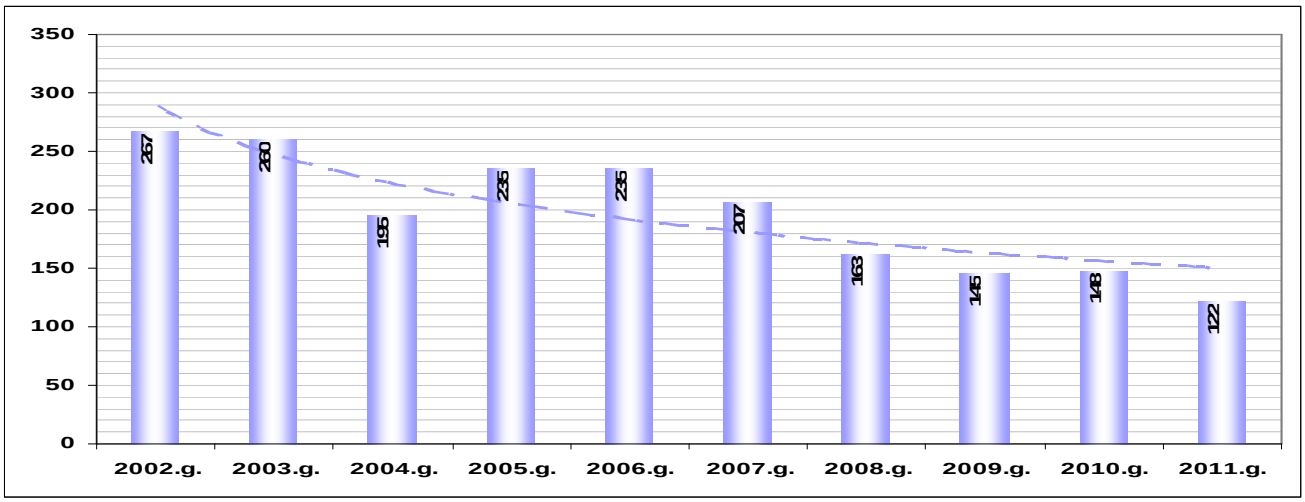

Fig.9. The number of killed and injured in fires

Figure 7 shows that the number of disasters in Latvia from 2000 till 2009 has grown 6 times in comparison with previous period from 1990 to 1999.

Collected statistics data of State Fire-Fighting and Rescue Service (SFRS) confirms that in 2011 the number of fires has grown by 8.97% in comparison with 2010, when the number of them was 8086, but the number of people killed in fires has reduced (Fig.8 and 9) [11], [12]. The number of rescue works, in comparison with 2010, has grown by 31.65%. Altogether, 4517 rescue works were recorded in 2011, which is 28.97% from common SFRS number of events in 2011. [13]

Main possible causes of fires are inattentive actions with fire (5771 cases) and damaged electric devices or their incorrect operation (1019 cases). 909 causes of fire were connected with damaged heating system or its incorrect operation, possible cause of 798 fires was indicated as deliberate burning, 129 cases – children playing with fire. In comparison with 2010, the number of fires, where possible cause was inattentive actions with fire, has grown by 11.63%, the number of fires causes by children playing with fire has grown by 57.32%. In its turn, the number of fires caused by damaged electric devices or their incorrect operation has

reduced by 3.41%. In 2011, 724 buildings and 161 vehicles were destroyed, 102 domestic animals and 154 domestic birds were killed in fires. [14]

In 2011, 122 people were killed in fires, it is 17.57% less than a year before, when 148 people were killed. [14]

The greatest number of people killed in fires was in rural areas and in rural populated areas – 50, in towns – 56 (40 of them in Riga), in other towns – 16.

The number of killed because of inattentive actions with fire (careless smoking, violation of fire-prevention regulations, an oven left without supervision, etc.) was 68%, because of heating – 10.1%, because of short circuit of electric devices/ electric equipment – 6.8%.

During heating season (from November to March) the number of people killed is from 60% to 65.6% in Riga as well as in the state.

Probability criteria for fires:

Probability of fire can be unequivocally characterised as very high, i.e. occurring once a year or more.

Influence criteria for a fire:

1. The most important fire influence criterion is effect on people. On the basis of statistic data, the probability for a person to be killed is 2 x 10-2 (during one year in 50 fires only one person can be killed), but the probability for a person to be injured is 2.4 x 10-2 (during one year in 42 fires one person can be injured). The probability for a person to be evacuated is 5.5 x 10-2 (during one year in 18 fires one person can be evacuated). Evaluating fires of last year's grass in connection with killed or injured, there are no killed or injured during the time period of 2008 – 2011. In its turn, there is one killed and one injured in 2012.

2. The second influence criterion is material loss, but such statistic data, unfortunately, is not available, as it is not saved and collected.

3. The third influence criterion is emission to the air, or damage to the environment. But this ratio has been calculated only for last year's grass and forest fires since 2009. It is defined by Ministry Cabinet Regulations No 157 as of 17th February, 2009 „Regulations Regarding the National Inventory System of Greenhouse Gas Emission Units".

Causality and influence scenario of fire risk in residential sector is shown in Figure 10.

III. FIRE RISKS

Having analysed fires, the number of killed and the number of inhabitants in Latvia, let us define fire risks. Source materials and results are in Table 2.

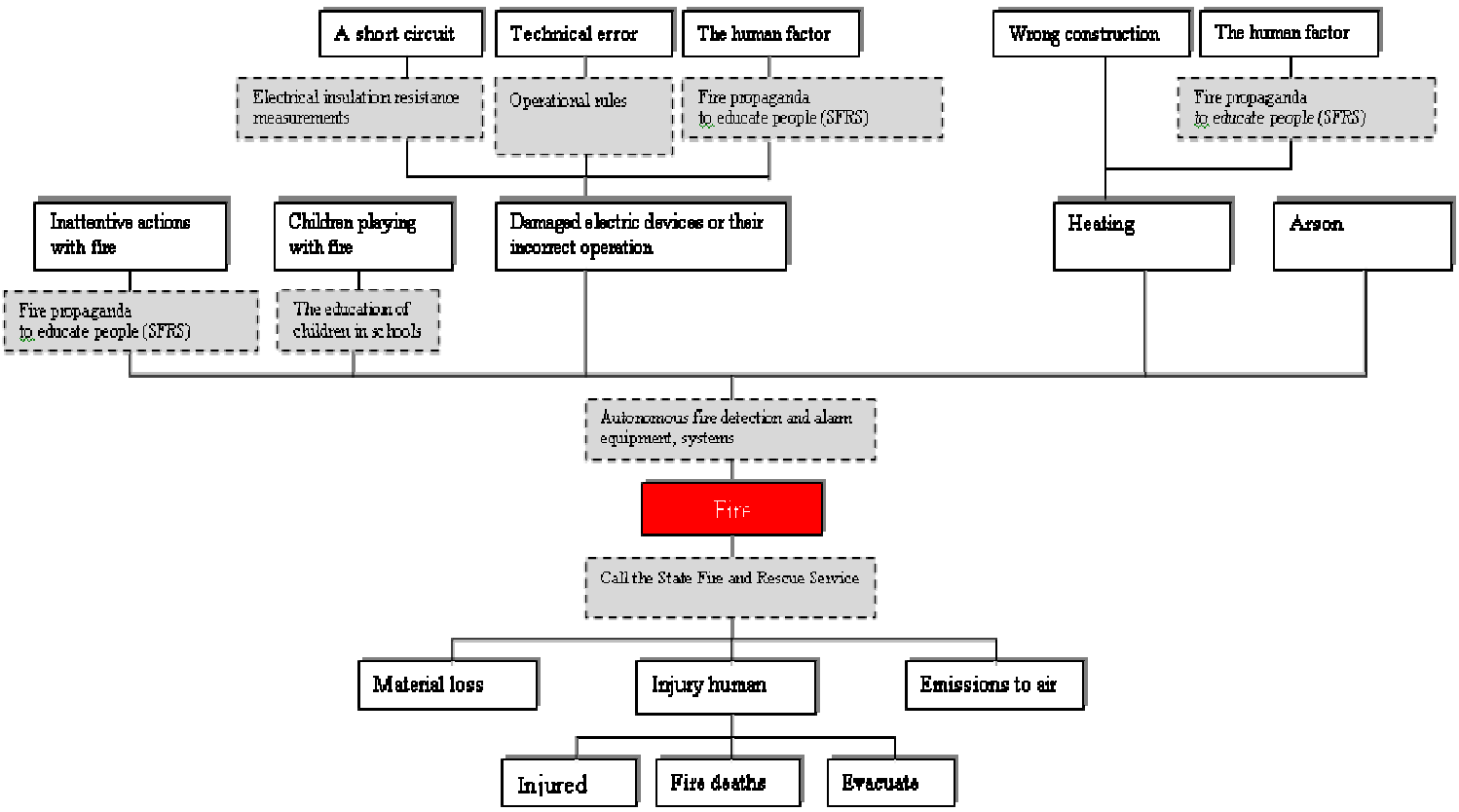

Fig.10. Causality and influence scenario of fire risk in residential sector

TABLE 2

FIRE RISKS

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Number of inhabitants (P)	2364254	2345768	2331480	2319203	2306434	2294590	2281305	2270894	2261294	2248374	2074605
Number of fires (F)	7479	11620	10574	9527	8853	16295	10179	8967	8997	8086	8812
Number of killed (D)	236	267	260	195	235	235	207	163	145	148	122
Number of injured (I)	181	234	236	193	265	318	271	245	194	242	252
Number of people rescued (S)	258	300	371	204	215	326	335	148	154	163	120
F (1,000)	7,48	11,62	10,57	9,53	8,85	16,30	10,18	8,97	9,00	8,09	8,81
D (1,000)	0,24	0,27	0,26	0,20	0,24	0,24	0,21	0,16	0,15	0,15	0,12
R_1	**3,16**	**4,95**	**4,54**	**4,11**	**3,84**	**7,10**	**4,46**	**3,95**	**3,98**	**3,60**	**4,25**
R_2	**3,16**	**2,30**	**2,46**	**2,05**	**2,65**	**1,44**	**2,03**	**1,82**	**1,61**	**1,83**	**1,38**
R_3	**9,98**	**11,38**	**11,15**	**8,41**	**10,19**	**10,24**	**9,07**	**7,18**	**6,41**	**6,58**	**5,88**
R_4	**2,42**	**2,01**	**2,23**	**2,03**	**2,99**	**1,95**	**2,66**	**2,73**	**2,16**	**2,99**	**2,86**
R_5	**7,66**	**9,98**	**10,12**	**8,32**	**11,49**	**13,86**	**11,88**	**10,79**	**8,58**	**10,76**	**12,15**

During the period analysed the number of inhabitants in Latvia has decreased 1.14 times from 2001 to 2011 (1). According to recalculations made by Central Statistic Board, during the period from 1st January, 2001 to 1st January, 2010, as well as to migration statistics for years 2000 – 2010, the number of inhabitants in Latvia decreased by 340,000 – by 211,400 as a result of migration and by 128,600 – because of negative natural growth of population.

$$P^{2001} / P^{2011} = 2364254 / 2074605 = 1{,}14 \quad (1)$$

wnere,
P– number of inhabitants.

The number of fires in Latvia has grown 1.18 times from 2001 to 2011(2).

$$F^{2011} / F^{2001} = 8812 / 7479 = 1{,}18 \quad (2)$$

where,
F – number of fires.

The number of killed in Latvia has decreased 1.93 times from 2001 to 2011 (3).

$$D^{2001} / D^{2011} = 236 / 122 = 1{,}93 \quad (3)$$

where,
D – number of killed.

The number of fires and people killed for 1,000 inhabitants is presented in Figure 11. During the period analysed the tendency of killed has rapidly reduced, in its turn, the tendency of the number of fires almost has not changed.

Situation in the state is the best characterised by coefficients that can be calculated defining fire risks. Fire risk R1 (the risk that fire will occur) is calculated with the formula (4):

$$R_1^{gads} = \frac{F}{P} * 10^3 \quad (4)\,[15]$$

Let us define fire risk R1 for years 2001 and 2011 to identify changes.

$$R_1^{2001} = \frac{F}{P} * 10^3 = 3{,}16$$

$$R_1^{2011} = \frac{F}{P} * 10^3 = 4{,}25$$

During the period analysed, the risk that fire will occur has grown 1.34 times in Latvia from 2001 till 2011 (5).

$$R_1^{2011} / R_1^{2001} = 4{,}25 / 3{,}16 = 1{,}34 \quad (5)$$

Fire risk R2 (the risk of a person being killed in fire) is calculated with the formula (6):

$$R_2^{gads} = \frac{D}{F} * 10^2 \quad (6)\,[15]$$

Let us define fire risk R2 for years 2001 and 2011 to identify changes.

$$R_2^{2001} = \frac{D}{F} * 10^2 = 3{,}16$$

$$R_2^{2011} = \frac{D}{F} * 10^2 = 1{,}38$$

During the period analysed, the risk that a person will be killed in fire has decreased 2.28 times from 2001 to 2011 (7).

$$R_2^{2001} / R_2^{2011} = 3{,}16/1{,}34 = 2{,}28 \quad (7)$$

Fire risk R3 (the risk for a person to be killed in fire during a year) is calculated with the formula (8):

$$R_3^{gads} = \frac{D}{P} * 10^5 \quad (8)\,[15]$$

Let us define fire risk R3 for years 2001 and 2011 to identify changes.

$$R_3^{2001} = \frac{D}{P} * 10^5 = 9{,}98$$

$$R_3^{2011} = \frac{D}{P} * 10^5 = 5{,}88$$

During the period analysed, the risk that a person will be killed in fire during a year has decreased 1.70 times from 2001 to 2011(9).

$$R_3^{2001} / R_3^{2011} = 9{,}98/5{,}88 = 1{,}70 \quad (9)$$

Fire risks R1, R2 and R3, as well as their tendencies can be seen in Figure 12.

Fire risk R4 (the risk for a person to be injured in fire) is calculated with the formula (10):

$$R_4^{gads} = \frac{I}{F} * 10^2 \quad (10)$$

Let us define fire risk R4 for years 2001 and 2011 to identify changes.

$$R_4^{2001} = \frac{I}{F} * 10^2 = 2{,}42$$

$$R_4^{2011} = \frac{I}{F} * 10^2 = 2{,}86$$

During the period analysed, the risk that a person will be injured in fire has grown 1.18 times from 2001 to 2011 (11).

$$R_4^{2011} / R_4^{2001} = 2{,}86/2{,}42 = 1{,}18 \quad (11)$$

Fire risk R5 (the risk for a person to be injured in fire during a year) is calculated with the formula (12):

$$R_5^{gads} = \frac{I}{P} * 10^5 \quad (12)$$

Let us define fire risk R5 for years 2001 and 2011 to identify changes.

$$R_5^{2001} = \frac{I}{P} * 10^5 = 7{,}66$$

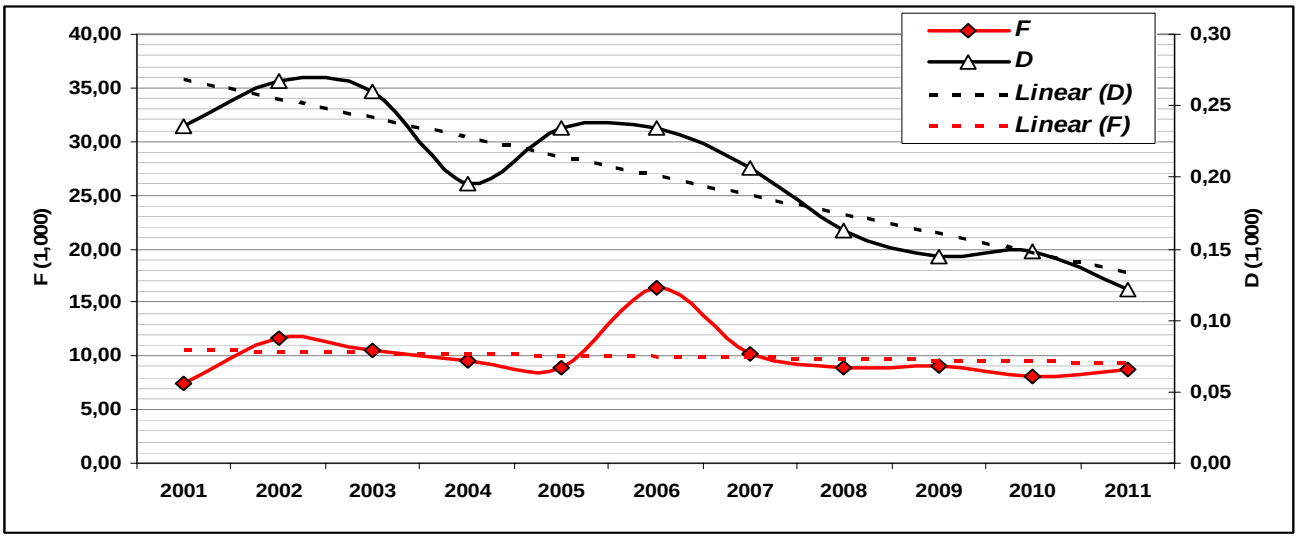

Fig. 11. The number of fires and killed for 1000 inhabitants

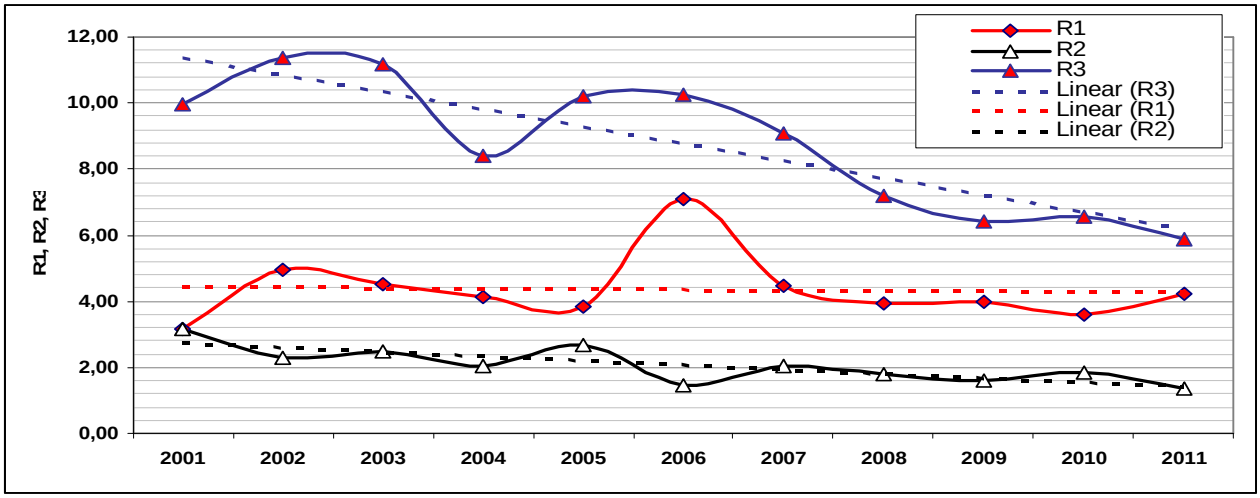

Fig.12. The risk of dying in fire

$$R_5^{2011} = \frac{I}{P} * 10^5 = 12{,}15$$

During the period analysed, the risk that a person can be injured in fire during a year has grown 1.59 times from 2001 to 2011 (13).

$$R_5^{2011} / R_5^{2001} = 12{,}15 / 7{,}66 = 1{,}59 \quad (13)$$

IV. Conclusions

Having evaluated possible emergency situations, one can note swift increase in the number of disasters all around the world. During the period of last two years CRED has not registered disasters in the territory of the Republic of Latvia. In their turn, 6 disasters have been registered during the period of previous ten years. The number of fire has decreased in comparison with the average number of fires, but has increased in comparison with years 2001 and 2010. The number of killed in Latvia from 2001 to 2011 has decreased 1.93 times, which can be mentioned as positive tendency.

Fire risk R1, the risk, that a fire will occur, has increased 1.34 times from 2001 to 2011. It is connected with the decrease in the number of people in Latvia by about 340,000 people.

Taking into account difficult economic situation in the country, when everybody is trying to save, great attention should be paid exactly to the preventive measures, to the education of people and their training, in order to avoid or reduce possible consequences of disasters. If there exist any negative risks, they should be analysed and the causes of them should be found, as well as the decision about further actions should be made.

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