UDC 351.792

ANALYSIS OF GEOSPATIAL AND TEMPORAL DISTRIBUTION OF FLOODS AS NATURAL EMERGENCIES

Teaching Assistant **Vladimir Cvetković**, MSc[1]
Academy of Criminalistic and Police studies, Belgrade

Abstract: Floods as hydrological emergencies, every day increasingly threaten the safety of people and their property. As such, they intensely attract the attention of researchers in the field of geospatial, technical, natural, information and other sciences, but also experts in the field of emergency who want to better understand it. Bearing in mind that this is a mass phenomenon, which consists of multiple units, most preferred method of scientific research and drawing conclusions about the phenomenology of flood is a statistical method. Guided by this fact, the subject of this paper is a descriptive statistical analysis of geospatial and temporal distribution of flood in period from 1900 until 2013 at the global level. Thereby, a statistical study was conducted in such a way that in the first step it was taken raw (unprocessed) data in format of "Excel" file from the international database on disasters (CRED) in Brussels, which were then analyzed in the statistical SPSS data processing. Within the temporal analysis it is examined the distribution of the total number and impacts of floods on an annual, monthly and daily basis, with a special focus on the top 5 countries by the number of different effects (killed, injured, affected, homeless). On the same principle, within the geospatial distribution it is analyzed the total number and consequences of floods by continents and countries, with special emphasis on the top five states in terms of total number and variety of consequences. Therefore, for more effective and efficient protection and emergency response caused by the deleterious effect of flooding, it is needed to comprehensively explore specified natural phenomena, so that the subject of the paper will be form, consequences, temporal and geospatial distribution of manifestation of flooding. In addition, it is important to mention that geospatial and temporal analysis of floods gives meaning, content and value to a comprehensive effort to better understand natural hazards and their effects, in order to timely protect people from them, and in this case, adjust to the flood risk.

Keywords: security, floods, emergencies, statistical analysis, protection and rescue.

INTRODUCTION

Natural emergencies increasingly endanger the safety of modern mankind. Not only that the past decades it is obvious increase in the number, but there is increase in their destructiveness. [2] This results in a higher loss of life, material and non-material damage. Therefore, natural emergencies are events that have a large and tragic impact on society, damaging the common ways of life, hinder economic, cultural, and sometimes political conditions of life and slow the development of the community and require special measures taken by emergency and rescue services in emergency situations.[3] It can be said that natural emergencies are the consequences of mutual influence of natural events (geophysical processes and other processes in nature) and human systems (socio - economic, cultural and physical). [4]According to Mohamed, natural emergencies can be classified as: natural phenomena of complex physical origin of the Earth's surface (earthquakes, tsunamis, volcanic eruptions), natural phenomena of complex physical origin of the Earth's surface (landslides, avalanches), meteorological/hydrological phenomena (storms, cyclones, typhoons , hurricanes, tornadoes, snow storms, sea surges, floods, drought, heat wave/cold wave), and biological phenomena (invasion - swarms of locusts and bugs, epidemic or infectious diseases - cholera, dengue fever, Ebola, smallpox, meningitis, malaria,

1 Teaching assistant of subject „Security in emergency situations".
2 *Mijalković, S., Cvetković, V.: Vulnerability of Critical Infrastructure by Natural Disasters.* Belgrade, In Procesiding „National Critical Infrastructure Protection, Regional Perspective", 2013, стр. 93
3 Cvetković, V.: *Intervetno-spasilačke službe u vanrednim situacijama*. Beograd: Zadužbina Andrejević, 2013. godine, str. 9.
4 Mladan, D., Cvetković, V.: *Classification of Emergency Situations*. Belgrade: Thematic Proceedings of International Scientific Conference "Archibald Reiss Days", Academy of criminalistic and police studies,1-2. march 2013, pp. 106.

yellow fever, AIDS, SARS, avian flu).[5] They differ from natural hazards, which generate natural emergencies only after endanger people and their material goods. [6]More specifically, they occur due to the impact of natural hazards on people, property, infrastructure and natural resources. These events have a large and tragic impact on society, damage the common ways of life, hinder economic, cultural, and sometimes political conditions of life and slow the development of the community. [7]In principle, they are of polymorphic character (two instances of the same origin and intensity usually produce different overall effects), accompanied by the phenomenon of parallelism (affecting only certain geospatial areas where significant change living conditions and environment) and have specific, usually massive consequences (social, health, physical and environmental).[8]

One of the most important natural emergencies certainly is the flood. Risk of flooding only exists as part of the relationship between water and human habitation (activities). For most of the world's population, flooding is regular seasonal phenomenon that ensures the growth of crops as it brings danger. Floods are important to the ecology of many areas. They fertilize and irrigate river valleys and fill reservoirs of water. Floods are a normal part of the regime of every river, and flood of water can come from the oceans, large rivers, smaller tributaries, urban runoff, snowmelt, and dam or levee failure.[9] Flooding can be caused by weather conditions, away from areas affected by floods.

It can be said that the flood as a natural emergency is difficult to define. It can be said partly because there are no natural boundaries in the global geographic space, and the fact that the threshold values of flood are selected based on human criterion, which may varies. Flooding is usually defined as a result of overflow of the river over its levees and spreading over nearby valley.[10] The term flood can be defined as the water on the earth, which is not usually submerged.[11] This can be extended to a large increase in the amount of water in areas such as wetlands and lakes. Flooding is a natural part of the process, but only becomes a "threat" when happens a hazard or an impending danger or harm to humans, their activities or the things that

5 Mohamed, S. I.: *Disaster types*. *Disaster Prevention and Management,* Vol. 16, Iss: 5, 2007, str. 706.

6 Wisner, B.: *At Risk: Natural Hazards, People's Vulnerability and Disasters.* London: Routledge, 2004. year, str. 134. There is a significant difference between emergency, hazard and risk. The risk is the result of a combination of hazards, conditions, vulnerabilities and insufficient capacities or measures to reduce the potential negative consequences of risk. However, when hazard or threat becomes reality, ie. when it materializes, the risk becomes an emergency. For example, a river valley may be prone to flooding. The risk exists only if the affected comunity or assets are located in the area that is prone to flooding. If the risk materializes, ie. the flood actually occurs, it will cause a loss in the affected population or property, creating an emergency situation. Edward, B.: Natural Hazards, Second Edition. Cambridge, University Press, 2005, str. 103.

7 According to the United Nations International Strategy for Disaster Risk Reduction, these are "serious disturbances in the functioning of a community or society causing widespread human, material, economic or environmental losses which exceed the capabilities of the affected community to deal with them using their own resources". See for more details: UN - ISDR United Nations - *International Strategy for Disaster Risk Reduction*, 2004, p. 5. Similarly, according to the UN Center for Human Settlements Research "Natural emergency situation is the interplay of natural hazards, caused in most cases by sudden and unexpected natural events, and the conditions of vulnerability, which cause serious losses to human and his environment (built and natural). These losses create suffering and chaos in the normal frames of life, socio-economic, cultural, and sometimes political. Such situations require external assistance from international and national institutions, as a contribution to independent and joint responses. See for more details: UNCHS (United Nations Center for Human Settlements) (1994) *Sustainable Human Settlements in an urbanizing World, including Issues Related to land policies and mitigation of natural disasters*. 15th Session of the Commission on Human Settlement. Unpublished Draft Paper Theme.

8 Jakovljević, V., Đarmati, Š.: *Civilna zaštita u Saveznoj Republici Jugoslaviji*, Beograd: Studentski trg, 1998, str. 35

9 For example, in the geographic space of Serbia, precipitation in July, 1999 caused flooding on smaller rivers in Great and Western Morava river basin (where the high water on some tributaries occurred 2-3 times in a period from 10 to 20 days), and in December of the same year, there have been high water in Drina and Sava river basins. On Tisza and Tamis rivers in March and April, 2000, the floods have occurred due to the rapid melting of snow and the simultaneous occurrence of precipitation. In June 2001 again a large amount of rainfall caused flooding in the Drina river (the Ljubovidja, Jadra, Stiri). In April 2005, the simultaneous melting snow and intense rainfall caused the flooding of the Tamis, Tisza and Danube rivers, right tributary of the Drina and South Morava. Milojković, B., Mlađan, D.: *Adaptivno upravljanje zaštitom i spasavanje od poplava i bujica – prilagođavanje poplavnom rizku*. Bezbednost, Year LII, 1/2010., str. 175.

10 Marlene, B., Carmichael, R.: *Notable Natural Disasters.* California: Salem Press, Inc, 2007., 122.

11 Schumann, A.: *Flood Risk Assessment and Management.* Bochum, Germany: Springer, 2001., 43.

they value.[12] They can be caused by climatic conditions and factors.[13] Climatic conditions include heavy rains from tropical storms and hurricanes, severe thunderstorms, cyclones, frontal winds, rapid melting of snow and ice. Climatic factors consist of tides and storms in coastal areas. Other factors that can cause floods have earthquakes, landslides and dam failures. Conditions which increase flooding include fixed basin characteristics such as size, shapes, slope, and elevation. Variable characteristics of the basin are water storage capacity and portability in soil and rocks, soil infiltration rate and extent of wetlands and lakes. Channel characteristics such as length, slope, roughness and shape, can also enhance the flood, as can the human effects of river regulation: joint use of groundwater, transfer among watersheds, wastewater discharge, water diversion and irrigation, urbanization, dams and land drainage. Generally, there are the following types of floods: floods caused by rain and melting snow, icy floods; flooding due to the coincidence of high water levels, flash floods, and floods caused landslides, floods caused by dam failure, etc.

Because of an ability of a flood to cause a lot of damage to human health, material and cultural resources and the environment, knowledge of causes, frequency, regularities of geospatial and temporal distribution and the possibility of the return of these phenomena would be very useful for flood control, and for the organization and implementation of protection and rescue measures based on the concept of "adjustment to flood risk."[14] It is, therefore, hydrologists use statistical methods for calculating authoritative probability of high water, or in order to get an assessment of the probability that a flood of a certain size will happen in a given year, one in a hundred, five hundred or thousand.[15]

Since this is a really extensive matter, the subject of this work will be analysis of forms of expression, number, temporal and geospatial distribution of floods only. Phenomenology of other types of natural emergencies will be the subject of future research.

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, were taken from the center (www.emdat.be). [16] The download is made 5/6/2013. Subsequently, the data were 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 made, which were further processed in, "MS Word 2013". Results of processing of quantitative data are displayed text, tables and graphics in the form of cartographic visualization by method of thematic mapping - volume cartography. [17] The results of processing these 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 ran out of his 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.

12 Stoltman, J., Lindston, J., Dechano, L.: *International Perspectives on Natural Disasters: Occurrence, Mitigation, and Consequences.* The Netherlands.: Published by Springer .O. Box 17, 3300 AA Dordrecht, 2007., str. 78.

13 Proverbs, D., Soetanto, R.: *Flood Damaged Property A Guide to Repair.* Oxvord: Blackwell Publishing Ltd.,2004, str. 31.

14 Milojković, B., Mlađan, D.: *Isto*: str. 172.

15 Rao, A., Hamed, K.: *Flood frequvencyanal analysis.* Washington: CRC Press, 2000, pp. 24.

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

17 Filipović, I., Milojković, B.: *Osnovi kartografije sa topografijom,* Niš: Prirodno-matematički fakultet – Departman za geografiju, 2010., str. 165.

ANALYSIS OF GEOSPATIAL DISTRIBUTION OF FLOODS

To understand geospatial and temporal distribution of floods it is important to know the basic qualitative and quantitative indicators of natural emergencies at the global level and in the long run. Namely, in the period from 1900 to 2013, there were 25,552 natural emergencies. Most of them were hydrological and meteorological, geophysical, climatic and biological disasters.[18] Therefore, in this period there were 9,557 hydrological emergencies. They killed 13,987,140, 2,655,118 were injured, 6,891,172,180 were affected, 185 223 183 homeless. Therefore, the total affected were 7,079,050,481 people, while the total damage amounted to 1,200,003,042 U.S. dollars. Also, looking by the number of events, hydrological emergencies are in the first place, then meteorological, geophysical, climatic and biological in the end (Table 1).

Disaster sub-group	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
Meteorological	7149	2766859	2641153	1742924832	105054916	1850620901	1872273246
Geophysical	3037	5331007	5177147	309279694	45930226	360387067	1522543792
Hydrological	9557	13987140	2655118	6891172180	185223183	7079050481	1200003042
Biological	2820	19152311	968153	90325323	0	91293476	460264
Climatological	2989	23772449	3779656	4532945549	903962	4537629167	471765608
Total	25552	65009766	15221227	13566647578	337112287	13918981092	5067045952

Table 1. Overview of the world's natural disasters in the period from 1900 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

At the annual level was happening 85 annual, 7 monthly and 0.6 per day hydrological emergency situations. Generally speaking, after atmospheric, hydrological emergencies are the most common (Table 2).

Disaster sub-group	Annual	Month	Day
Atmospheric	90	7.5	0.25
Geophysica	27	2	0.07
Hydrological	85	7	0.6
Biological	24	2	0.06
Total	226	18.5	0.98

Table 2. Overview of natural emergencies in the period from 1900 to 2013, classified by annual, monthly and daily distribution. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

In percentage terms, of total number of natural emergencies, due to the consequences of hydrological emergencies, 54.94% of people were homeless, 50.79% were affected, 21.52% died, and 17.44% were injured (Figure 1).

18 Cvetković, V., Mijalković, S.: *Spatial and Temporal distribution of geophysical disasters*. Serbian Academy of Sciences and Arts and Geographical Institute Jovan Cvijic, Journal of the Geographical Institute "Jovan Cvijić" 63/3, pp. 346.

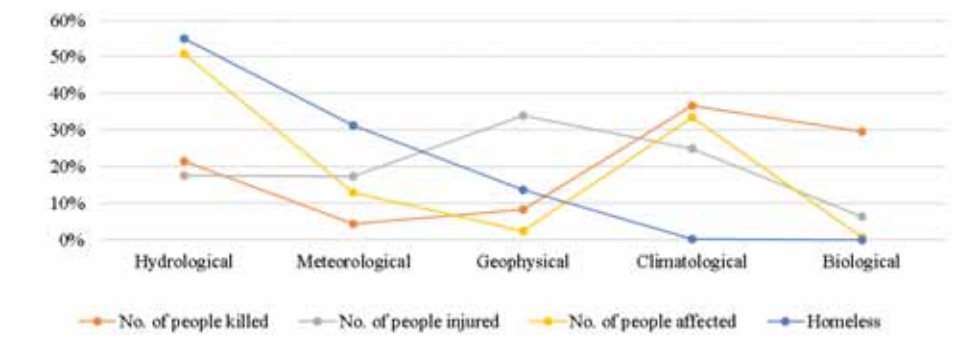


Figure 1. Share of the consequences of natural emergencies to people in period from 1900 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

Also, to understand these issues it is important to bear in mind the results of previously conducted and published research. After examining the large number of foreign papers about floods, it can be concluded that a large number of authors dealt with the problem of geospatial and temporal distribution of floods: Chow[19] (1964), Yevjevich[20] (1972), Haan[21] (1977), Kite[22] (1977), Singh[23] (1987), Potter[24] (1987), Bobee i Ashkar[25] (1991), McCuen[26] (1993) and so on . They are all in different ways wanted to examine the frequency of their occurrence. In the period between 1946-2006 in geographic space of Serbia the following historic floods happened: 5/14/1965 and 5/14/1979 on the West Morava river, 11/19/1979 on the Ibar river, 6/26 and 6/27/1988 on the Lužnica river (left tributary of the Vlasina river) and the Vlasina river and 4/17/1996 on the Ribnica river.[27] The research results undoubtedly point to the fact that floods occur every day around the world. The causes of their occurrence are varied. Based on the collected and processed data on geospatial distribution from specified base it can be said that the highest number of floods in period from 1900 to 2013occurred in Asia with 3427 floods, and the lowest number in Oceania with 258. Bearing in mind all the continents, by number of flooding in the first place is Asia, then America, Africa, Europe and Oceania in the end (Table 3).

Continent	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
Africa	1669	50557	55947	119555483	11910538	131521968	14630498
America	1943	208047	88300	165740994	7133925	172963219	195930880
Asia	3427	13589418	2438303	6560968177	153660678	6717067158	722929790
Europe	1034	18148	51712	23873756	3835628	27761096	220657128
Oceania	258	1016	184	2126518	214970	2341672	28954750
Total	8331	13867186	2634446	6872264928	176755739	7051655113	1183103046

Table 3. Overview of the total number and impacts of floods to people from 1900 to 2013, sorted by continents. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

19 Chow, T.: *Handbook of Applied Hydrology. New York:* McGraw- Hill, 1964
20 Yevjevich, V.M.: *Statistical and Probability Analysis of Hydrologic Data, Part II, Regression and Correlation Analysis*, Sec. 8-II, *Handbook of Applied Hydrology, V.T. Chow, editor-in-chief, McGraw-Hilll Book Company, New York, NY, 1964.*
21 Haan, T.: *Statistical Methods in Hydrology*. Iowa State University Press, Ames, IA, 1977.
22 Kite, G.W.: *Frequency and Risk Analysis in Hydrology*. *Water Res. Publications,* Fort Collins, CO, 1977.
23 *Singh, V., Singh, K.: Parameter Estimation for TPLN Distribution for Flood Frequency Analysis,* Water Resources Bulletin, Vol. 23, No. 6, pp. 1185-1191.
24 *Potter, W.:Research on Flood Frequency Analysis, 1983-1986,* Reviews of Geophysics, Vol. 25, No. 2, 1987., pp. 113-118.
25 *Bobee, B., Ashkar, F.: The Gamma Family and Derived Distributions Applied in Hydrology,* Water Resources Publications, Littleton, CO, 1991.
26 *McCuen, H.:. Microcomputer Applications in Statistical Hydrology,* Prentice Hall, Englewood Cliffs, NJ, 1993.
27 Milojković, B., Mlađan, D.: *Isto*: str. 176.

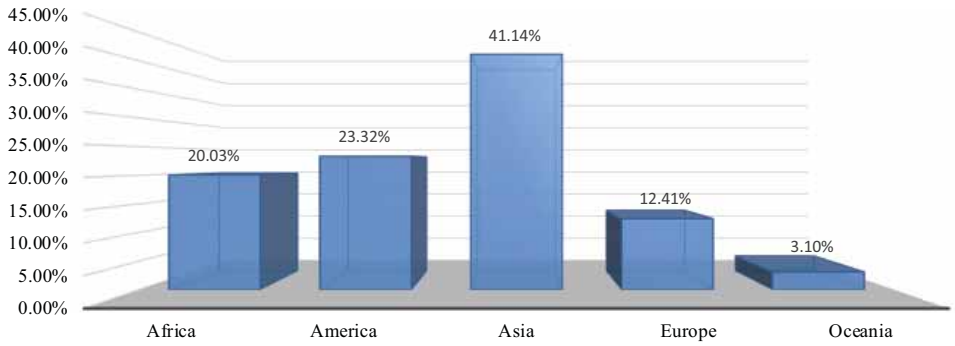
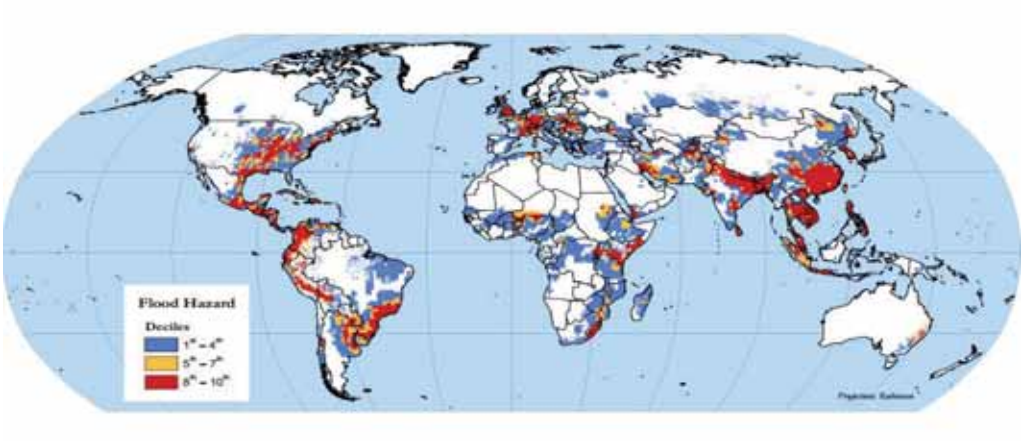


Figure 2. Percentage overview of the total number of floods in period from 1900 to 2013, sorted by continent. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.



Picture 1. Global view of distributions of floods in the period from 1985 to 2003.[28]

In percentage terms, in the period from 1900 to 2013, Asia had 41.14%, America 23.32%, 20.03% Africa, Europe 12.41% and Oceania 3.10% of floods. Therefore, if we take into account the average value of flood occurrence, it can be concluded that in Asia, they occur above average, compared with Europe and Oceania, where the number is below the average. Of course, in Africa and the United States they occur within certain average in relation to the total number of floods in the world (Figure 2 and Picture 1).

28 Dilley, M, Robert, C., Uwe D., Arthur L., Margaret A.: *Natural Disaster Hotspots: A Global Risk Analysis*. Washington, D.C.: World Bank, 2005, str. 21.

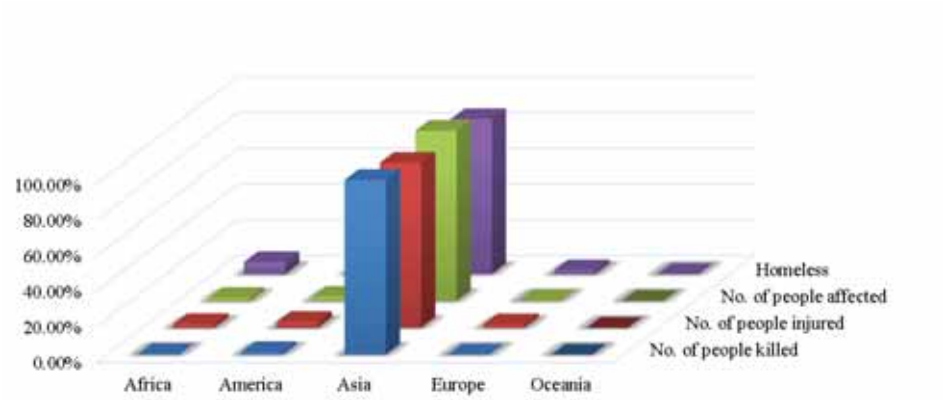
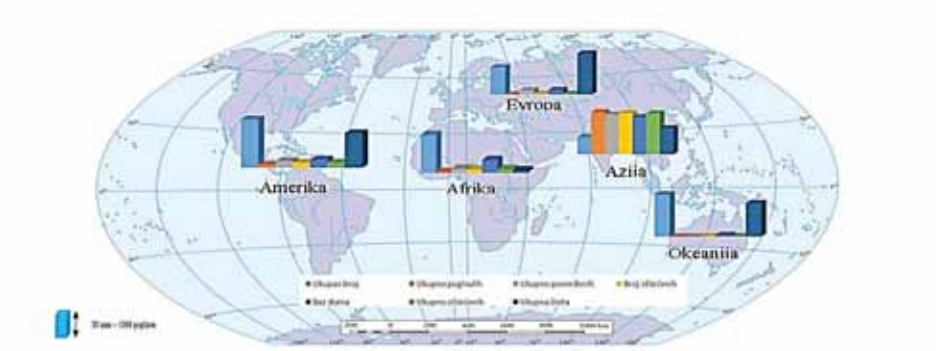


Figure 3. Percentage overview of the consequences of flooding to people in the period from 1900 to 2013, classified by continent. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.



Picture 2. The cartographic representation of the total number and impacts of floods in the world in the period from 1900 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

In comparison to percentages of flood events, it is clear that the highest percentage of the killed (98%), injured (92.55%), affected (95.47%) and homeless (86.93%) has remained in Asia. While on the other hand, all percentages were the lowest in Oceania (Figure 3 and Figure 2).

Country	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
Avganistan	499	8010	2256	2376836	121390	2500482	792000
Albanija	452	38	0	273968	0	273968	49346
Algerija	318	9728	2410	1272300	267340	1542050	3087834
Samoa	309	12	6	0	0	6	100000
Angola	264	975	94	2170574	223580	2394248	20000

Table 4. Top five states by the floods in the period from 1900 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

During the period from 1900 to 2013, the highest number of floods happened in Afghanistan 499. Thus, by the number of floods in the first place is Afghanistan then Albania with 452, Algeria 318, Samoa 309 and Angola 264 (Table 4).

Country	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
Kina	70	13196986	1653752	3845305864	86704258	3933663874	372685592
Indija	32	122416	3588	1598677710	32178000	1630859298	72092376
Bangladeš	130	104466	204784	626545924	8510724	635261432	24076800
Gvatemala	38	81816	760	1786398	8540	1795698	360826
Venecuela	2	60792	6496	1463832	330556	1800884	6994252

Table 5. Top five states by the number of the killed by floods in the period from 1900 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

During the period from 1900 to 2013, the highest number of the killed due to the impacts of floods was in China 13.196.986. Thus, by the number of the killed due to the impacts of floods in the first place is China, India 122 416, Bangladesh 104 466 81 816, Guatemala and Venezuela 60 792 (Table 5).

Country	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
Kina	70	13196986	1653752	3845305864	86704258	3933663874	372685592
Indonezija	32	12885	510394	17518374	356060	18384828	11302094
Bangladeš	130	104466	204784	626545924	8510724	635261432	24076800
Sudan	4	1546	38076	9389204	2906960	12334240	1102400
El Salvador	55	1356	36000	822684	0	858684	2563000

Table 6. Top five states by the number of the injured in floods in the period from 1900 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

During the period from 1900 to 2013, the highest number of the killed due to the impacts of floods was in China 1,653,752. Thus, by the number of the injured due to the consequences of the floods in the first place is China, then Indonesia 510 394, Bangladesh 204 784, Sudan 38 076 and El Salvador 36 000 (Table 6).

Country	Occurrence	No. of people killed	No. of people injured	Broj pogođenih	Homeless	Total affected	Estimated damage ($)
Kina	70	13196986	1653752	3845305864	86704258	3933663874	372685592
Indija	32	122416	3588	1598677710	32178000	1630859298	72092376
Bangladeš	130	104466	204784	626545924	8510724	635261432	24076800
Pakistan	12	31854	17466	138922014	8468830	147408310	34936356
Tajland	4	7668	7382	103461510	322966	103791858	89602816

Table 7. Top five states by the number of the affected by floods in the period from 1900 to 2013. Source data: EM-DAT: The OFDA/CRED International Disaster Database.

During the period from 1900 to 2013, the highest number of the affected due to the impacts of floods was in China 3.845.305.864. Thus, by the number of the injured due to the consequences of the floods in the first place is China, then India 1.598.677.710, Bangladesh 626.545.924, Pakistan 138.922.014 and Thailand 103 461 510 (Table 7).

Country	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
Kina	70	13196986	1653752	3845305864	86704258	3933663874	372685592
Indija	32	122416	3588	1598677710	32178000	1630859298	72092376
Bangladeš	130	104466	204784	626545924	8510724	635261432	24076800
Pakistan	12	31854	17466	138922014	8468830	147408310	34936356
Šri Lanka	4	2592	2183	18562323	7733748	26298254	1961128

Table 8. Top five states by the number of the homeless by floods in the period from 1900 to 2013. Source data: EM-DAT: The OFDA/CRED International Disaster Database.

During the period from 1900 to 2013, the highest number of the homeless due to the impacts of floods is in China 86.704.258. Thus, by the number of the injured due to the consequences of the floods in the first place was in China, then India 32.178.000, Bangladesh 8.510.724, Pakistan 8.468.830 and Sri Lanka 7.733.748 (Table 8).

Country	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
Kina	70	13196986	1653752	3845305864	86704258	3933663874	372685592
SAD	2	5582	720	24222342	70600	24293662	112822520
Tajland	4	7668	7382	103461510	322966	103791858	89602816
Indija	32	122416	3588	1598677710	32178000	1630859298	72092376
Italija	30	2134	424	2736300	2996300	5733024	46711200

Table 9. Top five states by the assessed value of property damage by floods in the period from 1900 to 2013. Source data: EM-DAT: The OFDA/CRED International Disaster Database.

During the period from 1900 to 2013, the highest assessed value of property damage due to the impacts of floods is China 372.685.592. Thus, by assessed value of property damage due to the consequences of the floods in the first place are China, then USA 112.822.520, Thailand 89.602.816, India 72.092.376 and Italy 46.711.200 (Table 9).

ANALYSIS OF TEMPORAL DISTRIBUTION OF FLOODS

A number of researchers every day have fear of confirming the fact that the number of natural emergencies increases every year. In order to eliminate uncertainty, it is important to consider their temporal distribution. The aim of such analysis is certainly influencing certain prognostic plans. That is why it is very important to perform temporal analysis of flooding. Accordingly, in the period from 1900 to 2013 8,331 floods happened, with 13,867,186 of the killed, 2,634,446 of the injured, 6,872,264,928 of the affected and 176 755 739 of the homeless. Observed annually, it can be said there were 74, 6 floods per month, 0.20 floods per day (Table 10).

Type	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
Flood	8331	13867186	2634446	6872264928	176755739	7051655113	1183103046
Yearly	74	122718	23313	60816503	1564210	62404027	10469938
Monthlz	6	10226	1942	5068041	130350	5200335	872494
Daily	0.20	340	65	168934	4345	173344	29083

Table 10. Overview of the total number and impacts of floods in the period from 1900 to 2013, with reference to the annual, monthly and daily distribution. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

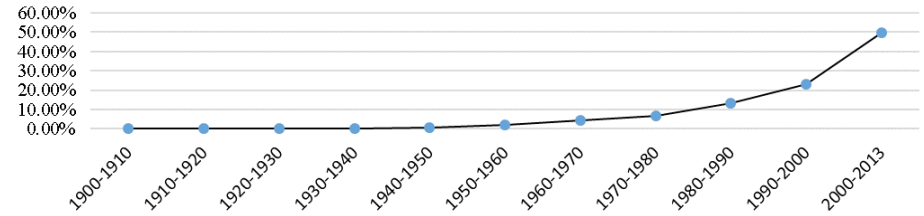


Figure 4. Percentage overview of the total number of floods in period from 1900 from 2013 year, classified by decades. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

Up until 1980 the floods have occurred within a certain average of 10%. After this period it can be noticed a significant increase in the number of floods, and the culmination is the period since 2000 to 2013 when it happened 49.85% of the total number of floods for the period. The minimum number of floods occurred in the period from 1900 to 1910 and it is 0.17% (Figure 4).

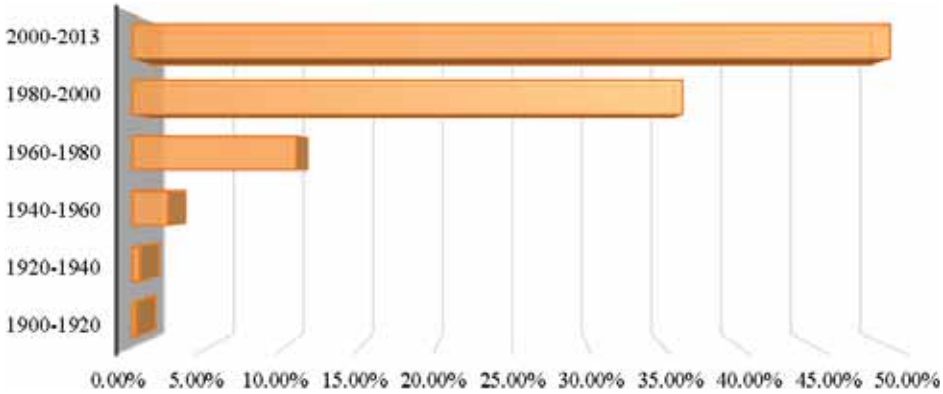


Figure 5. Percentage overview of the total number of floods in period from 1900 to 2013, classified by twenty years periods. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

In the periods of twenty years, the largest number of earthquakes occurred in the period from 2000 to 2013 (49.85%) and lowest in the period from 1900 to 1920 (0.26%) (Figure 5).

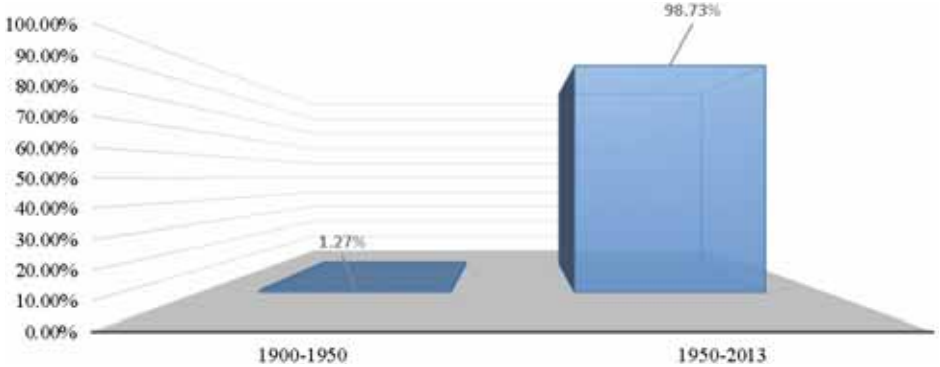


Figure 6 Percentage overview of the total number of floods in period from 1900 to 2013, classified into two periods: from 1900 to 1950 and from 1950 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

Based on the graph shown above, one can clearly notice that most of the flooding occurred in the period since 1950 to 2013 and it was 98.73%, in contrast to the period from 1900 to 1950 (1.27%) (Figure 6).

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
1900-1910	14	4014	0	0	0	0	960000
1910-1920	8	200000	0	7270000	0	7270000	40000
1920-1930	20	8564	0	12000	4000	16000	100460
1930-1940	24	8723180	0	20060000	7204000	27264000	3676000
1940-1950	40	209430	0	20264000	0	20264000	2030000
1950-1960	156	4136934	0	5917768	509000	6426768	3358000
1960-1970	358	50126	250346	133860212	6690926	140801484	12606358
1970-1980	542	115990	80466	427578276	22108188	449766930	17180318
1980-1990	1090	86676	173416	923911336	15626140	939710892	93326142
1990-2000	1926	198522	1634260	2828933946	97143650	2927711856	466065314
2000-2013	4153	133750	495958	2504457390	27469835	2532423183	583760454

Table 11. Overview the total number and consequences of flooding to people and property in the period from 1900 to 2013, classified by decades. Source of data: EM-DAT: The OFDA/ CRED International Disaster Database.

During the period from 1900 to 2013, the largest number of 4153 floods occurred in the period since 2000 to 2013 and a minimum of 8 floods from 1910 to 1920. The largest number of the killed were from 1930 to 1940 872,318 and the lowest one, 4014, occurred in the period from 1900 to 1910. By the number of the affected due to the consequences of floods in the period from 1900 to 2000 the highest number was 2,828,933,946 and minimum without consequences from 1900 to 1910. In the period from 1900 to 2000, there was the highest number of the homeless, 97,173,650 (Table 11).

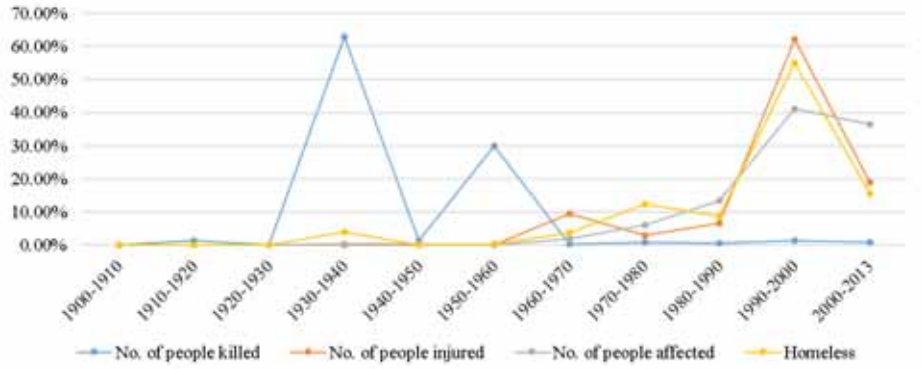


Figure 7. Percentage overview of the consequences of flooding to people and property in the period from 1900 to 2013, classified by decades. Source of data: EM-DAT: The OFDA/ CRED International Disaster Database.

In percentage terms, most people were killed in the period from 1930 to 1940 (62.91%) and the lowest percentage from 1900 to 1920 (1.47%). In the period from 1990 to 2000 the highest number was the injured (62.03%), affected (41.16%) and homeless (54.96%). The lowest percentage was injured (0%) in the period 1900-1960, the affected in the period from 1900 to 1910 (0%), and the homeless in the period from 1900 to 1930 (0%) (Figure 7).

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
1900-1920	22	204014	0	7270000	0	7270000	1000000
1920-1940	44	8731744	0	20072000	7208000	27280000	3776460
1940-1960	196	4346364	0	26181768	509000	26690768	5388000
1960-1980	900	166116	330812	561438488	28799114	590568414	29786676
1980-2000	3016	285198	1807676	3752845282	112769790	3867422748	559391456
2000-2013	4153	133750	495958	2504457390	27469835	2532423183	583760454

Table 12. Overview of the total number and impacts of floods to people in the period from 1900 to 2013, classified by twenty years periods. Source of data: EM - DAT: The OFDA/ CRED International Disaster Database.

During the period from 1900 to 2013, the largest number of 4153 floods occurred in the period since 2000 to 2013 and a minimum of 22 floods from 1910 to 1920. The largest number of the killed was from 1920 to 1940 8.731.744 and the lowest one, 133.750, occurred in the period from 2000 to 2013. The highest number of affected was in the period from 1980 to 2000 and the lowest number was 7.270.000 from 1900 to 1920. In the period from 1980 to 2000, there was the highest number of the homeless, 97,173,650 (Table 11).

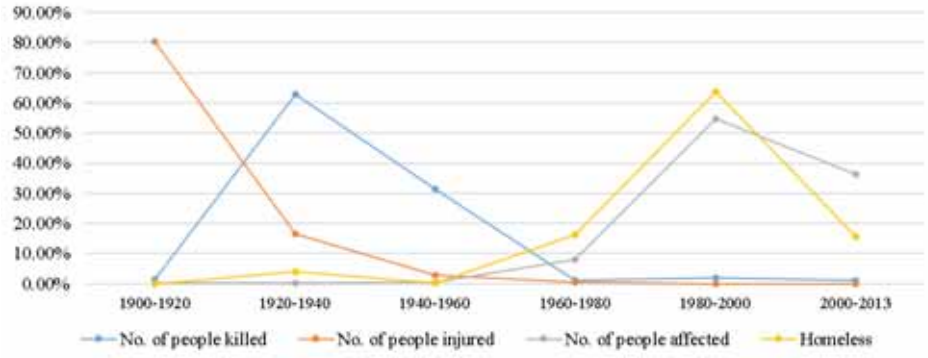


Figure 8 Percentage overview of the consequences of flooding to people Fin the period from 1900 to 2013, classified by decades. Source of data: EM - DAT: The OFDA/CRED International Disaster Database.

In percentage terms, most people were killed in the period from 1920 to 1940 (62.97%) and the lowest percentage from 1900 to 1920 (1.47%). In the period from 1980 to 2000 there was the highest number of the injured (62.62%), affected (54.61%) and homeless (63.83%). The lowest percentage was injured (0%) in the period 1900-1960, the affected in the period from 1900 to 1910 (0%), and the homeless in the period from 1900 to 1920 (0%) (Figure 8).

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
1900-1950	106	9145188	0	47606000	7208000	54814000	6806460
1950-2013	8225	4721998	2634446	6824658928	169547739	6996841113	1176296586

Table 13. Overview of the total number and impacts of floods to people in the period from 1900 to 2013, classified into two periods from 1900 to 1950 and from 1950 and 20013. Source of data: EM - DAT: The OFDA/CRED International Disaster Database.

Looking at a period of fifty years, it is noted that after 1950, there was a significantly higher number of floods. Thus, the total number of floods from 1900 to 1950 amounted to 106, and from 1950 to 2013 8225 (Table 13).

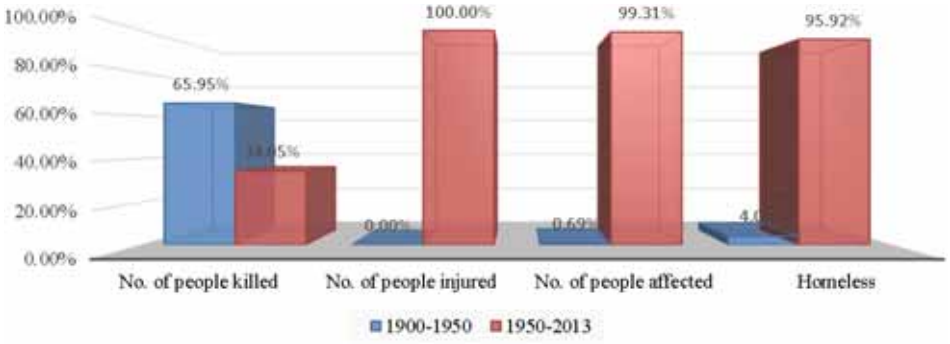


Figure 9. Percentage overview of the consequences of flooding to people in the period from 1900 to 2013, classified into two periods: from 1900 until 1950 and since 1950 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

In percentage terms, the highest number of the killed (65.95%), injured (100%) and affected (99.31%), as the number of people left homeless (95.92%) was in the period from 1950 to 2013, and the lowest number in the period before 1950. (Figure 9).

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
2006	452	11686	4398	51336414	9277884	60618696	15611884
2007	436	17214	13300	353718102	1940494	355671896	49172134
2005	386	11508	3842	148649078	1400698	150053618	35879340
2010	366	16892	20766	375605606	1341440	376967812	96052294
2002	344	8472	77790	335269752	193904	335541446	53651022

Table 14. Top five years by floods in the period from 1900 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

During the period from 1900 to 2013, in 2006 most floods happened, 452. So, in the first place by flooding is 2006, then 2007, 2005, 2010 and 2002 in the end (Table 14).

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
1931	2	7400000	0	0	0	0	2800000
1959	26	4006792	0	26000	0	26000	0
1939	4	1000020	0	0	0	0	0
1935	2	284000	0	20060000	0	20060000	0
1911	2	200000	0	0	0	0	0

Table 15. Top five years by the number of deaths due to the consequences of floods in the period from 1900 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

During the period from 1900 to 2013, in 1931 most people were killed due to the consequences of floods and the number was 7,400,000. In the first place by the number of deaths due to the consequences of the floods is 1931 then 1959, 1939, 1935 and 1911 in the end (Table 15).

Year	Occurrence	No. of people killed	No. of people injured	Broj pogođenih	Homeless	Total affected	Estimated damage ($)
1996	184	16094	505654	354835800	10012572	365354026	56994000
1992	118	10630	504240	30700328	7991020	39195588	15725326
2003	318	7772	306304	335095952	3520902	338923158	41731296
1998	188	21306	247922	551071240	36006208	587325370	87858302
1968	40	14612	200400	47668384	1789168	49657952	834362

Table 16. Top five years by the number of the injured due to the impacts of floods in the period from 1900 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

During the period from 1900 to 2013, in 1996 most people were injured due to the consequences of floods and the number was 505.654. In the first place by the number of the injured due to the consequences of the floods is 1996 then 1992, 2003, 1988 and 1968 in the end (Table 16).

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
1998	188	21306	247922	551071240	36006208	587325370	87858302
1991	154	11704	64854	444466296	11067628	455598778	25035276
1995	188	15912	142148	381295332	5445014	386882494	55111588
2010	366	16892	20766	375605606	1341440	376967812	96052294
1996	184	16094	505654	354835800	10012572	365354026	56994000

Table 17. Top five years by the number of the affected due to the impacts of floods in the period from 1900 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

During the period from 1900 to 2013, in 1998 most people were affected due to the consequences of floods and the number was 551.071.240. In the first place by the number of the affected due to the consequences of the floods is 1998 then 1991, 1995, 2010 and 1996 in the end (Table 17).

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
1998	188	21306	247922	551071240	36006208	587325370	87858302
1994	176	13542	45570	245092526	14428246	259566342	41005612
1975	34	1696	186	64098410	14160300	78258896	2272486
1991	154	11704	64854	444466296	11067628	455598778	25035276
1996	184	16094	505654	354835800	10012572	365354026	56994000

Table 18. Top five years by the number of the homeless due to the impacts of floods in the period from 1900 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

During the period from 1900 to 2013, in 1998 most people were homeless due to the consequences of floods and the number was 36.006.208. In the first place by the number of the injured due to the consequences of the floods is 1998 then 1994, 1975, 1991 and 1996 in the end (Table 18).

Year	Occurrence	No. of people killed	No. of people injured	No. of people affected	Homeless	Total affected	Estimated damage ($)
2011	310	12308	4048	270468184	2418572	272890804	141514094
2010	366	16892	20766	375605606	1341440	376967812	96052294
1998	188	21306	247922	551071240	36006208	587325370	87858302
1993	168	12300	3140	297750036	748670	298501846	65735886
1996	184	16094	505654	354835800	10012572	365354026	56994000

Table 19. Top five years by estimated value of property damage due to the impacts of floods in the period from 1900 to 2013. Source of data: EM-DAT: The OFDA/CRED International Disaster Database.

During the period from 1900 to 2013, the highest estimated property damage due to the consequences of floods was in 2001 and the number was 1.414.514.094. Thus, by estimated property damage due to the consequences of the floods in the first place is 2011 then 2010, 1998, 1993 and 1996 in the end (Table 19).

CONCLUSION

Managing the security and rescue of the flood is one of the oldest civilization heritages of human. As such, it has always exercised by good forecasts of meteorological phenomena and elements, water level and flow, good hydraulic engineering interventions on water regulation, construction of dams, dikes, retention ponds and clear water management interests. It is, therefore, geospatial and temporal distribution of floods in the world for the period from 1900 to 2013, provides a general overview, which can certainly be directly/indirectly used as an argument to advocate for the implementation of certain policies and procedures to protect and save people and their property from flooding based on the principle of "living with a flood" or steady and investment projects and reducing the exposure of the population relation of non-investment and attributes of the environment flood risk.

It is, therefore, analyzing numbers, trends, impacts and temporal and geospatial distribution in the flood period from 1900 to 2013, we came to the following conclusions in relation to the total number of flood events by continent, in this period, the highest number happened in Asia, then in America, Africa, Europe and the lowest number in Oceania. Compared by continents, the highest percentage of the killed due to consequences of flooding was in Asia (98.00%) and lowest in Oceania. Most of the injured, affected, and homeless were in Asia, and the lowest number of injured, affected and those who were left homeless was in Oceania. Compared by states, the highest number of floods happened in Afghanistan, followed by Albania, Algeria, Samoa, and Angola, by the number of deaths in the first place is China, followed by Haiti, India, Bangladesh, Guatemala and Venezuela, by the number of people injured due to the consequences of flooding in the first place is China, followed by Indonesia, Bangladesh, Sudan and El Salvador, by the number of affected people due to the impacts of floods in the first place is China, followed India, Bangladesh, Pakistan and Thailand, by the number of people who were left homeless due to the consequences of floods in the first place is China, followed by India, Bangladesh, Pakistan and Sri Lanka, in the period from 1900 to 2013 there were 8331 floods, There were 13,867,186 of the killed, 2,634,446 were injured, 6872264928 affected, and 176755739 homeless, the highest number of floods occurred in the period from 2000 to 2013, a minimum from 1900 to 1920, most of those killed were from 1920 to 1940, the lowest number, in the period from 2000 to 2013, most people have been affected during the period from the 1980 to 2000, and the lowest number was, in a period from 1900 to 1920, most of the homeless in the period from 1980 to 2000.

Processed and analyzed data indicate a potential threat to national geographic space, despite the fact that Europe is in fourth place by the stated indicators of vulnerability to flooding. Also, research results indicate higher frequency and greater human and material losses in the last 14 years compared to other similar time equivalents in the observed period. Therefore, it is expected this trend will continue in the future, especially given the level of climate change and less material resources of society. The floods that have occurred in the geographic space of Serbia in the last 14 years, largely confirmed the specified possibility, because in that period of time were historical high water levels on the Danube, Sava, Tisza, Tamis, Morava, Lim and other waterways.[29]

Therefore, sound and organized record keeping of floods and their impacts and consequences gives us the information necessary to create an effective and efficient system of early warning and risk assessment, and all this in order to reduce their consequences. By collecting and analyzing data on floods to study the probability of occurrence of maximum flows and water levels significantly improves prevention and preparedness of the state to respond to these types of emergencies that cannot be completely prevented.

From the above, it is necessary to continue ongoing research phenomenology and monitoring methodology and forecasting floods as a kind of natural disaster, to normatively improve the system of preventive care especially in the area of more consistent compliance with urban planning standards of construction of buildings according to the risk assessment of vulnerability by floods and flash floods (e.g. prohibition of construction in the area of 20-year high water levels). Also, it is necessary to create conditions for greater proactive action through regulation of critical waterways, safe and high quality construction of hydroelectric plants (dams, reservoirs, retention basins), decision support systems subjects for subjects of protection and rescue system from national local level, awareness of the potentially affected population and higher level of training and equipping of forces for action in terms of elimination and mitigation of catastrophic flooding - specialized units of civil defense, fire and rescue units of the Serbian Army, Red Cross Mountain Rescue and authorized and qualified entities for the protection and rescue in emergency situations such as water management, construction, utilities and other enterprises. Finally, special emphasis should be placed on improving the monitoring system of national, transnational watercourses and waterways that have torrential hydrological regime, and promoting international cooperation and action of national rescue forces outside of national geographic space, from the regional to the global level.

REFERENCES

1. Bobée, B., Ashkar, F.: *The Gamma Family and Derived Distributions Applied in Hydrology, Water Resources Publications, Littleton, CO, 1991.*
2. Centre for Research on the Epidemiology of Disasters (2003), "EM-DAT: the OFDA/CRED International Disaster Database", available www.cred.be/emdat/welcome.htm (pristupljeno 05.06.2013. godine).
3. Chow, T.: *Handbook of Applied Hydrology. New York:* McGraw- Hill, 1964.
4. Cvetković, V., Mijalković, S.: *Spatial and Temporal distribution of geophysical disasters*. Serbian Academy of Sciences and Arts and Geographical Institute Jovan Cvijic, Journal of the Geographical Institute "Jovan Cvijić" 63/3, 345-360, SASA: Special issue: International Conference Natural Hazards Links Between Science and Practice.
5. Cvetković, V.: *Intervetno-spasilačke službe u vanrednim situacijama*. Beograd: Zadužbina Andrejević, 2013. godine.
6. Dilley, M, Robert, C., Uwe D., Arthur L., Margaret A.: *Natural Disaster Hotspots: A Global Risk Analysis*. Washington, D.C.: World Bank, 2005.
7. Edward, B.:*Natural Hazards, Second Edition*. Cambridge, University Press, 2005.

29 Milanović, A., Urošev, M., Milijašević, D.: *Poplave u Srbiji u periodu 1999-2009 godine – hidrološka analiza i mere zaštite od poplava*, Glasnik Srpskog geografskog društva, sveska XC, br. 1, 2010., str. 106.

8. Filipović, I., Milojković, B., (2010). *Osnovi kartografije sa topografijom,* Niš: Prirodno-matematički fakultet – Departman za geografiju.
9. Haan, T.: *Statistical Methods in Hydrology*. Iowa State University Press, Ames, IA, 1977.
10. Jakovljević, V., Đarmati, Š.: *Civilna zaštita u Saveznoj Republici Jugoslaviji*, Beograd: Studentski trg, 1998.
11. Kite, G.W.: *Frequency and Risk Analysis in Hydrology*. *Water Res. Publications,* Fort Collins, CO, 1977.
12. Marlene, B., Carmichael, R.: *Notable Natural Disasters.* California: Salem Press, Inc, 2007.
13. McCuen, H.: *Microcomputer Applications in Statistical Hydrology, Prentice Hall, Englewood Cliffs, NJ, 1993.*
14. Mijalković, S., Cvetković, V.: *Vulnerability of Critical Infrastructure by Natural Disasters*. Belgrade: In Procesiding „National Critical Infrastructure Protection, Regional Perspective“, 2013, pp. 91-102.
15. Milanović, A., Urošev, M., Milijašević, D.: *Poplave u Srbiji u periodu 1999-2009 godine – hidrološka analiza i mere zaštite od poplava*, Glasnik Srpskog geografskog društva, sveska XC, br. 1, 2010., str. 93-121.
16. Milojković, B., Mlađan, D.: *Adaptivno upravljanje zaštitom i spasavanje od poplava i bujica – prilagođavanje poplavnom rizku*. Bezbednost, Year LII, br. 1/2010., str. 172-237.
17. Mlađan, D., Cvetković, V.: *Classification of Emergency Situations*. Belgrade: Thematic Proceedings of International Scientific Conference “Archibald Reiss Days“, Academy of criminalistic and police studies, 1-2. march 2013, pp. 275-291.
18. Mohamed, S. I.: *Disaster types*. *Disaster Prevention and Management,* Vol. 16, Iss: 5, 2007, pp. 704 -717.
19. Potter, W.:*Research on Flood Frequency Analysis, 1983-1986, Reviews of Geophysics, Vol. 25, No. 2, pp. 113-118, 1987.*
20. Rao, A., Hamed, K.: *Flood frequvencyanal analysis.* Washington: CRC Press, 2000.
21. Schumann, A.: *Flood Risk Assessment and Management.* Bochum, Germany: Springer, 2001.
22. Singh, V., Singh, K.: *Parameter Estimation for TPLN Distribution for Flood Frequency Analysis, Water Resources Bulletin, Vol. 23, No. 6, pp. 1185-1191.*
23. Stoltman, J., Lindston, J., Dechano, L.: *International Perspectives on Natural Disasters: Occurrence, Mitigation, and Consequences.* The Netherlands.: Published by Springer .O. Box 17, 3300 AA Dordrecht, 2007.
24. UNCHS (United Nations Center for Human Settlements) (1994) *Sustainable Human Settlements in an Urbanizing World, including Issues Related to land policies and mitigation of natural disasters*. 15th Session of the Commission on Human Settlement. Unpublished Draft Theme Paper.
25. UN-ISDR United Nations – *International Strategy for Disaster Risk Reduction*, 2004.
26. Wisner, B.: *At Risk: Natural Hazards, People's Vulnerability and Disasters.* London: Routledge, 2004. year.
27. Yevjevich, M.:*Statistical and Probability Analysis of Hydrologic Data, Part II, Regression and Correlation Analysis*”, Sec. 8-II, Handbook of Applied Hydrology, V.T. Chow, editor-in-chief, McGraw-Hilll Book Company, New York, NY, 1964.