

CHARACTERISTICS AND CONSEQUENCES OF NATURAL DISASTERS IN THE TERRITORY OF THE REPUBLIC OF SERBIA

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Abstract: *Natural disasters are the cause of great damage, they complicate and partially or completely prevent the functioning of various systems in society. As a result of natural disasters, human lives, material and cultural goods, infrastructure of various purposes are lost, while financial losses are measured in tens of millions of euros. Only in the 21st century, Serbia was affected by a large number of natural disasters that claimed human lives and caused large financial losses. Some of the most destructive natural disasters that have affected Serbia and for which there are real indications that they will be repeated in the future are earthquakes, floods and fires. A characteristic of all of them is that they do not occur at specific time intervals, but the areas where floods or forest fires can occur are well known, also the areas affected by earthquakes cannot be determined with certainty because in the previous 100 years, many devastating earthquakes occurred in different parts of Serbia. The consequences of these disasters are as great as the investments to eliminate them, and recovery from such events takes a long time.*

Key words: *natural disasters, earthquakes, floods, fires, consequences*

1. INTRODUCTION

Since their first ever communities, people have encountered natural disasters and other misfortunes that they could not explain. They often tried to explained these phenomena as the desire of a supernatural force, which manifested itself as a consequence of people's bad behavior. Disasters, both natural and those caused by technical - technological and other accidents, in recent decades represent an increasing threat to the life and work of people all over the world. Natural disasters in all their forms are the cause of great damage, they complicate and partially or completely prevent the functioning of various systems in the society. As a result of natural disasters, human lives, material and cultural goods, infrastructure of various purposes are lost, while financial losses are measured in tens of millions of euros.

This paper deals with some of the most devastating natural disasters that have affected the territory of Serbia and for which there are real indicators that they will be repeated sometime in the future. Earthquakes, floods and forest fires are the natural disasters that take the most lives and cause the greatest financial and material losses. A characteristic of all of them is that they do not occur at specific time intervals, but the areas where floods or forest fires can occur are well known. Part of the work also refers to the consequences of these natural disasters. Since the floods in Obrenovac in 2014 or the earthquake in Kraljevo in 2010, the affected citizens and the Republic of Serbia have been recovering for a long period of time.

2. THE CONCEPT OF NATURAL DISASTERS

"Disasters are natural calamities or technical-technological accidents whose consequences threaten the safety, life and health of a large number of people, material and cultural goods or the environment on a larger scale, and the occurrence and consequences of which cannot be prevented or eliminated by the regular action of competent authorities and services" (Law on Disaster Risk Reduction and Emergency Management). In Serbian legislation, the concept of elemental disasters is equal to the concept of natural disasters, which is not often the case with the legislation of other European or world countries. Natural disasters are defined in the Law on Emergency Situations as "events of hydrometeorological, geological or biological origin, caused by the action of natural forces such as earthquakes, floods, storms, extreme temperatures, epidemics of infectious diseases... which can threaten the health and life of people or cause damage on a larger scale" (Law on Emergency Situations).

Natural disasters are part of the ecological sphere in which we live. Floods, hurricanes, storms, earthquakes play an important role in regulating the larger natural systems on which we all depend. Attempts to physically modify these systems often have serious consequences including increased vulnerability to hazards and post-disaster damage. Natural disasters are sudden and seemingly inevitable, but natural disasters can also occur as a result of events that take place over a number of years. Many geomorphological hazards that progress slowly (drought, soil erosion and degradation, desertification, rising of the sea levels, loss of biodiversity etc.) can have long-term catastrophic results and cause natural disasters with serious consequences (Mladjan, 2015).

Natural disasters lead to financial, environmental and human losses. The loss depends on the vulnerability of the affected systems and the readiness of the state administration to respond to the challenges. In practice, the terms natural phenomenon and natural disaster are often confused. "Natural phenomena are extreme climatological, hydrological, geophysical and other processes, which do not pose a threat to man and his property" (Mladjan, 2015); while natural disasters are phenomena that disrupt the stability of natural processes and can cause great damage to society and its parts. A strong earthquake in uninhabited parts of the world or fires that hit grassy or forested areas and do not directly affect human life and work do not represent a natural disaster but instead a natural phenomenon.

Natural disasters, as harmful events for people, their material goods and the environment, occur in different spheres of the country. According to the location of occurrence, natural disasters can be divided into the following categories: lithospheric (earthquakes, volcanic eruptions, landslides, rockslides, soil collapses and dangers from outer space); hydrospheric (floods, tsunamis, snow avalanches); atmospheric (intense precipitation, extreme temperatures, stormy winds, electric discharges, frost, ice, fog and droughts) and biospheric (epidemics, epizoonoses, epiphytonoses, forest fires) (Mladjan 2015).

2.1. Lithospheric disasters

The word lithosphere is derived from the Greek words "lithos" meaning stone and "sphaira" meaning ball (envelope) (vokabular.net/litosfera/). In translation, the lithosphere is the rocky or solid covering of the Earth or the Earth's crust. It is precisely in this part of the Earth that certain phenomena and processes occur that cause some of the most devastating natural disasters, namely earthquakes, volcanic eruptions, landslides, rockslides, and soil collapses. Dangers from the cosmos such as meteor or asteroid impacts are classified as lithospheric disasters because these celestial bodies are very similar to the Earth's crust in terms of their characteristics and composition.

Earthquakes, volcanic eruptions, landslides, rockslides and soil collapses are natural phenomena that occur on earth every day and are caused by phenomena that occur in the Earth's crust. These natural phenomena, if they occur in populated areas, cause great material damage, loss of human life, and thus we are talking about natural disasters. Earthquakes, as the cause of natural disasters, take by far the most human lives, as much as 47%, and are also responsible for the greatest material losses, as much as 35% (Mladjan, 2015).

2.2. Hydrospheric disasters

Hydrosphere is a word derived from the Greek words "hydro" meaning water and "sphaira" meaning ball (sheath) (vokabular.net/hidrosfera/). In translation, the hydrosphere is the water envelope of the Earth. The water envelope of the Earth includes all bodies of water on earth: oceans, seas, lakes (natural and artificial), rivers, ponds... It is precisely these forms of water bodies that cause natural phenomena that can be characterized and categorised as disasters when they threaten or cause loss of human lives, material and cultural goods. According to the processed data, in the period from 1900 to 2010, as many as 200.000 human lives were lost by floods in the world (Mladjan, 2015). A devastating tsunami is a rare natural disaster and is most often caused by a strong earthquake. One of the most devastating recorded tsunamis to hit the world happened in 2004. in Southeast Asia. It was caused by an earthquake with a magnitude of 9 on the Richter scale, and waves of 10 meters in height caused catastrophic material damage, while the death toll was around 320.000 (Mladjan, 2015).

2.3. Atmospheric disasters

Atmosphere is a word derived from the Greek word "atmos" meaning air and "sphaira" meaning ball (envelope) (vokabular.net/atmosfera/). The atmosphere represents the air or gaseous envelope of the Earth. Many human activities are connected and dependant on the events unfolding in the atmosphere. Atmospheric disasters are: droughts, extreme temperatures, large amounts of precipitation, stormy winds and electrical discharges. Atmospheric disturbances that cause natural disasters do not always have to result in lost lives. The loss of human life is most often caused by droughts, extremely high temperatures and large amounts of rainfall that cause floods. Such was the flood in Obrenovac in 2014. which was caused by extreme rainfalls, or large-scale fires in Serbia from 2012. which caused severe droughts and extremely high temperatures.

2.4. Biosphere disasters

Biosphere is a word created from the Greek words "bios" and "sphaira", which includes all life on Earth, all plant and animal life (vokabular.net/biosfera/). Events caused by diseases of inhabitants, animals and plants are called biospheric (biological) disasters (Mladjan, 2015). The consequences of these disasters affect only the living world and are manifested by illness and death. They are divided into epidemics (the appearance of a disease in a number that exceeds its usual frequency in the population), epizoonoses (diseases of domestic and wild

animals, which can affect a large number of animals in a large area) and epiphytonoses (sudden plant diseases take on the character of a natural disaster, because they cause great material damage and endanger human lives). Plant diseases are particularly dangerous if the disease affects large areas under crops, which reduces the amount of food produced and, which in turn causes increased hunger that finally causes a rise in hunger-induced deaths, especially in poverty-stricken countries.

3. CHARACTERISTICS OF NATURAL DISASTERS IN THE TERRITORY OF THE REPUBLIC OF SERBIA

The geographical position and relief characteristics of Serbia are very favorable, and Serbia is rich in natural resources. More precisely we are talking about great natural riches of rivers and lakes, forests and mountains.

A large number of rivers, which in the northern parts of the country are also important waterways, often due to the features of the relief, the river bed, but unfortunately also due to the insufficient arrangement of the river banks, cause large floods, which take human lives and cause great financial losses. The wealth of coniferous, deciduous and mixed forests brings great benefits to Serbia, but also the constant danger of large forest fires. As a country located on the Balkan Peninsula, which is defined as a fragile area, in its past it had to fight with devastating earthquakes, which also claimed human lives.

3.1. Earthquakes

Earthquakes belong to the group of geophysical and lithospheric disasters and are very frequent, with most of them being of lower intensity. Stronger earthquakes can cause great material damage and serious consequences for people, by creating cracks in the Earth's crust, shaking the ground, causing floods and release of hazardous substances. Earthquakes as natural disasters are caused by the sudden stacking of large slabs of rock along fractures within the earth (Cvetkovic 2020). During an earthquake, violent movements cause waves and cause incredible destruction when they reach the earth's surface. These violent tremors can last for several minutes, destroying buildings, bridges and most other critical infrastructure facilities. The higher the population density and the number of endangered buildings and infrastructure, the greater the possibility of a disaster.

Analysis of seismic activities clearly shows that Serbia belongs to a region characterized by moderate (average) seismic activities, taking into account their number, frequency and intensity. Also, there is an irregular distribution of epicenters, which makes it much more difficult to distinguish seismic faults. In the period from 1900. to 1970. earthquakes of higher intensity were registered in the areas of Rudnik (mountain), Lazarevac, Juhor (mountain), Krupanj, Jagodina, Vranje and Vitina, while after 1970. three earthquakes of moderate intensity were registered in the areas Kopaonik, Mionica and Trstenik (Cvetkovic 2020).

Earthquakes of up to 6.1 on the Richter scale have occurred on the territory of Serbia. Considering the sheer amount of their energy, and considering the unfavorable invulnerability of the built infrastructure, such earthquakes can be very destructive. In the previous 100 years, the territory of Serbia was hit by about 400 earthquakes of strong and moderate intensity and about 6.000 of weak intensity. Kopaonik, Arandjelovac, Valjevo, Kosovo and Metohija (Gnjilane and Vitina) and Vranje are the parts of Serbia with the most seismic activity and the parts where strong and medium-intensity earthquakes have occurred and where there is a high possibility of earthquakes in general. (Assessment of the risk of disasters in the Republic of Serbia 2017).

3.2. Floods

Serbia has a favorable geographical position. Its waterways, especially the Danube River, have exceptional potential (Disaster Risk Assessment in the Republic of Serbia 2017). The largest rivers are transit watercourses, which also have great water management importance. However, in the basins of these rivers, lie the biggest water management problems, such as floods, sometimes strong soil erosion with the appearance of ravines and flash floods (Assessment of the risk of disasters in the Republic of Serbia 2017). According to the data of the Water Management Foundation of the Republic of Serbia, "close to 1.6 million hectares, of which about 80% is arable agricultural land, is at risk of flooding." There are more than 512 large settlements, 515 industrial and other economic facilities, 680 km of railways and about 4.000 km of roads on potentially threatened areas" (Assessment of the risk of disasters in the Republic of Serbia 2017).

Taking into account the territory of the Republic of Serbia, it can be said that the degree of threat to the population and material assets is not the same throughout the territory. The largest flood areas are located in the Tisa (2.800 km²), Sava (2.243 km²), Velika Morava (2.240 km²) and Danube (2.070 km²) river valleys (Cvetkovic 2020). In the previous ten-year period, numerous floods were recorded on the territory of Serbia. Small drops in the river beds, morphological characteristics of the terrain and wide alluvial plains cause frequent flooding in the Tisa valley. There is no doubt that various anthropogenic influences contribute to the increase in the risk of floods in Serbia. According to the size of the threatened areas, in second place, after Vojvodina, is the right bank of the Sava, and then the areas in the Morava basin, along the right bank of the Drina, in the Belo Drima, Kolubara, Sitnica, Timok, Binacka Morava and Lepenc basins. In Serbia both small and big rivers pose a threat of flooding. Floods can be caused by rainfall and snow thawing, or by the coincidence of high-water levels or caused by landslides and water dam destructions. (Cvetkovic 2020.)

3.3. Forest fires

Fires are a very common occurrence in modern society and are not considered disasters but extraordinary events, unless they cause more serious human and material losses. Fire, as a frequent and serious threat to the safety of people and property, involves the uncontrolled burning of fuel. In the period 2011-2013. according to the data of the Emergency Situations Sector, a total of 79.886 fires occurred in Serbia, in which 1.280 people were killed or injured. In 2012. fire damage in Serbia amounted to approximately fifty million euros (Cvetkovic 2020).

Forest fires are an increasingly common phenomenon in Serbia during the last fifteen years, and the years 2007. when more than 500 forest fires were recorded, and 2012. with more than 700 fires, stand out in particular (Cvetkovic 2020). Forest fires are the most devastating form of destruction of forest ecosystems in Serbia. On that occasion, large forest areas are destroyed in a short time, ecosystems are damaged and the habitats of many plant and animal species are damaged or destroyed.

Coniferous and mixed forests suffer the greatest damage from fires. All types of forests are not equally threatened by fire and, for example, coniferous forests are more endangered than deciduous forests, and certain types of trees are more sensitive than others. According to the degree of danger from fire, forests are classified into the following six categories: I degree - pine and larch forests; II degree - forests of spruce, fir and other conifers; III degree - mixed coniferous and deciduous forests; IV degree - oak and hornbeam forests; V degree - forests of beech and other deciduous trees; VI degree - thickets and non-vegetated areas (Cvetkovic 2020).

In general, there are three types of forest fires: a) underground, b) ground or surface c) high or canopy fire (Cvetkovic 2020). Underground fires in forests in Serbia are quite rare considering the type of forests and surface deposits. It is characteristic for them that the fire smolders under the surface of the earth, when deposits of moss, peat, leaves, veins, etc. burn in the deeper layers. They usually occur at a depth of approximately 20 cm, bearing in mind that this is the depth of the mentioned layers. Ground fires are the most common in Serbia and mainly involve different combustible materials in the ground layers of forests - dry grass, bushes, litter and wood waste, because they contain an abundance of small, easily flammable particles. If certain conditions are met (a sufficient amount of combustible material), it often happens that ground fires easily reach the treetops and grow into high fires. The next type of forest fires are high fires, i.e. fires that engulf the tops of trees. The rapid action of the wind creates large tongues of flame, which can spread quickly with the help of fire vortex and an abundance of flammable sparks.

Lightning strikes are one of the most common causes of forest fires. When we talk about human activity as the cause of forest fires, we mean different types of explosions, inattention and gross negligence, as well as fires caused by intentional ignition.

4. CONSEQUENCES OF NATURAL DISASTERS IN THE TERRITORY OF THE REPUBLIC OF SERBIA

As stated in the introductory part of this paper, the consequences of natural disasters that occurred on the territory of Serbia are great. In addition to losses in material and cultural assets, the biggest tragedy and loss for Serbia is the lost human lives. By analyzing the available data, the conclusion is reached that the financial losses of natural disasters were huge. The floods in Obrenovac in May 2014. alone cost Serbia around 1.5 billion euros, which represents a big blow to its budget and caused decreased investments in certain projects. The biggest consequences were caused by devastating earthquakes, floods and forest fires.

4.1. Consequences of the earthquake

How serious an earthquake is a threat to the safety of the citizens of Serbia is evidenced by the fact that just one strong earthquake can kill hundreds of thousands of people, cause material damage of one billion dollars in less than a minute, interrupt tens of thousands of business operations and leave hundreds of thousands of people without a roof, job, etc. elementary conditions for life (Cvetkovic 2020).

The largest earthquakes, where in addition to material damage there were also losses of human life, hit Lazarevac in 1922. when an earthquake with an intensity of 6.1 on the Richter scale was recorded (Cvetkovic 2020). In 1927. Gornji Milanovac was hit by an earthquake measuring 5.9 on the Richter scale, where 7 people lost their lives (Assessment of Disaster Risk in the Republic of Serbia 2017). In 2010. an earthquake with an intensity of 5.4 on the Richter scale occurred near Kraljevo, when approximately 258 earthquakes with magnitudes from 1.0 to 4.4 on the Richter scale were registered over several days. Unfortunately, two people died, many were injured, while the value of the material damage caused was estimated at more than 100 million euros (Cvetkovic 2020). The damage to infrastructure facilities was extensive, and some residential facilities had to be demolished due to the unprofitability of reconstruction.

4.2. Consequences of floods

Based on the analysis of the available data, the conclusion is reached that the floods in the territory of Serbia, which in the past mainly occurred as a result of "water spilling from the riverbeds, along sections where there are no flood protection facilities built, as well as due to

overflowing and demolition of protective facilities" (Assessment of the risk of disasters in the Republic of Serbia 2017). Significant and serious floods in the geospace of Serbia were recorded in 1999., 2000., 2005., 2006., 2007., 2009. and 2014. The locations where the biggest floods occurred in the last two decades are: Obrenovac (2006., 2010., and 2014), Novi Pazar (2011.), Ljubovija, Aleksandrovac, Sabac, Aleksinac, Krusevac, Trgoviste, Bogatic, Mali Zvornik, Loznica (2010.), Valjevo, Babusnica, Pirot (2007.), PoZarevac, Kraljevo, Belgrade - Savski venac, Ub, Smederevo, Golubac, Indjija, Zemun, Surcin (2006.) (Disaster Risk Assessment in the Republic of Serbia 2017.).

During July 1999. large torrential floods in the basins of the largest tributaries of the Velika Morava caused serious damage in Sumadija. On that occasion, numerous residential and commercial buildings were damaged and 30 bridges in the basins of Zapadna Morava, Jasenica, Kubrsnica and Lepenica were taken away. In 2000. the sudden melting of snow and heavy rainfall in the area of the Tisa and Tamish watercourses caused serious floods. Intense rains in May 2014. in the territory of Serbia, northern Bosnia and eastern Croatia, caused serious flooding. According to their characteristics (territorial representation, duration, consequences, etc.), those flood events surpassed all previous ones (Cvetkovic 2020).

The characteristics of floods in Serbia are that arable land was completely or partially flooded, and agricultural crops were mostly destroyed in the areas affected by the floods. Infrastructure of various purposes, including parts of critical infrastructure, were partially damaged or threatened. The residential infrastructure near the flooded rivers was damaged, and the return of people to their homes was only possible after a couple of weeks, after drying and disinfecting the buildings. Due to sudden torrential flows on small rivers and streams, which caused landslides, many village roads were damaged and some places were cut off. The material damage was measured in millions of euros, up to 1.5 billion, which is the amount of the flood damage in Obrenovac in 2014.

4.3. Consequences of forest fires

Large forest fires affect Serbia every ten years. The last big fires hit Tara and the immediate surroundings of Cacak in August 2012. when about 10.000 hectares of forest were damaged (Nedeljnik Vreme 2012). Underground fires have the greatest consequences for forest ecosystems, because the product of fires is only smoke, which is difficult to see if it appears in areas far from settlements. On that occasion, the root of the plant is destroyed and such trees are condemned to death. The most frequent forest fires in Serbia are ground fires, which damage saplings and undergrowth as well as tree roots. High fires, as the rarest type of forest fires, are characteristic of young conifer and oak forests (Cvetkovic 2020). The fires in 2012. were a combination of all three types of fires that can occur in forest ecosystems. Because of this, a large forest area was destroyed, and extinguishing was extremely difficult due to the inaccessible terrain, and without help from the air it was impossible to bring the fire element under control. On that occasion, a large number of animal habitats were damaged or destroyed.

5. CONCLUSION

Natural phenomena, which often, due to the consequences for people's lives, material and cultural goods, took on the character of natural disasters, in the previous 100 years caused great suffering to Serbia and its inhabitants. Natural disasters have particularly intensified in the last twenty years, and the consequences are more devastating than before. Earthquakes, forest fires and floods have claimed a large number of human lives since the beginning of the 21st century, and the total financial losses are measured from hundreds of thousands, across millions and even all the way to billions of euros. A greater number of natural disasters than before are the

result of climate change, which is directly related to the development and progress of industry, because unwanted products of industry affect changes in climate and natural ecosystems.

Increased population density and the development of cities located in large river basins have led to more lives lost in floods. Inadequate arrangement of the banks of large rivers and the characteristics of the relief and riverbeds result in large river overflows during heavy rainfall. Heavy rainfall is the most common cause of floods, which claimed human lives and caused great material losses. The high population density of cities has also led to an increase in human losses in devastating earthquakes. Based on the data, it can be seen that the biggest consequences of the devastating earthquakes that hit Serbia were felt by the cities. Lazarevac, Gornji Milanovac, Kraljevo, the cities that felt the most diverse earthquakes in Serbia, in addition to great material losses, also lost many human lives as a result of the earthquake. The natural disaster that affects Serbia every ten years, in the majority of cases, did not claim human lives, but it left great consequences.

REFERENCES

Mladjan D. (2015). Bezbednost u vanrednim situacijama. Kriminalisticko – policijska akademija, JP „SluZbeni slasnik“, ISBN 978-86-7020-309-9, Beograd.

Cvetkovic V., (2020.), Upravljanje rizicima u vanrednim situacijama, Naucno – strucno drustvo za upravljanje rizicima i vanrednim situacijama, Neven DOO, ISBN 978-86-81424-02-5, Beograd.

Cvetkovic V., (2022.), Taktika zastite i spasavanja u katastrofama, Naucno – strucno drustvo za upravljanje rizicima i vanrednim situacijama, Neven DOO, ISBN 978-86-81424-09-4, Beograd.

Zakon i smanjenju rizika od katastrofa i upravljanju vanrednim situacijama. SluZbeni glasnik RS, br. 87/2018. Beograd.

Zakon o vanrednim situacijama. SluZbeni glasnik RS, br. 111/2009, 92/2011 i 93/2012.

MUP (2017.), Procena rizika od katastrofa u Republici Srbiji, Beograd.

<https://www.vreme.com/vreme/srbija-u-plamenu/>

<https://vokabular.net/litosfera/>

<https://vokabular.net/hidrosfera/>

<https://vokabular.net/atmosfera/>

<https://vokabular.net/biosfera/>