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NATURE MANAGEMENT RISKS IN SIBERIA

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Abstract: The natural human environment is a source not only of resources for development, but also of a variety of hazards that can hamper this development. Abrupt climate changes, enormous consumption of natural resources, and pollution of the environment inevitably lead to an increase in the probability of making wrong decisions in various aspects of nature management. The paper considers five basic types of anthropogenic impacts on the Earth's ecosystem, namely: destruction of the biosphere, intensification of natural disasters, pollution of natural environments, depletion of natural resources, and land degradation. The features of Siberian nature that create special environmental situation conditions are shown. A scheme for studying the natural-anthropogenic risk at the regional level is suggested. Economic development of new territories in Siberia, including the development of oil and gas fields, and pipelines, power lines, and roads construction, leads to increased natural hazards. Knowledge of natural processes, assessment of hazard and risk of nature management, forecast of environmental hazards development, and proposals development to reduce the natural-anthropogenic risk is required.

Keywords: nature management, risk, environmental pollution.

Introduction

Among numerous risks, currently facing humankind, namely, political, economic, financial, and social, environmental risks hold a prominent place. This is attributable to growing global, regional and local environmental problems, the solution of which determines the state of the natural environment and human health.

The environmental risk is understood to be an integral characteristic or a quantitative measure of an environmental hazard. And the environmental hazard is a realized or possible environmental threat as a result of anthropogenic or natural impacts, causing deterioration of human health and environmental degradation (Ecological encyclopedic dictionary, 1999).

The problem of the environmental hazard was realized by the end of the 50s of the last century. The next two or three decades, characterized by notable

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depletion of natural resources, environmental pollution, confrontation between nuclear powers, and population explosion were responsible for the creation of the catastrophe theory (Zeeman, 1976). It was based on the notion of “limits of growth” of the negative impact of human activity on the natural environment (Meadows D.N. & Meadows D.L., 1972). In the 80s, the concept of maximum use of available resources to ensure the stability of the natural-anthropogenic systems was proclaimed.

The development of production started to be based on the concept of absolute security, striving to completely eliminate the risk in all the technological, industrial and social processes. The guidelines and standards for the evaluation of environmental pollution (MPC, MPE, MPD, etc.) were developed, which are in use up to date. As a result, some of the highly developed states managed to achieve an improvement of the ecological situation. But in most regions of the Earth, especially in the economically disadvantaged ones, the established standards didn’t work in practice because they were not adapted to local natural and socio-economic conditions.

By the end of the 20th century, it became clear that some of the global problems could be solved with appropriate political, legal and economic activities. A new geopolitical impetus was needed for the programs of development, and it was found in the concept of sustainable development. Sustainable development makes it possible to align the socio-economic level of developed and developing countries, to erase distinctions between the forms of life support, to reduce the negative impact on ecosystems, and to use natural resources in an optimal way. A concept of an acceptable tolerable risk was elaborated. In highly developed countries, it provided the basis for the safety legislation.

The concept of tolerable risk suggests that, objectively, there exist uncertainties in the prediction of natural hazards and in the motivations of decision-makers on nature management issues. It is impossible to achieve absolute security. Therefore, the concept of tolerable risk involves an individual approach to the assessment of human actions and qualities of natural systems, within the framework of which the economic activity is carried out, specifying the limits of anthropogenic loads, beyond which the destruction of the system integrity takes place.

Methods

Within the framework of the UNESCO International Decade for Natural Disaster Reduction Decade (IDNDR) (1991-2000), investigations of hazardous natural processes markedly pressed forward. For example, in Bulgaria, a genetic classification was carried out, and a special map of dangerous geomorphological processes with the subdivision of processes according to the intensity of their manifestation was compiled in the scale of 1:500 000. For this purpose the method of expert-statistical analysis was used (Vlaskov, 1993).

In the Czech Republic, the methods of measuring and mapping the movements of the earth's surface and the methods of correlation of geomorphological hazards and risks with the geodynamic activity of orogenic areas of the country are examined (Kaldova, 1996).

In Germany, a comprehensive research on the justification of the principles, goals and objectives of the analysis, assessment and management of natural risks is being carried out. Integrated data on the type of process, the volume of material involved in the process, and the way it moves are adopted as the criteria for the degree of hazard of geomorphological processes (Glade, 2003).

In Venezuela, to assess the impact of dangerous erosion processes on the productivity and properties of economically promising soils a study was undertaken on the productivity of soils and erosion risk, where the latter was dependent on the steepness of slopes and the intensity of rainfall. Zoning of regions was carried out with their subdivision into critical and supercritical lands with different requirements for their preservation (Lobo et al., 2005). There are examples of developments on assessment, mapping and forecasting of hazardous geomorphological processes and their relation to climatic and tectonic factors also for other regions of the world (Daanish, 2005; O´Hare & Rivas, 2005; Matveev & Nechiporenko, 2001).

At the regional level, to reflect the spread of hazardous natural processes and phenomena the probabilistic-areal approach is used based on indicators of hazard with the assessment of potential damage and differentiation of the territory according to the level of nature management risk. As an example, we consider the scheme of studying the natural-anthropogenic risk at the regional level, developed by T.A. Borisova (Borisova & Namzhilova, 2007).

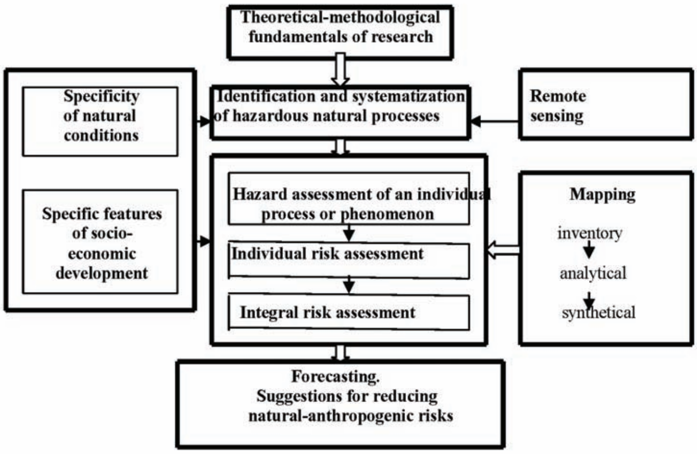

Fig. 1. The scheme of studying the natural-anthropogenic risk at the regional level [on 11].

Fig. 1. The scheme of studying the natural-anthropogenic risk at the regional level (on Borisova & Namzhilova, 2007).

The first stage consists in collection and analysis of the source statistical, cartographic, archival, and scientific information, and materials of field research expeditions on identification of hazardous processes, their spacio-temporal dynamics and organization according to the types of hazards. Much attention is paid to the analysis of various remote sensing data. The array of information is arranged as a database in the software environment ArcGIS. The evaluation stage includes a series of successive operations. A hazard assessment of an individual process or phenomenon consists in identification of quantitative indicators (area of distribution, intensity of manifestation, frequency of occurrence), taking into account the factors of their formation and development. A risk assessment or assessment of possible losses is determined by the vulnerability of a landscape. The calculation of this parameter makes it possible to determine the specific physical risk, and serves further as a basis for assessing the economic and social risks. A method used through the whole work is a mapping with the application of GIS-technologies and remote sensing techniques in the development of a series of evaluation maps of hazards and individual risks, as well as in the creation of an integrated map of the natural-anthropogenic risk. In conclusion, a forecast is given of hazardous processes and phenomena development, and recommendations for risk reduction are made.

Results

There are five major directions of anthropogenic impacts that have negative effects on the ecological system of the Earth in general and Siberia in particular.

1. Destruction of the biosphere. Life on Earth has existed for 3.85 billion years. Over the past 600 million years, the mean surface air temperature ranged between 10-20ºC. Stability of the Earth's liveable climate is due to the biotic regulation of the environment. Under anthropogenic loads, species populations of organisms respond to it and either adapts to new conditions of the natural environment or drastically reduces in their numbers and generally become extinct.

Under the biotic regulation of the environment, life is not only a set of species, which adapt to the environment conditions, but also a management mechanism of this environment, based on species selected in the course of the evolution, which contain genetic information necessary for the environment management (Danilov-Danil’yan et al., 2007).

Therefore, the destruction of natural ecosystems by human activity beyond the permissible limits leads to a global environmental hazard. Over the past 200-300 years, natural landscapes have been disturbed in 60% of the Earth's land area. The forest area has decreased by 65-70% and continues to be reduced at a rate of about 10 million hectares per year.

2. Intensification of natural disasters. The number of human losses and financial damages from natural disasters has increased notably during the last decades. Earthquakes, tsunamis, hurricanes, floods, forest fires, heavy snowfalls, and others do not depend directly on human actions, but the development of periodically inundated floodplains of rivers, deforestation, leading to a change in albedo, as a result cause thermokarst, solifluction, landslides, and occurrence of ravines. Trimming of slopes in the mountains cause avalanches and mudflows.

The bulk of the epicenters of earthquakes in Siberia are confined to the zones of activated deep faults, bounding the rift troughs. The Mondinskoe (1950, M = 7.1), Muiskoe (1957, M = 7.7), Srednebaikalskoe (1959, M = 6.9), and Slyudyanskoe (2008, M = 6.0) earthquakes generally had a typically rift mechanism. Hypocenters were in the depth range of 15-25 km. Earthquakes in the Altai tend to fault structures, separating blocks of the Earth's crust. The strongest of the recent earthquakes occurred in the Kosh-Agach district of the Altai Republic in 2003 with a magnitude of 7.5. The Tuvinskoe earthquake in 2011 was of M = 6.5.

Floods in Siberia occupy one of the leading places among natural disasters. They take place during high water and freshets. The maxima of rain freshets predominate in the mountainous areas of the Western and Eastern Sayan, Khamar-Daban, North-Baikal, Patomskoe and Stanovoe uplands, and Trans-Baikal middle mountains. On the Central Siberian Plateau and in Western Siberia the greatest flow rates and levels refer to the phase of spring or spring-summer high water. High water floods occur in May and June, while freshet floods take place in July and more seldom in August. High water floods and ice jam floods often coincide. In Eastern Siberia, the number of ice jam floods and damage caused by them are very high since the major rivers flow along the submeridional direction, which, as is well-known, mainly contributes to ice jams. It is noted that the basins of the Yenisei, Lower Tunguska, Lena, Yana, Indigirka, and Kolyma rivers are particularly objected to ice jam floods. There are 447 jam sections with a total length of more than 700 km in the territory of Eastern Siberia (Berezhnykh et al., 2002).

In May 2001, in consequence of overflowing of the Lena river 5162 houses in the town of Lensk were flooded, the town's population (about 25 thousand people) had to be evacuated. In the same year, during the summer flood in the Angara river basin more than 150 settlements with a total population of 460 thousand people were flooded and waterlogged. Henceforth, in the Lena and Angara rivers basins floods took place in 2007 and 2010. Large floods on the Selenga River occurred on 02.07.1911, 08.11.1932, 11.06.1936, 05.08.1940, 05.08.1971, and 29.07.1973. For the period of instrumental observations, more than 1720 floods were recorded on the river stations of Eastern Siberia.

Forest fires are one of the major environmental hazards in Siberia. Fires destroy not only the vegetation, but also a significant part of the animal world, and reorganization of ecosystems takes place. The soil cover is damaged, erosion develops, and desertification of a territory is under way. Places of traditional crafts of the population disappear (logging, hunting, gathering of wild plants and crop).

The first forest fires in Siberia occur generally in April and in some years in March. Fire hazardous period usually lasts until October. The peak of the spring fire hazard sets in May, when an active drying of soils and the ground cover is in progress under the influence of winds, which reach considerable speeds in this period, transforming into dust storms with minimum relative air humidity of 18-20% and with the absence or a very small amount of atmospheric precipitation.

The shift of the peak of forest fire danger in area to June and July is due to the events of forest fires at this time in the northern sparsely populated and remote part of Siberia. Extinguishing of such fires is difficult; consequently, they cover large areas.

To assess the potential forest fire hazard the D.A. Ped's drought index can be used (Ped). Analysis of long-term changes showed that with an increase of this index during the period from 1970 till 2009 the number of forest fires in Transbaikalia and Irkutsk oblast was growing significantly.

The number of natural disasters in Russia for the period 1995-2005 increased annually by 6.3%. Financial damage from natural disasters in 2000-2005 amounted to 30-60 billions of rubles per year.

3. Pollution of natural environments. In the atmosphere of cities, where sulfur and nitrogen dioxides, benzopyrene, formaldehyde, suspended solids, and phenol are transferred with the emissions from industrial plants, thermal power plants, and motor vehicles, in the late 20th century the average annual concentrations exceeded the maximum permissible concentration in 185 cities of Russia. The priority list of cities of the Russian Federation with the highest levels of air pollution includes 14 cities of Siberia, namely: Novokuznetsk, Chernogorsk, Chita, Kyzyl, Krasnoyarsk, Minusinsk, Lesosibirsk, Achinsk, Selenginsk, Barnaul, Norilsk, Bratsk, Zima, and Irkutsk. A critical situation develops in Norilsk: each 10th ton of harmful substances emitted into the atmosphere in the country is emitted here. Kemerovo oblast has the largest volume of emissions per unit of area – 13 tons per 1 km2, Altai krai – 1,4 tons, Novosibirsk oblast – 1.1 tons, Krasnoyarsk krai – 0.9 m, and Irkutsk oblast – 0.6 tons. In 2010, 505.3 kg of pollutants were emitted into the atmosphere from stationary sources per a resident of Kuzbass.

The main source of water bodies pollution is sewage discharge. Kemerovo and Irkutsk oblasts stand out in the volume of waste waters discharged into water bodies in Siberia (750 million m2 and 659 million m2, respectively). The most polluted water bodies are tributaries of the rivers, within the catchment areas of which enterprises of metallurgy and coal-mining industry are located. Significant sources of pollution are enterprises of chemical and petrochemical industry, and pulp-and-paper industry. The Vikhoreva river have remained the most polluted tributary of the Angara river for several years. It is characterized by high contents of sulfides, hydrogen sulfide, formaldehyde, lignin, as well as of oil products, and ammonium and nitrite nitrogen in water. The main source of pollution is the Pulp-and-cardboard mill.

Lakes, on the banks of which recreational and utility objects and livestock breeding complexes are located, are subjected to an increased anthropogenic load. Entry of pollutants into water bodies is due to both concentrated discharges by water users and scattered discharges from urban and agricultural areas.

4. Depletion of natural resources. Consumption of resources of the biosphere by humanity (nature management) in the world is steadily growing. Non-renewable mineral resources, oil, gas and coal are being reduced; their extraction is getting more expensive. Many mineral resources have been depleted, others are close to it. In their turn, renewable resources, i.e. fresh water, forests, soils, and living organisms are no longer renewed in the same quality and quantity. Drinking water becomes the scarcest resource. The steppe regions of southern Siberia are among the areas poor in water because of natural conditions. In the taiga territories, the problem of their quality is of current concern. In many Siberian regions the forest raw material and hunting-and-fishing bases are impoverished.

5. Land degradation. In the southern agricultural regions of Siberia, a high level of plowing under non-compliance with the soil-protecting technologies leads to land degradation, development of processes of water and wind erosion, desertification, salinization, and pollution with heavy metals and toxicants. In Altai krai, the area of agricultural lands, exposed to desertification, amounts to 6.8 million ha. 9.3% of the territory is subjected to strong digression; in Russia the average value is 1.2%. In the Kulundinskaya steppe, desertificated lands account for 71% of the territory. The main processes of desertification here are associated with soil salinization and deflation, to a lesser extent with water erosion.

Humus losses reach from 0.5 to 1.7 t/ha annually. The initial humus content in chernozems of the forest-steppe zone of Siberia (6-8%) has reduced to 3.8-5.0% to date since the 50s of the 20th century. More than 40% of soils are characterized by critically low humus content – 2.0-3.9%.

A gradual accumulation of specific pollutants takes place in soils, which leads to profound changes in their physico-chemical, agro-chemical and biological properties.

The structure of disturbed lands is dominated by the lands, disturbed by open-pit mining, and occupied with overburden dumps, ash and slag disposals, access roads, and industrial sites. In the subjects of the Siberian Federal District, 5592 ha of disturbed lands are registered; most of them are in Transbaikal krai (24.7%), Krasnoyarsk krai (21.9%), Irkutsk oblast (19.2%), and Kemerovo oblast (14.3 %).

In Russia, about 6 million km2 of lands (35%) of the total area of 17.1 million km2 are disturbed by economic activities. Among them, 2.2 million km2 are agricultural lands, 2.5 million km2 are forests being cut down, 0.6 million km2 are lands, disturbed by open-pit mining, and 0.1 million km2 of lands are flooded by waters of reservoirs, the rest part is occupied by buildings.

Specificity of Siberia. High seismic hazard of mountain areas of southern Siberia, increased radiation background in the mountains. Desertification, water shortages in the steppe agro-developed regions of the south of Western Siberia. Degradation of permafrosts, which are spread across most of Siberia. High frequency of occurrence of zero winds and surface inversions (in winter) makes dispersal of harmful substances difficult. In Eastern Siberia, dispersive capacity of the atmosphere is two times lower than in the European part of Russia. Frequent floods are related to sub-meridian extension of valleys of the main rivers of Siberia, namely: the Ob, Yenisei, Lena, and their tributaries, from south to north, and to a low broad floodplain and waterlogged catchment area of the Ob river.

Conclusions

Under the conditions of the nature management risk as a future aspect of social development, a balance between ecological and economic interests, and mutual compromises are necessary as the basis for a balanced development of natural-anthropogenic systems.

Regional maintained sustainable development is an ecological-economic compromise. Maintained stability in the country is provided in the field of economy – by human capital, natural resources and high technologies, in the social field – by modern living standards and in the field of ecology – by the possibilities to manage natural resources and by environmental management.

Acceptable tolerable risk depends on the development of the productive forces of the state or region. If public resources are high enough to spend any means to reduce the risk without loss of the quality of life of the population, it can use technologies that make it possible to reduce nature management risks to a minimum. If public resources are limited, it is forced to use the funds to cover the most basic social needs.

In Siberia, territories, which were previously considered to be uninhabitable according to natural-climatic indicators, have been actively developed in recent years (mainly this includes the development of oil and gas fields, and construction of roads, transmission lines, and oil and gas pipelines). This causes intensification of hazardous processes: flooding, forest fires, induced seismicity, aufeis formation, reservoir bank transformation, thermokarst, and waterlogging. Economic development of new territories is associated with the low level of forecasting natural hazards, with the imperfection of knowledge about them, and with strategic miscalculations in the policy of environmental safety, which is mainly aimed at the elimination of consequences of natural disasters, and not at their prevention.

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