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NatRisk

A HANDBOOK

for Civil Sector Training about Natural Disasters

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1. EARTHQUAKES AS NATURAL DISASTERS

1.1. SEISMICITY

The science that studies earthquakes and the inner structure of the Earth is called *seismology*, and is part of geophysics as a wider scientific discipline. In Greek "*Seismos*" means an earthquake. Seismology studies complex processes that are the cause of preparation and generation of earthquakes, then the processes of creation and spreading of seismic waves through the Earth's interior, tectonic processes in the hypocenter of the earthquake, mechanical effects of the seismic wave actions on the ground and its effects the structures and so on. It also deals with determination of seismic hazard parameters of wider regions, seismic micro regions; studies the possibility of prognosis of the occurrence of strong earthquakes, the creation and movement of tsunami, etc. Many phenomena can cause the occurrence of earthquakes: volcanic activity, explosions, displacement of tectonic plates and similar. Movement of tectonic plates is generated without any warning, and this cause from the engineering aspect is the most interesting.

CAUSES OF EARTHQUAKES

The most scientifically accepted explanation of the occurrence of earthquakes is connected to the model of plate tectonics. It describes the large-scale motions of Earth's lithosphere. The lithosphere is broken up into what is called "tectonic plates", six (6) continental-size plates and fourteen (14) sub continental-size plates (Figure 0). These plates move in relation to one another, and during their movement they slide next to the other or one plate goes under the other plate (subduction).

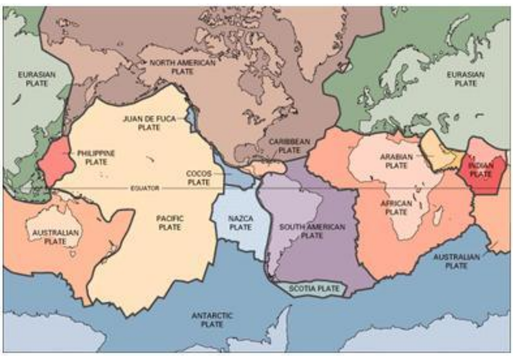


Figure 0 – Tectonic plates [4]

The occurrence of earthquakes is mostly, but not always, connected to a location where plates meet, called plate boundary. Earthquakes occur along breaks within the earth's crust known as faults. Most earthquakes occur along pre-existing faults, but a new fault can be created during an earthquake. However, when the plates have been locked for a long period of time, a large amount of energy has been accumulated and stored, so a sudden release would cause breaking of the plates and an enormous amount of energy would be released. Release of energy is manifested by body and surface waves. Energy is usually released within 10 to 15 seconds (even though in some situation periods of 30 to 60 seconds have been registered). Up to now, the largest release of energy was 1x1025 ergs (earthquake in Chile) which happened in 1960 [2].

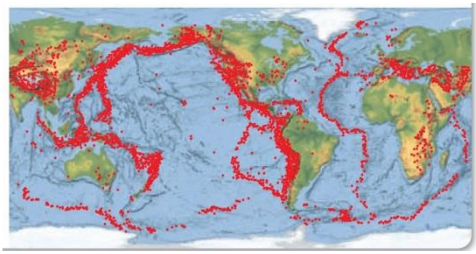
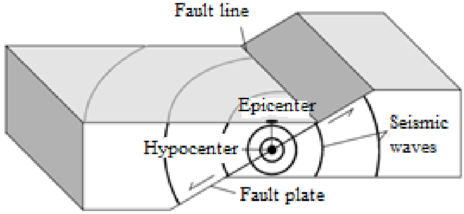


Figure 1 – Tectonic plates

It is believed that about 80% of the seismic energy is released within the "Ring of Fire" (Pacific belt), while only 15% in the second belt (Alpine belt), which begins in the area of the Mediterranean and extends eastward across Asia. The accuracy of earthquake registration depends on the network of installed seismic stations.

The basic elements of an earthquake are (Figure 23):
1. Fault-fault line
2. Epicenter
3. Hypocenter
4. Seismic waves

Figure 2 – Movement of faults



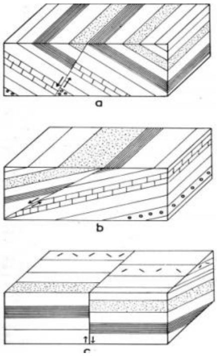


Figure 3 – Normal faults [5]

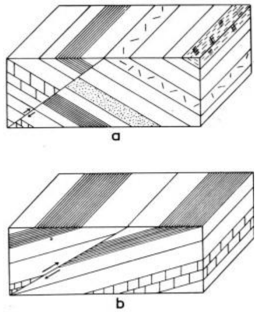


Figure 4 – Reverse faults [5]

There are three basic fault types:

Normal faults - they include all vertical faults (without movement) and faults plates under a certain angle by whose movement the fault blocks are being departed from each other, meaning that the plates are diverging (the foot wall is uplifted, while the hanging wall is being lowered), (Figure 3) [5].
Reverse faults - the hanging wall is being uplifted along the fault plate, so these faults occupy less space than the previous ones. The movement is reverse in comparison to the normal faults (Figure 4).
Strike-slip faults – the movement is just along the fault plates without any downward or upward movement. The displacement can be in two directions so two faults can be distinguished the right and left fault, depending on how the walls are shifted to each other (clockwise - in the right and counter-directional direction). They are called transcendental faults as well, those who change the movement are called transformed (Figure 5) [5].

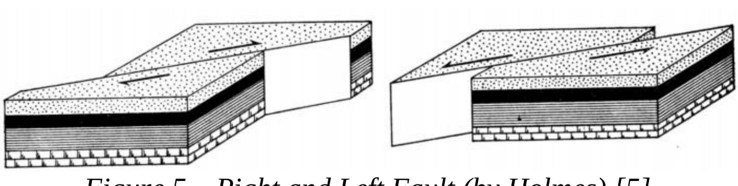


Figure 5 – Right and Left Fault (by Holmes) [5]

Transform faults (

Figure 6) are faults connected to the mid-ocean reefs and zones of opening of new oceans.

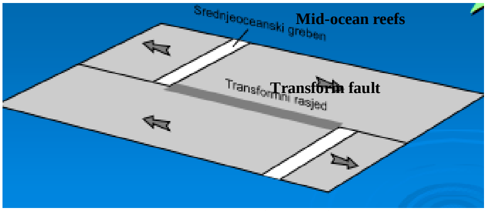


Figure 6 – Transform faults [5]

Epicenter (Greek word for seat above) is a place just above the hypocenter or earthquake focus. These two points represent constant points in which the distance between a point and the hypocenter is called "hypocenter spacing" and in relation to the epicenter - "epicenter spacing". The hypocenter spacing between the epicenter and the hypocenter is called the depth of the "focal point" (Figure 2).

Hypocenter is a location where the earthquake in the Earth's interior is generated. Hypocenter can be classified in three categories: shallow, medium and deep. Shallow are those up to a depth of 70 km below the surface of the Earth, most commonly in the areas of movement of lithosphere plates. Medium-depth hypocenters are those between 70 and 300 km below the surface. Deep hypocenters are located at depths between 300 km and 730 km below the Earth's surface, most often these hypocenters are in the zones of subduction (Figure 2).

Earthquake exhibit shaking of the ground in the form of waves due to interaction of tectonic plates. *Seismic waves* spread through the Earth's crust by the laws of physics. Since the interior of the Earth is not homogeneously distributed, it is expected that the seismic waves do not move in the straight line. The direction and the speed of their movement can be calculated depending on where the earthquake occurred and how long it took to register this earthquake on different seismic stations. Another thing that affects the type of earthquake is the depth of its origin.

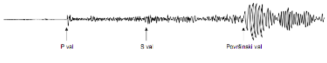
There are two basic types of seismic waves, body and surface waves (Figure 7). Body waves spread throughout the Earth's interior while the surface waves spread through the shallow layer on the free Earth's surface.

Body waves are faster than the surface waves and are manifested as two types - longitudinal and transversal.

The speed of *longitudinal waves* is 73% higher in respect to the transverse waves and are designated as primary (P) waves, while transverse waves are designated as secondary (S) waves. Both waves cause that the particles in the observed body oscillate around their balance position, but these oscillations are different. During the passage of longitudinal waves, the particle of the media oscillates in the direction of waves, analogous to acoustic oscillations. In the case of transverse waves, the particles of the media oscillate perpendicular to the direction of wave propagation, analogously to the light waves or electromagnetic waves. P waves are elastic seismic waves. Something like sound waves. In addition, a characteristic of the P wave is that it can passes through liquids, which is not the case for S wave. This is the basic condition for transferring P waves through the Earth's core. Thus, different seismic stations register different magnitudes and different waves. In homogeneous and isotropic materials, the P waves mostly move longitudinally. Substance particles that transmit P waves vibrate along or parallel to the wave motion (Figure 7).

The most common speed of P waves during an earthquake is from 5 km/s to 8 km/s. The speed varies depending on the media through which the waves propagate.

The other type of waves are S waves or shear waves. Sometimes they can be refereed as elastic waves because of the nature of their movement. They move through the media, unlike surface waves. S wave is a perpendicular wave. Therefore, its motion is perpendicular to the direction of wave propagation. S waves move like a wave on a rope, which is shaken, unlike the P waves, which one can say, "huddle". S waves created elastic deformation so it has an actual shearing effect on the structures that are affected by this wave and it represents a major problem for the structures (Figure 7).



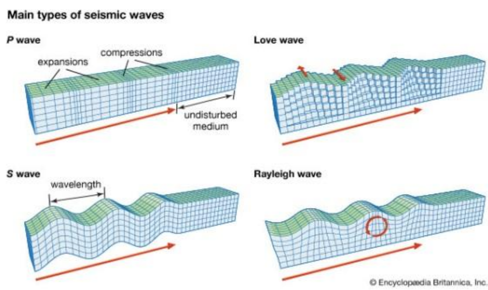


Figure 7 – Seismic waves [5]

For general analysis of seismograms, only longitudinal and transversal waves are considered. However, there are two types of surface waves, which often occur in distant earthquakes. They are named by the researchers who first analyzed and described them, called Love and Rayleigh waves (Figure 7).

Love wave is a special type of transversal wave in which the oscillations are performed in a horizontal plane, perpendicular to the direction of the motion, while *Rayleigh* wave is a combination of longitudinal and transversal waves in which the oscillations are conducted in a plane perpendicular to the surface and parallel to the direction of propagation.

Rayleigh waves typically have the highest amplitude on the vertical seismogram components, while *Love* waves are best recorded on horizontal seismogram components. With regard to the speed of propagation, both waves are slower than the body waves, with *Love* waves having higher speeds than *Rayleigh* waves.

Figure 7 shows the wave motion if the soil was homogeneous, but it has to be taken into account that this is not the case, so it is necessary to consider the reflection of waves and other components that will not be dealt here, but it is only noted here that the media is not homogeneous.

SCALES FOR EARTHQUAKE MEASUREMENT

Apart from locating the epicenter of an earthquake, it is very important to quantify its strength as well. Strength or power of an earthquake can be determined either by *magnitude* or by the *intensity* of the earthquake. As the reader is probably already well known, the most widely used scale (in our areas) for determination of the magnitude is the Richter scale, and the earthquake intensity is measured by the Mercalli–Cancani–Sieberg scale, or shorter by the Mercalli scale.

Determining the earthquake strength is not an easy task. The stronger the earthquake is, the more difficult it is to determine its magnitude. Earthquakes of weaker intensity are more accurately measured than stronger earthquakes. The stronger the earthquake, there is a bigger mistake when determining its magnitude. In the case of exceptionally strong earthquakes (as in the recent past in Japan), considerably more elements affect the earthquake, and those are:

- nonlinear increase of heat in soil due to friction,
- the creation of free oscillations due to big earthquakes,

- the impact on Earth's rotation, due to the redistribution of the mass and energy in its interior and
- permanent deformation.

It is important to point out that the earthquake can only have one magnitude because it is the amount of energy released in the hypocenter and may have more intensities depending on where it is being considered. This will be dealt with in the following sections.

Earthquake's magnitude

The real amount of energy released in the hypocenter of one earthquake determines the *magnitude* of the earthquake. This is an unnamed number, and the usual magnitude values are within the limits of 1 to 9, although the magnitude scale is opened both, from above and below. Very weak earthquakes can also have a negative magnitude (since the magnitude is defined by logarithmic function). Therefore, the magnitude is the equivalent energy measure of earthquake associated with its focal point, meaning it does not depend on the depth of the hypocenter. In honor of the seismologist Charles Richter, who in 1935 mathematically defined the magnitude as the energy measure of an earthquake, this earthquake parameter is also called Richter magnitude.

Earthquake's intensity

The *intensity* of the earthquake is a descriptive value of the destructive effects on the Earth's surface (determined by seismic scales). Earthquake intensity expresses the degree of surface effects of earthquakes - on structures, soil and humans. It is expressed in the full scale from I to XII degree and it is called Mercalli–Cancani–Sieberg scale, or short MCS, as well as equivalent, but much more detailed scales: EMS - 98 (European Macroseismic Scale 1998) or MSK - 64 (Medvedev–Sponheuer–Karnik Scale defined in 1964).
The intensity scale in the range from I to IX degrees is the so-called Japanese scale etc. Determination of "earthquake" destructive effects, i.e. according to the intensity, was useful before seismographs were discovered. So today, based on these historical descriptive data and the geological characteristics of the terrain, we can roughly estimate the magnitude of the previous earthquakes.
Earthquake intensity on Earth's surface depends heavily on earthquake hypocenter (deeper hypocenter with the same magnitude means less

intensity on ground surfaces and vice versa), but also from the extent of observation point up to the epicenter. Surfaces that in the wider area of the epicenter include zones with the same degree of intensity are called the earthquake isoseismics.

1.2. EARTHQUAKE FORECASTING

Since ancient times people have known that certain animals change their behavior before an earthquake occurs, in Mexico they use snakes as earthquake precipitators, and in Japan aquarium fish. Animals by their much differentiated nerve system and senses can detect changes in magnetism, earth's vibration, and similar events that precede the earthquake, but only a few minutes or a few hours before the catastrophe happens. However, animal behavior changes are neither a typical nor a reliable sign that, for example, a decision could be made to evacuate a city or area with millions of people. Scientific research to predict earthquakes is being conducted in many countries, especially in Japan, the United States and Russia, but no earthquake has been predicted yet by scientific methods.

Prediction of natural earthquakes implies forecasting the magnitude, the time and location. All attempts until now regarding the prediction were unsuccessful. This is primarily because comprehensive physical approach that causes the tectonics as the main seismicity generator on Earth is unknown.

Statistical seismology uses statistical methods and the history of the previous seismicity, which goes back millions of years in the past, in trying to typify and predict future earthquakes. Its success in seismic prognosis is minor, but it has a great importance in determining the seismic hazard parameters of particular regions, as well as in terms of defining micro regions of smaller spaces such as sites of construction objects. Its role is primarily in the determination of legal acts in the construction industry, i.e. the determination of the legal measures obliging aseismic design.

1.3. EARTHQUAKE EFFECTS

Generally, the earthquake effects can be divided into primary and secondary. The *primary earthquake effects* are those that originate directly from the earthquake itself. That includes: demolition of buildings and bridges; cracking of roads and curving of roadways and other infrastructure connections; breaking of glass and injuries/deaths resulting from this, the appearance and spread of panic and shock among people that are affected (Figure 9).

Figure 9 – Direct and indirect earthquake effects (different web sites)

Secondary effects are those that derive from the primary effects. For example, ground movement can lead to cracking of gas and water pipes (primary effects), which can lead to severe fire due to gas explosion and problems during putting out the fire due to lack of water from explosive networks (secondary effects) (Figure 9). Other secondary effects include homelessness, bankruptcy and job closure, etc. Secondary effects may include: consolidation, landslides, rock failure, and liquidation; floods due to demolition of dams and defensive embankments; sudden changes in water levels and occurrences of the tsunami; "Natech" events (technological disasters due to natural disasters) such as fires due to earthquakes, the release of hazardous materials, chemical and radioactive contamination, as well as the destruction of traffic, communal and technical infrastructure, residential buildings, industrial facilities and power plants; Illness and hunger due to lack of clean water and medical facilities; fatalities caused by low temperatures; Economic impacts can be significant in the event of strong earthquakes that may in some cases lead to the complete disruption of economic and social functions within a wider area [9].

1.4. SEISMIC ACTIVITY ON THE TERRITORY OF BOSNIA AND HERZEGOVINA

The territory of Bosnia and Herzegovina is included in the central parts of the Dinaric mountain system located northeast of the compressive geotectonic contact between the Adriatic mass and the Dinarides.

The micro Adriatic plate, as part of the African plate, is pressed between Apennines and the Dinarides along seismic active faults. The earthquakes recorded in the territory of Bosnia and Herzegovina are related to the energy generated by the subduction of the African plate under the European plate. In the territory of Bosnia and Herzegovina almost every day, earthquakes of intensity of less than III by Mercalli’s scale occur, which are registered only by the instruments. Stronger earthquakes are relatively rare. The depth of the hypocenter ranges from 2 km to 35 km [2].

Although it is ungrateful to give the "prognosis" of seismic events for any territory, however based on instrumental data (catalogs) and by applying a mathematical-physical model of seismicity, it has been concluded that over the next 100 years Bosnia and Herzegovina can expect earthquakes of maximum intensity up to VIII degree of Mercalli scale. Earthquakes of this intensity cause material damage to civil engineering structures. However, over a period of more than 100 years, according to these forecasts, destructive earthquakes in the Southeast and Northwest part of B&H (region of Trebinje, Neum, Banja Luka and Treskavica Mountain) could occur, which could cause huge damage to the construction facilities and take many human lives [10]. On the territory of Bosnia and Herzegovina, there were several devastating earthquakes with the highest intensity in focal zones of Ljubinje, Treskavica and Banja Luka [11].

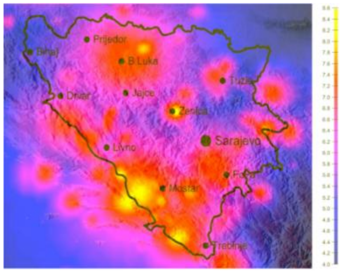


Figure 10 – Prognostic map of the seismic intensity for the territory of B&H in the next 100 years [10].

Southern and Western Herzegovina regions are the most endangered by earthquakes. The last earthquake that occurred in Livno was in 2004 of 3.3 degrees by Richter. The epicenter of the earthquake was again in the Golija Mountain, showing that several previous earthquakes in this area were not coincidental. In the last 104 years, 1.084 earthquakes have been recorded in Bosnia and Herzegovina, higher than magnitude 3 of Richter scale [11].

In addition, there are several major regional faults in Bosnia and Herzegovina, such as Bugojno, Višegrad, Neretva and Banja Luka, which can create earthquake of devastating strengths and often cause smaller shakings of the ground. Thus, according to the data of the seismograph, in Bosnia and Herzegovina about 1.100 earthquakes are recorded annually, or on average three earthquakes per day weaker than three by Mercalli scale. We are talking here about earthquakes that are recorded by devices, while people do not feel it, and around ten earthquakes per year are felt by the inhabitants of Bosnia and Herzegovina [11].

RETURN PERIOD AND SEISMIC EFFECTS

Seismographers argue that over the next 50 years in the territory of Bosnia and Herzegovina earthquakes of maximum intensity up to seven degrees by Mercalli scale can be expected, hence, with possible damage to housing and other facilities. However, for a period of 100 years or more for the area of Banja Luka, Treskavica mountain, and the area of Trebinje and Neum, there are forecasts of possible devastating earthquakes that would cause huge damage, and also have many human victims.

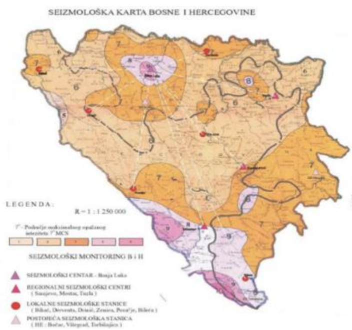


Figure 11 –Seismological map of Bosnia and Herzegovina [11].

On the Seismological Map of Bosnia and Herzegovina, the zones with maximum intensity of earthquakes are indicated and the majority of the territory is located in zones 7, 8 and 9 of the seismic intensity of the MCS scale [11]. The seismic area of Banja Luka, is seismically one of the most active focal areas of Bosnia and Herzegovina. In this seismic area, there have been several devastating earthquakes in the past, in the series: 1884, 1935, 1969 and 1981 [2]. It is worth mentioning that the depth of the hypocenter ranges from 4 to 30 km, so the hypocenter of these earthquakes is at a very low depth and their destructive power can be great because a large amount of energy is released on the surface and can cause material damage to the buildings and facilities.

SEISMIC HAZARD, SEISMIC RISK AND MANAGEMENT IN EMERGENCY SITUATION IN THE CASE ON AN EARTHQUAKE

Seismic hazard – It represents the likelihood of earthquake occurrence of relevant characteristics within a certain time and at a particular location, which will manifest itself in a certain way at that location. The seismic hazard is expressed by three mutually dependent elements: the amplitude of the ground movement, the return period and the probability of occurrence of such an event.

Seismic risk - It represents the degree of possible loss of human life and material assets in case of earthquake occurrence of a certain intensity in a given area and is usually expressed in relative numbers (in relation to the maximum possible loss). Mathematically, it is defined as the convolution of seismic hazard and the vulnerability function of the structure (quality or seismic resistance of the structure).

In the case of earthquakes, the degree of influence is independent of the likelihood of occurrence, the risk can be expressed algebraically in the following way:

Risk = the influence of danger x probability of occurrence

Seismic Risk Management is a process of systematic application of policies, procedures, treatments and monitoring of seismic risk [12]. Managing risks means looking into the future, thinking ahead about the potential events, actions and consequences that one can be faced with in the future as a result of earthquakes, and taking timely measures to minimize risks, thereby avoiding or reducing adverse effects .
Risk management includes: formal, quantitative evaluation of potential damage or loss at a given time interval; observation and correction of security deficiencies.
The main objective is to provide sustainability in three crucial segments: development of leadership (human resources), capacity development (funds), raising public awareness (information, training and education).
Assessment of seismic risk is a process in which priority risk management is performed and this is done by assessing and comparing the level of seismic risk with the level of acceptable (targeted) risk, which represents the level of protection that the society can accept according to its economic capabilities. Therefore, for a different development of countries acceptable risk will be different.

Figure 12 –Assessment risk components in accordance with IPCC SREX 2012 [13]

Emergency requires the organization and response of a society that is different from the actions that occur in normal situations.

Management of Emergency Situations includes Organized Analysis, Planning, Decision Making, and Allocation of Available Resources.
This is necessary for Prevention, [1][2] Reduction or Mitigation of Effects, Readiness, Response, and Recovery from the earthquake consequences (5 to 10 years or more).

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[1] "Establishing a culture of prevention is not easy. While prevention costs must be paid in the present tense, its benefits lie in the far future. Moreover, the benefits of prevention are not tangible; these are actually catastrophes that have not happened."(Kofi Annan, UN Secretary General, 1999).
[2] Experiences in EU countries - 1 Euro invested in a disaster intervention results in a savings of 4 to 7 Euros in response to the natural disaster [14].

There are certain problems that arise in the management of emergencies in the event of an earthquake:

- ✓ First, the earthquake phenomenon is sudden. As it is known earthquake appears without any warning; after a powerful earthquake, secondary shocks may warn on the occurrence of a new earthquake or a series of earthquakes (“*after tremors*”)
- ✓ Strong earthquakes (vibrations), the occurrence of faults and landslides, which can be combined with floods, and can cause large-scale losses, damage to housing, traffic facilities, communal and technical infrastructure, and other facilities.
- ✓ If there is no warning or if the warning does not come on time the number of victims can be significantly increased.
- ✓ In case that there are serious damages to the housing stock, it is urgent to act urgently in the sense to search the buildings, rescue and emergency medical assistance to the trapped population or to the population cut off from the rest of the region.
- ✓ In the event of an infrastructure cut off or breakdown, problems arise regarding the arrival to the site where the earthquake happened, and this should be dealt with using alternative solutions - the use of helicopters, the incorporation of the army and so on. In some cases, even the engagement of neighboring countries would be necessary to provide assistance or developed countries with experience of earthquakes. Therefore, in this case, there is a problem of access to places affected by the earthquake and the limitation of movement.
- ✓ Difficulties are of bigger scale in the case of densely populated places as well as in high-rise buildings.
- ✓ If an earthquake occurs close to some chemical plants or nuclear power plants then there is a risk of release of hazardous materials and similar. This can have catastrophic consequences and they are not only of current character but are about the long-term consequences that will affect generations.
- ✓ Identifying victims can often be very difficult. In addition, with the possibility of spreading the infection, it is necessary to bury the bodies as soon as possible.
- ✓ Recuperation requirements can be very extensive and expensive.
- ✓ In some areas affected by the earthquake, it may have a negative impact on the counter-economy and the public's conscience. In the case of tourist sites, the occurrence of an earthquake will reduce the new inflow of tourists from fear of their security in the event of a new earthquake.

1.5. LEGAL FRAMEWORK REGARDING ENGAGEMENT OF DIFFERENT SUBJECTS IN THE PROTECTION AND RESCUE SYSTEM IN THE CASE OF EARTHQUAKE OCCURRENCE IN BOSNIA AND HERZEGOVINA

Laws that represent the basis for the protection and rescue of people and property are:

- ✓ Law on protection and rescue of people and property in the event of natural or other disasters, "Official Gazette Federation of Bosnia and Herzegovina", no. 39/03, 22/06 and 43/10.
- ✓ Framework law on the protection and rescue of people and property in the event of natural or other disasters in Bosnia and Herzegovina (Official Gazette of Bosnia and Herzegovina 50/08)
- ✓ The methodology for the development of risk assessment of Bosnia and Herzegovina in the event of natural or other disasters (Official Gazette of Bosnia and Herzegovina 86/09)
- ✓ The law on jurisdiction of the authorities of the Sarajevo Canton in the field of protection and rescue of people and property in the event of natural or other disasters ("Official Gazette of the Sarajevo Canton 39/08")
- ✓ The Law on Amendments to the law on jurisdiction of the authorities of the Sarajevo Canton in the field of protection and rescue of people and property in the event of natural or other disasters ("Official Gazette of the Sarajevo Canton 19/11")
- ✓ Law amending the law on jurisdiction of the authorities of the Sarajevo Canton in the field of protection and rescue of people and property in the event of natural or other disasters ("Official Gazette of the Sarajevo Canton 45/15").

Assessment of natural disaster risk for B&H was done in 2012 and it represents the fundamental document which is used for development of the Protection plan and rescue of people and property in the event of natural or other disasters in B&H and Programs for development of protection systems and rescue of institutions and authorities of B&H. This document is not final, and it, as any other document, represents a material that needs to be updated dynamically. It is subject to changes, amendments, additions, upgrading [28].

The plan of protection and rescue of people and property in the event of natural or other disasters of the institutes and bodies of B&H represents a

framework for action regarding preparation, organization and implementation of protection and rescuing of people and property of institutes and bodies of B&H in the case of natural or other disasters. In the plan for protection and rescue the organization as well as the measures and means of conducting these protection and rescue measures are determined as well as tasks for institutes and bodies of B&H in the protection and rescue as well as forces and financial means required for fulfilling the tasks that are coming from the Framework Law ("Official Gazette" 50/08) [14], Law on ministries and other administrative bodies of B&H ("Official Gazette"32/02, 5/03, 42/03, 26/04, 42/04, 45/06, 88/07, 35/09, 59/09 and 103/09), and other regulations that are dealing with the role and tasks of the institutes and bodies in the field of protection and rescue, as well as professional materials, international documents and practice. This plan gives guidelines for formation of protection plans and rescue at the entity level and Brčko District. The plan also aims to improve preparedness to natural or other disasters and to clarify the division of authority and responsibility in order to effectively protect people and property in the optimal use of resources. This plan actually is a practical information data and tool for coordination of risk reduction from natural or other disasters.
Assessment of risk was done for three cities Banja Luka, Grahovo and Ljubinje (Report done by Council of Ministers B&H in March 2011).

FEDERAL HYDRO METROLOGICAL INSTITUTE

The Institute, in accordance with law, carries out expert and other activities related to permanent monitoring in the field of meteorology, hydrology, environmental quality, seismology and astronomy; explores the state of the atmosphere, water resources, environmental quality (air, water, soil), seismological processes and astronomical phenomena; collects, processes, analyzes and publishes data from the scope of its activity in the Federation of B&H; publishes weather newsletters and forecasts on a daily basis, and actively cooperates with the World Meteorological Organization (WMO) by applying its standards in data exchange and service improvement.

PROTECTION AND RESCUE PLAN

In 2014, the Director of the Federal Meteorological Institute issued a protection and rescue plan [2].
The plan contains the organization and method of achieving the protection and rescue of human and material assets of the Federal Meteorological Institute from natural and other disasters as well as the way of performing tasks that are foreseen for a legal entity/person in the Protection and Rescue Plan of the municipality, Canton or Federation.
It is foreseen by this document to determine measures, procedures and tasks of a legal person to carry out tasks relating to the protection and rescue from natural and other disasters, and is being elaborated in particular for three situations: for the phase of preventive protection, for the rescue phase, for the phase of eliminating the consequences.
The plan for protection and rescue establishes [24]: disaster prevention and mitigation procedures and measures, operational force for protection and rescue, human resources and material and technical resources, management, coordination and command hierarchy in protection and rescue.

REPUBLIC HYDRO-METEOROLOGICAL INSTITUTE

The activity of the Republic Hydro-Meteorological Institute is defined by the Law on Meteorological and Hydrological Activity, Official Gazette of Republika Srpska No. 20/00 of 17 July 2000 [21], Law on Seismological Activity, Official Gazette of Republika Srpska No 20/97 of 28 July 1997 [22] and the Law on Air Protection, Official Gazette of Republika Srpska, No. 124/11 of 14 December 2011 [23].
The activity of the Institute is done through three sectors and one division:

- ✓ *Sector of meteorology*, with two departments: Department of Monitoring (watching) for climatology and agro-meteorology with two subdivisions: Subdivision of Climatology and Subdivision of Agro-meteorology.
- ✓ *Hydrology Sector*, with two departments: Hydrology Department and Ecology Department,
- ✓ *Sector of Seismology*, with two departments: the Department for Observatory Seismology and the Department for Instrumental and Engineering Seismology.
- ✓ *Division for financial and legal affairs*.

1.6. STUDIES, MEASURES AND ACTIVITIES FOR MITIGATION OF EARTHQUAKE EFFECTS BEFORE IT HAPPENS

Measures to mitigate the consequences of earthquakes have a long-lasting character and imply permanent engagement of the state and experts with the aim of establishing consistent scientific bases and their practical application for reduction and mitigation of seismic risk. In seismically active regions, earthquake mitigation components should be achieved by the joint efforts of each individual country in the region in close co-operation with other countries. Measures for reduction of seismic risk at the regional and national levels before an earthquake occurred include [12]:

- ✓ Studies of the region’s seismic activity based on registered and historical data on earthquakes that have occurred;
- ✓ Development of seism tectonic map of the region;
- ✓ Performance of seismic hazard studies and seismic hazard maps of each country of the seismically active region;
- ✓ Development of maps of seismic micro location of significant urban areas and zones exposed to seismic hazards of high intensity as a basis for design and planning;
- ✓ Performing detailed studies of vulnerability and the level of the acceptable seismic risk in each country of the seismically active region;
- ✓ Spatial planning of seismically active regions based on the assessment of damage and vulnerability studies;
- ✓ Development of state laws and regulations for protection from earthquakes;
- ✓ Developing of standards on the state (country) level, development of instructions and manuals for aseismic design for construction of new buildings and preventive measures for existing facilities, as well as continuous work on their improvement;
- ✓ Studies for planning, design and construction of buildings of vital importance;
- ✓ Development and improvement of organizations dealing with the control of design and construction with a specialized department in the field of earthquake engineering and engineering seismology;
- ✓ Development of research and training centers in the field of seismology, earthquake engineering, seismic risk, spatial and urban planning and planning in the phase of preparing an effective response in emergency situations, within existing civil engineering institutions,

organization for design and construction control, departments of civil engineering and architecture at universities, in close cooperation with seismological, geophysical, geological and other organizations and institutions and long-term cooperation among the countries participating in the region;

- ✓ Continuous education and further expansion and specialization the knowledge of scientists, engineers and planners for the application of established scientific bases in the spatial and urban planning, design and construction process in the region;
- ✓ Permanent monitoring and earthquake recording;
- ✓ Combining seismological instruments with other types of instruments for the purpose of short-term earthquake prediction;
- ✓ Development, installation, operation, maintenance and collection of data of regional networks for strong earthquakes, continuous monitoring of typical and buildings of major importance, facilities and installations, as well as the establishment of standardized earthquake data bases and caused damages;
- ✓ Development and improvement of the seismic stations network with computerized systems for rapid data collection and analysis of earthquake data.

PLANNING OF LAND USE

Earthquake effects can be reduces by proper land use policies. This is a gradual and continuous process which is ensured by spatial and urban planning processes and implies that the pattern of urbanization (land use, adopted structure type, distribution and concentration of material property, etc.) be harmonized with the level and spatial distribution of the expected seismic hazard.

In the case of already built urban centers (cores), it must be ensured that, in the event of any modifications, the situation does not worsen (adding new floors on existing buildings). However, in the case of a new region, in this case it is necessary to achieve close cooperation with specialized and authorized land use planning institutions and use all possible data and information in the design in order to minimize the consequences of the eventual earthquake or seismic hazard.

COMPREHENSIVE ASSESSMENT OF SEISMIC RISK

The strength, magnitude, location and frequency of earthquake occurrence in a particular location cannot be accurately predicted. However, management of seismic risk can be done based on the vulnerability (sensitivity) model and losses for buildings, infrastructure facilities and major facilities.

Vulnerability (sensitivity) depends on several factors. First, the age of the structure, construction type, the purpose of the structure, the geometry, the height, the degree of conservation, etc.

The level of losses of existing or planned regional/urban land use is a quantitative measure of existing or potential seismic risk and can be expressed based on:

- ✓ physical losses (percentage of damaged or demolished structures/gross area), or
- ✓ Functional losses (loss of functionality of the facility).

By applying an appropriate cost factor, damage to functions that represent the physical vulnerability of the structure, the economic loss can be estimated (value loss function) [12].

Losses resulting as the consequence of the incurred damage can be classified into two groups:

- ✓ specified losses, which are defined by investments;
- ✓ unspecified losses, related to the loss of human life and threatened population (injured and those who are left without their homes), which makes the appropriate quantification impossible.

The appropriate estimation of the size of the eventual disaster, as well as the necessary level of investment before the emergence of the disaster, are necessary in order to mitigate the consequences of the earthquake. They should be based on a loss model that can take into account the long-term effects of earthquake losses, which can lead to irreparable economic losses of the state [12].

CRITERIA FOR DESIGNING SEISMIC RESISTANT STRUCTURES

In order to define the design parameters of seismic-resistant structures based on seismic risk, it is necessary to know and analyze several factors, of which the most important are [25]:

- ✓ seismicity model of the area;

- ✓ probability occurrence of an earthquake and return period;
- ✓ exposure to seismic actions;
- ✓ service life of the building;
- ✓ the importance and purpose of the facility;
- ✓ Protection level, i.e. acceptable seismic risk.

Designing Seismic Resistant Structures (Aseismic Design) implies design that ensures adequate security against injuries and loss of life and minimal damage to material assets and ensures continuity in the operation of vital systems at acceptable costs. Complete earthquake protection is not economically viable nor technically feasible. Also, the risk of complete collapse of objects, especially buildings of high categories (nuclear power plants, dams, etc.), is completely unacceptable. Criteria for aseismic design of buildings include: have resistance to the action of weak earthquakes, without damages on the structures; have resistance to the actions of moderate earthquakes (so-called design earthquake that can occur one or more times during the service life of the building) without damage to the load-bearing (primary) elements that provide structural resistance to load and with a certain degree of damage to non-bearing (secondary) elements, mainly architectural components; have resistance to the powerful, catastrophic earthquakes (the so-called maximum earthquake, the probability of occurrence during the entire service life of the building being small, but still can occur) with acceptance limited damage of the load-bearing elements and vital damage to non-bearing elements, which will not affect the stability of the structure, i.e. cause collapse of the structure. The aim is to limit the damage of the load bearing elements to the level of damage that can be remedied.

By combining seismic hazard parameters with construction parameters defined according to standards for aseismic design (Eurocode 8 [26]) and the design philosophy, a decision is made regarding the level of acceptable seismic risk and an optimal concept of construction:

- ✓ construction of seismically resistant buildings;
- ✓ strengthening of existing buildings to be more resistant to seismic actions.

Taking into account economic constraints, the design codes for earthquake design in most countries, take the return period of 475 years. Accordingly, respecting the rules of aseismic design, it can be expected that loss of life will be prevented; of course, there can be significant damage to the structure, both its non-bearing and bearing parts, but in any case, its collapse should not occur.

CRITICAL INFRASTRUCTURE-PLANNING, DESIGN AND CONSTRUCTION

Under critical infrastructure one implies, transport systems (roads, railways, bridges, tunnels, airports, ports), water (supply, flood protection, sewage), delivery of various types of energy (electricity, gas, oil, nuclear energy), telecommunications and digital communications, finance, food delivery, health, research, security systems and emergency services. Seismic protection of critical infrastructure is of vital and crucial importance for an efficient response in emergencies, including supply of energy, water, food and communication services, health and emergency services, and transportation, as well as to provide numerous functions in the society after the earthquake and the emergence of social and economic recovery. In this sense, the correct decisions regarding seismic risk assessment and proper aseismic design and construction are of crucial importance and significance. The reason for this lies in the fact that even after the action of a powerful earthquake, the majority of these facilities should be operational, some facilities must retain their full function while on the other hand, some facilities will retain a partial function, but the function must be such as to enable faster intervention in the affected area. Structures that should remain undamaged or with the least possible damage are dams, nuclear power plants, chemical plants, pipelines, power plants and similar. One is dealing here with buildings where secondary action of the earthquake (fire, flood, complete interruption, radiation, etc.) can have even more significant and catastrophic consequences in relation to the earthquake action itself.

In this respect, during the design and construction of these facilities special attention should be paid to the following elements [10]:

- ✓ Regional studies to assess the seismic risk of the location with the aim to determine two levels of acceptable seismic risk, taking into account known and potential seismic zones;
- ✓ Detailed studies regarding local site conditions with the aim of determining amplification factors and modification of the expected field movement;
- ✓ Determination of two levels of design criterion (ultimate limit state and serviceability limit state) based on operational and safety requirements;

- ✓ Specific studies of the occurrence of faults, seismic stability of slopes, instability of undersoil, induced seismicity and others;
- ✓ Application of methods and techniques of planning, analysis and design of facilities in the preliminary and final phase of the project;
- ✓ Special requirements for planning, construction of detailed plans, quality control and seismic monitoring of facilities.

A systematically methodology approach is recommended for the risk assessment in which critical infrastructure facilities are treated as interconnected network [12]. The owners of these facilities and operatives are required to prepare security and service plans and to present the key sector that will be involved in the risk assessment process.

1.7. MEASUREMENTS AND ACTIVITIES AFTER EARTHQUAKE OCCURRED

In the phase of eliminating the consequences, it is actually about creating the conditions for normalizing life in the endangered area. After the proclamation of the termination of the state of natural and other disaster, it is necessary to undertake the implementation of the activities indicated in the following paragraphs.

In the first phase, it is necessary to work continuously on the collection, processing, analysis and archiving of hydro meteorological data necessary for the protection and rescue of people, material goods and environment, water management, water supply, agricultural and human meteorology, hydropower, irrigation, development of studies regarding large floods, droughts and pollution of the atmosphere, seismic activity. It is necessary to establish contacts, cooperation and coordination with services of the Cantons, Municipalities, Federation of Bosnia and Herzegovina, Brčko District, Republika Srpska and all over Bosnia and Herzegovina. This is all about achieving both scientific and practical goals.

URGENT MEASURES AND ACTIVITIES AFTER AN EARTHQUAKE

When addressing urgent measures of protection of population and material assets in the earthquake-affected area, as well as the measures of urgent rehabilitation of the functionalities of the systems, they are of vital and crucial importance [10].

Mobilization of Centers, which will take urgent protection measures in every city, town, village, municipality, canton and institution.

✓ Putting out the fire, at first glance by involving volunteers, and engaging fire brigades.

✓ Rescue: Emergency rescue of people who are captured and trapped in buildings and under ruins (equipment for detecting survivors).

✓ Treatment and taking care of victims: providing first aid, deprivation of deaths, identification of victims, organization of field triage centers in parks and/or grassy areas outside facilities, organization of improvised surgical rooms with operating desks for treatment of seriously injured, identification of needs in terms of treatment, hospitalization and medical evacuations; evacuation of injured persons who do not require urgent medical assistance and who are not in critical condition to medical centers in neighboring cities; organization of air transportation of seriously injured persons.

✓ Evacuation: evacuation from densely populated and vulnerable areas; determines whether it is necessary to immediately evacuate the population from the affected area or evacuation will take place later. Consideration whether there is a need to involve the auxiliary forces from neighboring municipalities, cantons, or from neighboring or other countries that have larger resources.

✓ Shelter: organization of temporary accommodation, medical centers and other public services based on urgent needs; providing shelter to those whose homes are destroyed or are not safe or secure: emergency rehabilitation of some facilities; providing tents, tarpaulins and/or containers as temporary shelters; placing homeless people in schools, sports halls etc.

✓ Food supply: establishment of food supply centers and organization of other emergency activities; organization of kitchens on the open; providing and distributing food to the endangered population as well as to protection and rescue teams; estimation of damage to food stocks; estimation of available food reserves (including unharvested crops).

✓ Communication systems: re-establishing radio, telephone, fax, facsimile and information (internet) connections.

✓ Clean-up and access clearing of key routes, airports and ports to enable access to vehicles, aircraft and ships; preparing the helicopter landing locations.

✓ Water and electricity supply: re-establishing of water and electricity supply, engagement of tankers. Supply of drinking water is often difficult, especially in the early stages immediately after the earthquake. Therefore, it is necessary to supply water purification equipment and/or use purification tablets.

✓ Supply of other means: provision of clothing and footwear, blankets, sets for elemental disasters, cooking utensils and plastic foils. This is all in order to enable the vulnerable population to stay in the area and thus reduce the need for evacuation.

✓ Health and sanitation: taking measures to protect the health of people in the affected area and maintaining the necessary sanitary facilities.

✓ Renewal of public services: clinics under improvised roofs, pharmacies, post offices and mobile shops.

✓ Public information: informing citizens in the affected areas about what they should do, especially in terms of self-help, and in what actions they can help; prevent speculation and rumor about the current situation and the future situation. Informing people who are not affected by the earthquake and giving directions how they can help people in affected areas.

✓ Security: maintain law and order, in particular to prevent robberies and unnecessary harm; ban on the entry of citizens into heavily damaged facilities that are not safe. Entry into this type of facility is allowed only for rescue services and people trained to work in emergencies.

SHORT-TERM STUDIES AND ACTIVITIES AFTER AN EARTHQUAKE

The aim of these measures is to obtain more practical and portable data that can potentially be used to develop revitalization, rehabilitation and long-term rehabilitation programs [10]. These measures include:

✓ Planning and providing temporary accommodation (prefabricated settlements), organization of medical centers, inventories, schools (hangars) and other.

✓ Rescue and relocation of archives and national wealth.

✓ Disinfection of the affected area by air spraying.

- ✓ Comprehensive inspection and classification of damage levels and usability of buildings, engineering facilities, local and regional infrastructure by applying a uniform methodology of damage classification.
- ✓ Studies on earthquake effects and distribution of occurred damage.
- ✓ Studies on seismic activity on existing and temporarily installed seismic stations and urgent installation of accelerometer and seismoscopes for strong earthquakes in order to record subsequent earthquakes.
- ✓ Collection of seismic records and their processing for the purpose of elaborating seismic criteria for the design of rehabilitation and strengthening of damaged structures.
- ✓ Creating requests and guidelines for rehabilitation and strengthening of damaged buildings and other facilities.
- ✓ Re-examination of spatial and urban plans with mapping of spatial distribution of earthquake effects.
- ✓ Estimate the value of damage caused by the earthquake, the planning of financial and legal actions to mitigate the consequences of the earthquake.
- ✓ Urban planning for the construction of new residential settlements, medical centers, schools and other public and communal systems based on urgent needs, number of usable facilities and the way for future urban development.
- ✓ Construction measures and activities: removal of ruins and unstable parts of buildings that pose a direct threat to tenants, users or pedestrians and the destruction (by explosives) of heavily damaged facilities whose sudden collapse can endanger people or other nearby facilities; during the demolition process, it is necessary to make plans for demolition in order not to damage the undamaged objects that may be in the immediate vicinity; rehabilitation and strengthening of damaged facilities with the parallel implementation of field research and production of design for rehabilitation and strengthening.
- ✓ Social assistance: addressing social problems of the population and citizens, including search for missing persons and the reunification of families.
- ✓ Maintaining public morality: measures to help physical and psychological rehabilitation of people who have suffered the consequences of a disaster. Involving psychologists and psychiatrists to reduce fear and stress.

EMERGENCY INSPECTION AND CLASSIFICATION OF DAMAGED FACILITIES

Objectives of the emergency inspection of damages

When it comes to the objectives of an emergency inspection, it is necessary to point out that they can be primary and secondary.

The primary objective is to save human lives and prevent injuries by identifying objects that are damaged by earthquake and in the view of their state they present potential danger and the degree of their vulnerability is greater if one or more stronger earthquake occur and in some cases even medium-sized earthquakes.

After the identification of damaged objects, under secondary objectives one imposes defining of emergency needs and strengthening measures, whether it is a kind of stiffening, supporting, partial or complete demolition and similar. Furthermore, one of the goals is to record damage and assess the usability of structures. Based on these data, the classification of structures will be carried out in terms of their use or permissibility to be used. It is necessary to ensure that as much housing facilities, as possible, can be used, taking into account the level of acceptable seismic risk. In addition, based on the assessment of the situation after the disaster, it is necessary to provide information on the necessary number of temporary housing units. It is necessary to indicate the traffic flows that can be exposed to the potential danger of nearby buildings collapsing. Based on field surveys, it is necessary to identify locations that are suitable for temporary shelters. Further, collecting the data necessary for obtaining reliable estimates of earthquake effects, based on which the relevant authorities will propose and take appropriate recovery measures, form disaster mitigation policy and allocate available resources. Based on a database of damages, a review of common causes of damage will be formed, and based on this, the adoption of potential and possible plans of rehabilitation measures based on the evaluations, which have been carried out. The collected information can also be used to produce different studies with the aim of reviewing urban planning by mapping the spatial distribution of earthquake effects; reviewing of existing standards for aseismic design and construction practices, as well as updating seismic maps; and, development of seismic vulnerability model for assessing potential seismic risk.

Collection of data regarding damages caused by an earthquake

The decisive factor in classifying the damage is the level of severity of damage in terms of the impact on the bearing capacity of the main constructive system, in other words, on the safety of the construction. The assessment of financial damage is also an essential factor, which has to be performed in order to determine and assess the damage from the financial aspect, but this is secondary because, above all, it is the life of the population, which is crucial. In the first moment, it is necessary to determine a good damage assessment, conduct its classification and determine whether the given structure can be used, or to determine the *usability* or *non-usability* of the facility. This is a very demanding job, and such assessments are always conducted by experts with high reliability of engineering judgment. Of course, the process of data collection itself largely depends on the level of preparation and training of inspection teams that should be carried out under normal conditions before the occurrence of an earthquake. Preliminary preparations are of crucial importance for the training of teams for the rapid and qualitative conduct of damage classification by applying uniform methodology. If these preparations have not been previously implemented, then in the duration of one week training courses should be done, as well classification testing of inspection teams should be conducted after the earthquake by engaging a significant number of instructors and supervisors. However, it should be borne in mind that the preparation of the necessary inspection documentation (maps and forms) and organization of the mobilization of inspection teams is very difficult to implement in extremely difficult conditions after the earthquake.

It is worth noting that the entire process of data collection should take place within one to two months after the earthquake. Photographing damages of buildings is very important for completing the evidence and information on earthquake-induced damage, bearing in mind that the condition, as is in the field, will disappear within a short period.

1.8. LONG-TERM MEASUREMENTS AND ACTIVITIES AFTER AN EARTHQUAKE

It should be noted, in essence, these are the same measures, as the ones applied before the occurrence of an earthquake. What is important to point out is that all the collected data and results obtained and collected when conducting activities immediately after the earthquake action should be applied and analyzed in an appropriate manner. A special emphasis is put on the data, which were obtained and are related to the classification of the damage, the distribution of damage, the degree of vulnerability, the sensitivity of the structure, the usability or the no usability of a particular structure after the earthquake. All these obtained data should be adequately processed and used to mitigate seismic risk in the case of repeated seismic activity that can be expected in realistic frameworks [10]. Long-term measures include appropriate reconstruction measures, construction of new buildings that have been demolished or significantly damaged during the earthquake. In addition, when constructing new buildings in truncated areas, it is necessary to apply the rules of aseismic construction and, in some cases, certain modern technologies (base isolation, the use of damper in bridges, etc.).

1.9. PLACE AND ROLE OF A CITIZEN IN CASE OF EARTHQUAKES

The Family Instruction Manual for Natural and Other Disaster Response was prepared by the Department of Protection and Rescue of the Ministry of Security of Bosnia and Herzegovina in cooperation with the Republika Srpska Civil Protection Administration, the Federation Civilian Administration of the Federation of Bosnia and Herzegovina and the Department of Public Safety of the Brčko District of Bosnia and Herzegovina within the project "Ready, saved", with financial and advisory support from the United Nations Children's Fund (UNICEF) in Bosnia and Herzegovina and the United Stated Agency for International Development (USAID) [25].

Namely, the consequences of natural disasters can be significantly mitigated if citizens are informed and familiar with the ways of preventing natural disasters. This means that if they are well aware of the risks and dangers in their local communities and know from whom to get information and how to organize themselves at critical moments, the lives of citizens and their neighbors will be safer. When the natural disaster occurs, the first reaction depends on the citizens themselves as individuals, so citizens become the main actors. Consequently, it is necessary for citizens to have knowledge regarding dangers, how to react to them, and the way of cooperation with others is of crucial importance. The manual was designed to assist citizens in how to behave in the event of natural disasters and what to do.

Every moment in a natural disaster is precious.

<u>What to do during an earthquake?</u>

✓ Stay calm and cool-headed and do not panic.

✓ Be aware that some earthquakes are just the first ones and that stronger earthquakes can happen after them.

✓ Do not create panic!

✓ Don to try to run!

✓ Drop on the ground, curl up and cover your head! Earthquake is caused by moving of tectonic plates, the Earth's crust movement or some kind of crash. The consequence of this is soil shaking and the release of great amount of energy. The strength of an earthquake depends on several elements.

<u>Instructions during the earthquake if you are indoors</u>

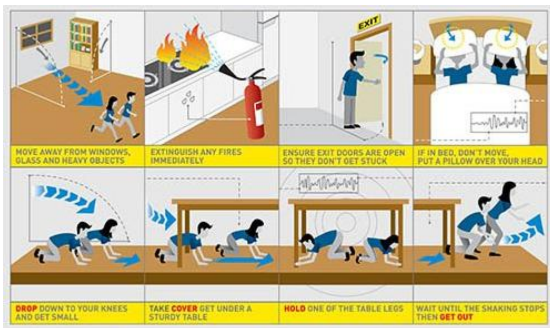
✓ Find shelter in secure places in the house such as door casting, load-bearing walls, underneath the table, solid furniture, and stay there until earthquake lasts.

✓ Cover your face and head with hands as a protective measure and move inside the corners of the inner walls.

✓ Move away from glass, windows, outer walls, outer doors, household items that can fall on you like chandeliers, bookshelves or other elements, etc.

✓ If you are in bed, crawl down next to the bed and protect your head.

✓ Stay in the house until the earthquake stops and until it is safe enough to get out. The research shows that the most injuries happen when people are trying to get out of the house or building during the earthquake.



✓ You can go out from the ground floor or from the first floor, taking care to find your shelter in the clearing, far from the building.

- ✓ As long as the earthquake lasts, avoid staircases and lifts.
- ✓ Do not use the lift!
- ✓ Do not go out to the terrace of balcony.
- ✓ Do not hold shelves above the bed.
- ✓ If you are near or inside a high building, move away from glass and exterior walls.
- ✓ If you are in a public facility (school, company, shopping center, store), stay calm and avoid panic. Keep away from the mass of people who are in panic and move toward the exit.
- ✓ Be aware of power cuts, and fire and other alarms may be activated.
- ✓ Always have a prepared battery lamp and spare battery as well as a small radio.
- ✓ Immediately turn off the supply of electricity, gas and water. If you have used any heat source, turn it off until earthquake calms down.
- ✓ If a fire occurs, try to put the fire out and inform the local fire department.
- ✓ If necessary and if you are able, join the rescue teams for rescuing people from the ruins and engage in seeking and assisting victims under the ruin of structures.

Instructions during an earthquake if you are outdoors

- ✓ Move away from street lighting, electrical cables, buildings, facilities.
- ✓ The greatest dangers are buildings, the outer and exterior walls of buildings, especially when it comes to cultural-historical structures, as the whole wall can be pulled out of its plane.
- ✓ If you are on the street, the risk of falling down of parts of high-rise buildings is large, so keep far away from possible falling down chimneys, tiles, glass, etc.
- ✓ Protect your head by hand or bag.

Instructions during an earthquake if you are in a moving car

- ✓ Stop the car on a location where it is allowed and safe.
- ✓ Avoid stopping nearby buildings, trees, overpasses, underpasses, power lines, and bridges.
- ✓ Drive carefully after the earthquake stops. Avoid directions that involve the crossing of a bridge or ramps that may have been damaged by the earthquake.

Instructions if you are under ruins

- ✓ Do not light a match.
- ✓ Do not move.
- ✓ Cover your mouth by cloth or handkerchief.
- ✓ Hit a pipe or wall to alert the rescuers about your position. If you have a whistle, use it. Shouting is the last option because you can endanger yourself by inhaling dangerous amount of dust.
- ✓ Keep calm and try to orient yourself.
- ✓ If you are pressed with some material, start with removal, saving your energy and be careful with sharp objects to avoid hurting yourself.

Instructions after the first earthquake hits

- ✓ Be prepared for the possible occurrence of additional earthquakes. If the structure is damaged, the possibility of a stronger earthquake represent a new danger, so leave the building calmly and without panic. Evacuation goes in the order: mothers with children, old, sick, disabled, etc.
- ✓ If you are in a damaged facility and feel the smell of gas or see broken cables, do not light the candle and match, as there is a risk of fire and/or explosion.
- ✓ Check if there are people that are hurt. Do not move seriously injured persons.
- ✓ Follow the instructions given by authorized persons.
- ✓ Use the phone only in the most demanding situations, so that the phone lines will not be occupied.
- ✓ Do not use cars as this will keep the roads open for rescue services.
- ✓ Avoid access to facilities, especially if electrical or gas installations are damaged.

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2. FLOODS

2.1. INTRODUCTION

Floods on the rivers are natural phenomena that far exceed the water management and hydraulic framework. In history, it is known that rivers and floods have had a significant impact on the development of human society. The discharge of large waters from river beds and the flooding of river valleys are classified into the oldest human experience, just as their antipode - drought.

Floods, as well as droughts, are extreme hydrological phenomena affecting the population, social and ecological systems. The flood is the flooding of a narrow or wider complex of soil, spilling water from a riverbed, lake or sea. It is caused by heavy rains, sudden melting of snow, strong earthquakes and winds and other natural disasters. In other words, floods are natural phenomena that indicate an unusually high water level, due to which the water from the river bed flows over the coast and floods the surrounding area. It is reduced or prevented by the construction of embankments, dams, canals or large reservoirs that accept most of the water (Imamović, 2015).

Although floods since the early civilizations were a major threat to the human community, this problem was actualized after several major floods in various parts of Europe and the world in the last decade of the twentieth century, followed by high damage and loss of human lives (Ivetić et al., 2014). Regardless of the causes of floods, the likelihood of flooding is always present, and this phenomenon as a natural phenomenon is not always possible to prevent, no matter how secure the defense system and the prevention measures were (Kuspilić et al., 2014).

As part of the evident climatic changes, floods represent only one of their manifestations. Changes in the propagation, duration, rainfall and drought periods indicate changes in total input data in the equation of the water balance. According to previous data, the annual rainfall amounts did not change in a larger extent, but their extremes became more pronounced and more frequent. Therefore, the impact of climate change can not be omitted or interpreted as unimportant. Floods, which, as stochastic phenomena, occur due to their unpredictability and speed of events, as well as due to the lack of time for a human organized reaction, cause great harm, not only material but also irreparable, expressed in lost human lives.

In addition to measures, activities and works, it is precisely the speed of reaction, during the event of flooding, that is crucial to minimizing flood damage. Defense plans with exact data, computer models of potential events, but also past experiences must be elaborated in detail and based on realistic requirements, but also on realistic possibilities, in order to be applicable in a given situation.

In order to reduce the risk of loss of human lives and the occurrence of flood damage, it is necessary to define the term and answer the question of what the flood is. The professional definition of the flood is the following:

″Flood is the temporary coverage of some land with water, which is usually not covered by water. This includes floods caused by rivers, mountain streams, torrential watercourses, as well as floods caused by the sea in coastal areas.″.

The preceding definition is given in the Flood Risk Assessment and Management Directive[1] (hereinafter: FD), and it is noticeable that floods arise due to the discharge of water from sewerage systems, whether atmospheric, sanitary or industrial sewage systems, are not treated as floods.

2.2. CAUSES AND TYPES OF FLOODS

The causes of floods are numerous, and generally it can be said that floods are caused by natural phenomena and artificial influences (Babić-Mladenović, 2009).

According to the causes of the flood, they can be divided into:

- Floods occurred due to strong precipitation,
- Floods that occurred due to accumulation of ice in watercourses,
- Floods that occurred due to slipping of soil or earthquake,
- Floods that occurred due to demolition of the dam or war destruction.

Given the formation time of the water wave, the floods can be classified into:

- Flat (flood) floods - floods on large rivers that require ten or more hours to form a large water wave,

[1] Directive on the assessment and management of flood risks – Directive 2007/60/ EC of the European Parliament and of the Council on the assessment and management of flood risks.

- torrential floods - floods on mountainous streams in which a large water wave is formed in less than ten hours,
- Accidental floods - floods where a large water wave is currently being formed by demolition of water management or hydroelectric facilities

According to the level of raising the water level in the rivers, the size of the flooded area and the size of the damage, river floods are divided into:

- • Low (small) floods - do not cause significant material damage and do not significantly impair the rhythm of life in the settlements. Appear every 5-10 years.
- High floods - in densely populated areas often imply the need to partially evacuate people and inflict significant material and moral damage. It happens every 20-25 years.
- Extraordinary (large) floods - catch the entire river basin. They paralyze economic activity and greatly disturb the communal way of life, inflict huge material and moral damage. During extraordinary floods, the need for mass evacuation of the population, material and cultural goods from the settlement as well as the need for protection the most important economic facilities. Such floods occur every 50-100 years.
- Catastrophic floods - cause flooding of large areas of one or more river systems. These kinds of floods are accompanied by great material losses in human lives, and occur once every 100-200 years. Blue more than 70% of agricultural land, settlements, communications and industrial facilities.

Natural floods occur most often in river valleys when water flows out of the river bed, covers the coastal soil or flows over it. The width of the flooded belt of the soil depends on the amount of water in the river during the flood, the depth of the river bed, the slope of the river valley and the protective belt built along the river.

U riječnim dolinama, poplave uglavnom nastaju kao posljedica hidroloških uvjeta u slivu. Nerijetko do poplave dođe nakon relativno umjerenih padavina, nisu vezane za određeno godišnje doba (javljaju se i ljeti i zimi), voda naglo nadolazi i kratkotrajne su (nekoliko sati do 1 dan). Floods in river valleys interrupt land transport, preventing the passage of pedestrians and motor vehicles for a prolonged period, and the river traffic is often made more difficult. Lake floods arise from the increased flow of water from the surrounding mountains to the lake pool. These floods are detrimental to the economy, and they rarely endanger settlements and human lives. In Europe, most floods are caused by strong and / or long rain (75%). However, the typical phenomenon, which causes the most devastating floods on this continent, is the emergence of a combination of rain and melting snow.

Figure 1- Rainfall caused by rain in Doboj, May 2014 (Foto: Emir Šarić)

Figure 2- Flash floods in suburban areas of Tuzla during 2010 (Foto: Uljić)

Artificial floods - anthropogenic impacts that can cause flooding can be: spillage of water from accumulation and retention caused by fractures of dams or hydrotechnical structures or their inadequate work and handling, then changes in the basin, riverbeds and inundation areas, etc. (Babić-Mladenović, 2009). Particular emphasis should be given to changes in the catchment area, riverbeds and inundation areas that have been caused by anthropogenic impacts, among which are the most significant deforestation, poor agricultural practice, inadequate water management, urbanization in areas of high flood risks and the pressures caused by the population by their activities.

Anthropogenic impact is mostly related to activities in the river bed itself, but also in the catchment area. By deforestation, the construction of facilities and roads, the channeling of rivers and other activities, the swelling speed and the quantity of swollen water from the basin increase, and the time of water concentration in the main basin is shortened, that is, the outflow coefficient from the catchment area is increased. Also, by regulating the watercourse and construction objects on the shores, or even in the watercourse, reduces the flow of water through the trough, but also reduces the flow profile, which directly reflects the increase in the height of the water in the trough.

Due to some anthropogenic impacts, such as, for example, slope deforestation, there are floods caused by slipping slopes that end in the watercourse, forming some sort of barriers. Anthropogenic influence is also expressed by the construction of a dam in the river bed (constitution, dam, bridges), causing the formation of a flood lake upstream from the barrier, and uncontrolled construction of facilities in inundations (the flow capacity of the water tank is reduced). Also, improper handling of water management facilities, such as dams, can lead to flooding.
The artificial (anthropogenic) influences that cause floods, which are caused by the demolition of dams or other hydraulic structures, are rarely occurring, and they will not be given any significance in this text. It is much more important to point out the causes of floods related to changes in the basin, riverbeds and inundation areas created by population activities in the river basin.

Deforestation is associated with poor forest management, unplanned and illegal felling of forests, forest fires, as well as cutting of forests for the use of land for settlements, roads, industrial zones or for agricultural purposes. The disappearance of forests in the higher regions and mountains leads to torrents and a faster drainage of water. Deforestation in the vicinity of river beds and coastal slopes causes loss of vegetation and strong root system of trees, and the soil becomes exposed to erosion and more intensive washing of soil particles into the water streams, resulting in changes such as raising the bottom of the trough and bottling the bottom. It is often emphasized that deforestation is one of the main culprits for landslides in rural areas. Floods also occur in parts of the basin affected by forest fires. From the aspect of water and floods in devastated forest areas, the protective role of forests has been lost, which is primarily the protection of soil from erosion and the balance of the hydrological system.

Poor agricultural practices are usually associated with the problem of pollution and water protection. However, starting from the cultivation of land, especially on slopes, types of cultures and ways of their cultivation, processes of erosion and rinsing of soil from arable land can have a significant impact on the occurrence of floods, especially in abundant precipitation. The increased risk of soil erosion also occurs in areas of excessive grazing, where the vegetation cover in the pastures is degraded, as well as in areas where fertility has been lost due to excessive exploitation over a long period of time. The change in the use of soil for the purpose of agriculture can be resuscitated by reducing the capacity of the insulation areas. The risk of flooding also exists in the cultivation of crops that have less water absorption capacity, so the soil quickly becomes saturated, and excess water is retained on the surface.

Inadequate water management mainly relates to issues of managing accumulations, as well as hydro-technical facilities for protection against harmful effects of water. In recent times, it has often been pointed out that engineering activities on watercourses, such as channeling (river bedding), regulation of the meander, the construction of embankments, bulkheads, inadequate application of deposits, etc., have in fact led to changes in the watercourse, among which are the most significant reduction of inundation (flood) areas, increasing the flow rate, or changing the shape of the hydrograph, such as reducing the time of concentration and increasing the maximum flow (Bonacci, 2014).

Urbanization is certainly the most significant anthropogenic cause floods in the last decades. Due to population growth, especially in urban areas, residential and industrial buildings are often built in inundation areas, which increases the risk that these objects will be flooded, even in cases of water of a smaller return period (10 or 20 years). Unplanned and illegal construction additionally increases the risk of flooding, especially when buildings are built almost in the river bed itself and inundations, which reduces the capacity and capacity of the watercourse. The construction of residential and industrial buildings is accompanied by the necessary road infrastructure, and the areas under the roofs and roads exposed to precipitation are not able to absorb water, which drains into the rain channels (sewerage) and is evacuated into watercourses.

In addition to these primary anthropogenic impacts, other activities, such as the disposal of construction waste, but also all other types of wastes in the watercourse can be affected by the flood. In this way, the flow in the river bed is reduced, but it also increases the ability to create "plugs" on narrower sections in the watercourse, such as, for example, bridge structures or other objects in the watercourse. Also, the discharge of wastewater, whose suspended matter is deposited at the bottom of the watercourse and causes a decrease in the flow profile, can have an impact on the floods. Influence can also have objects in the river bed, as well as swimming objects (rafts, barges, towers ...), as well as reducing the free space for water flow through inundation. One should not forget the influence of man on climate change, which results in an increase in the frequency and intensity of extreme precipitation, which is directly reflected on the outflow from the basin and, consequently, to the floods.

Anthropogenic impacts that contribute to the reduction of the impact of large waters are:

- Afforestation of previously cut areas in the basin;
- Arranging river beds in order to increase the permeability of the water, ice and water beds;
- Construction of reservoirs and retransmissions in order to reduce the waves of large waters.

2.3. FLOODS IN BOSNIA AND HERZEGOVINA

According to the natural conditions in Bosnia and Herzegovina, the plains, valleys of the river and karst fields are the only favorable potential areas for settlement, industrial construction, development of economic infrastructure. By increasing their occupation and filling these areas, their usefulness and total value are increasing and increasing the vulnerability and the need for flood protection.

The annual rainfall in Bosnia and Herzegovina is about 1,250 l / m2 or a total of 64 x 106 m3 of precipitation. From the territory of Bosnia and Herzegovina annually swells 1.155 m3 / sec or about 57% of the total precipitation, ie 62.3% of the Sava River Basin towards the Black Sea and 37.5% of the river basin to the Adriatic Sea. In general, according to total annual precipitation and water drainage, Bosnia and Herzegovina belongs to water rich areas. Climatic, geographical and other significant factors affect the hydrological regime unfavorably.

Inadequate water management with natural unfavorable distribution of water in space and time increases the risk of flooding. The hydrographic and hydrological diversity of Bosnia and Herzegovina is a result of the very complex impacts of the different components of the environment.

Among the most important are:climatic characteristics that determine the water mass, then geological, ie hydrogeological conditions and the relief of the territory. Other factors, including man, are influenced by hydrological conditions.

Floods in the wider area of BiH are conditioned by the unevenness and imbalance of numerous natural factors (water regime, climate, geological, topographic) and human activities. The area of BiH is characterized by a relief with great falls, which, with uneven precipitation, leads to an uneven outflow. The concentration time in the basins is quite short, and the conditions for retardation (except in some parts of the karst) are quite unfavorable, and relatively low precipitation also gives high yields. Particularly characteristic are the catchments of hilly watercourses from the lower mountains that limit the Sava River valley, as well as the upper (higher) parts of the basins of the direct tributaries of the Sava River. In addition, there is often a coincidence of flood waves, for example, the Sava and its tributaries. Thus, historical floods in Posavlje were mainly formed by the flood waters of Sava, Una and Vrbas (Central Sava) and Sava and Bosna (Donja Sava). Floods in Semberija can be said to be the result of a complex coincidence of the waves of the great rivers of the Drina and Sava rivers.

Floods in karst fields are the result of disproportionate inflow into fields and outflows from fields through sinks, surface flows or drainage tunnels. Floods are most often exposed to the following areas:

- In the upper flows of the Sava tributaries: Drvar (the river Unac), Tuzla (the river Jala), Olovo (the river Krivaja), the valleys of the Spreče river, Usora, Miljacka, Željeznice idr.;
- In the middle and lower flows of the tributaries of the Sava River: Kulen Vakuf, Bihać,
- Bosanska Krupa (Una River), Novi Grad, Prijedor, Sanski Most (Sana River), Gornji Vakuf, Bugojno, Donji Vakuf (Vrbas River), Sarajevo Field, Zenica, Maglaj, Doboj (river Bosna), Foča, Goražde, Zvornik , Janja (river Drina);U dolini rijeke Save poplavama su često bila izložena naselja: Dubica,
- Gradiška, Srbac, Brod, Derventa (Ukrina), Šamac, Orašje and Brčko;
- In the valley of Neretva: Čapljino polje, Gabela Polje, Višići, Svitava, Hutovo Blato, Brotnjo plateau, Rastok_Jezerac, the Neretva valley (part of Čapljina-Buna), Vir-Posušje, Ljubuško-Vitinsko polje (Trebižat river), Bijelo and Bišće polje the river Buna);

- In Karst fields: Imotsko-Beki polje, Mostarsko blato, Livanjsko polje, Kupreško piolje, Duvanjsko polje with Šujičko polje, area around Grahova Gatačko polje, Nevesinjsko polje, Dabarsko polje, Fatničko polje, Bilećko polje, Trebinjsko (Mokro) polje, Ljubomirsko field, Ljubinjsko polje and Popovo polje.

EXISTING FLOOD PROTECTION IN BIH

Floods as a natural phenomenon have always appeared and will appear in the future. Defending floods, people have taken many technical and non-technical measures, starting from the construction of embankments to creating complex systems to reduce the risk of flooding. The process of development of these systems and the increase in their role and importance, both in the increase of the level of protection of goods and the safety of life, is conditioned by the development of society in general. These complex systems exist in Bosnia and Herzegovina and they are most often multipurpose.
From flooding large waters in BiH are protected areas along the Sava River and somewhat along the Neretva River (where the problem is usually inadequate management of hydro accumulations), while on the Sava tributaries protective systems are unfinished or not in any way, with the exception of urban areas. Below is a short list of the most important protective structures, as follows:

1. **Water District of the Sava River**

In the Federation of Bosnia and Herzegovina: the embankments along the Sava river with total length of 59,475 km, embankment along the river Bosnia 6,905 km long, 7 coastal lines with a total length of 6,119 km, 4 peripheral channels with a total length of 21,217 km, 4 pumping stations with a total capacity of 26,90 m^3 / s, with accumulations in Gradacac ("Hazna" and "Vidara").
In the Republic of Srpska: Area of Dubičke ravni (unski embankments lenght 16,10 km, embankments along the Binjačku 17,00 km, Sava embankments 33,10 km, peripheral channels 7,10 km), area of Lijevče polja (Sava embankements 32,20 km, Jablanički - 8,50 km, Vrbaski - 10,80 km, peripheral channels 22,50 km), areas Srednja Posavina-Lončari ,

Ivanjsko polje, Srednja Posavina-Šamac, aerea of Semberija, and a total of 21 pumping stations with a total capacity of 108.20 m^3 / s.

2. **Water District of Adriatic Sea**

In the Federation of BiH: embankments along the river Neretva total length of 14,692 km, embankments along the river Bregava 3,991 km long, embankments along the river Krupa 4,08 km long, embankments along the river Tihaljina-Mlade-Trebižat length of 19,822 km, embankment along the river Vrioštica length 7,441 km , drainage tunnels with speedboats and towers in the Imotsko-Bekisko field and Mostar mud, channels with a total length of 17,762 km and one pumping station with a capacity of 4,00 m^3 / s.
In Republika Srpska: 3 pumping stations with a total capacity of 1.09 m^3/s.

2.4. DAMAGES OF FLOOD

The floods that occurred in June 2001 affected the Posavina, Tuzla, Zenica-Doboj and Central Bosnia Canton and caused enormous damage to agriculture, housing, equipment, roads and buildings of civil engineering and infrastructure. The Government of the Federation of Bosnia and Herzegovina has set aside 6,730,178.00 KM for damages caused by flooding of agricultural land and housing and infrastructure facilities, and the damage was, according to the reports of the commissions for assessing damage to municipalities and cantons, over KM 50,000,000.00.

Due to prolonged spring rains in the Federation of Bosnia and Herzegovina, in the spring of 2004 floods affected areas of all cantons with somewhat different intensity. The flood affected 13,455.95 ha of agricultural land, and the damage caused by floods amounted to 23.933.792,86 KM.
Floods that occurred in 2003 and 2004 in the territory of the Federation of Bosnia and Herzegovina confirm that these natural phenomena in our area are inevitable and warn that we have left the cycle of diminished large waters (which, fortunately, has been going on for about 20 years) and entered the hydrological cycle and significantly larger and more frequent occurrences of large waters. According to the latest analysis, a more frequent occurrence of intense precipitation with large amounts of water is noticeable. In addition, in 2009 and 2010 they were experiencing extreme

precipitation, but in 2011, rainfall was significantly below the perennial values.
It should be noted here that in 2010 the territory of the Federation of Bosnia and Herzegovina was affected by large floods that caused significant material damage to material goods (housing, communal and other facilities, infrastructure, agricultural land, etc.) and caused damage in the amount of more than BAM 87,000,000.00, with the largest damage registered in the Tuzla, Posavina, Bosanski-Podrinje, Zenica-Doboj and Herzegovina-Neretva Cantons.

Catastrophic floods caused by precipitation that exceeded the so far recorded phenomena, ranging from 14 to 19 May 2014, affected the wider area of the Sava River Basin in Bosnia and Herzegovina - BiH, the Republic of Croatia and the Republic of Serbia. Floods affected the entire territory of BiH belonging to the Sava River Basin and caused loss of human life and enormous material damage. In Fig. 5. shows the area affected by floods in BiH, Croatia and Serbia.
These were the worst floods in the last 120 years, brought by massive destruction in a country still recovering from the effects of the 1992-1995 war, where a significant number of people suffer from chronic poverty and unemployment. Elementary disaster hit a quarter of the territory of Bosnia and Herzegovina and about a million people, which makes up about 27% of its 3.8 million inhabitants. Nearly 50% of local governments are affected by floods, of which 46 have suffered severe damage and destruction, where urban, industrial and rural areas have been completely flooded for days, cut off from the world, without electricity, water and communications. Houses, infrastructure, schools, hospitals, private buildings, farms and crops were deleted from the face of the earth, which resulted in the disruption of the work of public services, local economy and agricultural works, and numerous landslides were launched and new ones were activated. The water retaining capacity in the soil and on slopes was more than twice as high.

Figure 5- Area affected by floods in May 2014

Early degradation of the environment associated with degradation factors such as forest degradation, interventions in riverbeds and construction in areas subject to hazard and risk, have created all preconditions for the emergence of such a disaster. The entire Sava River Basin was hit by generating torrents and moving the downstream diversified application, tracing the belt of destruction and devastation.

Downstream, on flat terrains, accumulated water, sludge and deposits have caused great floods. As the Sava River reached its maximum, the drainage of the terrain became impossible, causing water retention in the plain for a longer period.

Because of the catastrophic situation due to floods and associated phenomena, a large number of municipalities immediately declared the state of natural disasters. Approximately 81 local governments suffered, to varying degrees, damages, losses in human lives, material goods and enormous consequences for environmental protection. Approximately 90,000 people were temporarily evicted from their homes, and more than 40,000 stayed in public and private sanctuary for a longer period of time or moved temporarily with relatives and friends.

On the whole, the total economic impact of a disaster (destruction or serious damage to property, infrastructure and goods, as well as consequential effects on livelihoods, income and production, among other factors) is estimated at KM 3.98 billion. The bulk of this was hit by the private sector, family, and small, medium and large enterprises, as well as agricultural producers, including an unknown number of vulnerable population groups. In the Federation of BiH, the total damage is 2.03 billion KM, in RS, 1.89 billion KM, and in Brcko District, 57.89 million KM.

Damages are not uniform in different sectors and affected municipalities because of their different origin, eg landslides, floods or erosion, and intensity (Table 1)

Table 1- Total Damage and Losses in BiH (€ million) (RNA Source)

Secor	**Damage**	**Losses**	**Total**
Agriculture	104,35	82,86	187,21
Education	8,04	0,66	8,70
Energy sector	49,67	52,29	101,96
Flood protection	49,24		49,24
Health	5,79	47,13	52,92
Housing sector	424,78	28,43	453,21
Economy and Employement	346,55	446,90	793,04
Public services	18,36	9,05	27,41
Transport and Communications	261,76	85,94	347,70
Water supply and sewerage	5,44	2,07	7,51
Gender		8,46	8,46
TOTAL	**1.273,98**	**763,39**	**2.037,38**

Floods in May 2014, which hit a million inhabitants of Bosnia and Herzegovina and inflicted damage to infrastructure, businesses, households, farms and crops (Figures 6 - 9), are an event that has not been observed since systematic metrological and hydrological phenomena BiH, since 1892. Rainfall in the period from 13 to 17 May 2014 in some places was 2-3 times higher than the monthly average rainfall for May. Such high rainfall resulted in high water levels, ie extreme watercourse flows, which exceeded the 500 year return period.

Figure 6- Floods in Banja Luka, May 2014 (Photo: BUKA / E.P./)

Figure 7 - Floods in Banja Luka, May 2014 (Photo: BUKA / E.P./)

Figure 8- Effects of Flood Floods - Doboj, May 2014 (Photo: Sanja Vrzić)

Figure 9- Effects of Flood Floods - Doboj, May 2014 (Photo: Sanja Vrzić)

2.5. PROTECTION FROM FLOODS

INSTITUTIONAL FRAMEWORK IN THE BH WATER SECTOR

Water management is divided into the competencies of Bosnia and Herzegovina, Federation of Bosnia and Herzegovina, Republika Srpska, Brcko District, Cantons, Cities and Municipalities. Entity Laws on Water set out the institutional framework of water management. These laws, whose procedure of drafting and adopting lasted several years, have been in line with the approach to water resources management in the EU, and in an atmosphere of convergence of BiH's membership in this organization. Water laws have established a new structure for water management, which means that the basic unit of management is the Water District. The Ministry of Agriculture, Water Management and Forestry of the Federation of Bosnia and Herzegovina was established on the basis of the Law on Federal Ministries. Article 15 of this Law describes the general competence of this ministry: to perform administrative, professional and other tasks stipulated by law concerning the competence of the Federation in the field of agriculture, water management and forestry. Water management activities within the Ministry are assigned to the "Water Management Sector". The Ministry's activities relate to: water resources, development plans, water balances, water use, water protection, protection from water and other activities established by the Federal Ministry of Finance Act.

- In addition to the mentioned Agencies, the water sector in the Federation of Bosnia and Herzegovina is also related to the following professional institutions, by nature of activities and competencies:
- Federal Hydrometeorological Institute Sarajevo,
- Federal Institute for Agropedology Sarajevo,
- Federal Institute of Geology Sarajevo,
- Federal Administration for Geodetic and Property Legal Affairs Sarajevo,
- Agency for Statistics of Bosnia and Herzegovina, Sarajevo,
- Federal Bureau of Statistics Sarajevo,
- Federal Civil Protection Administration of Sarajevo.

At cantonal level, water management competencies are mainly at cantonal ministries of agriculture, water management and forestry, similar to the federal level, while in some cases they are in charge of the ministries of economy. The general competencies of cantonal ministries in the area of water, whether they have or do not have separate services and sectors, are: water protection, protection against harmful effects of water and water regime regulation; flood protection, erosion and torrential rain; water supply of the population and use of water for the economy; water drainage from agricultural areas and water sector development planning.

In Republic of Srpska water management is regulated in a similar way as in the Federation of BiH. The basic body that performs administrative, professional and other supervision is within the competence of the Ministry of Agriculture, Water Management and Forestry. Water agencies and Republic public companies are issuing their water management programs to which the Ministry provides. Such solutions do not disappoint if it is taken into account that Water Laws were adopted in the same year in the two Entities, subject to the provisions of international treaties that Bosnia and Herzegovina previously signed or took over from the earlier period of this convention and agreements in this area.

LEGAL FRAMEWORK IN THE WATER SECTOR IN BIH

The current state of water rights of Bosnia and Herzegovina (BiH) has distinct features that essentially differ from the national water systems of neighboring countries, ie the countries of South East Europe. These specifics arise primarily from the constitutional character of the internal organization of Bosnia and Herzegovina.

The legal framework in the water sector is in line with the constitutional organization of BiH and is made up of: Annex IV of the General Framework Agreement for Peace in BiH - Constitution of BiH, FBiH Constitution, RS Constitution, BD Statute, laws and subordinate acts done at BH, Entity FBiH RS, BD, cantons and municipalities. Below is a brief overview of the basic laws and subordinate legislation related to the issue of flood protection and water management.

In the FBiH, the Water Act was adopted [2] and a number of secondary legislation needed for implementation of the Act. The law regulates the issue of the institutional framework in the water sector in the FBiH and the financing of this activity, coordination with RS and BD in drafting water management plans for water areas, cooperation with RS bodies on water issues issues and water inspections. Due to the division of competencies, except for the level of FBiH, water laws were also issued at the cantonal level, which was also part of the water management competence transferred to the municipalities in FBiH.

The Law on Waters of the FBiH regulates the issue of drafting and adoption of water management plans for the Sava River Basin and the

[2] „Official Gazette of FBiH“, number: 70/06

Adriatic Sea Water Sector as well as the implementation of measures and activities aimed at reducing or preventing human and material damage from the harmful effects of water and eliminating the consequences of their action. Federal Operational Flood Defense Plan[3] is adopted by the Minister of Agriculture, Water Management and Forestry, and it defines the manner of implementing active flood and ice protection measures at the time of immediate danger from the occurrence of large (flood) waters and the elimination of flooding. Regulation on species and contents of protection plans against harmful effects of water [4] provides for the adoption of:

1. Flood risk management plans, including a preliminary flood risk assessment, risk mapping and flood risk maps, in accordance with the FPD provisions, until 2017,
2. Plan for the implementation of the active flood defense measures under the competence of the FBiH, issued by the relevant federal minister and plans for the implementation of active flood defense measures under the competence of the cantons issued by the competent cantonal ministers.

In the RS was adopted Law on Water of RS[5] as well as a number of bylaws needed to enforce the law. Water Law in RS regulates the way of integrated water management in the RS territory, including water protection, water use, protection against water damage, water management and other water bodies. This Law regulates the institutional framework, the way of financing of activities, coordination with FBiH in water management and other issues related to integrated water management. The Law stipulates the obligation to adopt management plans for the Sava River Basin River Basin and Trebišnjica River Basin.

Flood Defense Plan in RS[6] was adopted by the RS Government and it is a basic document for the coordination and implementation of activities of importance for the protection and rescue of floods. The Ministry of Agriculture, Forestry and Water Management issues the main operational plan for flood protection for each year, and it defines the way of active

[3] „Official Gazette of FBiH“, number: 7/11

[4] „Official Gazette of FBiH“, number: 26/09

[5] „Official Gazette of RS“, number: 50/06, 92/09 i 121/12

[6] „Official Gazette of RS“, number: 6/14

flood protection measures on built waterworks facilities at the time of immediate danger from the occurrence of large (flood) waters. The RS Water Law is applied in BD [7] as well as a number of bylaws needed to enforce the law. The BD Government's main operational plan for the current year is made by the Government of BD, and it defines the organization, method and procedure for flood and ice defense in the BD area. The BD is in the process of drafting a new Law on Waters.

The status and activity of the Federal Meteorological Institute is regulated by the Law on Federal Ministries and other federal administration bodies [8] and the Law on Hydrometeorological Affairs of Interest for the Republic BiH[9]. The status of the Republic Hydrometeorological Service of RS is regulated by the Law on Ministries [10] and the Law on Republic Administration [11]. The activity of the institute is regulated by the Law on meteorological and hydrological activity [12], The Law on Seismological activities [13] and the Law on Air Protection [14]

INTERNATIONAL AGREEMENTS AND EU DIRECTIVE

Below is an overview of international conventions and agreements in which BiH is a full member and actively participates in the implementation of the same, which are directly related to flood protection and water management. Furthermore, a brief review of key EU directives in this area is also given. The Convention on Cooperation on the Protection and Sustainable Use of the Danube River was signed on 29.06.1994. in Sofia, by the Danubian countries and the European Union. BiH has been a member of the convention since 2004. The main objectives of the convention are the cooperation of the Danubian countries on:

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[7] „Official Gazette of RS“, number : 10/98

[8] „Official Gazette of FBiH“, number: 58/02, 19/03, 38/05, 2/06, 8/06, 61/06, 57/09 i 50/11

[9] „Official Gazette of SRBiH“, number: 19/76 i 12/87, which is in accordance with Article IX.5.(1) Of the FBiH Constitution

[10] „Official Gazette of RS“, number:: 70/02

[11] „Official Gazette of RS“, number: 118/08

[12] „Official Gazette of RS“, number: 20/00

[13] „Official Gazette of RS“, number: 20/97

[14] „Official Gazette of RS“, number: 124/11

- Sustainable water system management in the Danube basin, including the conservation and improvement of rational use of water resources in the basin,
- Improving the quality of water resources management and water quality in the Danube Basin,
- Rational and sustainable use of water resources and environmental protection and ecosystems in the Danube River basin.

For the operational achievement of the set objectives and implementation of the provisions of the Convention, the measures adopted and the coordination of joint activities in this direction, the Member States have established a joint coordinating body, the International Commission for the Protection of the Danube River - ICPDR. In accordance with the requirements of the Water Framework Directive - WFD, the 2009 Convention Member States have adopted the Danube River Basin Management Plan with the Measure Program. Activities are currently being carried out on the Flood Risk Management Plan for the Danube River Basin. The Sava River Basin Agreement was signed by the Republic of Slovenia, the Republic of Croatia, Bosnia and Herzegovina and the State Union of Serbia and Montenegro in December 2002 as an expression of will and the need to strengthen mutual cooperation on the Sava River Basin. The objectives of the agreement are:

- Establishing an international river navigation regime for Sava and its naval tributaries,
- Establishing sustainable water management,
- Taking measures to prevent or limit the danger as well as remove the adverse effects caused by floods, ice, droughts and accidents involving substances that are hazardous to water.

The International Sava River Basin Commission - the Sava Commission was established to implement the objectives of the Framework Agreement and coordinate activities. The Sava River Basin Management Plan, in line with WFD requirements, has been drafted and its adoption is scheduled for December 2014. Furthermore, activities are being carried out on the preparation of the Flood Risk Management Plan, in accordance with the provisions of the Flood Protection Protocol adopted with the Framework Agreement.

Directive 2000/60 / EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy

(WFD) was adopted with a view to establishing a framework for the protection of surface water, transitional waters, coastal waters and groundwater. Water laws in force in the FBiH and RS are to a large extent over 90% in line with the provisions of the WFD, and through the project "Capacity Building in the Water Sector in BiH", further harmonization of domestic legislation with this and other directives is planned in the field water.

Directive 2007/60 / EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (FPD) was adopted with a view to establishing a framework for the assessment and management of flood risks in order to reduce the harmful effects of floods on human health, the environment, cultural heritage and economic activities. FPD introduces the obligation to develop a Preliminary Flood Risk Assessment, the development of hazard maps and flood risk maps and ultimately adopting flood risk management plans. Furthermore, the FPD requires harmonization with the WFD and River Basin Management Plans, public participation in the preparation of flood risk management plans and a coordinated approach to the implementation of measures to reduce the risk of floods.

ORGANIZATION OF FLOOD CONTROL IN BIH

According to Water Laws of FBiH, RS, and DB, the responsible Government adopts the Decree on the Flood Defense Plans (the Order). This Decree determines the types, content and method of production, the procedure for harmonization, adoption, updating and keeping of protection plans against harmful effects of waters. Protection against harmful effects of water refers to the protection from floods and ice on the watercourses, protection against erosion and torrents, and to the measures of protection and elimination of the consequences of sudden pollution of water caused by floods. The provision establishes a framework for the assessment and management of flood risks in order to reduce the consequences of harmful effects of water on human health, the environment, cultural heritage and economic activity. Measures, works and other activities undertaken to protect against floods in a particular area are defined in the appropriate flood protection plan for the area.

Based on the Decree on the flood defense plans and the proposals of the line ministries, the competent Government shall issue a Decision on the

Main Plan of Operational Measures for the Defense of Floods at the beginning of each year for the current year. The main plan of the operational flood protection measures and the organizational scheme for the implementation of the flood defense in the areas of Sava and Neretva, where water management facilities are built, is as follows: the body responsible for coordination and harmonization of the drafting of the Master Plan for operational measures and its implementation is the responsibility of the Ministry; the data providing organization is the Meteorological Institute; the operational center for coordination of key flood defense activities is the headquarters of the Ministry of Agriculture, Water Management and Forestry of FBiH Sarajevo and Banja Luka for RS. In the water area of the Adriatic Sea, the organization that performs all flood defense projects is the "Adriatic Sea Water Management Agency" Mostar, the Agency's director is the head of the flood defense. In the water area of the Sava River, an organization that performs all flood defense projects is the "Agency for the Water Area of the Sava River" Sarajevo, the Director of the Agency is the Chief Manager of the flood defense.

MEASURES FOR FLOOD PREVENTION

Bosnia and Herzegovina's Threat Assessment states that BiH is vulnerable to sudden torrential floods that are causing great damage. The protection program has determined that preventive measures of protection against natural and other disasters, and thus of floods, take precedence over all forms of planned protection. Managing the risks of floods from the aspect of prevention, protection and mitigation is achieved by a coordinated and coordinated action that must create significant added value and improve the overall level of flood protection. The planning and implementation of flood prevention prevention is the responsibility of institutions of several levels of government. For vulnerable areas, measures are foressed to be planned and implemented in accordance with the established priorities. Although progress is noted in the adoption of strategic, legal and other planning documents, this progress is not sufficient and in most cases does not monitor the undertaking of flood prevention activities in accordance with the priorities. Among other things, this is due to the lack of coordination, as well as the insufficient involvement of different levels in the planning and implementation of measures to achieve an increase in the level of flood protection across the entire water area.

As we noted in the introduction, planning is one of the basic functions of successful flood management management. Without an organized, timely and planned approach to planning, one can not speak of an efficient, or unique system of flood defense. Through a well-developed network of international cooperation, both through bilateral relations and through the forums of international organizations, an adequate flood protection system must be developed, especially in the planning segment, ranging from prevention and rescue, or to response to accidents, to the elimination of the consequences of their actions. For these reasons, it is necessary to establish synergies between regional and international bodies involved in flood management, which is, of course, the competence and responsibility of state bodies of Bosnia and Herzegovina.
Water management is based on the principle of ensuring protection against harmful effects of water, which primarily arises from the need to protect the population and property, and the need to eliminate the consequences of its harmful effects. Water protection includes all measures and activities that are planned, undertaken and performed in the wider area, in order to reduce (or eliminate) the consequences that result from the harmful effects of the unregulated water regime. The regulation of watercourses and other waters includes: reconnaissance, technical and investment maintenance of regulated watercourses, protective water facilities and buildings of melioration systems and other works that enable controlled and harmless flow of water and their intended use. Protection against harmful effects of water includes works and measures for flood protection (flood management), ice defense, protection against erosion and floods, the fight against drought, and the elimination of the consequences from the harmful effects of these.

BOSNIA HERZEGOVINA ACTION PLAN AS A BASIS FOR THE IMPROVEMENT OF THE FLOODS PROTECTION SYSTEM

Immediately after the flood, with the help of the World Bank, the EU Delegation to BiH and the UN, an estimate of the damage and recovery needs was made. The causes of floods, the extent of damage and the severity of the consequences that have arisen indicate that it is necessary that the competent authorities in BiH improve the system of flood protection and water management, which will ensure greater safety of the population in future similar phenomena. They can be expected as a consequence impact of climate change. The competent authorities in BiH in charge of water management issues, as well as flood protection, responded to the request of the EU Delegation to BiH, which officially requested from Bosnia and Herzegovina, on the basis of the RNA Assessment, to prepare a plan for renewal and improvement of flood protection and water management within the same consider issues of institutional regulation, policy and planning, mechanisms of financing and implementation of measures, with greater level of coordination and at the level of BiH and regionally.

Adoption and adoption of the Action Plan was set up by BiH as a prerequisite for the use of EU funds, as well as other providers of funds for the implementation of measures from that plan, and on 21 January 2015 the Council of Ministers of BiH adopted the Action Plan for flood protection and river management in BiH for the period 2014-2017. years. The adopted Action Plan is the only document adopted at the level of BiH for the area of water, and based on this, EU IPA 2014 funds for the rehabilitation of flood consequences in the amount of 15 mil. Euro for BiH for the reconstruction of the embankments along the Sava River and other watercourses, as well as the establishment and improvement of the monitoring and flood forecasting system on the river basin of Bosnia and 20 mil. euros for regional measures for BiH and the Republic of Serbia that included measures of flood protection on the Drina in Bosnia and Herzegovina and the Republic of Serbia and in the field of BD and Tuzla Canton, after 10 mil. Euro for each country.

In addition to the RNA Assessments for BiH, the existing entity and regional strategic and planning documents in the water sector, as well as the results of the following completed and ongoing projects, were used as basis for the development of an action plan:

- Support to Bosnia and Herzegovina's water policy in BiH, funded by IPA 2007,
- Strengthening environmental institutions in BiH and preparing for pre-accession funds, funded by IPA 2008,
- Capacity building in the water sector in BiH, funded by IPA 2011.

In line with the approach described above in the action plan, all the involved authorities and institutions have also identified six key measures that need to be implemented in the period from 2014 to 2017,

in order to improve the coordination of flood protection activities within BiH and regionally, in proportion to the funds secured. This would be:

- Monitored the consequences of floods, erosion and torrents from 2014,
- Improved the flood protection system in BiH,
- Established a more reliable hydrological forecast system in BiH,
- Create conditions for system sustainability and strengthen cross-sectoral cooperation,
- Continue activities to fully apply the principles of Integrated Water Management.

For each of the key measures of the Action Plan:

- Assessment of urgency for implementation
  - KR are short-term measures that need to be implemented within one year,
  - SR are medium-term measures that need to be implemented within three years,
- the competent institutions that carry the activities on the implementation of individual measures,
- Assessment of the necessary financial resources for the implementation of individual measures,
- Relevant remarks.

Activities on the implementation of the Action Plan are carried out by the competent authorities individually, and it is agreed to submit an annual report to the Council of Ministers of BiH and to the governments of the Entities and the BD BiH on its implementation. The key to the effective implementation of the measures and achievement of the objectives of the action plan is in the full engagement of local authorities at all levels of government on timely and harmonized identification and preparation of projects from their own and foreign resources and in the promptness of preparing applications for EU funds and other sources of financing and precise accountability for implementation . However, the implementation of the action plan achieves a part of the improvement of the flood protection system in the period 2014-2017. year, but a further permanent upgrade is also needed

Funds for the implementation of the Action Plan will be provided from loans, grants and budget funds. The total estimated funds for the implementation of the Action Plan are KM 592.7 million15. Out of the determined amount KM 267.2 million or 45% of the funds have already been provided through current credit lines, grant instruments and insured budget funds. Also, the projections are planned for providing additional financial resources in the amount of about 100 million KM, thus the total amount of the funds provided will be about 367.2 million KM or 61.9%. The most important projects through which additional financial resources will be provided, which can be realized within the verified period covered by the Action Plan, are:

- IDA loan WB for the Project for flood protection in the Drina River Basin, in the amount of US $ 24 million,
- IPA 2014 support to protect against floods and water management, a national component, in the amount of 15 million Euros,
- IPA 2014 reconstruction and construction of flood protection infrastructure, regional cooperation between BiH and Serbia in the amount of 10 million Euros,
- WBIF creation of hazard maps and flood risks in the amount of EUR 3.38 million,
- GEF-SCCF Water Management Project on the Drina River Basin in the amount of KM 4 million,
- Project "Integrating Climate Change in Reduction of Flood Risk in the Vrbas Basin" in the amount of US $ 5 million.

PROTECTION AND RESCUE IN CASE OF FLOOD

In the case of catastrophic floods, protection and rescue is regulated by the Law on the Protection and Rescue of People and Material Goods from Natural and Other Disasters [15]. This Law regulates the system of protection and rescue of people, plant and animal life, material, cultural, historical and other goods and environment from natural disasters - floods, rights and obligations of citizens and bodies of the Federation, cantons and municipalities, companies and other legal entities, as well as other issues of importance for the area of protection and rescue against natural and other disasters in the Federation of Bosnia and Herzegovina, in accordance with the Framework Law on the Protection and Rescue of People and Material Goods from Natural and Other Disasters in Bosnia and Herzegovina[16]. Protection and rescue of natural and other disasters includes: programming,

[15] " Official Gazette of the Federation of BiH ", no.39/03, 22/06 i 43/10)

[16] „Official Gazette of BiH ", no 50/08

planning, organizing, training, conducting, monitoring and financing measures and activities for protection and rescue against natural and other disasters in order to prevent danger, reduce the number of casualties and victims, and eliminate and mitigate harmful effects and the consequences of natural and other disasters.

- The unique organization of protection and rescue according to this Law, is realized by organizing and taking the following measures and activities:
- detection, monitoring and prevention of threats from natural and other disasters;
- informing the population about the dangers and giving instructions for protection and rescue;
- training for protection and rescue;
- organizing, equipping, training civil protection and establishing and maintaining other forms of protection and rescue;
- mobilizing and activating the forces and means of protection and rescue;
- eliminating the consequences of natural and other disasters to ensure basic living conditions;
- Supervision of the implementation of regulations on protection against natural and other disasters;
- Providing assistance to the Republic of Srpska and the Brcko District of Bosnia and Herzegovina, neighboring and other countries in case of natural or other disasters;
- seeking assistance from the Republic of Srpska and the Brcko District of Bosnia and Herzegovina and neighboring and other countries in the event of a natural or other disaster, in accordance with the Framework Protection and Rescue Law.

Measures and activities for protection and rescue are realized through civil protection, which represents an organized form of protection and rescue of people and material goods from natural and other disasters. Protection and rescue are carried out by citizens, authorities, companies and other legal entities, protection and rescue services, headquarters, units and civil protection commissioners, within their rights and duties.

Protectors and rescue carriers plan and prepare measures and procedures for the implementation of preventive protection in the event of imminent danger from the floods during the duration of the floods and plan and prepare measures and procedures for mitigating and eliminating the consequences of floods. Measures and procedures for protection and rescue are determined by the protection and rescue plans from natural and other disasters that must be mutually harmonized: protection plans of legal entities with a municipal protection plan, municipal protection plans with the canton protection plan, and canton protection plans with the Protection Plan of natural and other disasters. These plans are only adjusted in matters that determine the tasks for certain civil protection carriers.

In the preparation and implementation of protection and rescue, Red Cross organizations and other humanitarian organizations and associations of citizens (mountain rescue service, mountaineers, speleologists, mountaineers, radio amateurs, divers, etc.) are obliged to participate as part of their regular activities, in accordance with international treaties and agreements and their rules of organization. In carrying out these tasks, these organizations and associations cooperate with the civil protection authorities of the cantons and civil protection services of municipalities and act according to the order of the competent civil protection staff.

In conditions when forces and means of civil protection are insufficient to effectively rescue people and material goods from natural and other disasters, a request is made through the Ministry of Defense of Bosnia and Herzegovina to involve the Armed Forces of BiH in the protection and rescue tasks in the disadvantaged area, which is done in in accordance with the Law on Defense of Bosnia and Herzegovina[17].

2.6. CONCLUSION

Floods are everywhere in the world, including in Bosnia and Herzegovina, more frequent, more intense and more dangerous. They can not be prevented, but by taking effective preventive and operational measures their harmful consequences can be significantly mitigated. Prevention of floods is of strategic importance for each state, and damage caused by floods gives a special dimension to the seriousness of the approach in the implementation of preventive measures in flood protection. Despite the fact that built embankments have been in place for a long period of time, that many watercourses have been regulated, as well as that existing accumulations and retention are taking part in the protection, the current

[17] " Official Gazette of BiH ", No 88/05

activities in flood prevention in BiH are insufficient to significantly influence the reduction of harmful consequences. Planning to reduce flood risk is a very complex process that requires the synergy of all water management factors, protection and rescue, regardless of the level of government. However, despite the fact that the legislation that regulates the area of flood protection is comprehensive, floods are occurring that each year cause huge losses in material goods, but also in human lives.
It is indicative that flooding is repeated almost every year, in the same areas that were previously identified. According to the media, businessmen and the non-governmental sector: "Floods are always surprising because there is no prevention". From the point of view of the businessmen, the authorities have not done enough in the implementation of preventive measures, which has the effect of flooding buildings, agricultural land and settlements. Everything points to the fact that the activities on reconstruction and maintenance of existing and construction of new protective structures are insufficient and that evident stagnation is evident. Floods as a natural phenomenon can not be prevented, but by taking preventive measures, the harmful effects of water can be reduced. According to an expert's assessment: "Every dollar invested in prevention reduces flood damage and up to eight times."

Resolving the flood protection problem in Bosnia and Herzegovina, which has been stagnant for several years (since 1992), is based on providing information on built flood protection facilities and their condition, assessed the degree of flood risk of river valleys, and estimating potential damage, as well as the degree of human life threats, technical alternatives, and assessment of justification for investing in flood protection facilities in certain areas of river valleys and karst fields. Based on the collected data from the project documentation, site survey and reconnaissance, and hydrological data analysis, the "Assessment of the Flood Prevention Level in the Federation of Bosnia and Herzegovina and the Development of Improvement Program" study identified 31 flood threats only in the Federation Bosnia and Herzegovina (river valleys and karst fields).

The conclusion of all, so far conducted, analysis suggests that the high level of damage caused in BiH is primarily a result of the heavy rainfall in April-May 2014. Eliminating disadvantages in flood protection systems i
water management, meteorological and hydrological monitoring and flood forecasts, early warning and alerting, and protection and rescue of

population and material assets, urbanism and spatial planning and others is absolutely necessary in order to reduce the level of damage in similar flood events in the future. All deficiencies need to be identified and analyzed in order to identify priority and other measures whose implementation would address the consequences of the flood and achieve adequate improvements to the flood protection and water management system.

The flood and landslide risks require an active improvement of the flood protection system and the reduction of the flood risk in the territory of Bosnia and Herzegovina. For the implementation of this approach, coordination is required at the level of Bosnia and Herzegovina and internationally, at the level of common river basins, which is timely and substantively consistent with the obligations of the Joint Action Program for Sustainable Flood Protection at the Danube Basin, which in December 2004. was accepted by 13 member states of the Danube Convention, including Bosnia and Herzegovina.

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3. LANDSLIDES

3.1. INTRODUCTION

The topography of the central part of Bosnia and Herzegovina (BiH) features mountainous terrains with peaks ranging from 500 to 2000 m above sea level. Approximately 2,400,000 ha (or 48%) of the total land area is forested and the remaining about 2,700,000 ha (52%) are covered by agricultural lands
(CPDR 2007).

Due to the topographic characteristics as well as other natural conditions such as torrential rainfall, landslides are continuous and well-known hazards in BiH and represent complex and ever-increasing problems to communities and authorities at all levels. The risk assessment for BiH adopted by the Council of Ministers in 2012 has already registered a number of active landslides in the country.

The 1992 – 1995 war in the country also caused a massive migration of people, linked with the illegal construction of houses in the sloping areas or alongside riverbeds. In addition, lack of spatial planning documentation based on geological analysis leads to unsustainable territorial development and infrastructure investments, which in the long term also causes landslide hazards. Moreover, human activities relating to expansion on unsafe locations, unscientific mining, hazardous construction of roads, dams and ignoring natural features contribute to the increased intensity of landslides.

3.2. LANDSLIDES AND NATURE IN BIH

LANDSLIDES AND NATURE IN BIH

BiH terrain can be characterized by a miscellaneous and complex geological structure where different stratigraphic units of the Palaeozoic to Quaternary ages are found. The complexity is further increased due to a variety of lithological types of sedimentary, metamorphic and igneous rocks which are generally characterized by different degrees of weathering. Due to their variable physical and mechanical properties, these different rock massifs are subject to the process of decomposition and formation of clay and clay mixed with gravelly soils. The areas where top soil is deeper are potential areas for some geodynamic processes and phenomena including landslides. The stability map of FBiH is presented in Figure 1. (Hrvatović, 2000-2010).

Although majority FBiH lands are stable according to this map, considerable areas are also covered by potentially unstable materials. These potentially unstable areas are often affected by landslides due to human activities such as uncontrolled excavations, construction of facilities, uncontrolled drainage, uncontrolled agricultural developm ent, etc.

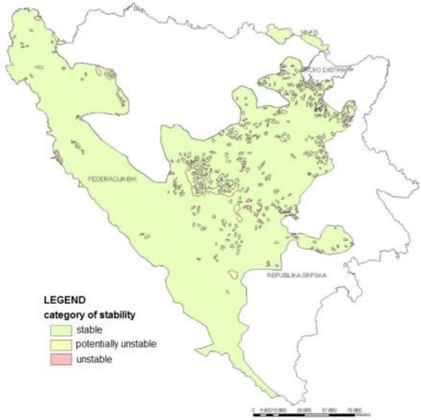


Figure 1 - Stability map of FBiH

LANDSLIDES CLASSIFICATION AND LOCAL EXAMPLES OF SOIL FAILURE

Geologists, engineers, and other professionals often rely on unique and slightly differing definitions of landslides (Highland and Bobrowsky 2008). The term “Landslide” is defined in various literature (eg, Varnes 1978, Cruden and Varnes 1996, USGS 2004 and Watari 2004). Landslides can be classified into different types based on various aspects such as the mode of movement, the rate of movement, the shape of the landslide surface and the type of materials involved. Among various landslide classifications, the classification proposed by Varnes (1978) is often cited (Figure 2). In some countries, the landslide classification based on the topographical features is also used (Figure 3). This classification system can provide a rough estimate of some basic information such as the age of the landslide, slope angles, strength of materials comprising the slope, allowable decrease of Factor of Safety (FOS) and the speed of landslide movement.

From the geological standpoint, many landslides in BiH appear to be related to the top soils and rarely to the failure of the underlying bedrocks. Areas consist of sandy clay, sandy silt soils and boulders are also affected by an increase of the pore water pressure (and subsequent reduction of the shear resistance). In many cases, the landslides in BiH are shallow and are observed on the relatively gentle slopes (typically less than 20 degrees) which often consist of thin layers of top soil and residual soils overlying weathered rocks. Many of these landslides can be classified into the "earth slide" or "earth flow" as per Figure 2 and "clayey soil slide" (Figure 3, 4 i 5).

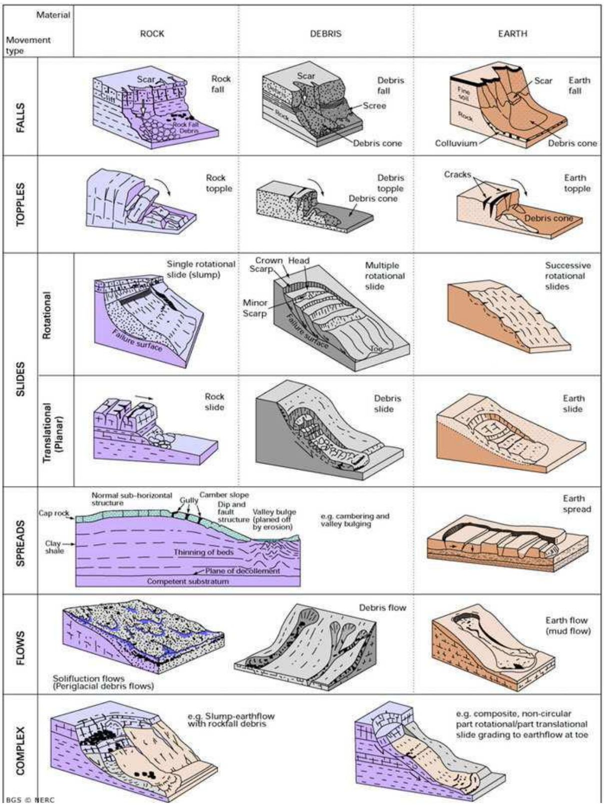


Figure 2 - Varnes' classification of slope movements

In addition, "rotational slide" shown on Figure 2 or "weathered rock slide" and "colluviums deposit slide" (Figure 3) are also occasionally observed in

BiH (Figure 7 and 8). Other factors such as suffusion, surface erosion, and human factors can very often contribute to landslide occurrence.

It is not so rare, that landslides occurred near or right under facilities (private houses in rural areas mostly). In that case, the serviceability is restricted, or sometimes total building failure can occur.

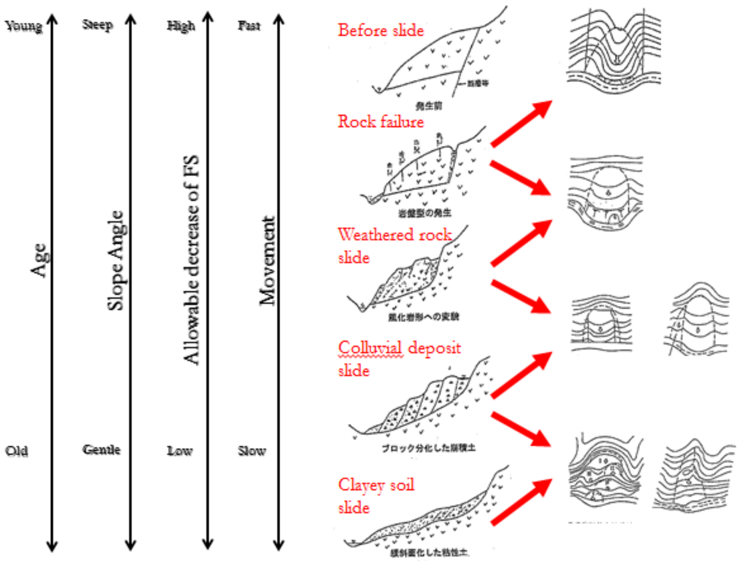


Figure 3 - Landslide classification based on topographic features (after Watari and Kobashi 1978)

Figure 4 - Typical shallow "earth slide" in BiH, creep movement is evident

Figure 5 - Typical shallow "earth slide" observed after heavy rainfall events


Figure 6 - Typical earth flow (mud flow) recorded during heavy rainfall events in May 2014.

Figure 7 - "Rotational slide" observed in BiH

Figure 8 - Typical deformed shape of soil surface due to rotation and translational displacement

LANDSLIDE MECHANISM

To manage and mitigate the landslide risks, it is of importance to identify the causes of landslides. Causes of landslides are generally classified as the primary causes and the triggering causes. The primary causes are factors related to topography, geology, hydrogeology, etc. and the triggering causes include both natural and human activities such as heavy rainfall, snowmelt, earthquake, earthworks, etc.

According to Custovic, approximately 83% of overall BiH land is located in the hilly area (300 to 500m above sea level), hilly or Mediterranean mountainous areas (500 to 700m above sea level) or mountainous area

(more than 700m above sea level). In these areas, the soil is often shallow and groundwater table is high. These topographic and hydrogeological characteristics are considered to be one of the primary reasons for the high change of landslides in BiH.
The mean annual precipitation of hilly and mountainous areas in BiH ranges between 1500 and 2000mm (southern region) and about 1000mm (central region). Rainfall and/or combination of rainfall and snowmelt are one of the most common landslide triggers in BiH. Continuous heavy rainfall in mid-May 2014 caused extensive landslides and flooding in BiH, Serbia, and Croatia.

In addition, an excessive deforestation and inappropriate conversion of grass area to arable land are the most common cause of landslides associated with human activities. Other human activities which often trigger landslides include excavation of cut slopes for roads, embankments at the top of the landslide area, devastated water supply systems.

3.3. THE ROLE OF INDIVIDUALS AND COMMUNITY IN THE PREVENTION OF THE LANDSLIDE OCCURRENCE AND RISK MANAGEMENT

The prevention measures of landslide occurrence and risk mitigation may include but not limited to:

- ✓ Proper engineering is mandatory. There are a number of illegal constructions of houses in the landslide-prone area
- ✓ Construction activities without proper engineering
- ✓ Construction of earthworks for slopes should comply with the relevant standard or codes.Examples of good and bad hillside construction practices are illustrated in Figure 9 and Figure 10, respectively.
- ✓ The rating of the landslide risk could be developed as a function of the probability of the landslide occurrence and its consequences (finance, safety, environment, reputation, etc). This may be linked to the landslide inventory system to determine the urgency and the priority of the landslide remediation.

- ✓ The landslide inventory system could be also linked to other relevant legalizations such as those associated with the development application system, planning control, building regulation, deforestation, civil defense and emergency management, etc. so that the proposed activities within the landslide-prone areas could be improved or restricted through proper engineering.

- ✓ Many landslides in BiH are triggered by rainfalls. Monitoring of hourly rainfall should be undertaken. Warning systems based on rainfall data and/or ground displacement could be utilized to minimise the landslide hazards. A statistical evaluation of rainfall and landslides could be utilized in establishing warning and evacuation control values.
- ✓ Excessive deforestation and inappropriate conversion of grass areas to arable land should be restricted. Vegetation dries out the surface layers. Plant roots can also help stabilize slopes by anchoring a weak soil mass to fractures in bedrock, by crossing zones of weakness to the more stable soil, and by providing long fibrous binders within a weak soil mass (Ziemer 1981).
- ✓ Water distribution services should be regularly maintained. Leakage of water from water distribution services can be a serious risk to the stability of slopes even at some distance away from the slopes. It may cause failure of a slope even without any noticeable signs of leakage at the ground surface (Environment, Transport and Works Bureau, The Government of the Hong Kong Special Administrative Region, 2006).
- ✓ The slope design should include details of inspections and maintenance requirement to enable the risk mitigation measure to remain effective for at least the design life of structure (AGS 2007). Regular maintenance is important for slopes and retaining structures to ensure their functionality and to avoid deterioration. This can be carried out by any responsible person with no professional geotechnical knowledge. When any damage or unusual state is found with slopes and retaining structures, it should be carefully observed and recorded for reporting and further follow-ups including inspection by a professionally-qualified geotechnical engineer.

In general, regular maintenance inspection of slopes includes the following items (Geotechnical Engineering Office, Hong Kong, 2003):

- Excavation of accumulated debris from drainage channels and slope surface;
- Repair of cracked or damaged drainage channels or pavement;
- Repair or replacement of cracked or damaged slope surface cover;
- Unblocking of weep holes and outlet drainpipes;
- Removal of any vegetation causing severe cracking of slope surface cover and drainage channels;
- Reseeding grass on slope surface areas;
- Repair of cracks in masonry walls;
- Removal of loose rock wedges and on rock slopes;
- Repair of damaged water distribution services;
- Repair or replace corroded steel pipes on slopes; and
- Maintenance of landscape treatment on the slope.

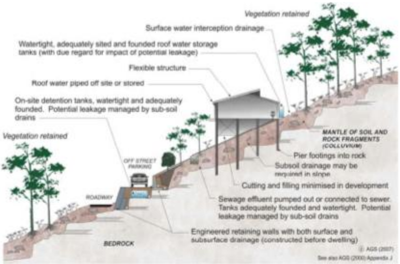


Figure 9 - Examples of good hillside construction practice (Australian Geomechanics Society 2007)

Figure 10 - Examples of bad hillside construction practice (Australijsko geomehaničko udruženje 2007.)

3.4. EMERGENCY RESPONSE AND LANDSLIDE REMEDIATION PROCESS

EMERGENCY MEASURES AFTER LANDSLIDE OCCURRENCE

Various emergency measures can be performed when soil instability is observed. The most frequently applied emergency measures are shown in Figure 11 (results of a survey conducted in 9 municipalities in BiH as part of the development of a manual on landslide risk management under the UNDP BiH in 2016). Survey results show that surface water runoff is the most common emergency measure implemented by local communities and individuals after detecting ground instability.

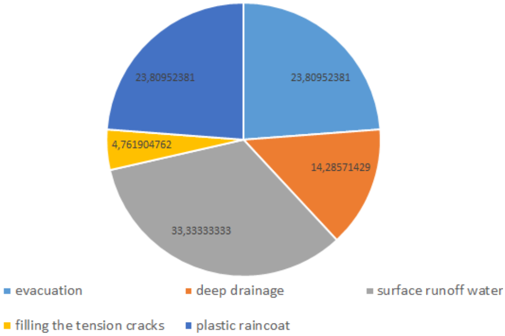


Figure 11 - Emergency measures used in local practice

It is interesting that the conclusions of the same survey indicate that on average only every seventh landslide was completely remediated, and the remediation measures on most landslides consist of only emergency intervention measures carried out during the initial sliding.

The procedure for landslide remediation, which should result in stabilizing the ground permanently, will be described in more detail below.

Landslides remediation process

Figure 12 shows the flow of the typical landslide mitigation steps. Based on results of the preliminary investigation, the basic mechanism of the landslide (Step 3) may be identified and requirements for the detailed investigation (Step 2) and the possible mitigation measures (Step 4) could be roughly determined.

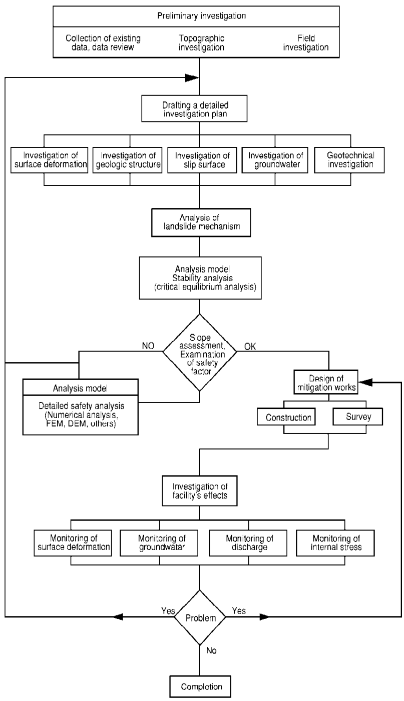


Figure 12 - Flow of the typical landslide mitigation steps (after Japan Landslide Society 2002)

The following sections describe the preliminary and detailed investigation techniques commonly available.

PRELIMINARY INVESTIGATION

Topographic Investigation

Topographic maps show the height and the land shape using contours. Good topographic maps are the fundamental and the essential information for the landslide investigation and mitigation. The topographic map of 1:500 to 1:1000 scale with 1m contour is considered appropriate for the investigation of the medium size landslides (eg, landslide width = 50m).

There are a number of survey techniques available to produce topographic maps. These include the conventional survey using digital leveling instruments, LiDAR, and photogrammetry. However, to the author's knowledge, appropriate topographic maps are often not available at the beginning of the project in BiH. In such a case, maps and images available on the internet (such as Google Earth) may assist with rough slope morphology until the proper survey results become available. With Google Earth, an elevation profile can be also produced for any given path.

A number of useful information such as the extent and angle of the landslide, signs of past instabilities, locations of gullies and ridges may be interpreted from the topographic map (see Figure 13). Other useful information such as the age of the strength of the materials comprising the slope, allowable decrease of Factor of Safety (FOS) and the speed of landslide movement can also be roughly estimated.

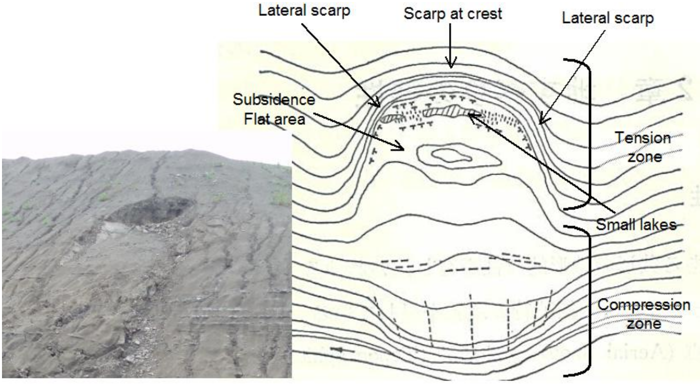


Figure 13 - Topographic map showing a number of landslide phenomena (after Fujiwara 1978)

For instance, the convex ridge type landslide showed on Figure 14 (a) can be interpreted that the area shown on this map may consist of relatively strong geomaterials and its slope angle could be moderately steep to steep. The speed of the landslide in this area could be potentially fast. On the contrary, a multiple hill terrain type landslide showed on Figure 14 (b) usually comprises weak soils (eg, cohesive soil with low undrained shear strength) and its slope angle is gentle (it can be as gentle as less than 10 degrees). This type of landslide usually shows creep movements.

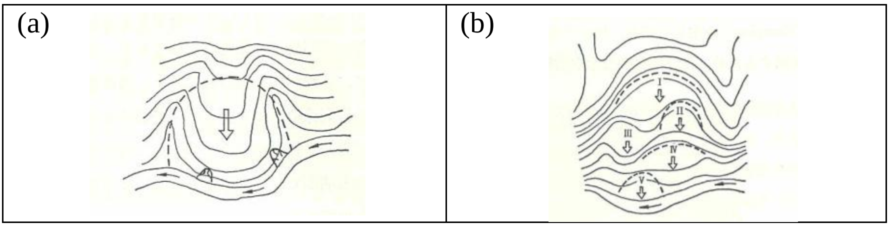


Figure 14 - Topographic maps showing convex ridge terrain (a) and multiple hill terrain (b) (after Fujiwara 1978, Watari 1978)

Site Walkover Investigation

The purpose of the site walkover is to establish the site (or area) specific topography and detailed observation of relevant features such as outcrops, topographic form and evidence of past instability. Some initial subsurface investigation may also be completed (AGS 2007).
The following features shall be inspected and mapped during the site walkover investigation:

- Extent (and depth if possible) of landslide;
- Nature and pattern of distress to ground;
- Degree of damage caused by landslide;
- Previous history or evidence of instability (ie, irregular contours, hummocky topography, scarp faces in area of tension cracks, curved and/or non-vertical tree trunks, cracked or uneven roadway surfaces, distressed houses or other buildings)
- Exposures of the geology;
- Slope angles both natural and artificial;
- Natural and artificial drainage; and
- Surface water and groundwater (eg, presence and depth of groundwater, seepage, swampy areas).

Figure 15 - Typical landslide phenomenon at crest and side, main scarp and lateral scarps are evident

Depending on the site conditions, opportunities for site walkover in natural slopes may be limited and not all areas may be accessed (eg, steep terrain). For the inaccessible areas, aerial photographs can assist with identification of slope morphology and geological features. Examination of aerial photographs, if available, taken over a number of years should be carried out in order to assist in determining potential landslides at the site or surrounding areas.

Results of site walkover inspections and aerial photographic study should include recommendations that clearly outline the following:

- Whether emergency actions (eg, evacuation, road closure, emergency mitigation measures) are required;
- Whether the site has a history of landslide;
- Relevant information about the slope, potential or actual failure mechanisms, current stability based on visual assessment, the extent of damage, elements at risk in the form of sketches or other illustrations. These include:
  - Plan showing major dimensions and features, and locations, preferably including photo locations; and
  - For areas where signs of instabilities are identified, at least one cross-section showing the slope geometry and distribution of geological units (if known).
- Photographs with their brief description;
- Whether any follow-up inspections are required;

A site walkover investigation is a screening process to assist the determination of the scope of detailed investigations and possible mitigation measures.

Detailed Investigation

The primary objective of the detailed investigation is to examine the following aspects of the landslide:

- Extent and movement of the landslide;
- Depth of the landslide;
- Groundwater level; and
- Subsurface ground conditions including the characteristic of soil and rock.

Surface Deformation Investigation

Monitoring of the surface deformation can provide useful information to predict the boundary of the landslide, the level, and mechanics of the landslide activities. Various monitoring techniques such as simple methods (eg, stakes or pins), crack gauges, extensometer, conventional laser survey and photogrammetric survey can be utilized to measure the movement of the landslide at the ground surface depending on the purpose, cost, accessibility to the site and the stage of the project. One of the simplest techniques is to use crack gauges or to install stakes (or pins on the road or structures) that can be repeatedly measured (Figure 16).

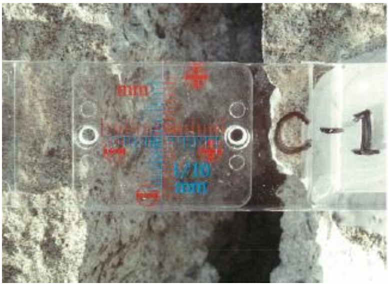


Figure 16 - Monitoring of surface deformation using crack gauge

Figure 17 - Monitoring of surface deformation using simple extensometer

The extensometer is generally installed near the crest of the landslide across the main scarp or tension cracks and is regularly monitored to assess rates and frequencies of crack extension and ground movement (Figure 16, 17 and 18). Both analog and digital recording system are used in the extensometer monitoring.

Figure 18 - Diagram showing typical extensometer installation (Japan Landslide Society 2002)

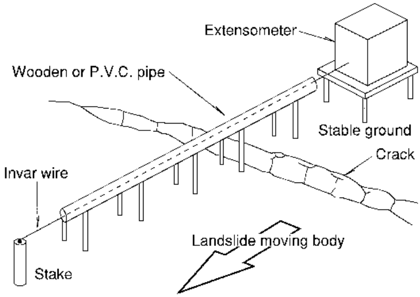


Figure 19 - Monitoring of surface deformation using analog extensometer

For areas where access is difficult or extent of landslides is unclear, the conventional laser survey, or photogrammetric survey may be utilized to measure the movement from digital photographs taken from the exact position of surface points. It should be noted that these monitoring techniques only show the landslide movement at the ground surface which could be different from the movement at some depth. In addition, from author's experience, the weak geomaterials tend to show drastic movement at the ground surface.

Slip Surface Investigation

Inclinometers and/or pipe strain gauges are commonly used to examine the landslide slip surface. These techniques measure the tilt of the boreholes which can be converted to a horizontal movement. An inclinometer is a device for monitoring the onset and continuation of deformation normal to the axis of the borehole casing by passing an inclinometer probe along the casing installed in the boreholes (Dunnicliff 1988). Inclinometer casing has two sets of grooves and usually, one set of grooves is aligned with the direction of the landslide (ie, downslope direction).

An inclinometer provides a continuous deformation profile along the borehole and suits to long-term precise monitoring if the deformation is not excessive. The rate of movement may be also estimated by making a series of reading over time.

However, this technique normally requires regular calibration of the inclinometer. Inclinometers are usually not interchangeable as each probe has own characteristics. Since this technique measures the tilt of the borehole, errors recorded at a deeper depth of the borehole will impact on the results at shallower depths.

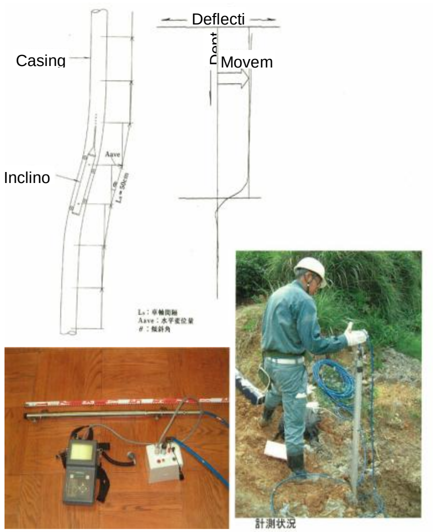


Figure 20 - Inclinometer equipment and measurement

When the borehole is not deep (eg, less than 10m deep), the pipe stain gauges may be an economical alternative technique to investigate the location of the slip surface. In this technique, a series of pairs of strain gauges attached to the PVC pipe (typically 1m depth interval) are installed in the borehole. The configuration of these pipe strain gauges is based on the Wheatstone bridge concept. The direction of the pipe strain gauges is aligned with the landslide movement. The void between the borehole walls and the PVC is filled with cement or other materials. Since a depth interval of the pipe strain gauges is typically 1m, the pipe strain gauges provide a discrete deformation profile along the borehole. Typical pipe strain gauge configuration and results are shown in Figure 20.

It should be noted that the pipe strain gauge ahs short lifetime (up to 3 years). A great care is also required not to damage the strain gauges and cables in particular during the installation. Moreover, the maximum monitoring depth is limited since each strain gauge pair has one set of cables and accommodating a number of cables in the clearance between the borehole and the PVC pipe could be an issue particularly when in deep boreholes. For above-mentioned investigations, boreholes are required to be drilled in a way which allows execution of for the slip surface monitoring. These boreholes must be sufficiently deeper than the depth to the potential slip surface.

Groundwater Investigation

The groundwater is one of the key parameters affecting the stability of the slope. It is of importance to obtain groundwater data at all boreholes together with rainfall information.The use of an automatic monitoring system which deploys the vibrating wire piezometer is desirable for the continuous measurement of the groundwater in the landslide project. This type of piezometer uses a vibrating wire pressure transducer to measure the pore water pressure of the fully or partially saturated soil by responding to changes in water pressure. The sensor is usually installed in the borehole (Figure 21). Existing wells are also good locations to record the groundwater table in the landslide area. The groundwater table can be simply measured by dropping a dip meter or a whistle level meter connected to a measuring tape down the well.

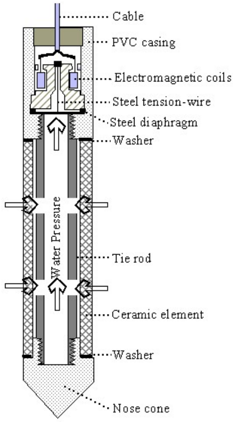


Figure 21 - Typical groundwater monitoring set up and schematic diagram of vibrating wire piezometer (after Indian Institute of Technology 2015)

Standpipe piezometers which consist of a filter tip joined to a riser pipe are also often used in a borehole to monitor piezometric water levels. In this configuration, the zone around the filter tip is backfilled with sand and a bentonite seal is placed above that to isolate the intake zone. The remainder of the borehole is backfilled with bentonite-cement grout. Pore water flows into the standpipe until the pressure equilibrium is reached (Slope Indicator 2015).

Geotechnical Testing

Soil and rock strength can be assessed in-situ or in the laboratory. The strength of the ground can be referred to the degree of load-carrying capacity and resistance to deformation which soil and rock can develop.

Various laboratory tests are available for examination of the soil and rock strength such as the shear box test, ring shear test, unconfined compressive test and triaxial test for soil samples and the point load index test and uniaxial compressive strength test for rock samples.

3.5. LANDSLDIES MITIGATION MEASURES

GENERAL

The simplest means of dealing with landslide hazard is to avoid steep slopes and existing landslides, however, this is not always practical (after USGS 2004). The landslide prevention measures or mitigation measures are often required to prevent the landslide occurrence, stop or reduce the landslide movement to avoid or minimise the resulting damages.
Figure 22 shows typical landslide mitigation measures used in Japan. They are broadly classified into the landslide control measures and landslide restraint measures. The landslide control measures are indirect measures which involve modifications of the natural conditions of landslides (eg, slope geometry and groundwater) and the landslide restraint measures are direct measures which apply resisting force to the landslide (eg, anchors and piles).
In BiH, approximately 50% of landslides are triggered by rainfall events. Therefore the current landslide mitigation measures in BiH are concentrated on control of the surface water since they are relatively simple and economical but effective measures.

Figure 22 - Typical landslide mitigation measures (after Japan Landslide Society 2002)

Depending on whether we want to prevent the potential landslides or to remediate already activated landslides, we perform mittigation or remedial measures. In order to prevent landslides, the following actions should be included:

- reloading (excavation) of the top of the lendslide area,
- reducing the slope inclination,
- backfilling the lower parts of the slope by the construction of retaining structures, or countewight
- regulation of surface waters on the slope including water from the house outlet,
- regular maintenance of water supply and sewage networks,
- regularly discharging the septic tank,
- regular maintenance and cleaning of sewerage channels,
- afforestation and restoration of the vegetation cover.

If the landslide was activated, remedial measures that will prevent the further development of the landslide and the material damage should be performed. Remediation measures can be classified as emergency (temporary) and permanent.

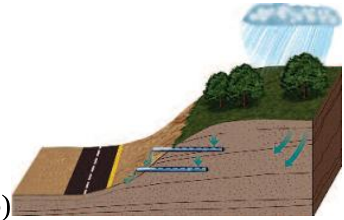
Emergency remediation measures are carried out as temporary measures that are implemented in situations where it is necessary to save people's lives, to enable traffic communication between villages or cities or to provide water, electricity etc. These measures are carried out immediately after observing or reporting the occurrence of the instability of the terrain with the aim of preventing further soil sliding or mud flow, which could lead to additional damage and catastrophic consequences for facilities, infrastructure or human life.

Emergency remediation measures include:

- drainage of surface waters outside the landslide area by excavation of drainage channels or by installing drainage pipes,
- filling the observed cracks by clay (especially in the landslide crest), covering the cracks by the nylon to prevent the further infiltration of surface waters into the slope
- planned landscaping of landslides by excavation of material (redistribution of mass),
- urgent cleaning of the existing channels if it is filled with debris, waste or earth material, in order to allow water to flow freely to the existing collectors, and to prevent the creation of a mini accumulation

- in the shallow landslide, the drilling of wooden or steel „piles“ in order to increase the resistance to additional slipping.

a) 

b) 

c) 

d) and e)

Figure 23 – Emergency remediation measures: a) nylon cover, b) horizontal drains and channels (c); d and e) „piles“ driving

3.6. THE ROLE OF INDIVIDUALS BEFORE AND AFTER LANDSLIDE OCURANCE

The following principles can be listed as the role of individuals in the community in terms of reduced risk of landslide occurrence:

- Do not build facilities without the consentaneity of local authorities (construction and spatial planning services)
- Advise professionals when choosing a construction site for your house
- Do not perform high excavations for (cut slopes) for roads and facilities
- Do not perform uncontrolled deforestation
- To plant different plants on the slopes

- Report to competent authorities and work on repair of damages on pipelines, reservoirs, wells
- In case of uncontrolled flow of water on the slope, excavate channels to route surface water to the nearest collector
- Inform representatives of the local authorities (civil protection service, representatives of the local community) about possible soil instability or cracks on the ground surface around facilities.
- Observe the flow of surface water and together with representatives of civil protection, work on the construction of surface channels for water controlling, filling of observed cracks with clay material, etc. These measures with temporary emigration can prevent a greater disaster (human casualties and complete demolition of facilities). After the end of the state of natural disaster, permanent remediation measures can provide stability of facilities and infrastructure.

The following tips are suggested to the population at the moment of landslide occurrence
- Stay away from the landslide area
- Ask for expert advice (geotechnical engineers, geologists, structural engineers)
- Help vulnerable neighbors who need help
- Report to the competent local authorities about damaged power lines, buildings and infrastructure facilities

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4. DROUGHT

4.1. INTRODUCTION

One of the natural phenomena that can change the climate system is drought. Like floods, diseases or hunger affect society regardless of the level of their economic development. No country is protected from the impact of drought on the production and supply of food and water. For industrial, richer countries, drought is largely an economic problem. In the rest of the world, especially in poor countries, drought can also lead to the loss of human lives. Although it can not be prevented, there are ways to have negative effects drought on people and their good downturn [3].

The drought represent extreme climatic events that can cause significantly greater negative consequences and in significantly wider areas than other natural disasters such as: floods, earthquakes, volcanic eruptions, large forest fires, tsunamis, landslides, etc. Drought destructively and in the long run affects ecosystems, and therefore all aspects of the environment [1].
The biodiversity of regions affected by drought is particularly affected. From an ecological point of view, one of the most serious, most obvious and the most severe consequences of drought is the creation of dry areas and the spread of deserts. This process has accelerated rapidly in the twentieth century as a result of the interplay of rapid demographic development, the negative impact of work
man (cutting forests, replanting land use and organizing intensive but not sustainable agricultural production) and climate change and / or variability on the planet, global warming first and foremost. Drought occurs slowly and rarely causes rapid loss of human life. Due to the phenomenon of drought caused by drought, the losses of the human population, and especially flora and fauna, are in some areas more drastic than any other natural disaster[2].

The World Meteorological Organization (WMO, 1992) defined the drought through several phenomena [7]:

- prolonged absence or accentuated precipitation deficiency,
- a period of unexpected dry weather in which the lack of precipitation causes a serious hydrological imbalance,
- deficiency of the precipitating water caused by a certain activity.

CHARACTERISTICS OF DROUGHT

The onset of drought is becoming increasingly common throughout the world and affects developed as well as undeveloped countries. So far, scientists have not found a more reliable method for safe forecasting of drought so that it is not possible to predict predictive approach and its forecast in real time. But regardless of the above, following and analyzing numerous meteorological, hydrological and hydrogeological parameters of drought, it is nevertheless possible to observe, and in some ways predict. In contrast to other natural disasters, drought appears slowly, takes a long time, and involves large areas, although its spatial distribution can not be accurately located in advance. Drought happens seldom, rarely causes rapid and dramatic loss in human lives, but due to droughts caused by drought, as a direct consequence, losses in human and animal populations are sometimes more drastic than any other natural disaster [3].

Drought represents a long-term and regionally comprehensive phenomenon of the amount of all types of waters lower than the average. It can be characterized by amounts of precipitation smaller than average, but also re-allocation of precipitation during the year, different from the usual distribution in the region. Drought is significantly affected by increased (above average) air temperatures. The drought is characterized by less than the average quantities: (1) surface waters (flow and / or water levels); (2) the level of groundwater; (3) moisture in the soil, etc [5].
Deficit of water as a cause of natural disaster:

- It can occur when in the conditions of an unsuitable hydrological regime at the water sources there is an extremely small water of the lower rank of the occurrence of small water from the intended for the given purpose,
- ie, when the yield of the source is reduced, so that the minimum reduced specific consumption can not be ensured in the long run (it is valid for the organized activities of public water supply systems, as well as for individual and group solutions).
- It can occur when there is a breakdown in the system, so there is no alternative solution over a longer period.
- It can occur when an incidental pollution of the spring or water course that feeds it occurs through the prescribed measure and in the longer term, which causes the exclusion of the sources from the water supply system.

TYPES OF DROUGHT

Before drought analysis, it is first necessary to define what is meant by the term "drying". For meteorologists, these are periods whose total precipitation is well below the average; In agriculture these are periods in which soil moisture is significantly below the average and insufficient for the growth and development of agricultural crops, and for hydrologists they are small flows on rivers and extremely low water levels in accumulations that last for a long time.

Drought can be divided into four groups [4][6]:

- **Meteorological -** Meteorological drought is caused by a reduced amount of precipitation relative to the perennial average or complete absence of precipitation over a certain period of time. Meteorological drought can be rapidly developed and abruptly stopped;
- **Hydrological -** The precipitation deficiency over a long period of time affects surface and underground water supplies: the flow of water in rivers and streams, to the level of water in lakes and to the level of groundwater. When the flows and the levels of reduction are concerned, the hydrological sushi is discussed. The start of the hydrological drought can be delayed several months for the beginning of meteorological drought, but also lasts after the end of the meteorological drought;
- **Agricultural -** occurs during the vegetation period when soil moisture and precipitation are insufficient to allow plants to grow normally and grow. Due to the intensive evapotranspiration, surface and then deeper soil layers are dried, causing water shortages in plants (winter, spring, summer and autumn drought differ) and
- **Socio-economic drought -** occurs when water shortages start to affect people, or when needs for water are greater than the ability to comply with technical measures.

The primary cause of drought occurs in the absence of precipitation in the wider area over a longer period of time. This type of drought is called meteorological drought. The water deficit from the atmosphere is further transmitted through the hydrological cycle causing all other and very different types of drought. In interaction with large amounts of evapotranspiration caused primarily by high air temperatures (higher than

normal for the analyzed region), as and above all with frequent and strong winds, there is a lack of moisture in the soil. Their interaction leads to the appearance of a lack of moisture in the soil, which significantly affects the reduction of conventional agricultural production, but also on the occurrence of various types of soil erosion and, finally, the formation of the desert. This type of drought in interaction with meteorological drought is the main cause of agricultural drought. This term is used in cases where soil moisture levels are insufficient to support crop development. Insufficient (below-average) storage of groundwater reserves, water in open watercourses, natural and artificial lakes causes the appearance of hydrological drought. More recently, the concept of ecological drought is increasingly being considered. It binds to the lack of water that causes stress in the ecosystem and negatively affects the life of plants and animals.
With regard to the effects of drought on economy and society, the notion of socio-economic drought should be mentioned. Negative economic consequences of drought are most strongly felt in densely populated areas where industrial and agricultural production is developed. Human activities based on the use of large quantities of water, especially for irrigation purposes, excessive pumping of underground and surface waters intensify the development of drought or even cause them [4].

Figure 1- Hydrological drought – Trebižat River, August 2017.
(Source: https://www.bljesak.info//)

Figure 2- Agricultural drought (Photo: BUKA / E.P. /)

DROUGHT INDICATORS

In order to compare droughts that have occurred in different parts of the world and in different periods throughout history, a numerical drought measure is required. Such a universal index is not easy to make because of the different definitions of drought mentioned above. Also, due to the complexity of this phenomenon, no index is capable of describing the drought completely. A number of different indexes have been created and used over the years, often for a limited geographical area, but they have been used elsewhere. Often, index creation is done directly with data and mathematical-physical index formulation, but without asking a few basic questions such as: "What is the purpose of the index?", "Who are the users?" Or "What kind of information do users require from the index?" [5]. However, there are also good examples of drought index development, such as the development of a standardized precipitation index of the SPI (Standardized Precipitation Index). SPI was defined by McKee, Doesken and Kleist in 1993 (Redmond, 2002) with the ability to (a) recognize and emphasize that the accumulated precipitation can be at the same time high and lacking by observing different time intervals; and (b) that it can answer four questions important in practical purposes [8]:

- What is the absolute amount of precipitation (mm),
- How much is the deviation of the absolute quantity from the mean (mm),
- How much is a relative deviation from the mean (%),
- What is the probability of occurrence of different quantities of precipitation (percentiles).

In order to determine the duration, intensity and frequency of drought, there is still a large number of indicators of the drought index. Drought indexes are used in numerous sizes: amount and precipitation, water level and groundwater level, imprint, air temperature, evapotranspiration, wind, humidity. The most frequently used drought indices are [9]:

- SPI (Standardized Precipitation Index),
- PDSI (Palmer's dry weight index),
- SWSI (Surface Water Supply Survey),
- SPEI (Standardized Index Evapotranspiration Index).

4.2. DROUGHT IN BOSNIA AND HERZEGOVINA

Drought can be presented in two ways: over the amount of water missing in soil in mm and through the relationship between actual and potential evapotranspiration (SET / PET) with the so-called drought coefficient [8]. The average annual water deficit in the soil in Bosnia and Herzegovina is about 125 mm, with the largest in the southern parts (300 mm), significantly smaller in the northern (100 mm) and the smallest in the central parts (50 mm). Agriculture must be protected not only from average droughts but also from those occurring once in ten years. Therefore, we must take into account the incidence of drought.

The highest coefficients (4.0) are in those areas (central) where we have the lowest average values. In contrast, the lowest coefficients (1.67) are in those regions (southern) where the average values are highest. In considering drought, atmospheric and soil droughts are also taken into account, using the water balance method of the soil [12].

FREQUENCY OF DESTRUCTION AND DAMAGE OF DROUGHT

The greatest risk of drought in Bosnia and Herzegovina is in the northeast and southwest, in the last 50 years. Seven dry periods have been recorded.
It was found that the strongest drought occur in the area of Mostar, where in 1952 a catastrophic drought was recorded with an annual water deficit in the land of over 400 mm. Very mild droughts have the Bihać area, or they are not at all. Other sites are between these two [12].
The descending order of drought that occurs once in ten years would be like this: Mostar> Bijeljina> Brod> Tuzla> Sarajevo> Livno> Banja Luka> Bihać

Table 1 - Annual water deficit in soil in mm [12]

Lokalitet	Godišnja deficijencija vode zemljišta u mm					
	0	1 -100	101 - 200	201 - 300	301 - 400	>
	Skala intenziteta					
	Nema suše	Veoma blaga suša	Blaga suša	Jaka suša	Voma jaka suša	Katastrofalna suša
Bihać	17	10	3	0	0	0
B. Luka	12	12	4	2	0	0
Brod	4	8	13	5	0	0
Bijeljina	3	6	13	7	1	0
Tuzla	12	13	2	3	0	0
Livno	6	17	5	2	0	0
Sarajevo	8	11	10	1	0	0
Mostar	0	8	9	10	2	1

Plant requirements define the concept of drought and it is not uncommon for a hydrological anchor time to cause drought as a natural disaster. Depending on climatic characteristics of the climate, crop rotation (one, two or more crops per year), drought can occur in different seasons and different intensities. It does not make any difference whether the drought destroys whole sowing or only reduces yield. Therefore, in the Mediterranean climate, the period of drought can last from 5 to 6 months per year, and in the karst fields and northern parts of the Federation of Bosnia and Herzegovina in the period August - October (3 months)[12].

The total moisture deficit depends on climate and culture and ranges from 3 to 6,000 m / ha annually, and in the northern part from 1,500 to 4,000 m / ha per year. In the total balance sheet, a total of 120 to 240 million m3 of water should be provided on a regular basis, while in the rest of the Federation of Bosnia and Herzegovina, 300 to 600 million m3 of water should be provided.
Natural disasters would occur if in the drought years 120 to 300 million m3 of water is not provided for around 230,000 ha once in 10 years or less, and in more cases damage to water deficits would manifest itself in the reduction of yield of 5-30% in some cultures and certain areas. The drought intensity is most often estimated to decrease yields, provided that other harmful factors have not been affected. If the yield is reduced to 20% it is a poor sushi, from 20 to 50% on medium sushi, and over 50% of severe drought.

The occurrence of drought is most frequent in the territory of Herzegovina in the summer months. Given this intensity and duration, it is particularly pronounced in southern Herzegovina. In the plain part of the Federation of Bosnia and Herzegovina, the drought is less pronounced than in Herzegovina, while it is least pronounced in the hilly and mountainous part of the Federation of Bosnia and Herzegovina.

In the Posavina Canton area, droughts in the months of March, April and May 2003 were recorded, while daily temperatures exceeded 34 ° C in the first half of May. Drought, which was more intense than that recorded in 2000, is when the lack of precipitation in the summer of 2003 caused a hydrological drought that was due to the reduction of surface and deep water supplies. The anthropogenic period resulted in the starvation of cereals, fodder crops and industrial plants.

The estimated damages from the aforementioned drought in the Posavina Canton area amounted to over 8,000,000.00KM. In addition, in the area of the Čelic municipality, in the Tuzla Canton, droughts were recorded in 2003, so the estimated damages amounted to over 2.000.000,00 KM. It should be emphasized that droughts in the Federation of Bosnia and Herzegovina in the period 2010-2012 caused damage in the amount of KM 156,000,000.00 [12].

The damage from natural disasters can also be attributed to the consequences of long-term water shortages in the water supply and supply system, which appear as a limitation of development, decline in production, occurrence of hydraulic diseases, epidemics, In plant production, drought as a natural disaster occurs when a moisture deficit occurs at the time of preparation for sowing, that is, at certain stages of the vegetation cycle of the plant. In this regard, the overall water balance of the plant plays a decisive role, and only indirectly there is a hydrological balance.

PLANNING PREVENTION AGAINST DROUGHT

Drought analysis based on the SPI index (Standardized Precipitation Index) shows an increase in drought years in the last decade. The basic characteristic of the SPI index is that it can be counted for different time intervals (1, 3, 6, 9, 12, 24 and 48 months). This diversity allows SPI to track short-term water supplies (important for agriculture) and long-term water supplies that are associated with water flows in rivers, water levels in lakes and underground water wells (important for hydrology). 2003 year should be added to the series of years with extreme drought that occurred during the spring and summer [12].

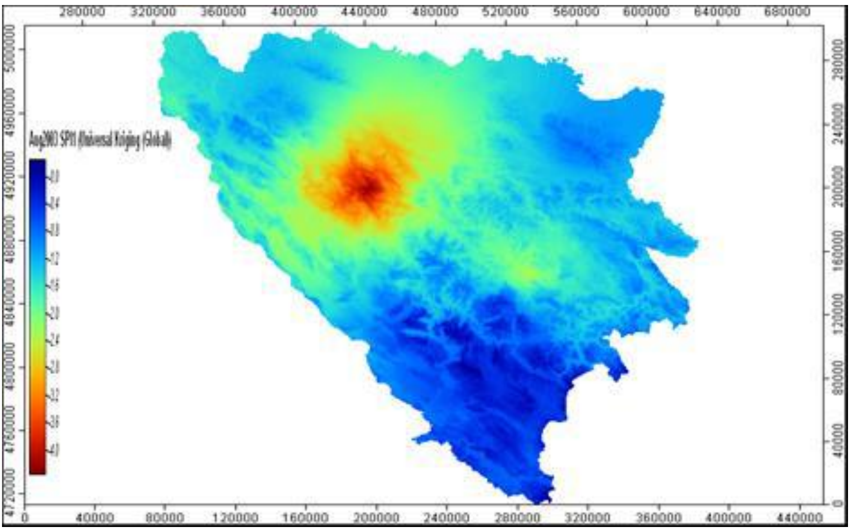

Figure 3 - SPI index for August 2003.[12]

Drought monitoring in Bosnia and Herzegovina has been established within the IPA project DMCSEE (Drought Management Center for the Region of South East Europe www.dmcsee.org, www.dmcsee.eu) co-funded by the European Union through a program of interstate cooperation in South-East Europe.

Monitoring is carried out by calculating the SPI index (ie, the standardized rainfall index) at different time intervals (eg 30 days, 60 days, month, season, year, etc.) and through the monthly display of the FVC and LAI indexes relating to vegetation, and are calculated from the data obtained through satellite LANDSAF.

The SPI index is characterized by simplicity, because it only requires precipitation to calculate it. SPI index analyzes the start, duration and intensity of drought. Otherwise, the index represents the likelihood of realization of the drought, and it can also be used for monitoring of humid conditions or floods. It was developed by T.B. McKee, N.J.Doeken and J. Kleist 1993 at the Climate Center in Colorado [8].

ABOUT VAPORITY MAP

One of the main apses to mitigate drought and planning is to assess who and what is vulnerable and why. Within the DMCSEE project, a map of the vulnerability of agricultural areas to drought has been made. The factors that determine the vulnerability to drought are numerous, and their involvement often depends on the availability of data (for example, land use, coverage, mitigation measures, such as irrigation, social and economic status of the population, etc.) In this case, for obtaining a map of the vulnerability of agricultural areas to drought, the following are included: slope of the terrain, duration of sunshine, precipitation variation coefficient, type of land and land use [12].

This map should serve as an indicator of areas requiring a more detailed assessment of drought risk, which could be of assistance to decision makers in identifying appropriate mitigation measures before the next drought, as well as planners in order to reduce the impact of drought and create the conditions for the sustainable development of the agricultural sector.

4.3. PLANNING THE FIGHT AGAINST DROUGHT

In the last two decades in Bosnia and Herzegovina, the frequency, intensity and duration of meteorological droughts have increased, as a result of higher temperatures, reduced summer precipitation and longer long drought periods. Drought fighting in the past has been reactive, unmanageable and poorly coordinated. A common past practice was the establishment of crisis staffs when a disaster had already taken place. The emphasis of the plans was on an urgent response to drought or crisis management, not crisis management. However, this type of combat for mitigating the consequences of drought only gives boring results and does not affect the elimination of society's vulnerability to drought. It is therefore necessary to have a multidisciplinary approach to address the crisis in the event of drought [13]. When planning the fight against drought, it should be known that irrigation solves only the problem of agronomists and can be generally stated [13]:

- Major socio-economic problems arise due to drought
- There is no data on the change in water quality caused by drought
- There is no correlation between reporting different droughts and mutual conditioning
- Poor regional research
- No water use strategy has a clearly quantified calculation - which is really the amount of water available and for what time period
- What needs to be emphasized is that drought is not only important for farmers but for the entire ecosystem
- Dry soil is more susceptible to slaughter and slopes, losing stability in torrential waters
- Dry years affect the hydropower system
- Lack of studies of consequences analysis, threshold in the system of reacting due to political nonconformity of the definition of natural hazard
- The consequences of drought in Bosnia and Herzegovina are still being treated and not prevented today

- Historically speaking in data and archives, although studies and analyzes show a marked problem with droughts, drought is officially proclaimed only in a few years to avoid the consequences of covering damages
- The lack of water can not be compensated, the existing water must be distributed and there must be a plan and a system of measures.

Many of the damage caused by drought imposes the need to take appropriate measures to eliminate the risk of drought. Drought is a natural disaster, it can not be avoided, but society can reduce its vulnerability through alleviation and readiness, or through risk management.

Therefore, a systemic and institutional fight is required to mitigate the effects of drought, that is, the planning of drought as a form of response to the detrimental effect of drought. The concept of managing disasters should unify all components of disaster management in general and is commonly referred to as crisis management. The activities of this concept indicate that it is necessary to combine many scientific disciplines in the planning of drought to solve problems related to forecasting, detection, response and preparation for future droughts. The disaster management process itself is divided into [11]:

- risk management and
- crisis management.

The risk management process takes place before the onset of drought and presents preparatory - protective works for the occurrence of a disaster. This process consists of the following activities: mitigation, preparation and forecasting and early warning.

The crisis management process occurs when drought occurs and represents activities that should be predicted for a faster and more efficient recovery from drought. Crisis management includes the following activities: drought impact assessment, response to drought, recovery and reconstruction. In the past, the emphasis on managing the disaster was mainly on the response and recovery of this cycle, which explains why society generally went from disaster to accidents, with little or no attention to mitigation, readiness and forecasting.

ACTION PROGRAM
FOR FIGHT AGAINST LAND DEGRADATION
AND MITIGATING THE EFFECTS OF DROUGHT
IN BOSNIA AND HERZEGOVINA

Efforts to combat desertification / land degradation should be an integral part of national development strategies. The national program of measures should define long-term strategies and priorities, along with the necessary legal and institutional frameworks. On the basis of Decision 3 / COP 8, UNCCD member countries in 2007 adopted a 10-year strategy to improve the implementation of the Convention (2008-2018). With this Decision, Member States are invited to implement the Strategy in accordance with their own priorities, including the alignment of APs and other relevant segments relating to the implementation of the Convention. APs are key instruments for UNCCD implementation. They are often supported by action programs on a sub-regional (SRAP) and regional (RAP) level. APs are developed through a participatory approach involving various stakeholders, as well as relevant government agencies, academic institutions and local communities. APs propose practical steps and measures to be taken to combat degradation in specific ecosystems. The purpose of the AP is to identify factors that contribute to the degradation measures and the practical measures necessary for its suppression and mitigation of the effects of drought. AP should determine the appropriate roles of government, local communities and land users and resources that are available and necessary. Among other things, the Action Program (AP BiH) [13]:

a) develop a long-term strategy for combating degradation and mitigating the effects of drought, as well as its implementation plan and integrated into national policies for sustainable development;
b) allows changes in accordance with the resulting changes and is sufficiently flexible at the local level to deal with different socio-economic, biological and geophysical conditions;
c) devotes special attention to the implementation of preventive measures for land that has not yet been degraded or which are only slightly degraded;
d) Improve national climatological and hydrometeorological capacities and early warning devices against drought;

e) promote policies and strengthen institutional frameworks that develop cooperation and coordination, in the spirit of partnership, between donors, governments at all levels, the local population and the community, and provides access to the local population with appropriate information and technology;
f) ensure the effective participation of non-governmental organizations and the local population, both women and men, in particular resource users, including farmers and livestock farmers and organizations representing them, in policy planning, decision-making, and implementation and review of APs at local, state and regional levels,
g) it requires regular reviews and reports on their implementation.

In order to combat degradation, AP describes the general guidelines and mechanisms to be considered in the future. At the same time, AP does not specify the detailed and developed measures to be taken in each specific case, as many of these measures require a consistent scientific review.

4.4. CONCLUSIONS

In our country, until recently, drought did not represent such a big problem as in recent years. In recent years, drought has become more pronounced because we have a temperature rise over a longer period of time. At the same time, it also drains the water that drains our water reserves in the country. Then there is a drought. It is questionable to compare drought only to meteorological and hydrological parameters. The drought should be compared to the negative consequences it caused. This task is very difficult, if at all possible, objectively done. It should be taken into account not only economic damage, but also environmental (especially long-term).

The effects of drought feel everywhere on the planet, but they are extremely differently distributed. They should include impacts on water users, including farmers, industry and cities. As decreasing amounts of water and increased air and water temperatures often result in a decrease in the quality of water resources, this can especially affect the natural ecosystems negatively. It seems that in order to fulfill a complex and very important task of reliable and objective quantitative assessment of the negative effects of drought, science will not be ready for a long time.

Until the ability to meet this key task, but also a number of others related to drought, it would be advisable to avoid "final" and generally panic conclusions that could cause more harm than benefits.

Drought can occur anytime and anywhere on the planet. They can take very different times, and they can affect a wide variety of areas, from those covering only about ten square kilometers to those that span in regions whose surface exceeds several hundred thousand square kilometers.

The most severe consequences are caused by droughts that last for many years, and extend to large areas. Every time there is a drought, there is a need for answering the same questions: (1) What are the damages to (what is the industry, the environment, social stability, etc.) and where? (2) Who should compensate? (3) How should we prepare ourselves to alleviate the damage of future droughts?

Bearing in mind the above, some general conclusions can be drawn to prevent the risk of drought as follows:

- In order to prevent the risk of large-scale drought damage that could endanger people and property, it is necessary to ensure the reduction of losses in water systems, reconstruction and faster flow through the system.
- By introducing new technologies in production processes, reduce the need for additional quantities of water with the same quality improvement of the used and discharged water (large industrial consumers, irrigation).
- Ensure sufficient quantities of water for irrigation of arable land, thus creating conditions for intensive agricultural production.
- Ensuring additional quantities of water from available or prepared new sources to improve the population's supply through already covered public water supply and extending them to a larger number of settlements where the flow of inflows into the reservoirs occurred.
- Protect and develop existing sources and find new, to ensure additional water quantity in vulnerable areas.

- Carry out the acceptance and capture of large waters, when they are available and made available under conditions of need, through the construction of artificial reservoirs, which, in addition to electricity generation, create conditions for tourism development, protects from floods of the downstream area, provides water for irrigation.
- Plan and ensure the transport of water by tanks to remedy the needs of the most vulnerable consumers, for which it is necessary to systematically procure and preserve a sufficient number of means of transport.
- It is necessary to provide spare quantities of water, construction or installation of water tanks, etc. for effective fire protection (especially in the open area).

The general goal of preventing and reducing the risk of drought is to improve the timely response to drought in Bosnia and Herzegovina and to improve the willingness to manage drought by introducing new tools for monitoring and assessing drought risk. Specific objectives are:

- Establishment of operational monitoring of drought for the purpose of more accurate and effective drought prevention, using all available measured data and satellite products and modern web sites,
- Preparation of a transnational protocol for the development of a risk assessment of drought, i.e. by combining the currently existing different methodologies for risk assessment,
- Development of the Strategy for Improving Timely Response to Drought by Equalizing the Decision-Making Process in the Field of Interest to make the Drought Management (Monitoring - Impact Assessment - Response - Recovery) readily efficient.

FHMZ plays an important role in preventing and reducing the risk of drought, and it is necessary to actively participate in achieving all goals, as well as in education of end users and decision makers on risk management and possible consequences from drought in the FBiH.

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