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IMPACT OF CLIMATE CHANGE ON THE DISTRIBUTION OF EXTREME TEMPERATURES AS NATURAL DISASTERS[1]

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Much of the scientific community agrees that global temperature as a result of climate change has increased significantly in the last century, and will continue to grow in the near future. According to the Third Assessment Report of the IPCC, 2001 (IPCC - Intergovernmental Panel on Climate Change), the global average temperature has increased by about 0.6 degrees in the 20th century, although climate warming was not uniform neither spatially nor temporally, as was indicated by observed changes and modelling studies. Variations in global or regional cases of extreme air temperatures that occurred due to changes in climate cause more and more attention lately as living beings and ecosystems and human society are sensitive to the severity, frequency and persistence of cases of extreme temperatures. In this regard, in order to effectively protect and respond to emergencies caused by harmful temperature extremes, it is necessary among other things to comprehensively investigate the mentioned natural phenomenon, so the subject of this paper will be an analysis of climate change as well as form, consequences, temporal and geospatial distribution of extreme temperatures. Using an international database on natural disasters of the Centre for Research on the Epidemiology of Disasters (CRED), based in Brussels, with the support of program for statistical analysis (SPSS) and the method of thematic cartography, we have tried to point out the number, trends, consequences, temporal and geospatial distribution of extreme temperature in the period from 1900 to 2013, as well as the need for an adequate response of society to this type of natural hazard.

Key words: *security, emergency situations, climate change, extreme temperatures, adaptation, disaster, distribution*

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Introduction

Climate changes are among the most researched risks of global disasters (Dimitrijević 2010). No other environmental issue has received so much attention in the popular press and expert analyses, although perhaps the effects of pandemics or other natural hazards could be more serious (Cvetković 2014; Cvetković, Milojković and Mlađan 2013). According to the US Environmental Protection Agency (EPA), climate change is a significant change in climatic conditions, such as temperature, precipitation and winds that last for a decade or longer, and can occur as a result of: natural processes within the climate system (changes in ocean circulation), changes in the intensity of solar radiation or human activities that affect the composition of the atmosphere (through the burning of fossil fuels) and soil (deforestation, urbanization, desertification) (Dimitrijević 2010). The signatories to the United Nations Convention on Climate Change and the Kyoto Protocol 1997 accepted that climate changes bring with them many potential hazards such as sea level rise, increased frequency of storms and floods, spread of infectious diseases, decline in biodiversity and reduced food and water availability.[2] Such impacts are a threat not only to human lives and the quality of the environment but also for sustainable community development. According to current trends, the average global temperature will rise by 2-3°C over the next fifty years, which will cause many severe impacts, often manifested through the water (Climate change, studies and analyses 2010), ablation will firstly increase the risk of natural disasters (floods, droughts, storms), water supplies will be reduced to a great extent; there will be a decline in crop yields (food security will be compromised), especially in Africa where millions of people could remain with no food without the ability to produce or purchase sufficient food; each year, sea level rise will result in hundreds of millions of additional people experiencing flooding; natural disasters will be more intense, more frequent and more severe; Ecosystems will be particularly vulnerable to climate change, about 15-40% of species will potentially face extinction after warming of only 2°C.

Scientists agree that climate change caused (Climate change, studies and analyses 2010): very likely increase in sea level in the second half of the twentieth century; likely changes in wind patterns, affecting directions extra-tropical storms and temperature patterns; likely increase in temperatures of extremely hot nights, cold nights and cold days; increased risk of heat waves, broadening the area affected by drought, the frequency of heavy rainfall; warming which is the greatest on land and at the highest latitudes, and the lowest over the Southern Ocean and parts of the North Atlantic; contraction of the area under the snow, increased thaw depth in most areas and reduced volume of ice in the sea; very likely increase in precipitation at high latitudes.[3] Thus, climate change affected all natural processes, changing their many features, which will have different consequences for people.

[2] Although the United Nations Convention on Climate Change and the International Strategy for Disaster Reduction within the United Nations differ, they have overlapping basic principles: reducing the risks associated with rapid climate change.

[3] In the period from 1906 to 2006, the average temperature on Earth has risen by 0,6-0,9°S, and sea level by 17 cm^2. If global warming trends continue, by the end of the XXI century, sea level will rise by another 1,4 m.

Similar warnings could be found in numerous media statements and policy documents. The organization „Christian Aid" warns that by the end of the 21st century in Africa alone 184 million people could die from the effects of climate change, which would have caused floods, famine, drought and conflicts. In October 2006, it a so-called Stern Review on economic implications of climate change was published in the UK, which indicates that hundreds of millions of people, directly or indirectly, may be affected by extreme weather conditions that could lead to the emergence of famine and disease due to lack of water and other resources. Although the report of the Ministry of Finance of the Great Britain emphasizes the economic consequences of climate change, it also presents the possible scenario of mass migration and conflicts in developing countries. According to the report, conflicts would result from forced migration, and by 2050 about 200 million people could be forced to change their permanent place of residence (*Stern Review 2006*). In the spring of 1995, residents of the island of Bhola in Bangladesh were forced to forced migration when half of their island disappeared under the water. UN Refugee Agency considers that they were the first „climate refugees", and it is anticipated that a similar fate awaits at least 20 million people of Asian countries by 2030 (Милинчић и Шабић 2009). World Yearbook of natural disasters of the International Red Cross in 2001 gave an overview of countries and regions whose populations were affected and / or threatened by natural disasters in the period from 1981 to 2000. A total number of registered disasters in the period 1991-2000 increased from 454 to 752 (Cvetković 2013; Cvetković 2014; Cvetković i Mijalković 2013; Цветковић, Милојковић и Стојковић 2014; Цветковић и Драгићевић 2014; Цветковић, Гаћић и Јаковљевић 2014), while in the same period 4,703 accidents caused by climate change were recorded. In 1991, 170,093 persons were killed, and in the period to 2000, 752,521 people were killed, while 2,108,025 persons were directly threatened by the devastating impact of natural disasters, which caused extensive damage. It is often claimed that the degradation of the environment is one of the main reasons that can lead to armed conflict, though in the scientific community that deals with this problem, there are objections that the IPCC (IPCC Intergovernmental Panel on Climate Change) relies on the information with little empirical corroboration (Димитријевић, Милинчић и Ђорђевић 2010).

Indeed, since the first report of the Intergovernmental Panel on Climate Change[4] in 1990 a significant progress has been made in terms of: 1) determination of reality of anthropogenic climate change, and 2) a sufficient understanding of the scale of the problem in order to confirm that it requires a public response. However, there remain considerable scientific uncertainties. Specifically, the researchers were not able to narrow the range of uncertainties about the reactions of the average global temperature to a doubling of carbon dioxide compared to preindustrial levels. Advances in science made us more aware of the uncertainty created by the previously untested processes. Discussions about „turning points" in the Earth system have raised awareness of the

[4] The main conclusions of this report: a) the greenhouse effect exists, emissions resulting from human activities significantly increase atmospheric concentrations of greenhouse gases (carbon dioxide, methane, chlorofluorocarbons, nitrous oxide, etc.). Increase in concentration of these gases intensifies the greenhouse effect resulting in warming of the atmosphere; b) carbon dioxide is responsible for over half of the amplification of the greenhouse effect; v) the expected increase in global mean annual temperature during the 21st century is 0.2 degrees Celsius per decade; g) there is still a lot of uncertainty in the forecasts and projections of climate change in particular as regards the timing, intensity and regional particularities; d) the expected rise in sea level due to thermal expansion and melting of ice is 6 cm per year (Cvetković, 2014).

possibility that climate change and the processes they cause are much more dangerous than we anticipated and that some of the worst attacks may begin earlier, creating an alarming picture of the contemporary generation that created the conditions for the beginning of a climate disaster (Kemp 2007). Meanwhile, most theoretical analyses showed differences between direct, indirect or structural threats, personal risks (which affect the individual and his closest community) and covariant (which affect the smaller or larger groups, so we can talk about meso risks and macro risks), i.e. fatal and bearable risks. The limits of acceptable risk of climate change are usually formulated in terms of „dangerous" risk. For these reasons, the United Nations Framework Convention on Climate Change (UNFCCC) drafted a framework through which a nation can respond to climate change. Under the Convention, governments share information and try to develop a national strategy for reducing greenhouse gas emissions, at the same time adapting to the expected impacts. The focal point of the Convention, in Article 2, is the intention to stabilize the concentration of greenhouse gases, and thus the climate. Article 2 introduced problematic, inevitable concept of „dangerous anthropogenic interference" (DAI) into the climate system, and into the dictionary of scientific and public communities (Frame and Allen 2011). DAI has been the subject of much debate, with its presentation by multitude of simple studies, primarily in terms of possible thresholds of global average temperature (O'Neill and Oppenheimer 2004; Masstrandrea et al. 2004) or the equilibrium reactions to some unspecified atmospheric concentrations of CO_2.[5]

Efforts to reduce vulnerability to climate change

The fight against climate change and the reduction of greenhouse gas emissions have become priorities for many countries in the world and for many world organizations. The introduction of climate change topics in the realm of politics is the first but very important step, because most political leaders have become aware of the risks that climate changes represent and the need to respond to them. The second step is that the topic of climate change becomes part of care of institutions and citizens (Gidens 2010). The basic document to conduct and coordinate global efforts to reduce emissions of carbon dioxide is the United Nations Framework Convention on Climate Change (UNFCCC), which was adopted in 1992 at the World Summit in Rio de Janeiro. By itself, this Convention does not constitute a binding document, but it provides for the adoption of the protocol that introduces binding provisions for the signatory countries. The most important such protocol is the Kyoto Protocol, which was adopted in 1997 and entered into force in 2005. According to this protocol, the most developed signatory countries (37 countries listed in Annex I of the Protocol) have an obligation to reduce their emissions by 5% of the value of those in 1990 in the period

[5] Research shows that since 1800, the concentration of carbon dioxide has increased by about 35%, and during the last century its global emissions increased by 77%, which is one of the main causes of the rise in average temperatures by 0,7°C. During the last two decades, the annual global carbon emission into the atmosphere constantly exceeds six billion tons, which, in comparison with the mid-twentieth is an increase by four times. The average annual increase of the concentration of SO2 in the atmosphere is 0.4% and it is considered to be one of the main causes of global warming, increasingly pronounced temperature extremes, general instability of the atmosphere, climate zone shifts, more frequent extreme pluviometric regime, and ultimately distortion of global laws in the geographic space (Nordhaus 2005).

2008-2012. In addition to these limitations, the Protocol provides the ability to implement mitigating mechanisms, namely: emissions trading, the Clean Development Mechanism and joint implementation projects. In addition to this global initiative there are other regional ones. The European Union has developed a set of strategic and legal documents related to climate change. The document that is directly related to this issue is the EU White Paper on adaptation to climate change. By this document, EU has set a framework for solving the problems of adaptation at the community level and at the same time committed its members to serious and strategic approach to solving this problem (Assessment of vulnerability to climate change-Serbia, South East European Forum on Climate Change Adaptation, 2012). Serbia as a candidate for EU certainly has to expect these obligations and certainly in the future it will work intensively on the issue of climate change, especially on adaptations. Previous activities in Serbia in the process of adaptation to climate change were very modest and there are strong hopes that such a document will contribute to faster and more expedient organization of system adaptation. South East European Forum on Climate Change Adaptation was formed within the same project and it brought together about 80 members that are organized in four national networks in one of the regions that are considered most vulnerable to climate change in Europe.

There are four national networks of civil society organizations in Serbia, Croatia, Macedonia and Montenegro, with the aim to strengthen the capacity of civil society and to raise public awareness and dialogue through activities with decision makers at national and regional levels in order to draw the attention to the issue of climate change. It is believed that, for us, this is the most important initiative of the European Union, which is reflected in the so-called 20-20-20 goals. The European Union has adopted a set of legal documents entitled “Climate and energy package”, which obliges member states to reduce emissions by 20% of level in 1990 by 2020, to achieve a level of energy production from renewable sources by 20% and to reduce primary energy consumption by 20% through improvement of energy efficiency. All measures that are based on the reduction of emissions, i.e. the prevention of causes of climate change are called mitigation or mitigation measures. Despite the efforts to reduce emissions as one of the main causes of climate change, it is clear that the exclusive use of mitigation measures is not sufficient to cope with climate change. The effects of climate change are already visible and it is clear that it will become more intense in the near future. Even if drastic reduction of greenhouse gas emissions occurred instantly, the effects of emissions from the past would be felt for many years. Practically, climate change cannot be stopped in the short term. Predictions are that greenhouse gas emissions will grow over the next few decades, so it is impossible to expect positive effects of “mitigation measures” for many years (IPCC 2001). For this reason, in recent years, special attention has been given to adaptation measures to climate change at the international level. Adaptation means finding ways to reduce the vulnerability of natural systems and human communities to climate change. Adaptations in fact represent an increase in tolerance to climate change. During all analyses of possible measures for adaptation to climate change, it must be taken into account that all these predictions are related to a number of uncertainties. These uncertainties are product of use of different methods for predicting (different models, selection of scenarios, selection of periods for verification and prognosis, selection of methods of lowering the modelling results from the global to the regional level, and the like), and unreliability of data

(insufficient number and quality of certain data lack of compatibility of different studies, and the like). However, it must also be taken into account that these uncertainties are not of the same order of magnitude. For example, it is of quite high reliability to predict that the average seasonal temperatures will rise, a much lower reliability is that there will be a reduction in average annual rainfall, while it is particularly unlikely what changes will occur on seasonal basis. Given the many uncertainties, it is desirable that the measures that would be applied in order to adapt to potential climate change do not cause adverse effects in case of deviations from the planned changes. In other words, it is desirable to apply such measures that would reduce the risks of climate change, but would have other positive effects on society, economy and environment. Efforts to solve the problem of climate change but also opposing views were expressed on the Copenhagen two-week UN Climate Change Conference, where representatives of 192 countries negotiated and tried to reach a mutual agreement whose application would result in slowing the pace of global warming. The conference resulted in a loose arrangement in which the participating countries of COP 15 agreed to "note" the final document of the summit, the Copenhagen Declaration. The final document of COP 15 was agreed on by 26 countries, among which are the US, China, India, Brazil, South Africa and the leading EU countries, but its adoption has not been accepted by a number of developing countries (Sudan, Venezuela, Nicaragua, Bolivia, Cuba). These countries were dissatisfied with both the content of the document and the way in which it was agreed. Developing countries have agreed to subsequently submit a notification about whether they will join the Declaration and to support its conclusions. The Copenhagen Declaration was a legally non-binding document, and it was left to the will of the participating countries of summit to identify and communicate their national goals related to reduction of greenhouse gas emissions. Opening the COP 15 summit, UN Secretary-General Ban Ki-moon said: "Climate change is the dominant geopolitical and economic issue of the 21st century, which disturbs the balance of world development, peace and prosperity" and he added that failure to reach a global deal in Copenhagen would be "morally inexcusable, economically short-sighted and politically unwise". The Copenhagen Declaration contains no specific figures related to the obligations of countries to reduce greenhouse gas emissions, either in the short term until 2020 or in the long term until 2050, and it only specifies that the increase in global temperatures over the next hundred years should be kept within the boundaries of two degrees. In the same vein, there was the largest conference of world leaders on climate change opened in September 2014 at the UN headquarters in New York, in the midst of calls for urgent action to stop global warming. UN Secretary-General Ban Ki-moon hosted a summit of 120 leaders, the first such gathering at the highest level of the Copenhagen conference on climate change in 2009. Diplomats and experts for climate consider the summit as crucial event on the eve of the conference in Paris, scheduled for the end of 2015 in the struggle to reduce gas emissions by 2020. At the climate summit, there was talk about the economic aspect for climate action, benefits of climate action for health and job of the next generations. Opening the Climate Summit, UN Secretary-General Ban Ki-moon said that a joint action to reduce emissions of harmful gases into the atmosphere was necessary, but also pointed out that by the end of this century, the mankind must cease to produce carbon, and he sent the appeal to the world famous companies to reduce emissions of carbon dioxide.

Climate change and extreme temperatures

Much of the scientific community agrees that global temperature as a result of climate change has increased significantly in the last century, and will continue to grow in the foreseeable future. According to the Third Assessment Report of the IPCC, in 2001, it was stated that the average global temperature has risen by about 0.6 degrees over the twentieth century (Houghto et al. 2001), although climatic warming was not uniform either spatially or temporally, as was indicated by observed changes and modelling studies (Folland et al., 2001; McAvaney et al. 2001). Important aspects of climate change are variable properties of daily temperature, especially changes of extreme values of distribution of daily temperature. It is expected that the increase in average temperature will be accompanied by an increasing number of hot days and warm nights. Since these changes can be identified, it is expected that there will also be changes in cases of extreme temperatures, such as an increasing number of days with extremely low or extremely high temperatures. As shown by Katz and Brown, climate change is reflected more in extreme temperatures than in their average values (Katz and Brown 1992; Meehl et al., 2000; Frich et al. 2002). This means that if global climate change is an actual phenomenon, it could be detected and clearly shown through the patterns of behaviour of extreme climatic events. Variations in global or regional cases of extreme air temperatures that occur due to changes in climate draw more and more attention lately as living beings and ecosystems and human society are sensitive to the severity, frequency and persistence of extreme temperatures (Easterling et al., 2000).

Houghton et al. showed how continuous and increasing variation affects the extreme temperature where the temperature rises to reach a normal distribution. Many scholars have noted that this type of warming is not uniform throughout the day, with a lower degree of warming observed in maximal temperatures and significantly higher level in minimal temperatures. For example, Karl and Easterling have found that in the period from 1951 to 1990, global temperatures during the day and daily average temperature rose by 0.28 degrees C, while night (minimal daily) temperature rose three times more, by 0.84 degrees Celsius (Easterling et al. 2000). In other words, the warming is stronger in minimal daily temperature than maximal temperatures. As a consequence, it reduces the amplitude of daily temperature measured at the surface of the soil above large land masses. Such asymmetric changes of day and night temperatures have been confirmed in many other studies but with different magnitudes and regional differences (Turkes and Summer 2004; Weber et al., 2007; Qian and Lin 2004). In recent years, an increasing number of studies deals with observational analysis, which includes variability and trends in cases of extreme temperatures in various regions of the world, taking into account that the amplitudes of extremes at regional level are greater than the amplitudes of extremes at global level, as well as the importance of regional studies of climate change in assessment of climate impacts. For example, various analyses of daily minimal, daily maximal and extreme temperatures were made in North America (Robeson 2004), Canada (Bonsal et al. 2001), Europe (Klein and Konnen 2003), Australia and New Zealand (Plummer et al., 1999), East Africa (Kinguyu, Ogallo and Anyamba 2000), India (Roy and Balling 2005) and South Korea (Ryoo, Kwon and Jhun 2004). As in much of the world, there has been varying degrees of warming in China, andthere is a general

tendency towards a higher rate of warming when it comes to the minimal winter temperatures in comparison with the maximal summer temperatures (Zhai and Pan 1999). Zhai et al. also showed that in northern China there is a reduction in the number of days with extremely low temperatures. Recent studies have further documented the temperature extremes and trends in China (Yan et al., 2002; Gong, Pan and Wang 2004). Since this is a really extensive and complex material, the subject of this paper will be an analysis of forms of manifestation, number, consequences, temporal and geospatial distribution of extreme temperatures, especially bearing in mind that the effects of extreme temperatures have caused more damage to people and their property than other natural hazards.

Methods

The survey was conducted based on extensive material of the Centre for Research on the Epidemiology of Disasters (CRED). It was realized in such way, as in the first step the raw – unprocessed data in format of "excel" file with 25,552 registered events was taken from the Centre (www.emdat.be).[6] The download was conducted on 5/6/2013. Subsequently, the data was processed by the program for statistical analysis of data, "IBM SPSS Advanced Statistics 20.0". Frequencies and percentages of the considered variables were calculated by program operations. Also, tables and charts were made by the program, which were further processed in "MS Word 2013". The results of processing of quantitative data are displayed in the text, tables and graphics in the form of cartographic visualization by method of thematic mapping – volume cartography (Filipović and Milojković 2010). The results of processing of the data are displayed in text, tables and graphics.

The meanings of terms that are used in the paper are: the death toll - the number of people with confirmed death and the number of missing, apparently dead people, the number of injuries - the number of people suffering from psychological injury, or trauma requiring immediate medical attention; the number of affected – the number of people requiring immediate assistance during and after a disaster, including deployed or evacuated people, homeless - the number of people who need emergency accommodation because they lost their house, the affected toll - a summary of injured, homeless and affected, the total damage - a global picture of the economic impact of flooding, given in U.S. dollars.

Analysis of geospatial distribution of extreme temperatures

Results of analysis of geospatial distribution of extreme temperatures for the period from 1900 to 2013, indicate that most (439) extreme temperatures occurred in Europe, and the least (12) in Oceania. The number of most people killed (280349) due to the extreme temperatures was in Europe, and the lowest number (454) in Oceania. When it comes to the number of the injured and the affected, the situation is as follows: the

[6] Natural event will be recorded in the database as a natural emergency situation if the following criteria are met: there are ten or more people killed, 100 or more people affected, declared emergency and call for international assistance.

highest number of injured people (3649796) was in America and affected (6373404) in Asia. In contrast, the lowest number of injured (1516) and affected (170,379,476) people was in Asia. When analysing the total number of people left homeless due to the extreme temperatures, it is evident that the number was the lowest (0) in Africa and the highest (466000) in Asia (Table 1).

Table 1 – *Review of consequences of extreme temperatures to people in the period from 1900 to 2013, classified by continent. Source: author's calculations*

Continent	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
Africa	22	454	210	2015000	0	2015210	95618
America	206	17894	3649796	6865500	32000	10547296	34529700
Asia	291	43163	68788	170379476	466000	170914264	47654666
Europe	439	280349	44562	2564504	2680	2611746	32374702
Oceania	12	740	5568	9200000	0	9205568	400000
Total	970	342600	3768924	191024480	500680	195294084	115054686

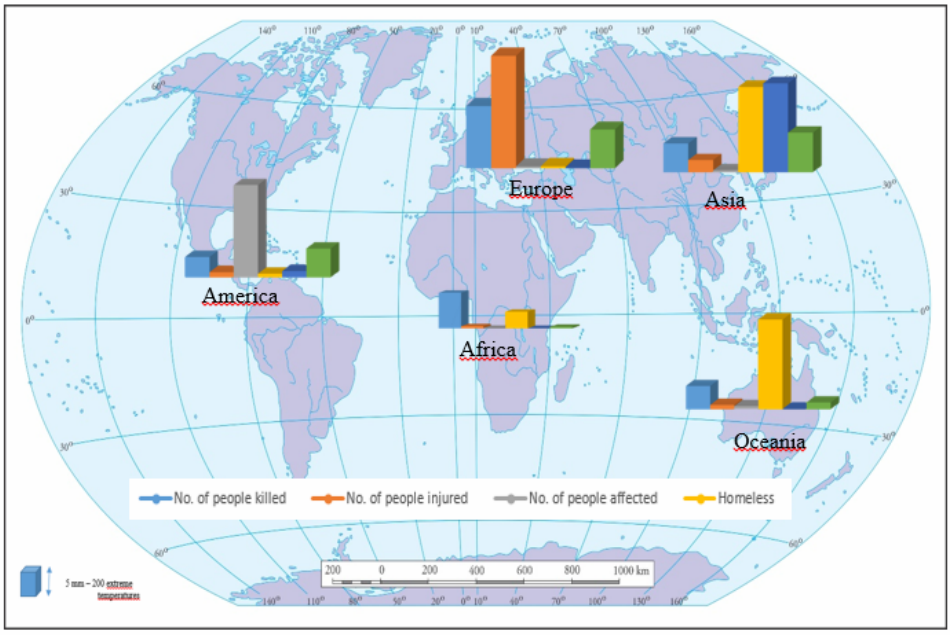

Figure 1 – *A thematic map of the total number and consequences of extreme temperatures in the world for the period from 1900 to 2013. Source: author's calculations*

Observed by continents, the highest number of extreme temperatures occurred in Europe (45%), followed by Asia (30%), America (21%), Africa (3%) and finally Oceania (1%) (Figure 1).

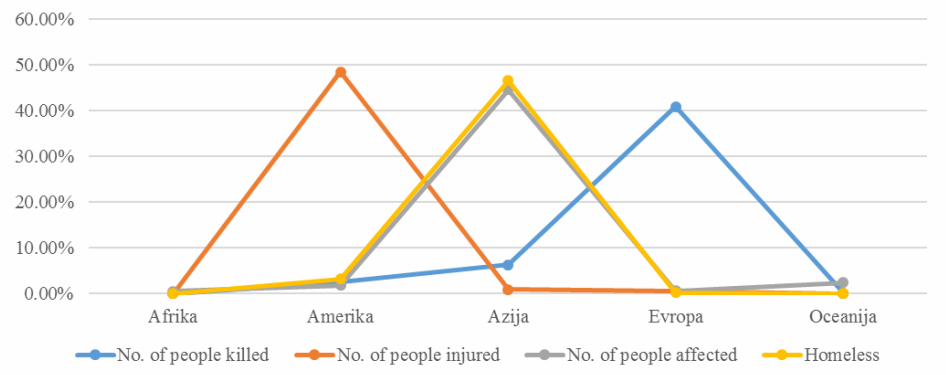

Figure 2 – *Percentage review of the effects of extreme temperatures on the people in the period from 1900 to 2013, classified by continents. Source: author's calculations*

As a consequence of extreme temperatures, in terms of continents, most fatalities (45.26%) were in Europe and the least (1.24%) in Oceania. Most injuries (96.84%) were in America and the lowest number (0.15%) in Oceania. The highest number of the affected (89.19%) was in Asia and the lowest number (1.34%) in Europe. The highest number of people (93.07%) left homeless in Asia and the lowest (0.54%) in Europe (Figure 2).

Table 2 – *Top five countries by number of extreme temperatures during the period from 1900 to 2013. Source: author's calculations*

Country	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
India	103	29085	500	0	0	500	1088000
USA	68	10322	62	0	0	62	27170000
Bangladesh	44	4880	4400	824000	0	828400	0
Russia	42	115828	5996	1512400	0	1518396	2800200
Romania	36	1032	2518	18000	0	20518	0

In the period from 1900 to 2013, the highest number of extreme temperatures occurred in India 103. Thus, by the number of extreme temperatures, in the first place is India, followed by USA 68, Bangladesh 44, Russia 42 and Romania 36 (Table 2).

Table 3 – *Top five countries by number of people killed due to extreme temperatures during the period from 1900 to 2013. Source: author's calculations*

Country	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
Russia	42	115828	5996	1512400	0	1518396	2800200
France	28	41912	400	20000	0	20400	10344000
Italia	16	40338	0	0	0	0	9065202
Spain	16	31232	140	0	0	140	3608600
India	103	29085	500	0	0	500	1088000

Analyses show that the highest number of people killed due to the extreme temperatures in the period from 1900 to 2013 was in Russia, 115,828. Thus, by the number of people killed due to the extreme temperatures, in the first place is Russia, France 41,912, Italy 40,338, Spain 31,232, and India 29,085 (Table 3).

Table 4 – *Top five countries by number of people injured due to extreme temperatures during the period from 1900 to 2013. Source: author's calculations*

Country	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
Peru	18	2986	3648524	6331560	0	9980084	0
Japan	8	556	50600	30000	0	80600	0
Ukraine	12	2056	25252	270000	0	295252	170000
China	24	678	9644	161964360	466000	162440004	42860400
Belarus	8	18	6350	20200	0	26550	60600

The highest number of people injured due to the extreme temperatures during the same period was in Peru, 3,648,524. Thus, by number of people injured due to extreme temperatures in the first place is Peru, followed by Japan 50,600, Ukraine 25,252, China 9,644 and Belarus 6,350 (Table 4).

Table 5 – *Top five countries by number of affected people due to extreme temperatures during the period from 1900 to 2013. Source: authors' calculations*

Country	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
China	24	678	9644	161964360	466000	162440004	42860400
Australia	10	740	5568	9200000	0	9205568	0
Peru	18	2986	3648524	6331560	0	9980084	0
Tajikistan	6	2	0	4005000	0	4005000	1680000
Liberia	2	0	0	2000000	0	2000000	94000

In the period from 1900 to 2013, the highest number of affected people due to extreme temperatures was in China, 161,964,360. Thus, by number of affected people due to extreme temperatures in the first place is China, followed by Australia 9,200,000, Peru 6,331,560, Tajikistan 4,005,000, and Liberia 2,000,000 (Table 5).

Table 6 – *Top five countries by number of people who were left homeless due to extreme temperatures during the period from 1900 to 2013. Source: author's calculations*

Country	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
China	24	678	9644	161964360	466000	162440004	42860400
Mexico	34	2376	0	240000	32000	272000	1165200
Albania	8	152	0	471790	2680	474470	0
Australia	10	740	5568	9200000	0	9205568	0
Peru	18	2986	3648524	6331560	0	9980084	0

Data show that the highest number of people who have lost their home due to the consequences of extreme temperatures during the same period was in China, 466,000. Thus, by number of people who lost their home due to the extreme temperatures in the first place is China, followed by Mexico 32,000, and finally Albania, 2,680 (Table 6).

Table 7 – *Top five countries by estimated value of the material damage caused by extreme temperatures during the period from 1900 to 2013.*
Source: author's calculations

Country	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
China	24	678	9644	161964360	466000	162440004	42860400
USA	68	10322	62	0	0	62	27170000
France	28	41912	400	20000	0	20400	10344000
Italia	16	40338	0	0	0	0	9065202
Canada	6	1000	0	400	0	400	4000000

In the period from 1900 to 2013, the largest estimated damage caused due to the extreme temperature was in China 42,860,400. So, by estimated material damage caused by the extreme temperatures in the first place is China, followed by US 2,717,000, France 10,344,000, Italy 9,065,202 and Canada 4,000,000 (Table 7).

Temporal distribution of extreme temperatures

Data from analyses of temporal distribution of extreme temperatures in the period from 1900 to 2013, show that 970 extreme temperatures happened, 342,600 people were killed, 3,768,924 were injured, 191,024,480 affected and 500,680 left homeless. Thus, on an annual basis, 8.6 extreme temperatures happened, monthly 0.7, and daily 0.02 (Table 8).

Table 8 – *Review of the total number and consequences of extreme temperatures during the period from 1900 to 2013, with emphasis on annual, monthly and daily distributions.*
Source: author's calculations

Type	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
1900-2013.	970	342600	3768924	191024480	500680	195294084	115054686
Yearly	8.6	3031.9	33353.3	1690482.1	4430.8	1728266.2	1018183.1
Monthly	0.7	252.7	2779.4	140873.5	369.2	144022.2	84848.6
Daily	0.02	8.4	92.6	4695.8	12.3	4800.7	2828.3

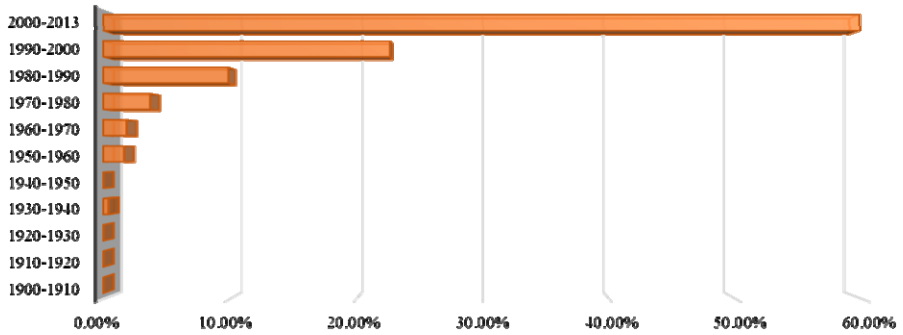

Figure 3 – *Percentage overview of the total number of extreme temperatures during the period from 1900 to 2013, classified by ten-year periods. Source: author's calculations*

Until 1980, extreme temperatures occurred in the average number which amounted to 6%. After this period, a significant increase in the number of extreme temperatures has been noted, and the peak is period from 2000 to 2013, when 59.79% of the total number of extreme temperatures for the given period happened. The lowest number of extreme temperatures occurred in the period from 1900 to 1930, because during these periods there were no recorded events (Figure 3).

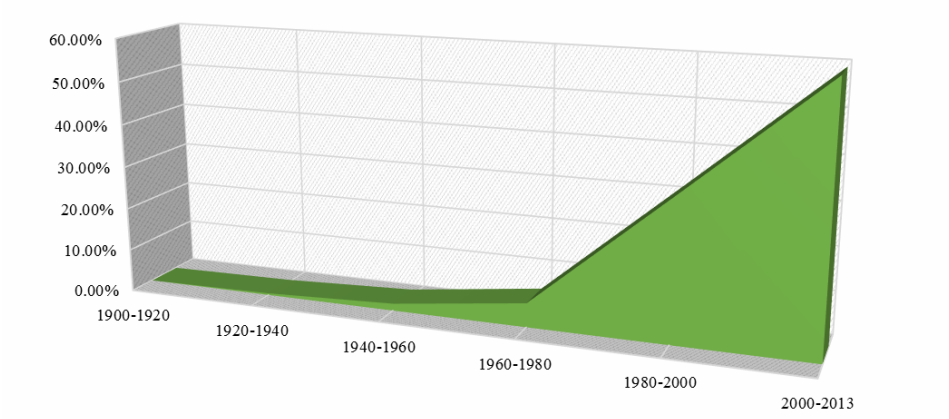

Figure 4 – *Percentage review of the total number of extreme temperatures during the period from 1900 to 2013, classified by twenty-year periods. Source: author's calculations*

Observed by twenty-year periods, the highest number of extreme temperatures (59.79%) occurred in the period from 2000 to 2013, and the lowest number (no recorded events) in the period from 1900 to 1920 (Figure 4).

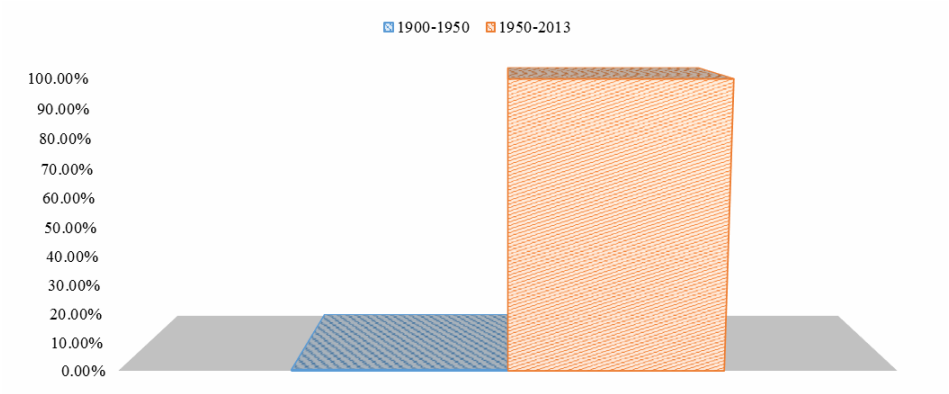

Figure 5 – *Percentage review of the total number of extreme temperatures during the period from 1900 to 2013, classified by fifty-year periods. Source: author's calculations*

When observing a fifty-year period, it is noted that after 1950 there is a significantly greater number of extreme temperatures. Accordingly, in the period from 1950 to 2013, 99.59% of extreme temperatures of the total number occurred. In contrast to that period, 0.41% of extreme temperatures occurred from 1900 to 1950 (Figure 5).

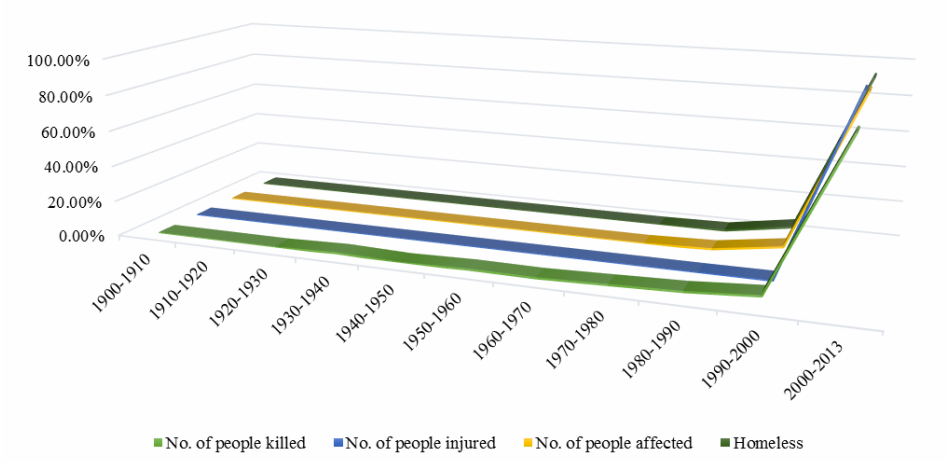

Figure 6 – *Percentage review of the effects of extreme temperatures on the people in the period from 1900 to 2013, classified by ten-year periods. Source: author's calculations*

In percentage terms, due to consequences of extreme temperatures, the highest number of killed people (59.79%) was in the period from 2000 to 2013, and the lowest (no consequences) in the periods from 1900 to 1930 and from 1940 to 1950. The highest number of injured people (99.77%) was in the period from 2000 to 2013, and the lowest

(no consequences) in the period from 1900 to 1970. The highest number of affected people (92.48%) were in the period from 2000 to 2013, and the lowest (no consequences) in the period from 1900 to 1980. The highest number of homeless people (93.07%) was present in the period from 2000 to 2013, and the lowest number (no consequences) in the period from 1900 to 1980 (Figure 6).

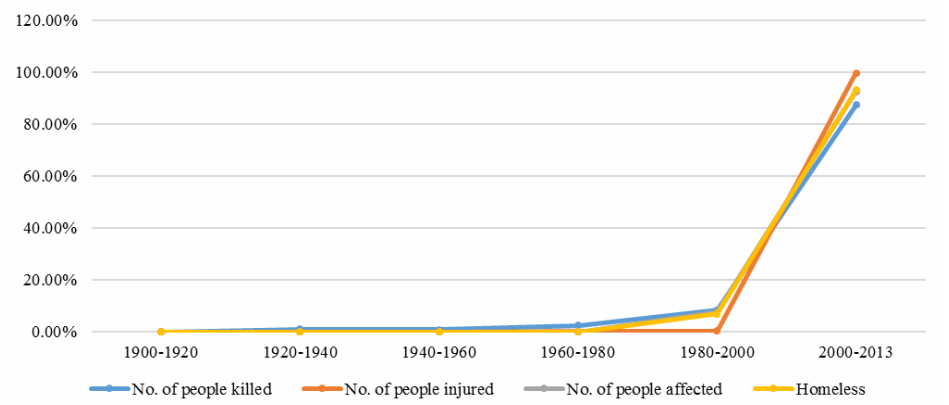

Figure 7 – *Percentage review of the effects of extreme temperatures on the people in the period from 1900 to 2013, classified by twenty-year periods. Source: author's calculations*

Observed by twenty-year periods, the highest numbers of killed people (87.47%), injured (99.77%), affected (92.48%), and homeless people (93.07%) were in the period from 2000 to 2013. The lowest number of killed people (no consequences) was in the period from 1900 to 1920, injured (no consequences) in the period from 1900 to 1960, affected (no consequences) in the period from 1900 to 1980, and homeless people (no consequences) in the period from 1900 to 1980 (Figure 7).

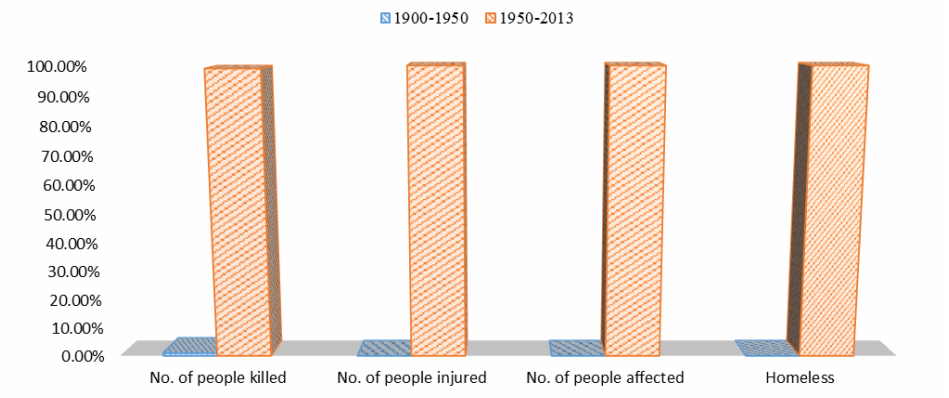

Figure 8 – *Percentage review of the effects of extreme temperatures on the people in the period from 1900 to 2013, classified by fifty-year periods. Source: author's calculations*

When observing a fifty-year period, the highest extreme temperatures occurred in the period from 1950 to 2013: killed people (99.01%), injured people (100%), affected people (100%) and homeless people (100%). The lowest consequences were in the period from 1900 to 1950: killed people (0.99%), injured people (no consequences), affected people (no consequences) and homeless people (no consequences) (Figure 8).

Table 9 – *Review of the total number and consequences of extreme temperatures during the period from 1900 to 2013, classified by decades. Source: author's calculations*

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
1900-1910	0	0	0	0	0	0	0
1910-1920	0	0	0	0	0	0	0
1920-1930	0	0	0	0	0	0	0
1930-1940	4	3386	0	0	0	0	0
1940-1950	0	0	0	0	0	0	0
1950-1960	16	2992	0	0	0	0	1240000
1960-1970	18	2254	0	0	0	0	0
1970-1980	36	5884	1200	0	0	1200	11160000
1980-1990	96	9850	434	2077290	2680	2080404	3967700
1990-200	220	18570	7126	12285614	32000	12324740	21574918
2000-2013	580	299664	3760164	176661576	466000	180887740	77112068

In the period from 1900 to 2013, the highest number of extreme temperatures (580) occurred in the period from 2000 to 2013 and the lowest number that is 4 extreme temperatures occured from 1930 to 1940. Of that, most fatalities were from 2000 to 2013, 299,664, and the lowest number, 2,992 in the period from 1960 to 1970. The highest number of affected people due to the extreme temperatures was in the period from 2000 to 2013 - 176 661 576, and lowest number in the period from 1900 to 1950 – no consequences. In the period from 2000 to 2013, most people were left homeless - 466,000 (Table 9).

Table 10 – *Review of the total number and consequences of extreme temperatures to people in the period from 1900 to 2103, classified by twenty-year periods. Source: author's calculations*

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
1900-1920	0	0	0	0	0	0	0
1920-1940	4	3386	0	0	0	0	0
1940-1960	16	2992	0	0	0	0	1240000
1960-1980	54	8138	1200	0	0	1200	11160000
1980-2000	316	28420	7560	14362904	34680	14405144	25542618
2000-2013	580	299664	3760164	176661576	466000	180887740	77112068

The highest number of extreme temperatures, 580, occurred in the period from 2000 to 2013 and the lowest number, that is, four extreme temperatures, from 1920 to 1940. Of that, most fatalities were from 2000 to 2013 299 664, and the lowest number, 2992, in the period from 1940 to 1960. Most affected people due to the extreme temperatures

was in the period from 2000 to 2013 - 176 661 576, and lowest number in the period from 1980 to 2000 - 14,362,904. In the period from 2000 to 2013, most people were left homeless 466.000 (Table 10).

Table 11 – *Review of the total number and consequences of extreme temperatures to people in the period from 1900 to 2013, divided into two periods from 1900 to 1950 and from 1950 to 2013. Source: author's calculations*

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
1900-1950	4	3386	0	0	0	0	0
1950-2013	966	339214	3768924	191024480	500680	195294084	115054686

In the period from 1950 to 2013, the highest number of affected people – 191,024,480, was in the period from 1950 to 2013, while the lowest number of affected people was in the period from 1900 to 1950, that is, without consequences (Table 11).

Table 12 – *Top five years by number of extreme temperatures in the period from 2003 to 2012. Source: author's calculations*

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
2012	104	3614	11314	1211136	0	1222450	305602
2005	78	4330	25400	102000	0	127400	2800000
2000	62	1882	3418	51954	0	55372	740318
2010	56	114176	22	145500	0	145522	800000
2003	50	149396	400	3679776	0	3680176	25040000

In the period from 2003 to 2012, the highest number of extreme temperatures occurred in 2012 - 104. Thus, in the first place by number of extreme temperature is 2012, followed by 2005, 2000, 2010, and finally 2003 (Table 12) .

Table 13 – *Top five years by number of the killed due to consequences of extreme temperatures during the period from 1998 to 2010. Source: author's calculations*

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
2003	50	149396	400	3679776	0	3680176	25040000
2010	56	114176	22	145500	0	145522	800000
2006	28	7498	600	0	0	600	0
2002	30	6738	7572	200400	0	207972	0
1998	24	6538	772	72000	0	72772	8550000

In the period from 1998 to 2010, in 2003, the highest number of people was killed due to consequences of extreme temperatures and it amounted to 149,396. In the first place by number of deaths due to consequences of extreme temperatures is 2003, followed by 2010, 2006, 2002, and finally 1998 (Table 13).

Table 14 – *Top five years by number of the injured due to consequences of extreme temperatures during the period from 2004 to 2012. Source: author's calculations*

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
2004	32	510	3600826	678934	0	4279760	0
2009	38	2836	54082	1658212	0	1712294	2324000
2011	32	870	44944	8228066	466000	8739010	1562246
2005	78	4330	25400	102000	0	127400	2800000
2012	104	3614	11314	1211136	0	1222450	305602

In the period from 2004 to 2012, in 2004, the highest number of people was injured due to consequences of extreme temperatures and it amounted to 3,600,826. In the first place by number of the injured due to consequences of extreme temperatures is 2004, followed by 2009, 2011, 2005, and finally 2012 (Table 14).

Table 15 – *Top five years by number of affected people due to consequences of extreme temperatures during the period from 1993 to 2011. Source: author's calculations*

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
2008	30	3386	1404	158341004	0	158342408	43880000
2011	32	870	44944	8228066	466000	8739010	1562246
1993	8	212	1120	6000400	0	6001520	0
2003	50	149396	400	3679776	0	3680176	25040000
2008	30	3386	1404	158341004	0	158342408	43880000

In the period from 1993 to 2011, in 2008, the highest number of people was affected due to consequences of extreme temperature and it amounted to 158,341,004. In the first place by number of affected people due to consequences of extreme temperatures is 2008, followed by 2011, 1993, 2003, and finally 2008 (Table 15).

Table 16 – *Top five years by number of people who were left homeless due to consequences of extreme temperatures during the period from 1985 to 2011. Source: author's calculations*

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
2011	32	870	44944	8228066	466000	8739010	1562246
1992	14	776	0	0	32000	32000	6056000
1985	16	912	0	11490	2680	14170	288000
2008	30	3386	1404	158341004	0	158342408	43880000
1993	8	212	1120	6000400	0	6001520	0

In the period from 1985 to 2011, in 2011 the highest number of people due to the extreme temperature was left homeless and it amounted to 466,000. In the first place by number of people who were left homeless due to consequences of extreme temperatures is 2011, followed by 1992, 1985, 2008, and finally 1993 (Table 16).

Table 1**7** – *Top five years by estimated value of material damage incurred due to consequences of extreme temperatures during the period from 1977 to 2008. Source: author's calculations*

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
2008	30	3386	1404	158341004	0	158342408	43880000
2003	50	149396	400	3679776	0	3680176	25040000
1998	24	6538	772	72000	0	72772	8550000
1992	14	776	0	0	32000	32000	6056000
1977	2	0	0	0	0	0	5600000

In the period from 1977 to 2008, the largest estimated damage caused due to consequences of extreme temperature was in 2008 and it amounted to 4,388,000. Thus, by estimated material damage caused due to consequences of extreme temperatures in the first place is 2008 followed by 2003, 1998, 1992, and finally 1977 (Table 17).

Conclusion

Nowadays, the fight against climate change represents one of the priorities in the policy of international community. Climate change already adversely affects ecosystems and throughout the century it will increase in rate and degree of occurrence. This means that food and water will be less available, natural disasters will occur more often, human health will be threatened, species will disappear and ecosystems will be destroyed or degraded. The expected effects of climate change are complex and far-reaching, so it is not surprising that a number of global initiatives are focused precisely on these problems. In addition to the activities to mitigate climate change, it has become an inevitable urgency to develop a system of adaptation to climate change. Correlation between adaptation to climate change with all other problems of development and the necessity of a comprehensive resolution poses special challenges for all sectors, including politics, science, economy and civil society. Much of the scientific community agrees that global temperature as a result of climate change has increased significantly in the last century, and will continue to grow in the foreseeable future. According to the Third Assessment Report of the IPCC, 2001, the average global temperature has risen by about 0.6 degrees during the twentieth century, although climate warming was not uniform either spatially or temporally, as it is indicated by observed changes and modelling studies. It is expected that the increase in average temperature will be accompanied by an increasing number of hot days and warm nights. Since these changes can be identified, it is expected that there will also be changes in cases of extreme temperatures, such as the increasing number of days with extremely low or extremely high temperatures. Climate change is more reflected in extreme temperatures than in their average values. This means that if global climate change is an actual phenomenon, it can be detected and clearly shown through the patterns of behaviour of extreme climatic events. Variations in global or regional cases of extreme air temperatures that occur due to changes in climate draw more and more attention lately, as living beings and ecosystems and human society are sensitive to the severity, frequency and persistence of extreme temperatures.

Using an international database on natural disasters of the Centre for Research on the Epidemiology of Disasters (CRED) with the support of program for statistical analysis (SPSS) and thematic cartography methods, we have tried to point out the geospatial and temporal distribution of temperature extremes in the period from 1900 to 2013. By analysing geospatial distribution of temperature extremes by continents, it can be concluded that the greatest number of extreme temperatures affected the geographical area of Europe, so that the greatest number of people killed due to the impact of extreme temperatures was recorded on this continent. However, looking at individual countries, by the number of people killed due to consequences of extreme temperatures, Russia is in the first place, followed by France, Italy, Spain and finally India. Data from the analyses of temporal distribution of temperature extremes in the period from 1900 to 2013 show that 970 extreme temperatures happened, whereas in the same period, 342,600 people were killed, 3,768,924 injured, 191,024,480 affected and 500,680 were left homeless.

At the end of the 1970s, a significant increase in the number of extreme temperatures can be noted, while the peak is in the period from 2000 to 2013, when 59.79% of the total number of extreme temperatures for the given period happened.

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