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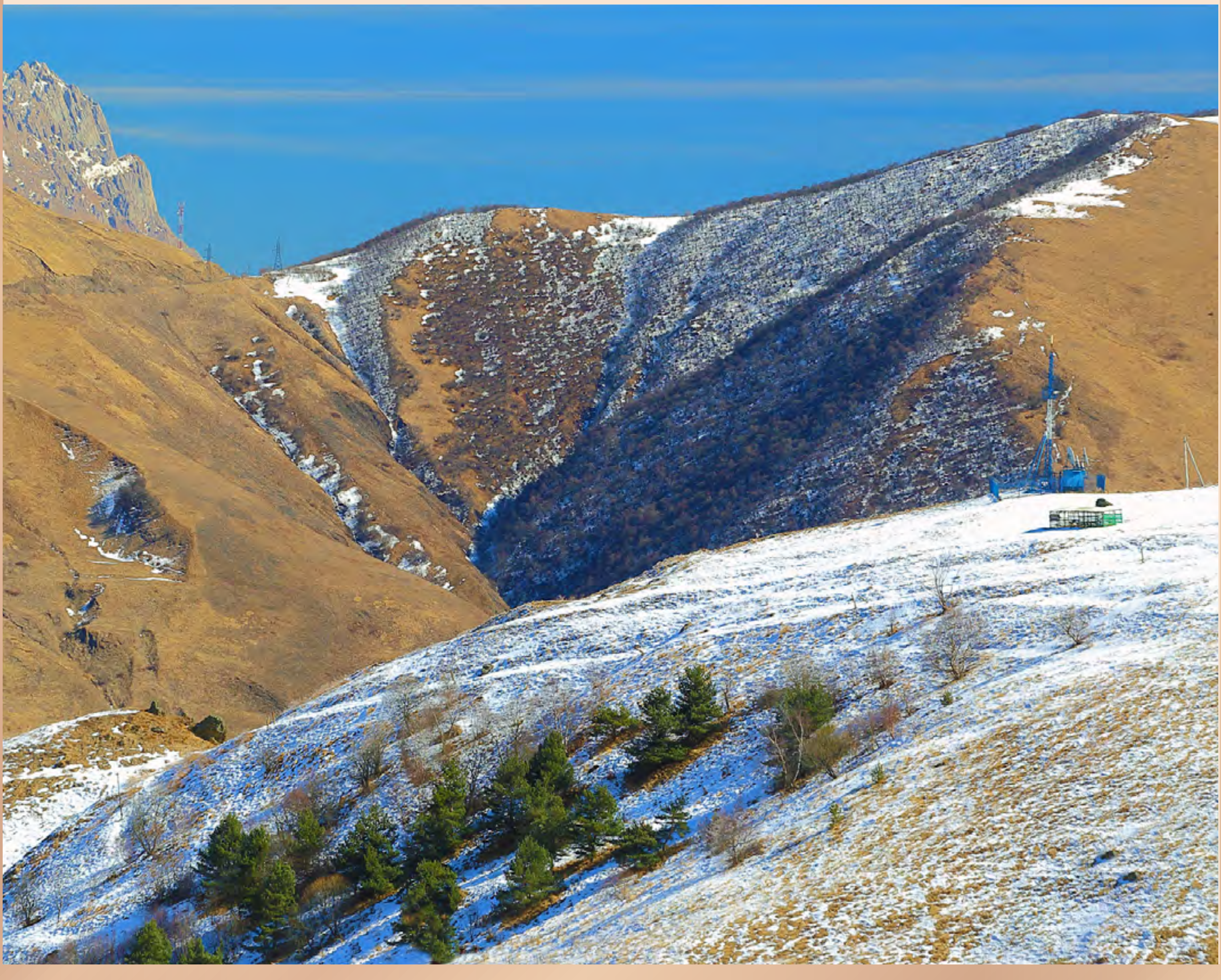

СОДЕРЖАНИЕ

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НАШИ ГОСТИ

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NATURAL HAZARDS AND DISASTERS IN MOUNTAIN AREAS

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Mountainous and coastal areas are the most affected regions for natural hazards. Certain mountainous areas are vulnerable to landslides but have also been affected by earthquakes. When an earthquake occurs in such areas, the risks for a landslide to occur grow tremendously. Natural hazards cause huge damage in the world and kill many people each year. The concept of natural risk can be successfully used for natural hazards analysis and reduction.

Mountain and foothill areas of Northern Caucasus are located in the zone of alpine tectonomagmatic activation of Greater Caucasus and they characterized by intense geodynamic processes, the presence of active volcanoes, pulsating glaciers high seismicity (9-10 points) and broadest development of geohazards with different genetic types.

The problem of seismic hazard and risk assessment of the North Caucasus is genetically related to the activity of the Greater Caucasus, the strongest seismic events of which play a determining role for some regions of the North Caucasus.

Keywords: geological hazards, volcano, earthquake, landslide, seismic hazard, seismic risk, insurance.

NATURAL HAZARDS AND DISASTERS

Natural hazards are potentially damaging physical events and phenomena, which may cause the loss of life, injury or human life disruption, property damage, social, economic, and political disruption, or environmental degradation.

Natural hazards can be divided into different groups: geological, hydro-meteorological, climatological, outer space, and biological hazards.

Natural hazards can be single, multiple, regional and global in space. Each natural hazard is characterized by its location, intensity and probability.

A disaster is a serious disruption of the normal functioning of a society causing widespread human, material, economic or environmental losses. A disaster results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk, and exposure.

For the last 35 years the frequency of the disasters associated with natural hazard events has been steadily increasing. An average number of 405 events per year was registered by Munich Re in 1980-1989, 650 events in the 1990s, 780 events for the period of 2000-2009, and more than 800 events in the 2010s [Wirtz et al., 2014]. Figures 1-6 shows that total number of disasters increase, but number of geological disasters has not been much changed for the last 30 years compared to the number of hydro-meteorological and climatological events. Victims and economic damage increase drastically.

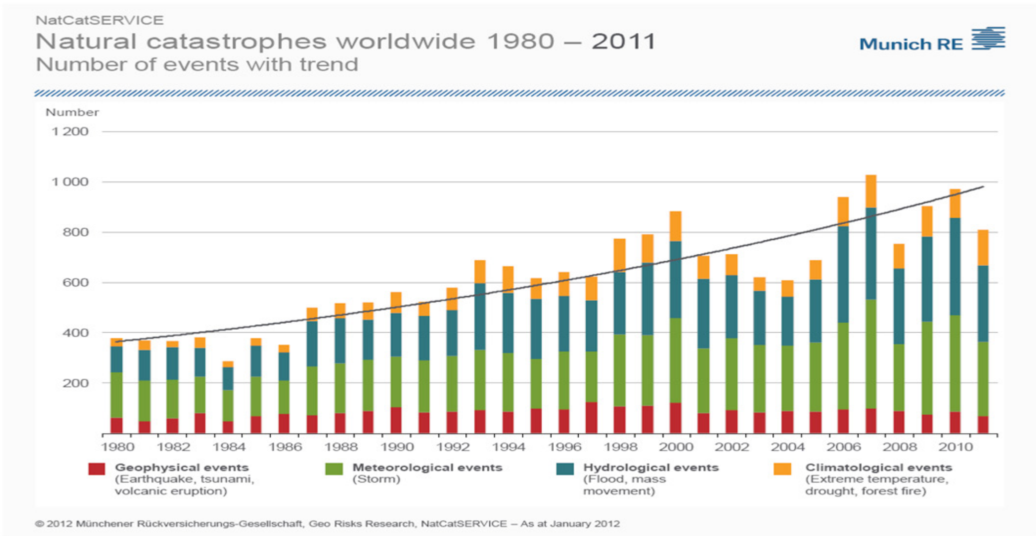

Fig. 1. Annual number of disasters associated with natural events from 1980 to 2013. 1: red color marks geological events; 2: green meteorological events; 3: blue hydrological events; and 4: orange climatological events (NatCatSERVICE, Munich Re, 2014).

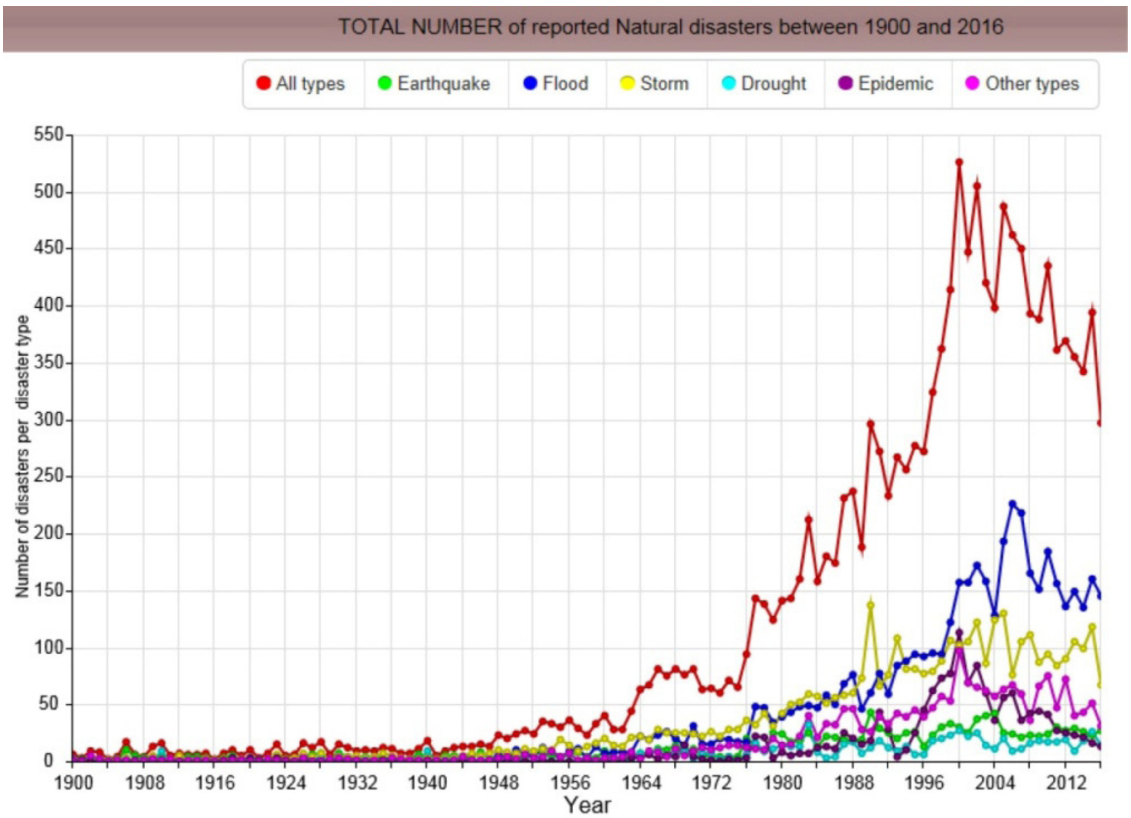

Fig. 2. Total number of natural disasters, 1900-2016. http://emdat. be/.

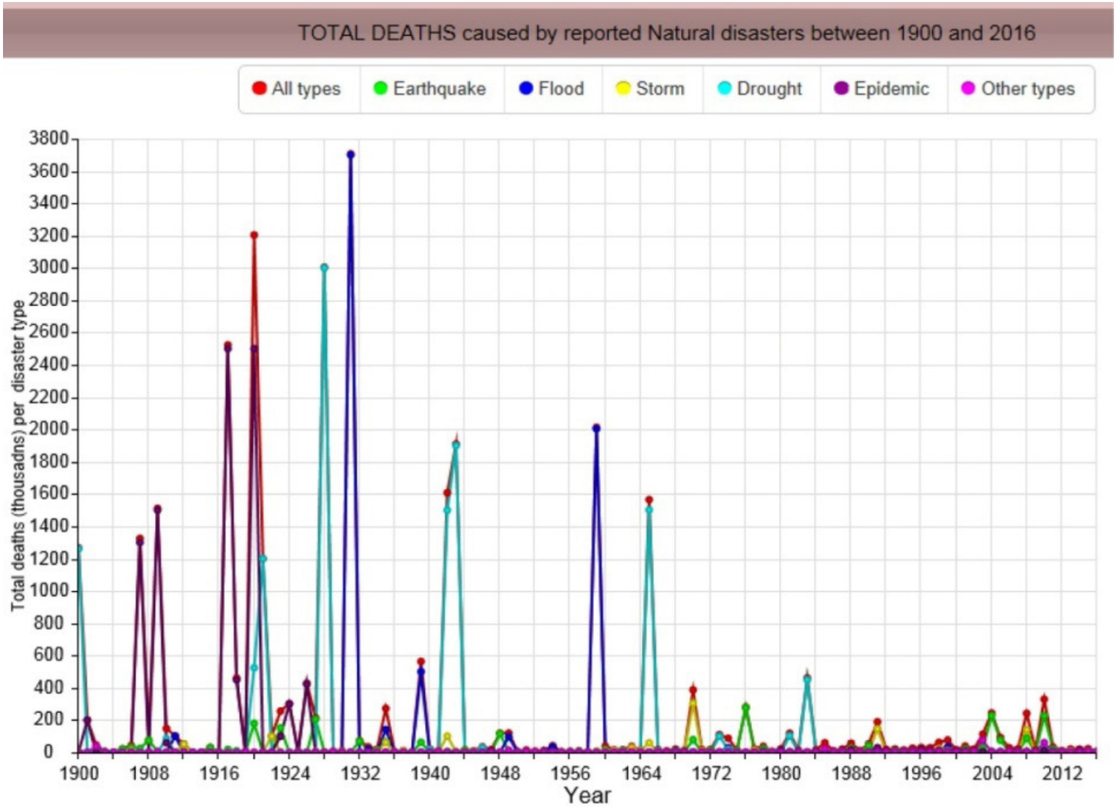

Fig. 3. Total deaths caused by natural disasters, 1900-2016. http://emdat. be/.

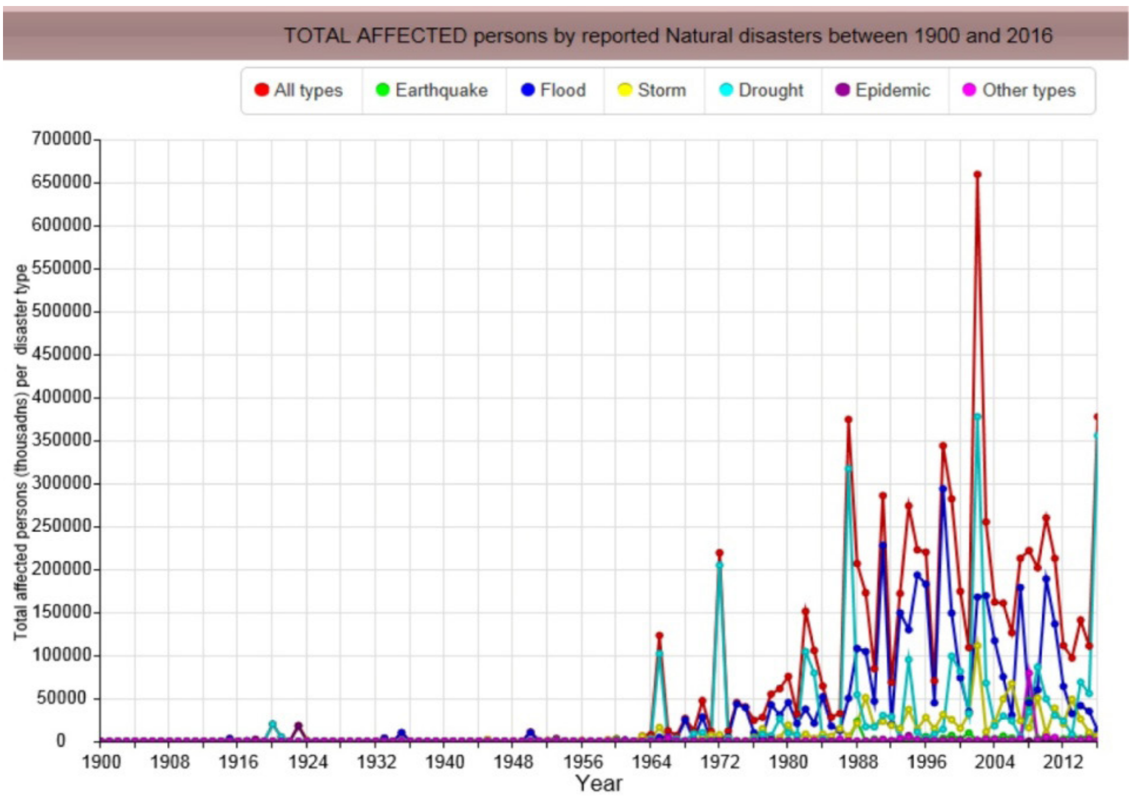

Fig. 4. Total affected persons by natural disasters, 1900-2016. http://emdat. be/.

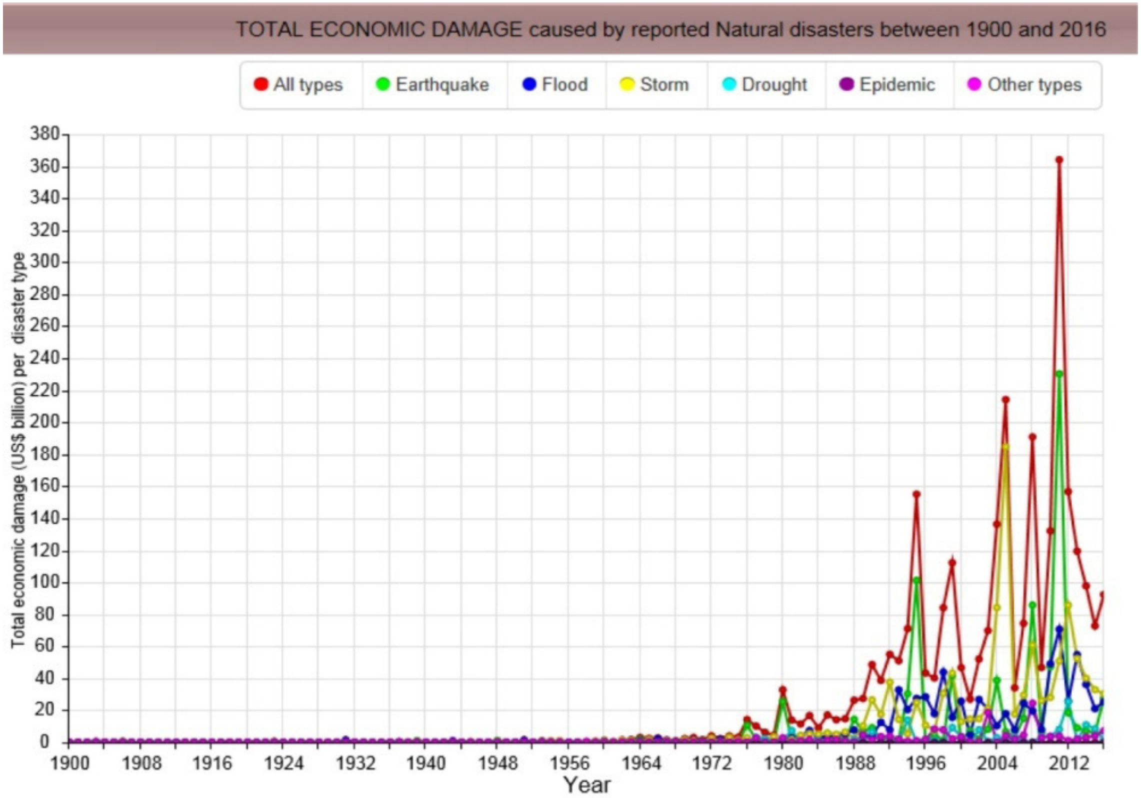

Fig. 5. Total economic damage caused by natural disasters, 1900-2016. http://emdat. be/.

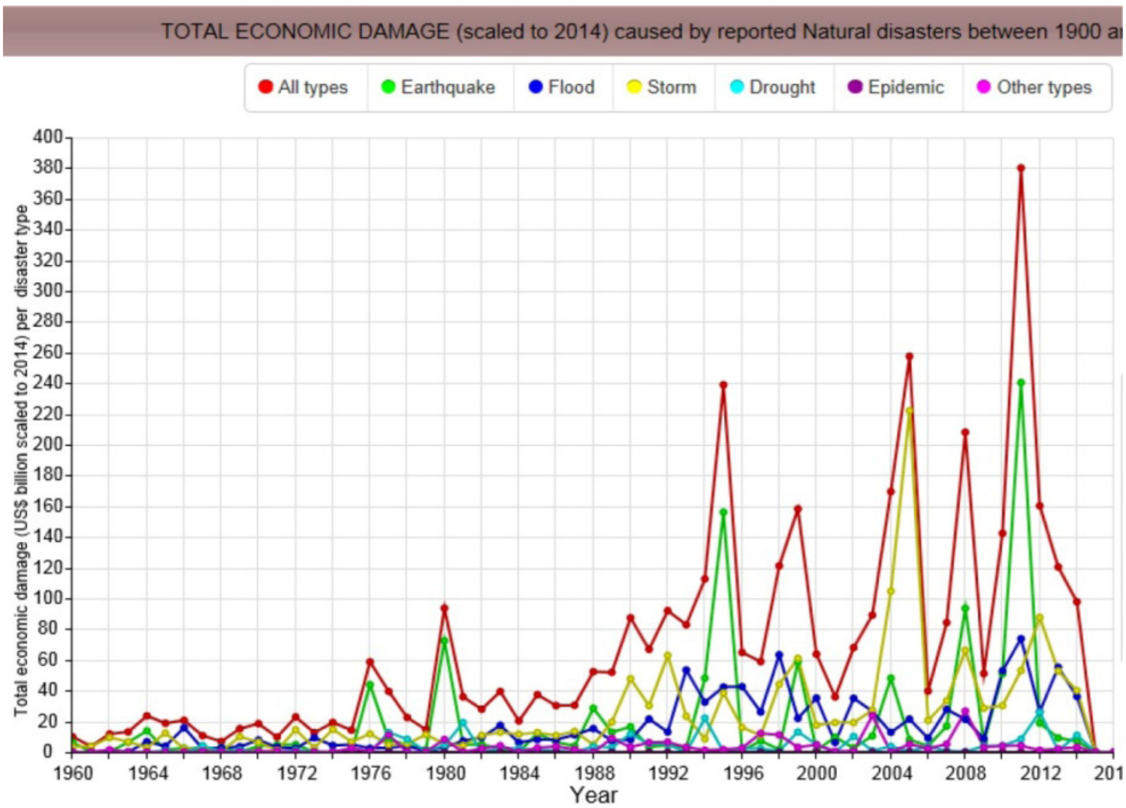

Fig. 6. Total economic damage (scaled to 2014) by natural disasters, 1960-2016. http://emdat. be/.

Earthquakes, volcano eruptions, tsunamis, curst, suffusion, coast erosion, and landslides belong to geological hazards [Kutepov et al., 2002; Osipov et al., 2002; Svalova, 2011a].

According to the global risk analysis carried out by the World Bank, an area of about 10 million km^2, the equivalent of 7,5% of the total area of the planet, is estimated to have a 10% probability of peak ground acceleration (intensity of ground shaking) of at least 2 m s-2 in a 50-year period. This area is inhabited by approximately 1,2 billion people, that is 20% of the world population.

Volcanic activity is concentrated on about 0,4 million km^2 with a 93 million population potentially affected, particularly in countries such as Iceland, Japan, the Philippines, Indonesia, the United States, Mexico, Central America, Colombia, Ecuador, and Chile.

3,7 million km^2 of land are susceptible to sliding, while the population exposed is in the order of 300 million. Areas of high risk of landslides are inhabited by 66 million of inhabitants, occupying a land surface of 820,000 km^2.

Mountainous and coastal areas are the most affected regions, but that does not mean that the other areas are safe.

Landslides cause huge damage in the world and kill many people each year. Casualties are caused by rock slides, rock falls and debris falls. In order to know this phenomenon better, and eventually protect themselves from its destructive action, people should be aware of how landslides are formed and how they act [Edison et al., 2016; Elayaraja et al., 2015; Ganapathy, Rajawat, 2015].

The word “»landslide» describes different processes that have as a result the movements of materials like soil, rock, earth, mud, debris, artificial fill, snow, ice, ash, combination of these materials and others.

When these materials start moving, they may be falling, toppling, sliding, spreading, flowing and others. According to the moving trajectory the landslides could be rotational or translational. There are some specific types of slides or mass movements as lahars, solifluction, avalanches, glaciers and others.

Landslides are associated with mountainous areas, but they also affect low relief areas. In this case the trigger factors could be failures determined by building or roadway excavations, collapse of mine piles, slope failures associated with quarries, lateral spreading landslides, river bluff failures and others.

Depending on the location and type of human activity, the landslide effect could be lessened. People should know hazard zones and avoid activities like digging in such areas.

14 million of people are exposed to tsunamis. The major potentially affected areas are located along the coasts of countries facing the oceans and seas (UNISDR 2009).

Millions of human lives are lost due to earthquakes and volcano eruptions, and property damage has exceeded hundreds of billions USD. It is not possible to make reliable earthquake forecast now, but there exist a few success examples. It is possible to estimate the vulnerability of territories to the possible earthquake hazard and means are available to develop earthquake resilient societies.

‘Earthquake early warning’ is the rapid detection of earthquake in progress and alerting people of the ground shaking that could be hazardous. Application of this technique has demonstrated its usefulness. Developing earthquake scenarios, as what would happen if an earthquake repeats, where it had occurred in the past, is also very effective in developing earthquake resilient societies.

Societal impacts of volcanic eruptions (e. g., damages, disruptions, severe health problems) are associated with ash fall, lava flows, gases, hot ash clouds, lahars and related hazard to aviation. Predicting of a volcanic eruption is an interdisciplinary science where continuous observation of a number of parameters such as volcanic earthquakes (volcano seismology), changes in ground conditions (geodesy, magnetic studies), ground water (hydrology) etc. provide a clue of the forthcoming eruption.

While the earthquakes, volcanoes or landslides take place on specific areas, the effects of tsunamis are widely distributed in space and time, and consequences can be global, as it was the case of the 2004 Sumatra earthquake-induced tsunami, which affected a number of countries around the Indian Ocean.

A global tsunami warning system was set up to tackle with the challenging problems of tsunami disasters. Also local and regional warning systems generate scientific-based information. Scientific modeling and tsunami forecasting are still to be improved so that the time available between warning and action can be used in the best possible way.

HYDRO-METEOROLOGICAL AND CLIMATOLOGICAL HAZARDS/DISASTERS

Hydro-meteorological and climatological hazards are the most frequent causes of the disaster events among all natural hazards (Fig. 1-6). The most common meteorological hazards are heavy rains, storms, hurricanes, droughts, tropical cyclones, rainstorm floods, heat waves and low temperature disasters. Moreover, meteorological hazards include lightning, tornadoes, dust storms, hail, frost, fog, and haze. Some hazards, such as drought span the weather to climate continuum extending for seasons and even decades. Although extreme weather and climate events occur infrequently, they impose great impacts on environment including socio-economic impacts and livelihood impacts. Adverse impacts from weather and climate extremes can be considered meteorological disasters when they produce widespread damage and cause severe alterations in the normal functioning of communities or societies. The severity of meteorological disasters depends not only on the extremes themselves but also on exposure and vulnerability.

The breakdown of all disasters associated with natural events worldwide from 1980 to 2011 by regions is illustrated in Figure 7. Figures 8-13 show maps of some natural disasters in the world. Almost 2/3 of all fatalities (about 1,5 million) as well as 40% of all events (8,080) occurred in Asia and the Pacific (Australia/Oceania). As far as economic losses are concerned, Asia and the Pacific is also leading with 45% with North America incl. Central America and Caribbean ranks second with 37% of total losses. There is a different aspect of catastrophes in Africa. Although only 9% of all events occur in Africa, more than 1/4 of all fatalities are registered on this continent. A comparison of the loss events and fatalities shows that the regions with economically less-developed countries have more fatalities [Wirtz et al., 2014].

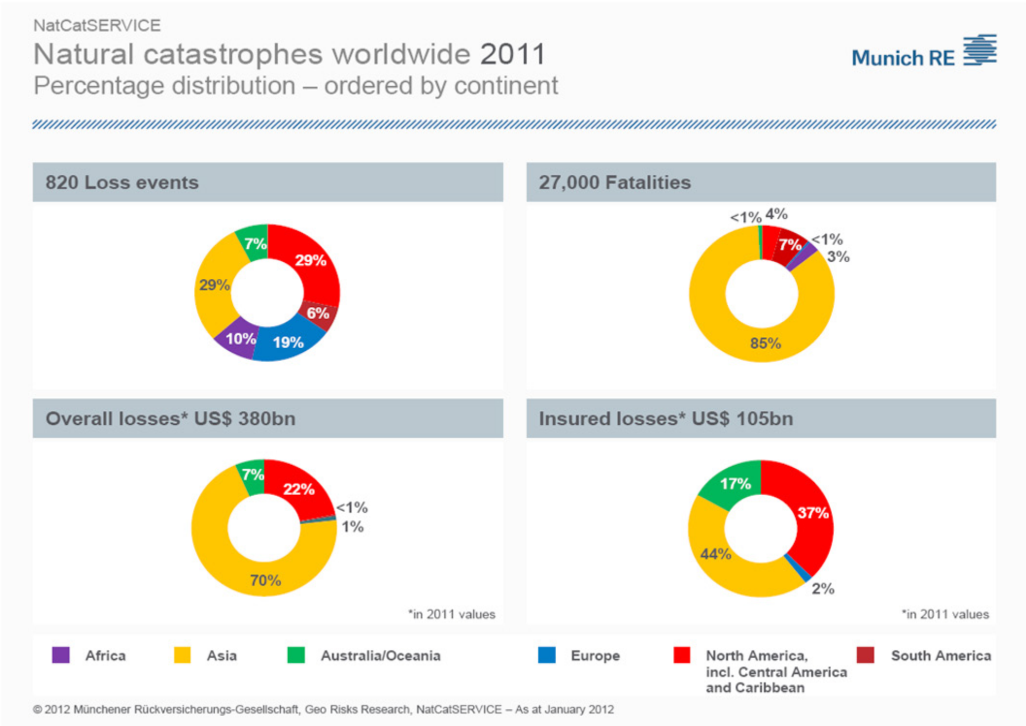

Fig. 7. Regional distribution (in per cents) of loss events (total 20,200), fatalities (total 2,275,000), and losses (total USD 3,530 billion in 2011 values) for 1980-2011 (NatCatSERVICE [Wirtz et al., 2014].

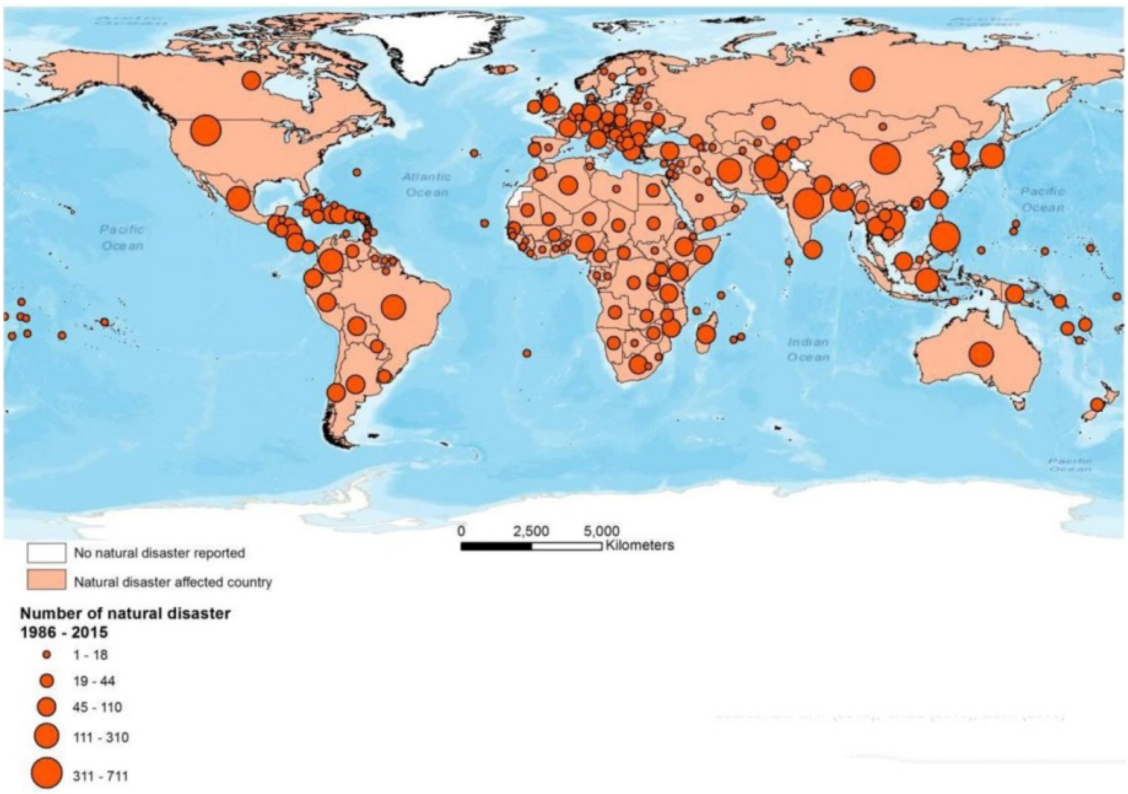

Fig. 8. Number of natural disaster by country, 1986-2015. http://emdat. be/.

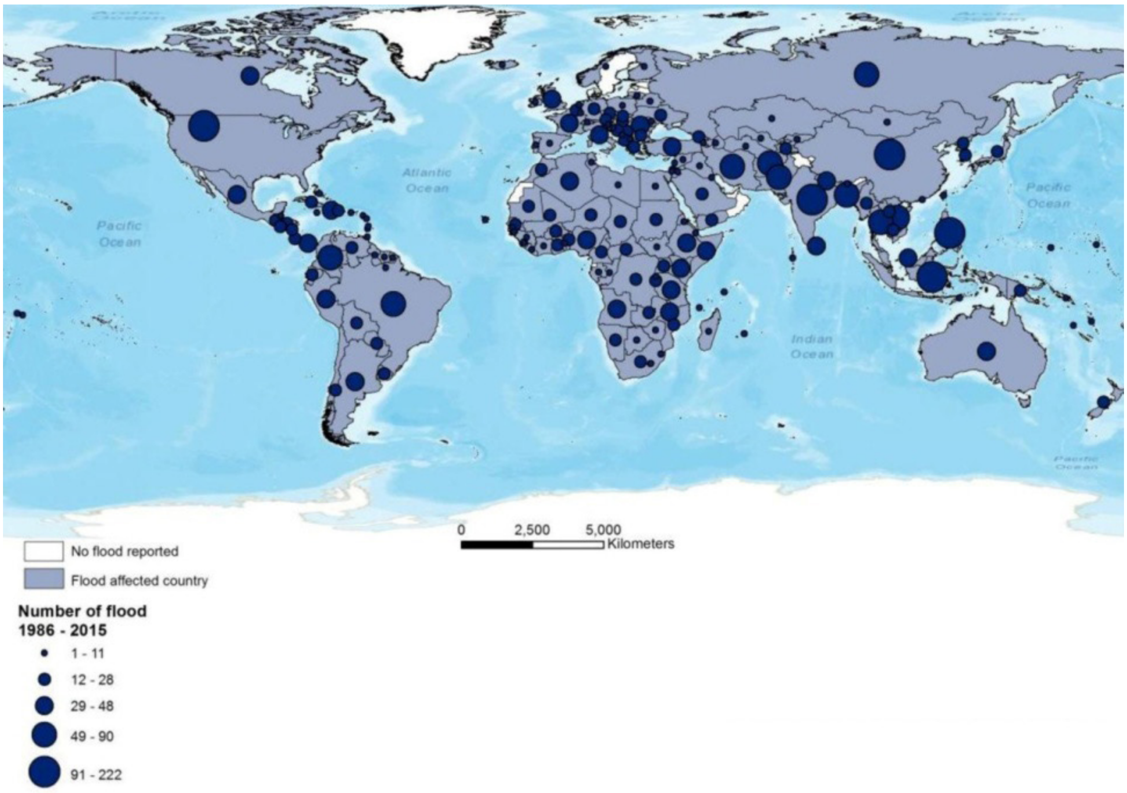

Fig. 9. Number of flood by country, 1986-2015. http://emdat. be/.

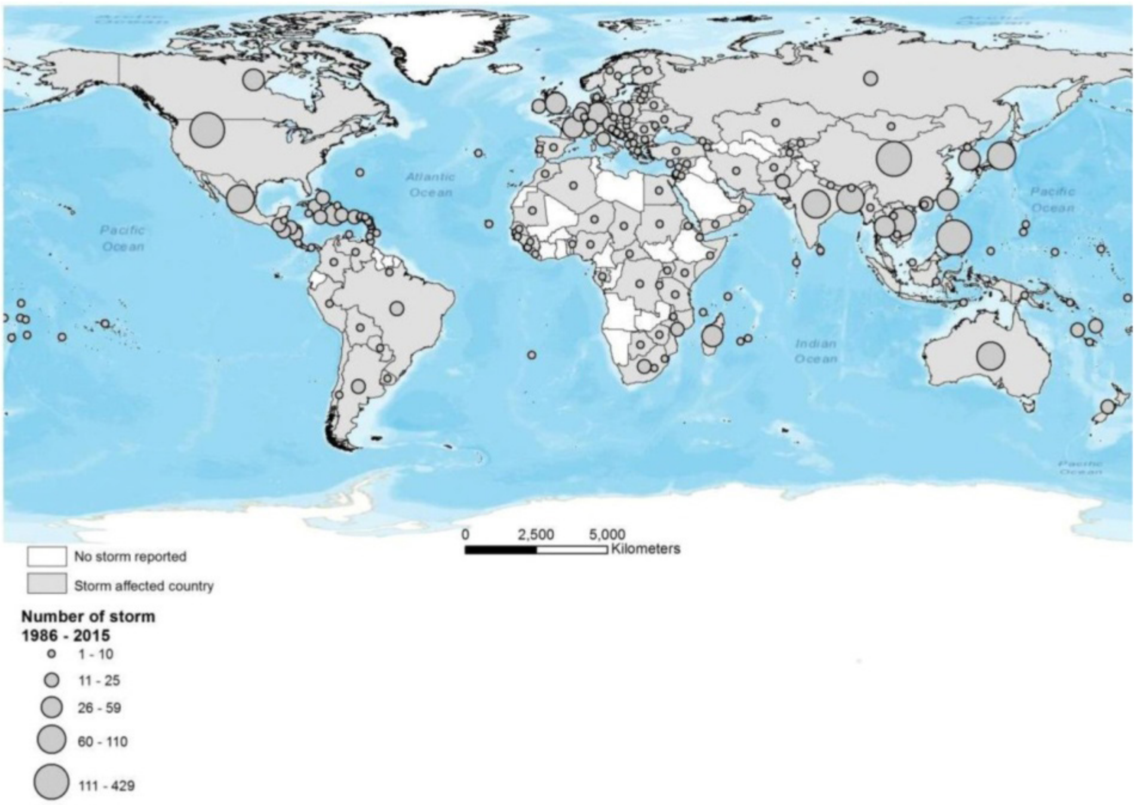

Fig. 10. Number of storm by country, 1986-2015. http://emdat. be/.

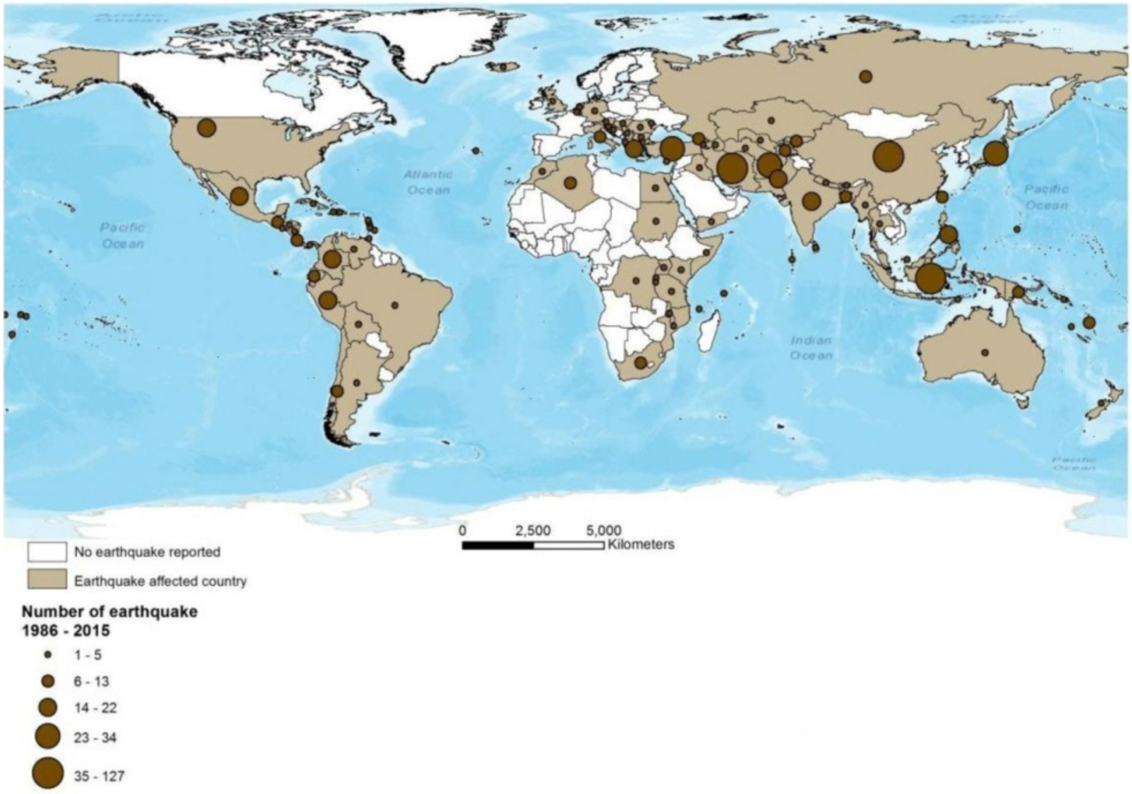

Fig. 11. Number of earthquake by country, 1986-2015. http://emdat. be/.

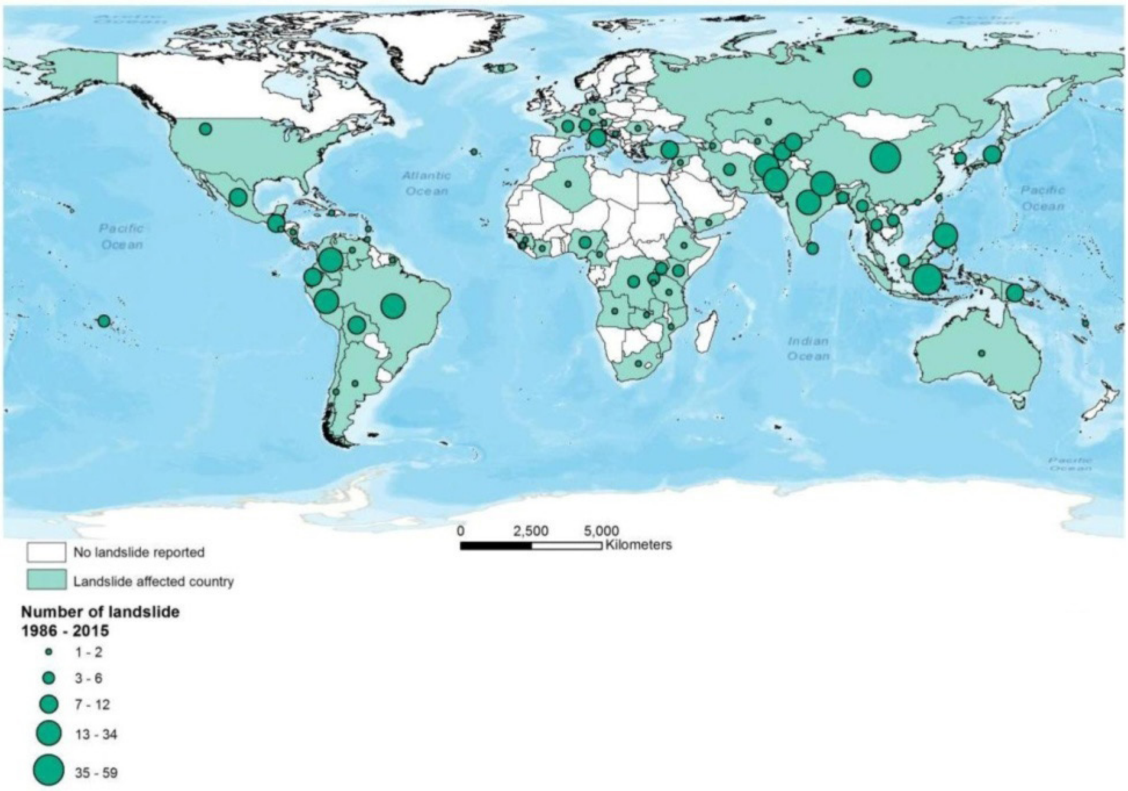

Fig. 12. Number of landslide by country, 1986-2015. http://emdat. be/.

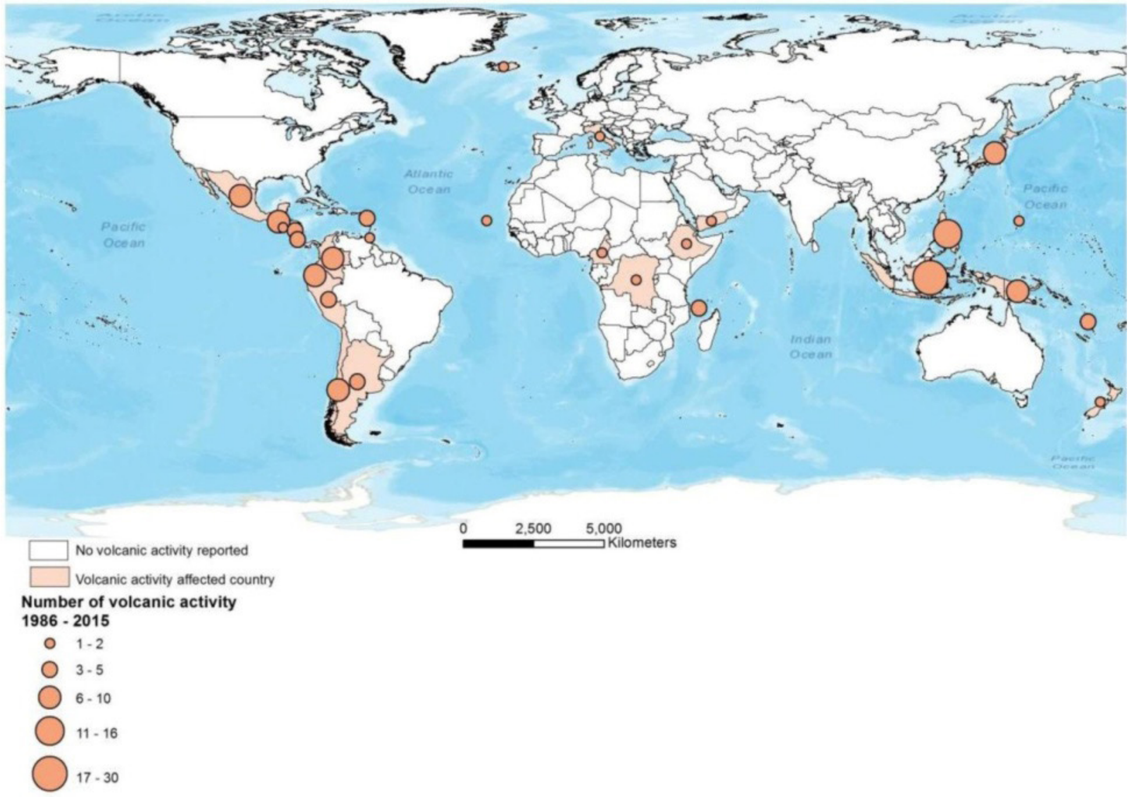

Fig. 13. Number of volcanic activity by country, 1986-2015. http://emdat. be/.

NATURAL RISK

For systematic analysis of landslide hazard it is fruitful to use the notion of risk [Corominas et al., 2014; Rфgozhin, 2003; Slavova, 2011b, 2014, 2016a – c, 2017a, b, 2018; Vranken et al., 2015].

Geological risk is a relatively new and not fully explored concept. There are many definitions of geological risk. And often scientific study or scientific approach to the problem begins with a presentation of the author's position and the choice of the definition of geological risk for the problem under consideration. One of the most common approache defines that risk is the expectation of the damage, or risk is the product of the probability of possible hazardous events on the damage produced by.

The problem of landslide risk management is considered as measures leading to landslides risk reduction. It includes landslides monitoring, mapping, landslide forecast, engineering works, slopes strengthen, insurance and others. Strictly speaking, geological risk management includes:

1) Hazard Identification;
2) Vulnerability evaluation;
3) Risk analysis;
4) Concept of acceptable risk;
5) Risk assessment;
6) Risk mapping;
7) Measures for risk reduction:

– legislative;
– organizational and administrative;
– economic, including insurance;
– engineering and technical;
– modeling;
– monitoring.
– information.

It is the responsibility of the local governments to establish rules meant to reduce the effects of eventual landslides. Land-use regulations and policies are required in areas that are prone to landslides. The absence of such regulations and destructive human activities are among the main factors that favor a landslide.

Whenever a landslide occurs, no matter if it is caused by slope saturation with water, seismic activity or a volcanic eruption, the damages are disastrous. Thousands of households may be swept away or buried in mud and tens to hundreds of people could lose their lives.

This apocalyptic image should make local governments pay more attention to the prevention of such natural phenomena. It is important for a local government to know which areas are prone to landslides and take appropriate measures in order to reduce vulnerability to such hazards.

Vulnerability to landslides depends on location, frequency of landslide events, type of human activity in the area and other factors.

The effects on people and buildings can be lessened if hazardous areas are avoided or if activities in such areas are restricted or deployed under certain conditions. Local governments are responsible for land-use policies and other regulations meant to reduce the risks for landslides to take place.

Exposure to hazards may be reduced if individuals educate themselves on the past history of these phenomena. Departments of local governments that are responsible with planning and engineering may help a lot with their advice.

People can also benefit from the professional services of engineering geologists, civil engineers, or geotechnical engineers, all qualified to evaluate the potential of a hazardous site.

Due to the huge losses that landslides imply, their prevention is of maximum importance for all the people living in the area of hazard. Preventing a landslide from causing material damage and human losses should be a main goal of local authorities.

WORLD CONFERENCE ON DISASTER RISK REDUCTION

The World Conference on Disaster Risk Reduction is a series of United Nations conferences focusing on disaster and climate risk management in the context of sustainable development.

There were 3 Conferences: in Yokohama in 1994, in Kobe in 2005 and in Sendai in 2015. As requested by the UN General Assembly, the United Nations Office for Disaster Risk Reduction (UNISDR- United Nations International Strategy for Disaster Reduction) served as the coordinating body for the Second and Third UN World Conference on Disaster Reduction in 2005 and 2015.

The conferences bring together government officials and other stakeholders, such as NGOs, civil society organizations, local government and private sector representatives from around the world to discuss how to strengthen the sustainability of development by managing disaster and climate risks. The Third UN World conference adopted the Sendai Framework for Disaster Risk Reduction 2015-2030. Previous conference outcomes include the Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters in 2005 and the Yokohama Strategy and Plan of Action for a Safer World in 1994.

The Third United Nations World Conference on Disaster Risk Reduction was held in Sendai, Japan from 14 to 18 March 2015, drawing 6,500 delegates to the conference itself and 50,000 people to the associated Public Forum. Sendai is the largest city of Miyagi Prefecture, in north-eastern Japan. It has a prominent status as it was hit by the Great East Japan earthquake (11 March 2011), 130 kilometres from the epicentre. The conference included discussion of the aftermath of the Japanese response to the 2011 disaster and how Japan's early warning system can save lives when earthquakes and tsunamis strike. The conference included an announcement of a US$ 4 billion fund to prepare for disasters over four years. The conference adopted the Sendai Framework for Disaster Risk Reduction 2015-2030. The Sendai Framework is the first major agreement of the post-2015 development agenda, with seven targets and four priorities for action. It was endorsed by the UN General Assembly in June 2015.

HAZARDOUS GEOLOGICAL PROCESSES OF THE NORTH CAUCASUS

Mountain and foothill areas of Northern Caucasus are located in the zone of alpine tectonomagmatic activation of Greater Caucasus and they characterized by intense geodynamic processes, the presence of active volcanoes, pulsating glaciers high seismicity (9-10 points) and broadest development of geohazards with different genetic types.

In the zone of their impact there are populated areas, economic objects and elements of infrastructure life support (roads, power lines, communication wires).

The economic damage from their annual impact is determined by billions of rubles and it is often accompanied by human casualties.

The negative impact of exogenous geological processes is greatly amplified against the background of actively developing endogenous processes (volcanoes, seismic).

Undoubtedly, among the most hazardous and all-threatening processes, the first place, is taken by endogenous processes which manifest themselves sporadically, but their destructive power is enormous. [Shempelev et al., 2017; Zaalishvili, 2017; Zaalishvili et al., 2017a]

Volcanoes. According to different researchers there are two active volcanoes in the considered territory erupting in historical time – the volcanoes Elbrus and Kazbek.

Remains of Lahars are traced on 50-70 km downstream of the Baksan and Malka rivers, as a result of the Elbrus volcano activity.

The zone of negative influence in the form of flooding is much wider.

The same applies to the volcano Kazbek, in the zone of its impact, is located city of Vladikavkaz.

Geodynamic processes. The mountain system of the Greater Caucasus experiences vertical movements (uplifts) on average 2-3 mm per year. The individual, most active its parts move at a speed of up to 12-15 mm per year. These include the intensively dislocated geological blocks of Elbrus and Kazbek. Moving of individual rocks plates in their contours occurs along the latest tectonic zones, and thus creates enormous stresses in rock formations, which unloading leads to earthquakes and landslides.

Breakthroughs of pond water accumulators. From exogenous and glaciological processes for their unpredictability and the catastrophic effects as the most hazardous should be considered breakthroughs of pond water accumulators occurring in the result of overlapping channels watercourses landslide by mudflow and ice sediments.

Pulsating glaciers. To date, there are 12 pulsating glaciers in the North Caucasus, of which two (Kolka and Devdorak) have intensified several times in the historical period.

In the opinion of most researchers, the effect of pulsation (accelerated motion of ice masses) depends on the accumulation of critical ice masses under backwater conditions. The most typical pulsating glacier is Kolka whose ice masses, reaching critical mass, begin to move at a speed of 100-200 m per day. Depending on the time of year the activation takes place either in a peaceful (October 1969, January 1970), or catastrophic way, with the formation of water-ice-rock mudflows of breakthrough type (1902, 2002).

The most hazardous pulsating glacier is Devdorak that is located on the territory of Georgia, in the case of activation it may block the Terek river (like the events of 1834) and in the event of the breakthrough the water masses can become a source of increased hazard for the downstream settlements, including the city of Vladikavkaz.

Mud flows. The mud flows throughout the territory cause the largest annual damage to the economy and human settlements. In the mountainous part of the Southern Federal District there are thousands of them with different genetics, morphology and volumes of a single emission of a solid component.

Up to 30% of individual subjects in mountain areas of the Federation of the Southern Federal District are affected by mudflows.

Floods. At anomalously high levels of precipitation with flood waters are affected, not only the mountain and foothill parts of the North Caucasus, but also in a significant part plain areas.

Territories that have undergone maximum impact of the nature require immediate reassessment of damage by hazardous processes and, if necessary, emergency relocation of individual settlements.

Landslides. This type of hazardous geological processes has the widest distribution in the North Caucasus.

The total number of landslides is determined by many thousands. Suffice it to say that only in the coastal Black Sea strip with a width of 1 to 4 km in the interval from Anapa to Adler, were recorded more than 1000 landslides.

Landslide activation in zone of Advanced ridges that is constructed by younger rocks of Neogene and upper Palaeogene (clay, sand, sandy loam, loam, and marl etc.) under active elevations and development of folded bearing structures, has catastrophic areal character with moving large volumes of bedrock.

Avalanches. Despite the seasonal nature of the impact of avalanches, they cause great economic damage throughout the mountainous part of the North Caucasus.

Every year in the North Caucasus, people are killed by avalanches. Thus for the period of Transkam operation since 1986, more than 100 people died.

Collapses. Tragic events on September 20, 2002 in the Republic of North Ossetia-Alania have shown that in the North Caucasus there is rarely a special type of hazardous geological processes, which has nothing in common with the pulsation of glaciers in their traditional form, when the speeds of moving ice masses (up to 200 m / day) provide a chance to carry out activities to protect the public.

Even in the preliminary analysis of the territory of the mountainous part of the North Caucasus, can be clearly marked areas with the conditions for the formation of such catastrophic collapses and with traces of paleocollapses.

Seismic hazard and seismic risk. In accordance with the map of seismic zoning of the territory of Russia (OSR-97), the mountain and foothill areas of the North Caucasus are in the zone of increased seismic risk.

The territory acquired an important economic importance in the Russian economic system, which marked the rapid growth of industry and agro-industrial complex in the region, the development of urban agglomerations, and the growth of investments in the development of the economy. At the same time, the considered region is characterized by a high intensity of dynamic geological processes and the associated hazards of both natural and anthropogenic nature. The most significant among these hazards is seismicity, accompanied by a wide range of secondary processes. The numerous seismogravitational phenomena, such as landslides, collapses, stone and mud avalanches observed in the mountainous regions of Racha and South Ossetia during the Racha earthquake (1991), can be noted as an example of such hazards. [Chachava et al., 2017 a – c; Zaalishvili et al., 2017b]

The problem of seismic hazard and risk assessment of the North Caucasus is genetically related to the activity of the Greater Caucasus, the strongest seismic events of which play a determining role for some regions of the North Caucasus. In most of this area earthquakes of magnitude M-6 can occur, and in seismogenic structures, seismic events with a maximum magnitude M = 7 and higher are expected. To areas with such high magnitudes after the Racha earthquake of 1991. belong the central and eastern parts of the Greater Caucasus. At the same time, in general, the Greater Caucasus zone is a zone of moderate seismicity. Although no events with M > 7,0 were recorded during the period of instrumental observations in this region, from the point of view of seismic effect this region is characterized by high engineering and geological hazards.

SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION 2015-2030

The Sendai Framework is a 15-year non-binding agreement which recognizes that the State has the primary role to reduce disaster risk but that responsibility should be shared with other stakeholders including local government and the private sector. It aims for the following outcome:

"The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries."

The Sendai Framework emerged from three years' of consultations and negotiations, supported and coordinated by UNISDR, during which UN member states, NGOs and other stakeholders made calls for an improved version of the existing Hyogo Framework, with a set of common standards, a comprehensive framework with achievable targets, and a legally-based instrument for disaster risk reduction.

The Sendai Framework sets four specific priorities for action:

1) Understanding disaster risk;
2) Strengthening disaster risk governance to manage disaster risk;
3) Investing in disaster risk reduction for resilience;

4) Enhancing disaster preparedness for effective response, and to “Build Back Better” in recovery, rehabilitation and reconstruction.

To support the assessment of global progress in achieving the outcome and goal of the Sendai Framework, seven global targets have been agreed:

1) Substantially reduce global disaster mortality by 2030, aiming to lower average per 100,000 global mortality between 2020-2030 compared to 2005-2015;
2) Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 between 2020-2030 compared to 2005-2015;
3) Reduce direct disaster economic loss in relation to global gross domestic product by 2030;
4) Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030;
5) Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020;
6) Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the framework by 2030;
7) Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030.

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ПРИРОДНЫЕ ОПАСНОСТИ И БЕДСТВИЯ В ГОРНЫХ РАЙОНАХ

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Горные и прибрежные районы являются регионами, наиболее подверженными стихийным бедствиям. Некоторые горные районы, которые уязвимы для оползней, также подвергались воздействию землетрясений. Когда в таких районах происходит землетрясение, риск возникновения оползня значительно возрастает. Природные опасности наносят огромный урон в мире и ежегодно их жертвами становятся множество людей. Концепция естественного риска может быть успешно использована для анализа природных опасностей и смягчения риска.

Горные и предгорные районы Северного Кавказа расположены в зоне альпийской тектономагматической активации Большого Кавказа и характеризуются интенсивными геодинамическими процессами, наличием активных вулканов, высокой сейсмичностью (9-10 баллов) пульсирующими ледниками и самым широким развитием геологических опасностей различных генетических типов.

Проблема сейсмической опасности и оценки риска Северного Кавказа генетически связана с активностью Большого Кавказа, самые сильные сейсмические события которого играют определяющую роль для некоторых регионов Северного Кавказа.

Ключевые слова: геологические опасности, вулкан, землетрясение, оползень, сейсмическая опасность, сейсмический риск, страхование.