Chapter 12

Risk Analysis and Land Use Planning

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http://dx.doi.org/10.5772/intechopen.79776

Abstract

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. Systematic approach to the natural hazard research on the base of risk concept is a very fruitful and progressive method. Areas of possible disaster events could be the places of the highest risk at the natural risk maps of the territories. It is necessary to use big databases and data banks and GIS technologies for such map constructions. Sometimes people have to live in such dangerous places. It is necessary for people living under natural risk to understand and estimate this risk and to know how to overcome it and how to act in case of crises events. Risk management concept is a good instrument for systematic approach to the problems of the rational land use.

Keywords: risk, risk management, risk analysis, risk assessment, mapping, land use planning

1. Introduction

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.

Earthquakes, volcano eruptions, tsunamis, karst, suffusion, coast erosion, and landslides belong to geological hazards [1–3].

About 20% of the world population, approximately 1.2 billion people, live in earthquake dangerous area of about 10 million km^2 that is near 7.5% of the total area of the planet.

93 million population of such countries as Iceland, Japan, the Philippines, Indonesia, the United States, Mexico, Central America, Colombia, Ecuador, and Chile occupy about 0.4 million km^2 of land where volcanic activity is concentrated.

3.7 million km^2 of land is 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.

14 million 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.

"Earthquake early warning systems" alert people of the hazardous ground shaking. 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.

It is important to develop earthquake-resilient societies. It could be useful to investigate earthquake scenarios as it had occurred in the past.

Volcanic eruptions have great societal impacts connected with damages, disruptions, health problems, ash fall, lava flows, gases, hot ash clouds, lahars, and hazard to aviation.

Predicting a volcanic eruption is possible on the base of interdisciplinary approach that includes continuous observation of different parameters such as earthquakes and changes in ground and water conditions. Joint efforts of scientists and cooperation of volcano seismology, geodesy, magnetic studies, and hydrology lead to eruption forecasting.

The effects of tsunamis are widely distributed; the consequences can be global. So it was in 2004 during Sumatra earthquake-induced tsunami. Many countries around the Indian Ocean were affected.

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 modelling 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.

Hydrometeorological and climatological hazards include heavy rains, storms, hurricanes, droughts, tropical cyclones, rainstorm floods, heat waves, low-temperature disasters, lightning, tornadoes, dust storms, hail, frost, fog, haze, and others. They are the most frequent causes of the disaster events among all natural hazards.

Local authorities must be ready for constant monitoring and technical-engineering works in such areas. Good examples of monitoring organization and engineering works are demonstrated and suggested in some different areas. But sometimes people do not pay enough attention to the problems. Sometimes it is necessary to evaluate whether to reconstruct the object after disaster event or to change the place for another similar construction or living.

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Sure the best way is to forecast disaster events and provide protective measures in advance. Life and work in areas of high natural risk demand knowledge, resources, equipment and willing to be ready for prognosis, forecast, people education, and information. In case of disaster events, it is necessary to be ready for the consequence liquidation and the territories and object reparation. The most important thing is to provide help to people. Sometimes people have to live in such dangerous places. It is necessary for people living under natural risk to understand and estimate this risk and to know how to overcome it and how to act in case of crises events. It is necessary to elect and appoint responsible people with good knowledge and special education for managerial posts. Risk management concept is a good instrument for systematic approach to the problems of the rational land use decision.

1.1. 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 three 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 [United Nations International Strategy for Disaster Reduction (UNISDR)] served as the coordinating body for the Second and Third UN World Conference on Disaster Reduction in 2005 and 2015.

The second conference accepted 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 UN World conference accepted the Sendai Framework for Disaster Risk Reduction 2015–2030.

2. Natural risk

Natural risk is a relatively new and not fully explored concept. There are many definitions of natural risk. And often a scientific study or a scientific approach to the problem begins with a presentation of the author’s position and the choice of the definition of natural risk for the problem [4–13].This individualistic approach is difficult to avoid. Spores are carried out so far, for example, if there is a risk without material damage to people or not.

If one of the main systematic approaches to hazard research is their classification, so now also the concept of risk **management** can be considered as new step of science development and new basement for systematic hazards investigations.

Development of the **risk** concept demands the promotion of the methods for **risk assessment** and calculation. It makes the theory of **risk** the scientific discipline with good mathematical background. It is necessary to elaborate common approaches to the risk calculation for different types of natural hazards. The methods of seismic risk assessment as the most promoted ones must be spread to landslides, karst, suffusion, flooding, pollution, and other types of natural hazards and risks and also to complex and multi-risk.

Arising from everyday life, gambling, finance, business, and building the **risk** concept became the subject for scientific research and basement for systematic investigations of natural and man-made hazards and disasters.

Risk management is an important way to risk reduction. The main aspects of natural risk management could be considered as risk assessment and mapping, monitoring, and engineering methods for rational land use.

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
   - Modelling
   - Monitoring
   - Information

Vulnerability to natural hazards and disasters depends on location, frequency of dangerous events, type of human activity in the area, and other factors.

Systematic approach to the natural hazard research on the base of risk concept is a very fruitful and progressive method.

According to the most common definition, the risk is the probability of the natural hazard event multiplied by the possible damage:

$$R = P \times D, \tag{1}$$

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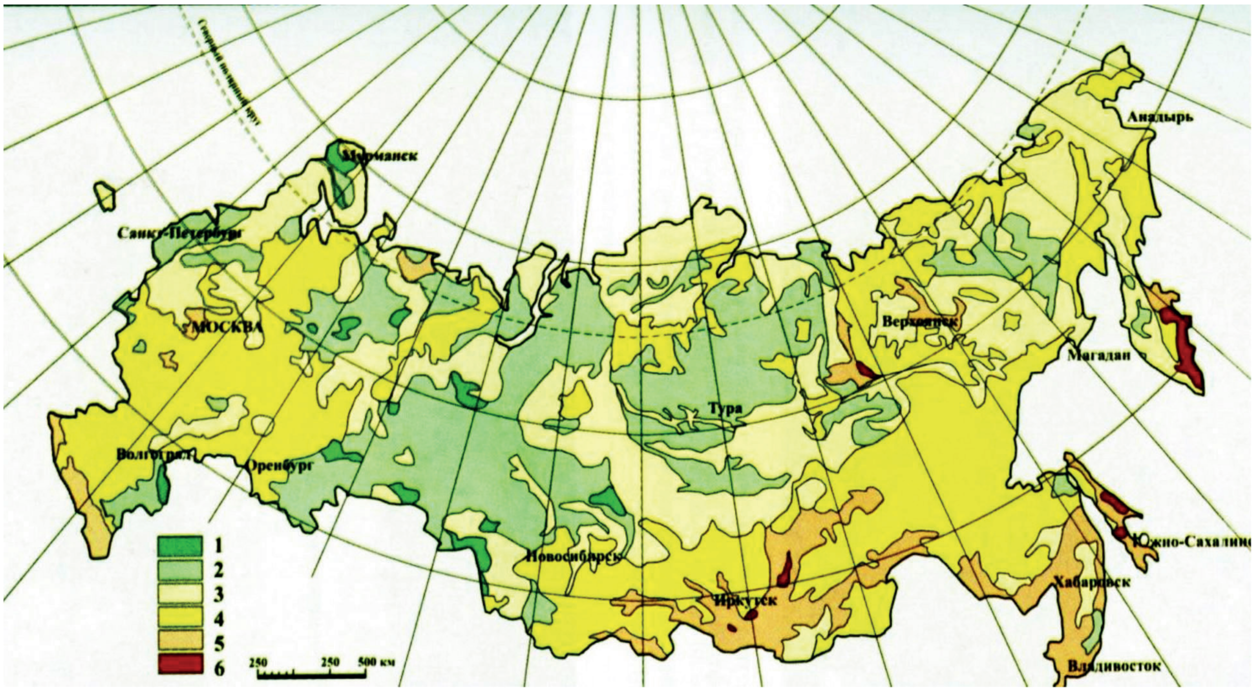

Figure 1. Map of the natural economic risk of construction development and land use of the territory of the Russian Federation [5]. One point corresponds to the average annual damage of 1 million rubles per year (in 1990 prices) on an area of 20 thousand square km): 1, very small (<2). 2, small (10–2). 3, medium (20–10). 4, significant (80–20). 5, large (200–80). 6, huge (>200).

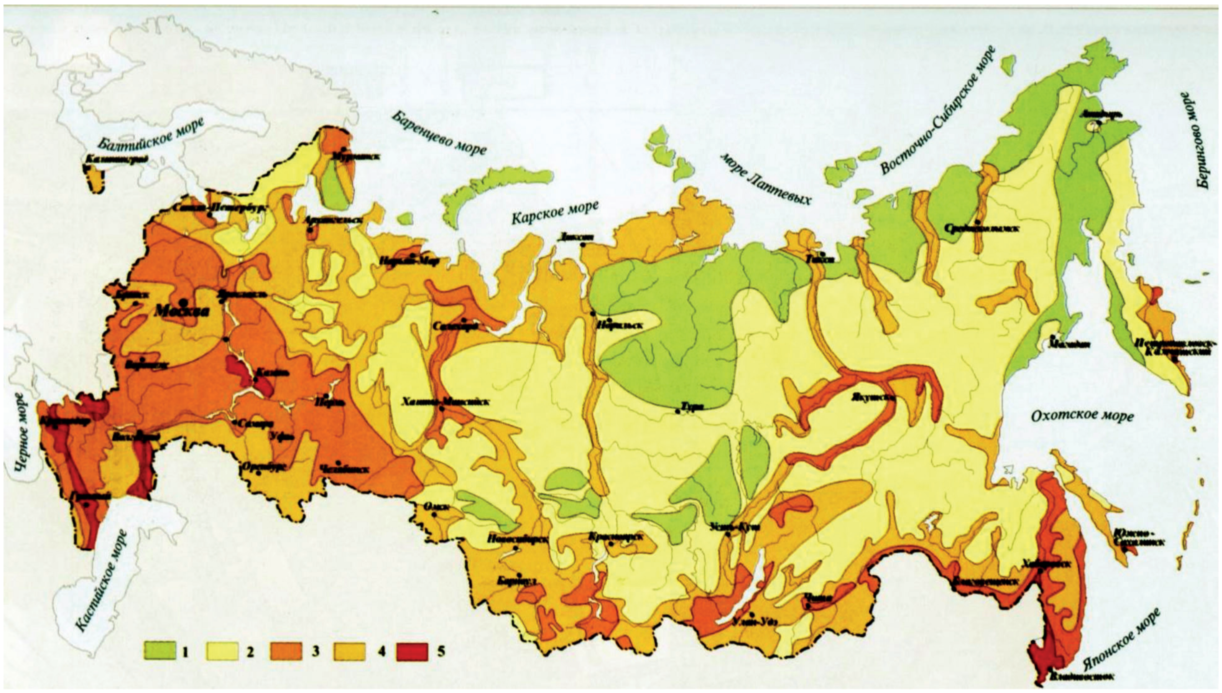

Figure 2. Map of the natural disasters on the territory of Russia, caused by earthquakes, floods, cyclones, squalls, tornados, heavy rains, snowfalls, snowstorms, hail, snow avalanches, and landslides (A. L. Shnyparkov). Frequency of occurrence (cases/year): 1, $<10^{-5}$; 2, 10^{-5}–10^{-4}; 3, 10^{-4}–10^{-3}; 4, 10^{-3}–10^{-2}; 5, $>10^{-2}$.

Figure 3. Map of individual seismic risk for Russian Federation, 2005. IEG RAS (www.geoenv.ru).

where R is risk, P probability, and D damage.

For multi-risk assessment it is possible to use sum of risks of different hazards:

$$R = \sum R_i \tag{2}$$

For risk map construction, it is necessary to use the natural hazards maps and maps of possible damage. These maps can be of local, regional, federal (sub global), and global levels. It is necessary to use big databases and data banks and GIS technologies for such map constructions.

Areas of possible disaster events could be the places of the highest risk at the natural risk maps of the territories.

On the base of this approach, different risk maps and natural hazard maps can be constructed (**Figures 1–3**).

3. Monitoring systems for natural hazards

3.1. Topsides Induced Acceleration Monitoring System (TIAMS) for oil and gas offshore platforms

Early warning system can be elaborated on the base of analysis of seismological phone changes.

The "system monitoring acceleration induced on the upper part of the offshore oil and gas platforms" was developed for deposits Lunskoe-A (LUN-A) and Piltun-Astokhskoye (PA-B) for Sakhalin-2 project.

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The system was developed by Sergeev Institute of Environmental Geoscience RAS (IEG RAS) and was intended to ensure the safety of the operation of these platforms [14–17].

This system can be used for safety operation of environmentally hazardous facilities like pipelines, nuclear power plants, chemical industry, etc.

According to the Sakhalin II Project, Sakhalin Energy Investment Company was building offshore oil and gas platforms PA-B and LUN-A at the Sakhalin Island shelf within the seismically dangerous area where destructive earthquakes are likely to occur (**Figure 4**).

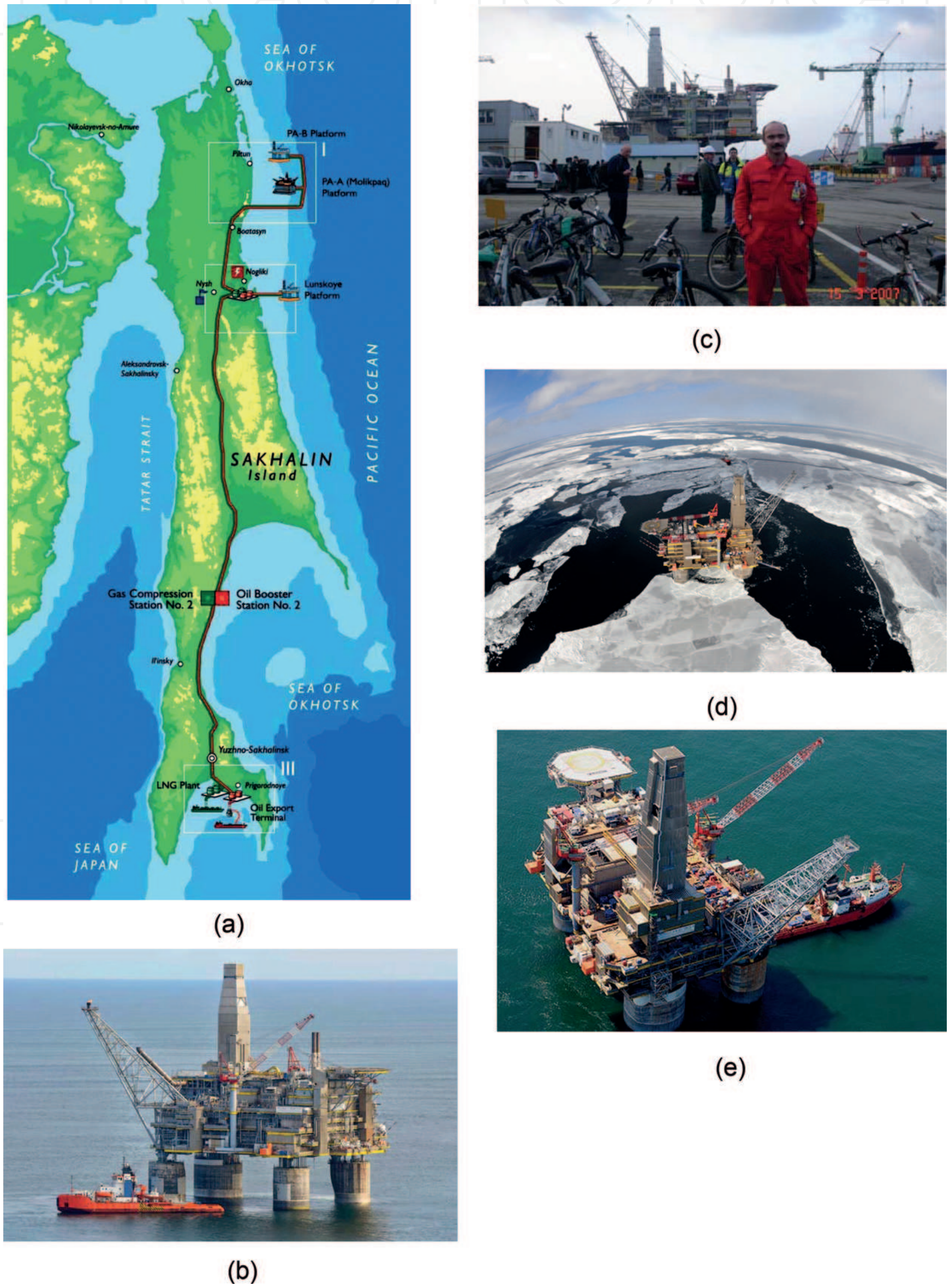

Figure 4. (a) Sakhalin Island and oil-gas platforms. (b) Platform for PA-B deposit. (c) Commissioning works in South Korea. (d, e) Platform for Lunskoe-A (LUN-A) deposit.

To reduce the risk of environmental accidents that can appear during oil and gas production as a result of destructive earthquake, Client took a decision to provide platforms with Topsides Induced Acceleration Monitoring System (further referred as TIAMS).

Function of the TIAMS is to distinguish dangerous earthquakes from other impacts induced to the platform. Ice impacts, ship impacts, wave impacts, drill snatch, etc. also can cause accelerations at the topsides of the platforms. The TIAMS will initiate the emergency shutdown signal (ESD) in case the destructive earthquake has been detected. The signal will be done if acceleration level will exceed the threshold of 0.5 g in any key point of the platform.

3.2. Landslide monitoring system for coastal slope of the river Yenissei

Experience of the system creation was used for real-time early warning landslide monitoring system construction. This system was successfully used for landslide monitoring of coastal slope of the river Yenissei.

Geohazard monitoring system designed to monitor landslide at the coastal slope of the river Yenissei in real time [15–17]. The system provides rapid collection of measurement data on the state of the observed landslides, processing, and analysis of monitoring results (**Figure 5a**).

The monitoring system provides collecting, processing, and distributing data. It includes eight mass displacements of ground points, two points of monitoring changes in the level of groundwater, and automatic workplace of a geologist (**Figure 5b–d**).

Equipment set deep frame is designed to measure linear displacement by its transformation into a digital code (**Figure 5b**). Complete registration of groundwater level is designed for continuous automated measurement level, water temperature, and atmospheric pressure well, and transfer of the measurement results in digital form (**Figure 5b–d**).

The monitoring system has two operating modes: normal and abnormal. If the ground speed displacement mass or velocity of groundwater level changes less than threshold, the information is recorded, analyzed, and compared with data obtained previously. When the speed of the displacement of soil mass or rate of change of groundwater level exceeds a predetermined threshold, the equipment sends an alarm. Alarm is the basis for decisions on a more detailed examination of the coastal slope and, if necessary, the evacuation of people from the building and further strengthening of the coastal slope (**Figure 5e**,**f**).

3.3. Landslide monitoring system for objects of the 2014 Olympics in Sochi

It is necessary to elaborate specific monitoring system for every type of landslide. One of the case studies was mountain area of the 2014 Winter Olympics in Sochi, Caucuses. The main geologic hazards along the road from Adler to Krasnaya Polyana are landslides. Monitoring systems are installed at a number of Olympic structures (**Figure 6**).

Also monitoring systems were used during construction of the roads.

It was determined that the most widespread type of landslides within the study area is a debris slide. Several sites, especially ones at the beginning of the route, exhibited block-type landslides of compression extrusion.

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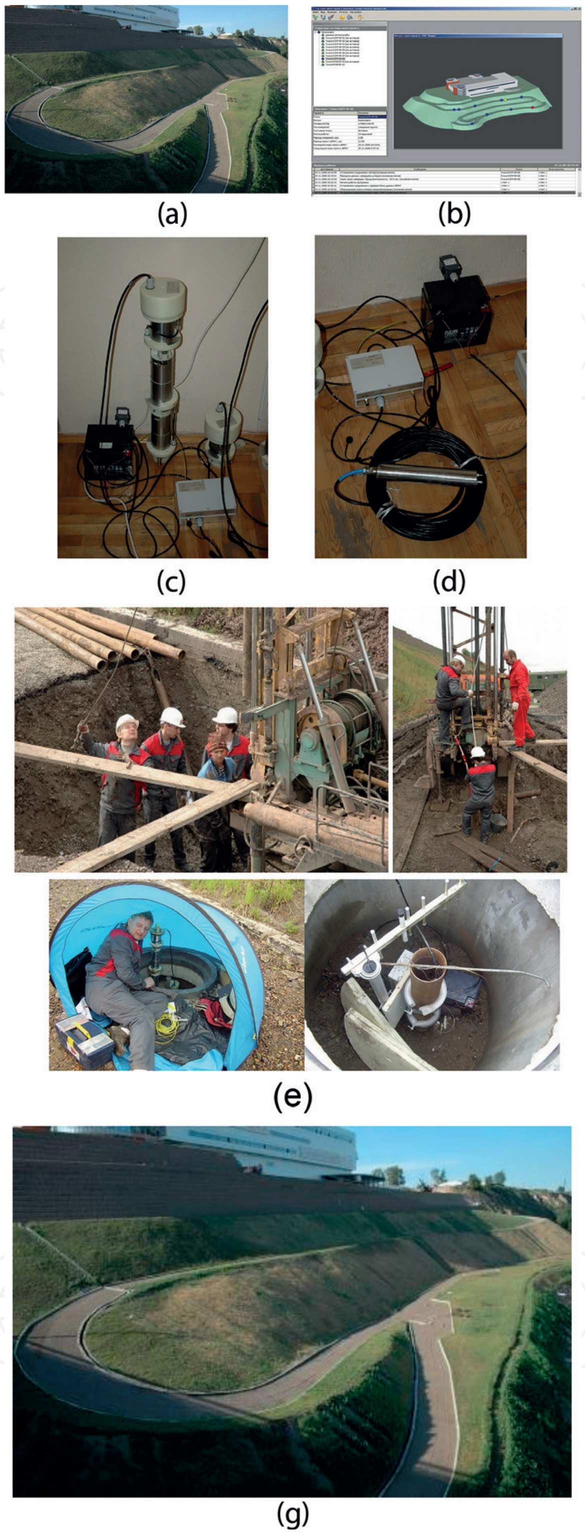

Figure 5. (a) Trade and amusement complex "JUNE," located on the monitored coastal slope of the river Yenissei. (b) The main window of the work program. (c) Equipment set deep frame. (d) Complete registration of groundwater levels. (e) Installation and commissioning of geohazard monitoring system (Ginzburg). (f) After installation and commissioning of geohazard monitoring system (Ginzburg).

Two general methods of observations were accepted in the automatic monitoring system along the combined highway and railway: (1) extensometer and (2) inclinometric measurement in

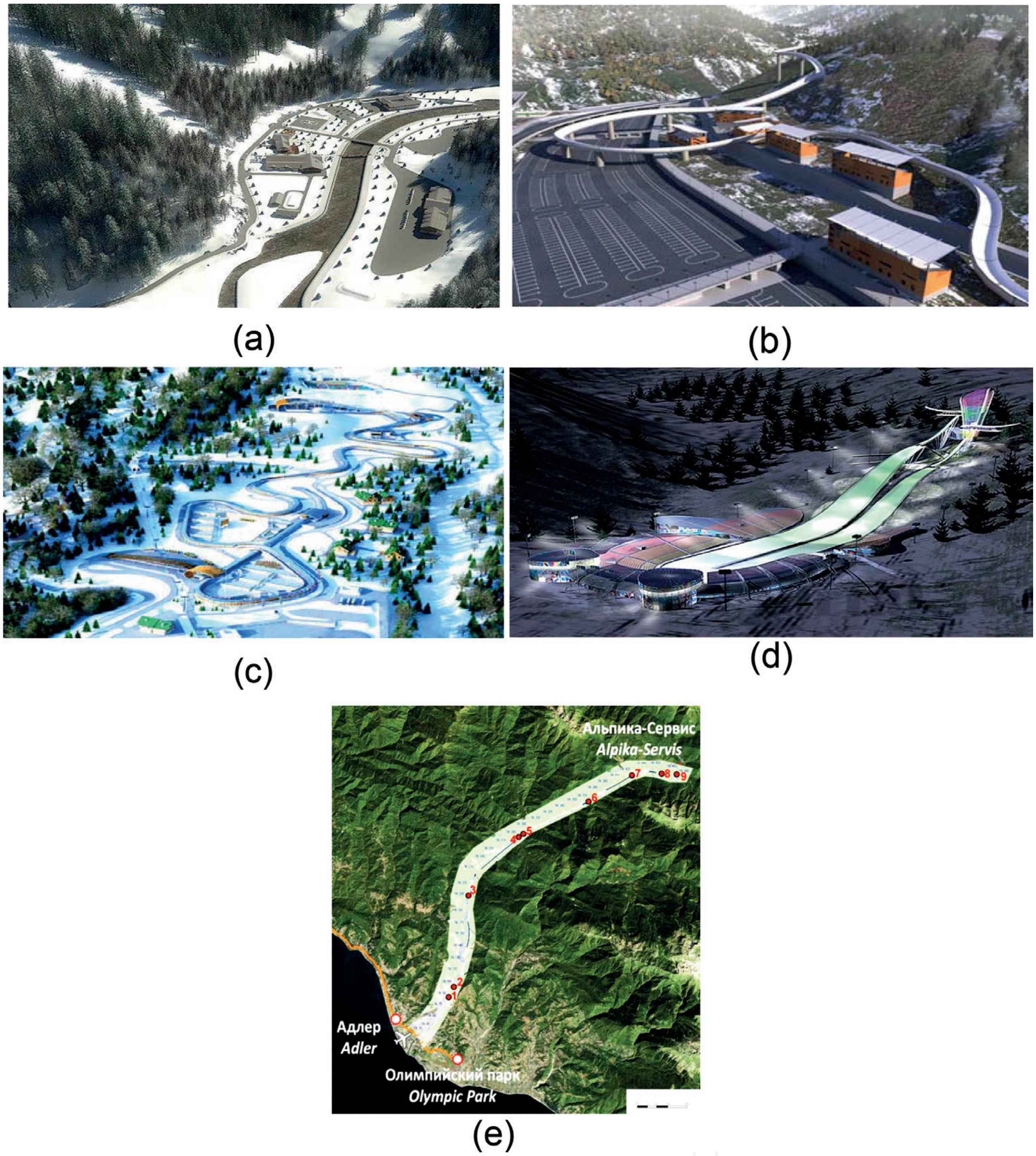

Figure 6. (a) Ski slope. (b) Bobsleigh track. (c) Bobsleigh track. (d) Ski jump. (e) The location of landslide sites along the combined road from Adler to Alpika service (Krasnaya Polyana).

drills. The results of research have shown that the most useful parameters related to the characterization of an active landslide state and sliding dynamics are landslide displacement velocity, depths of slip surfaces, and propagation of active displacements within the territory [17].

Landslide hazard criteria were proposed for the constructions of the road based on the monitoring data of an active landslide along the railway from Adler to Krasnaya Polyana. Several monitoring methods as related to the landslide hazard were recommended along the

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Adler-Krasnaya Polyana railway: automatic observations of displacements over the slope surface using extensometers and inclinometers (during site visits and in partly automatic mode).

3.4. Russia-Turkey gas pipeline "Blue Stream" monitoring system

The construction of the Russia-Turkey gas pipeline "Blue Stream" was accomplished in 2002 (**Figure 7**).

The pipeline route has a total length of 1226 km. It crosses the Black Sea. The pipeline crosses the northwestern slopes of the Big Caucasus Ridge. Thirty-five landslides are registered there; seven of them are very hazardous. The online operating automatic control system of landslide processes was developed for these sites. The next registering devices were installed at each of the seven sites: the seismic acoustic control unit, the inclinometer control unit, and the groundwater-level control unit.

The measurement complex included the gauge of seismic acoustic emission and two units of data registration and collection. Three-point extensometer was applied for rock mass displacement measurement. The measured data are transferred to the monitoring center, where they are processed using the special software.

Also the remote sensing control based on the high-resolution space and aerial survey is used. The remote survey data are also processed using the special software. The developed monitoring system permits to control the conditions of the landslide-prone slopes and thus ensure the safety of pipeline operation at the site of high geological risk.

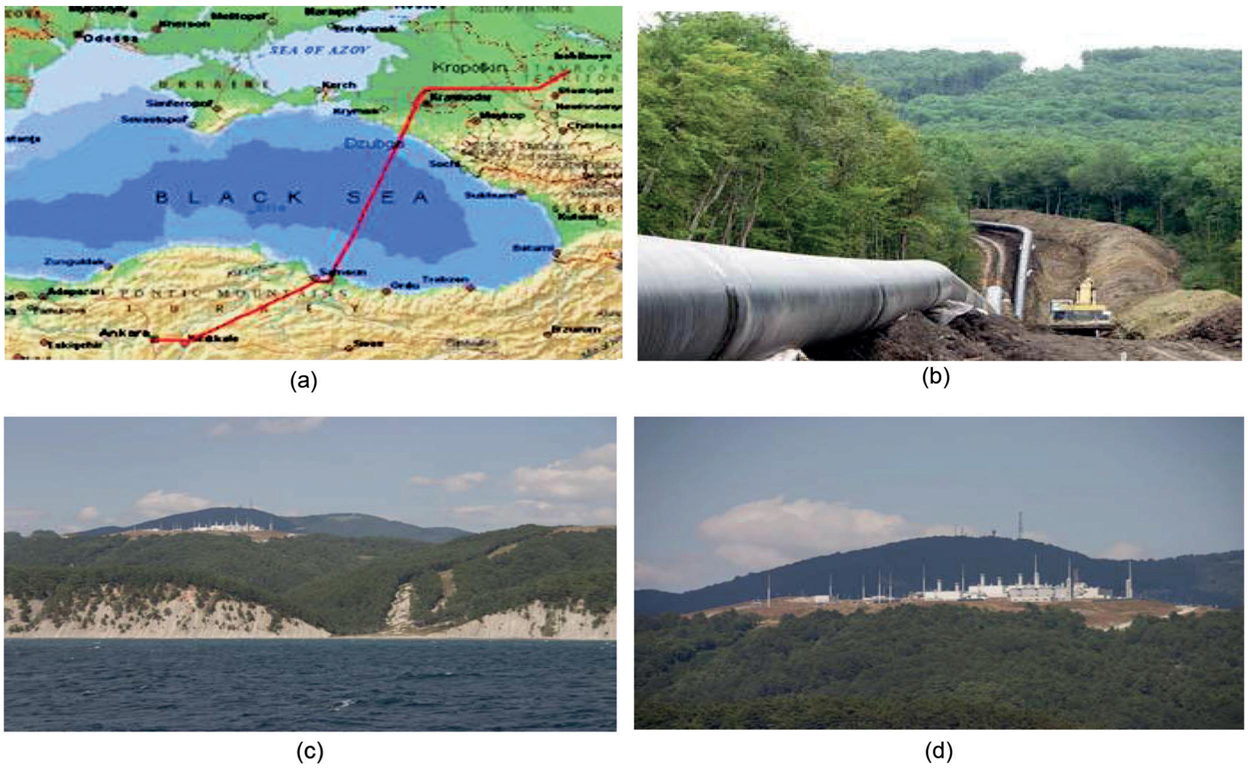

Figure 7. (a) "Blue Stream" scheme. (b) "Blue Stream" during construction. (c) The compressor station "Beregovaya," view from the sea. (d) The compressor station "Beregovaya," visible glade in which the pipeline is buried.

Figure 8. (a, b) Eastern Siberia-Pacific ocean oil pipeline (c, d, e, f). ESPOOP construction.

3.5. Eastern Siberia-Pacific ocean oil pipeline

Similar monitoring system was elaborated and constructed for ESPOOP. The Eastern Siberia-Pacific Ocean oil pipeline (ESPO pipeline or ESPOOP) is a pipeline system for exporting

http://dx.doi.org/10.5772/intechopen.79776

Russian crude oil to the Asia-Pacific markets (Japan, China, and Korea). The pipeline is built and operated by Russian pipeline company Transneft. The 4857-kilometer pipeline is being laid by the route of Taishet-Kazachinskoye-Skovorodino-Kozmino. Because of protests of environmental organizations, the initial pipeline route was moved 40 kilometers north of Lake Baikal (**Figure 8**).

During the construction of pipelines, the necessity of laying tracks on sloping areas or near them (at the intersection of rivers, construction along the coast, etc.) arises (**Figure 8**).

IEG RAS provided geological research before and during ESPOOP construction and elaborated ESPOOP monitoring system.

4. Conclusions

Risk management concept is a good instrument for systematic approach to the problems of the rational land use. Measures for risk reduction could be legislative; organizational and administrative; economic, including insurance; engineering and technical; modelling; monitoring; and informative. Monitoring system organization and construction are two of the most important methods for natural hazard forecasting, prognosis, and early warning.

Conflict of interest

There is no conflict of interests in the chapter.

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References

[1] Kutepov VM, Sheko AI, Anisimova NG, Burova VN, Victorov AS, et al. Natural Hazards in Russia. Exogenous Geological Hazards. Moscow: KRUK; 2002. 345 p

[2] Osipov VI, Shojgu SK, Vladimirov VA, YuL V, Avdod'in VP, et al. Natural Hazards in Russia. Natural Hazards and Society. Moscow: KRUK; 2002. 245 p

[3] Wirtz A, Kron W, Löw P, Steuer M. The need for data: Natural disasters and the challenges of database management. Natural Hazards. 2014;**70**:135-157

[4] Corominas J, van Westen C, Frattini P, Cascini L, Mallet J-P, et al. Recommendations for the quantitative analysis of landslide risk. Bulletin of Engineering Geology and the Environment. 2014;**73**(2):209-263

[5] Ragozin A, editor. Natural Hazards of Russia. Evaluation and Management of Natural Risk. Moscow: KRUK; 2003; 316 p

[6] Svalova VB. Landslide Risk: Assessment, Management and Reduction. New York: Nova Science Publishers; 2017; 253 p

[7] Svalova VB. Modeling and monitoring for landslide processes. In: Linwood K, editor. Chapter in Book: Natural Disasters—Typhoons and Landslides—Risk Prediction, Crisis Management and Environmental Impacts. NY USA: Nova Science Publishers; 2014. pp. 177-198

[8] Svalova VB. Monitoring and reducing the risk of landslides in Taiwan. Monitoring. Science and Technology. 2016;**3**:13-25

[9] Svalova VB. Landslides modeling, monitoring, risk management and reduction. East European Scientific Journal, Poland. 2016;**7**(11):43-52

[10] Svalova VB. Risk analysis, evaluation and management for landslide processes. Sciences of Europe (Praha, Czech Republic). 2016;**4**(6):15-25

[11] Svalova VB. Landslide risk analysis, management and reduction for urbanized territories. In: Proceedings of WLF4 (World Landslide Forum 4); Ljubljana, Slovenia:Springer; 2017. pp. 439-445

[12] Svalova VB, editor. Risk Assessment. Rijeka: In-Tech; 2018. 380 p

[13] Vranken L, Vantilt G, Van Den Elckhaut M, Vandekerckhove L, Poesen J. Landslide risk assessment in densely populated hilly area. Landslides. 2015;**12**(4):787-798

[14] Svalova VB. Monitoring and modeling of landslide processes. Monitoring Science and Technology. 2011;**2**(7):19-27

[15] Svalova V. TXT-tool 3.007-1.1: Mechanical-mathematical modeling and monitoring for landslide processes. In: Sassa K, Tiwari B, Liu KF, McSaveney M, Strom A, Setiawan H, editors. Landslide Dynamics: ISDR-ICL Landslide Interactive Teaching Tools. Springer; 2018. pp. 315-319

[16] Ginzburg A, Nikolaev A, Svalova V, Manukin A, Savosin V. TXT-tool 2.007-1.1: Monitoring alarm system of landslide and seismic safety for potentially hazardous objects. In: Sassa K et al., editors. Landslide Dynamics: ISDR-ICL Landslide Interactive Teaching Tools. Springer; 2018. pp. 309-325

[17] Ginzburg A, Nikolaev A, Svalova V, Postoev G, Kazeev A. TXT-tool 2.007-1.2 landslide and seismic monitoring system on the base of unified automatic equipment. In: Sassa K et al., editors. Landslide Dynamics: ISDR-ICL Landslide Interactive Teaching Tools. Springer; 2018. pp. 327-340