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THREATS AND RISKS TO SUSTAINABLE DEVELOPMENT IN THE AMUR RIVER BASIN

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Existing and potential global and regional threats and risks to sustainable development in the Amur River basin, including trans-boundary conditions, are described. Main preconditions to achieve sustainable nature management are determined.

The Amur River basin is a great ecosystem covering an area of about 2 million km^2 (Fig. 1). It includes territories of 4 countries: Russia, China, Mongolia and Democratic People's Republic of Korea (Table. 1). In this connection, the Amur basin geosystem is transboundary.

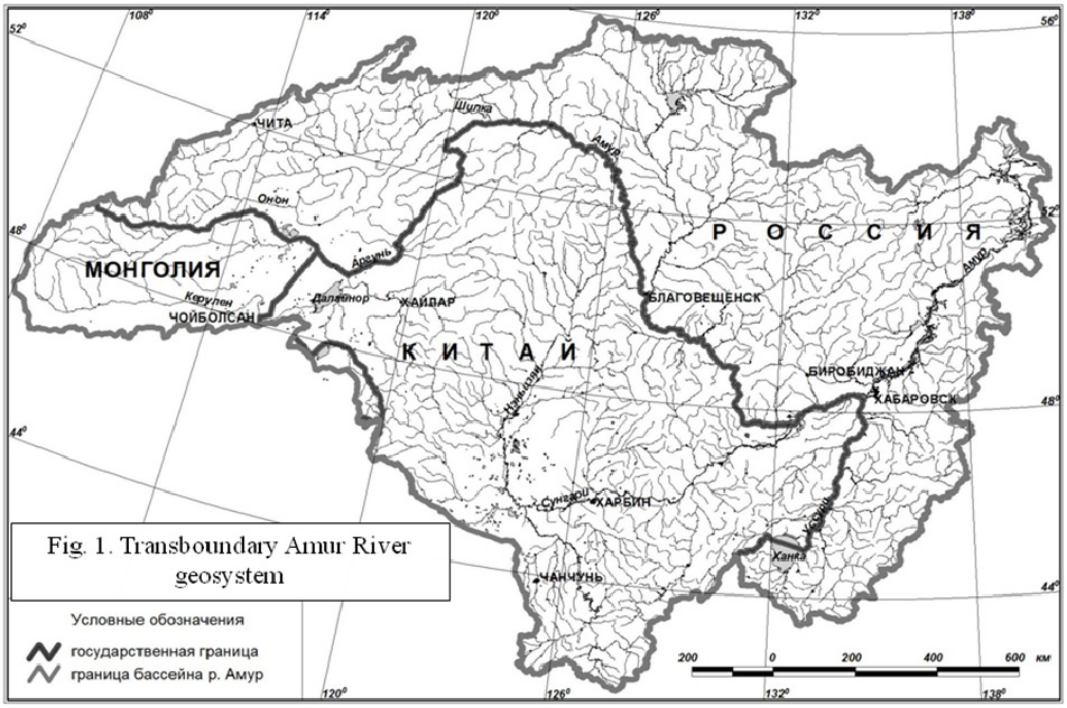

Fig. 1. Transboundary Amur River geosystem

Table 1 Composition of the transboundary Amur River basin

Country	Territory of basin part (km^2)	Share (%)
Russia	1003000	54.067
China	820000	44.20
Mongolia	32000	1,73
DPRK	60	0.003
Whole basin	1855060	100

Source: [2, p. 80]

As for geography, the Amur River basin is presented by different types of landscapes: from semi-arid, steppe and plain to forest, mountain, mountain taiga and alpine. Within the basin, there are different kinds of natural resources: fuel and energy (petroleum, gas, coal, hydropower resources), non-ferrous metals, chemical raw materials, forest, water, land, fish, building materials. The recreational resources are also characterized by a wide variety. The areas of the North-East China, Khabarovsk and Primorsky Krais, Amur Oblast are distinguished by variety of natural resources and their reserves.

By now, different types of nature management have formed in the basin geosystem: forest exploitation, agricultural land utilization, water consumption, mining, transport, building zone, природоохранное, рекреационное и др. In different countries and even in some areas of the same country, many homogenous types of nature management have different structures, stabilities and efficiencies. At the same time, both national and regional interests agree that the common problem and task are to reach the sustainable nature management within the transboundary basin.

By a sustainable nature management is meant such nature management which spatio-temporal structures provide, over a long period of time, a conservation of the natural resources potential and high quality environment sufficient for the sustainable regional development. The effect of global and regional factors (regional, technogenic, anthropogenic) on the Amur River geosystem which hamper an achievement of the sustainable nature management or can be cause of its disturbance in succeeding years can be considered as global and regional threats to the sustainable nature management respectively. The probabilities of their realization on different scales: global, regional and local including different levels of the Amur river geosystem, can be treated as global, regional and local risks to the sustainable nature management.

Within the Amur river basin as a whole, the following regional threats and risks to the sustainable nature management can be identified: floods, forest fires, technogeneous accidents and catastrophes with crucial effect on the aquatic and air environments, prolonged accumulation of irrational nature management (forest, land and water utilization), long disturbance and pollution of environment (with solid, liquid and gaseous waste). At that, under transboundary conditions of the basin geosystem, almost all of such threats can be also transboundary, i.e. they can come from basin portions and geosystem components of one country and affect those of other countries within common basin. The high relative integrity of basin geosystems under transboundary conditions is a precondition of connectivity both of the nature management structures within the whole geosystem and ecological problems [3, 2 etc.]. Disturbance and pollution of natural systems and their components in one part of the geosystem and basin can be extended to the whole basin.

In spite of quite small period of active basin territory development (about 150 years), its population is about 90 million people and more than 90% of them reside on the China territory.

Therefore, many natural complexes of the Amur River basin are subject to essential anthropogenic impacts and some of them underwent cardinal reconstruction. As our studies have shown, more than 70% of the basin territory is at one or another stage of active

anthropogenic successions forming here a quite complex and, in whole, unfavorable ecological situation, high degree of nature management dynamics and instability and, in a number of cases, spacious zones of critical and catastrophic transformations of natural environment. The latter, as a rule, are formed under the influence of essential technogeneous and pyrogenic impacts, large-scale timber-industry and agricultural development as well as complex environmental effect within areas of major urbanized settlements. Owing to the large-scale transformations of the Amur River region natural systems, various structures of the nature management (NM) were here formed including those with a weak adaptation to the natural-ecological peculiarities of the region. In this connection, the Amur River basin including territories of four states (RF, PRC, MR and DPRK) requires considerable national and international efforts aimed at the improvement of ecological situation and transition from processes of uncoordinated and, in some cases, disordered NM and degradation of the territory's resource-ecological potential to the creation of the sustainable nature management in the region. By this, identification and analysis of global and regional treats and risks to the sustainable nature management in the transboundary region as a whole should be preceded.

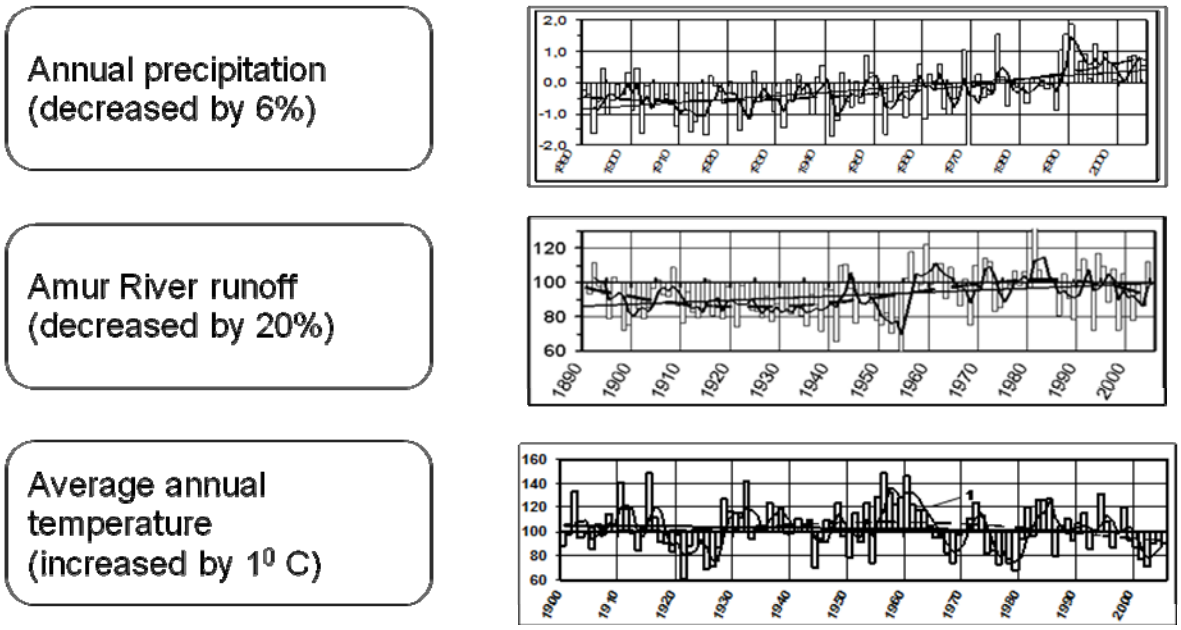

Fig. 2. Long-term (1891-2005) dynamics of climatic and hydrological characteristics in Amur River basin

The global threats and risks include, first of all, climate warming that may lead, in the southern Amur River basin, to the strengthening of the landscape steppification and desertification, wind erosion, fall in ground water level, shallowing of watercourses and water bodies, change in bed-movement, variations of qualitative and quantitative characteristics of terrestrial and aquatic ecosystems in the southern Amur basin. At the same time, a climate warming in the Lower and Middle Amur River region on retention of the pronounced monsoon features will lower an environmental comfort level for local population (temperature rise against the background of high humidity) in summer. In the northern regions, the processes of permafrost melting (depergelation) and, as a consequence, thermokarst and bogging processes become more active under the influence of elevated temperature and

precipitation. According to P.V. Novorotsky's data [10], mean temperature and average rainfall in Amur River region have increased by 1°C and 10% respectively in the last 120 years (Fig. 2). If these tendencies will maintain, a strengthening in the flood catastrophism degree on rivers of this part of the region, falling of forest stand on early cryogenic soils of low plains and lower relief areas are possible. The essential ecosystem reconstruction can take place within appropriate portion of the Amur River basin.

A series of regional threats and risks is much wider and impressive. To them, the repetitive floods as well as continuing transformation of natural ecosystems under the action of the economical activity: direct withdrawal of natural-resource components and drastic alterations as a result of residential and industrial building construction, development of farming industry, timber harvestings, fires, pollution of surface waters in the course of water consumption and erection of waterside structures should be assigned. It should be noted that the residential, transport and industrial construction, withdrawal of lands for agriculture, pollution of aquatic ecosystems are in a greater degree characteristic of the Chinese side. Here, a population density is an order of magnitude higher than on the rest of territory, industry and agriculture for which about 70% of the Chinese territory in the basin is utilized are intensively developing in recent years. The volume of untreated industrial and residential waste waters discharged to the Amur basin watercourses only in Heilongjiang province reaches 11 740 million m^3 [6] or 20 times greater than a "contribution" of the Russian side (approximately 500 million m^3 of untreated sewage). To this must be added the considerable surface wash from farm fields to the Chinese part of Amur River and its tributaries basin of chloroorganic compounds (pesticides), nitrites, nitrates, phosphates (ingredients of mineral fertilizers), hydrocarbons. The Sungari and Argun rivers flowing into Amur River carry often an enormous amount of suspended materials, 423 mg/l and 852 mg/l respectively [8]. Transboundary pollution of waters creates the most considerable regional threats and risks within the Amur River basin. Apart from a chronic Amur River pollution caused by the Chinese side, there are catastrophic discharges of pollutants caused, first of all, by periodic accidents at some Chinese industrial plants. So, chemical emergency in Jilin town in November, 2005, resulted in a discharge to the Sungari River of more than 100 tons of benzene, nitrobenzene and aniline which traces were observed even in the lower reaches of Amur River. At that, much more toxic derivatives of these compounds - ethylbenzene, toluene (methyl benzene), xylene (methyl benzene) etc. – were also found in Amur waters [7]. It should be noted that, in 3 succeeding years, more than 20 accidents happened at Chinese plants within the Sungari River basin as a result of which a considerable part of pollutants arrived, as before, at the Amur River.

Great regional threats and risks are periodic floods in all rivers of the basin as well as hazardous water-resources situations. According to evaluations by B.I. Gartsman et al. [12], all the complex of hazardous hydrological and water-resources situations (threats and risks) is caused by two main features of the Amur River basin – high instability of the hydrological regime in the within-year and long-term dynamics and high contrasts in the economical and social development of the Russian and Chinese parts of the region (Fig. 3).

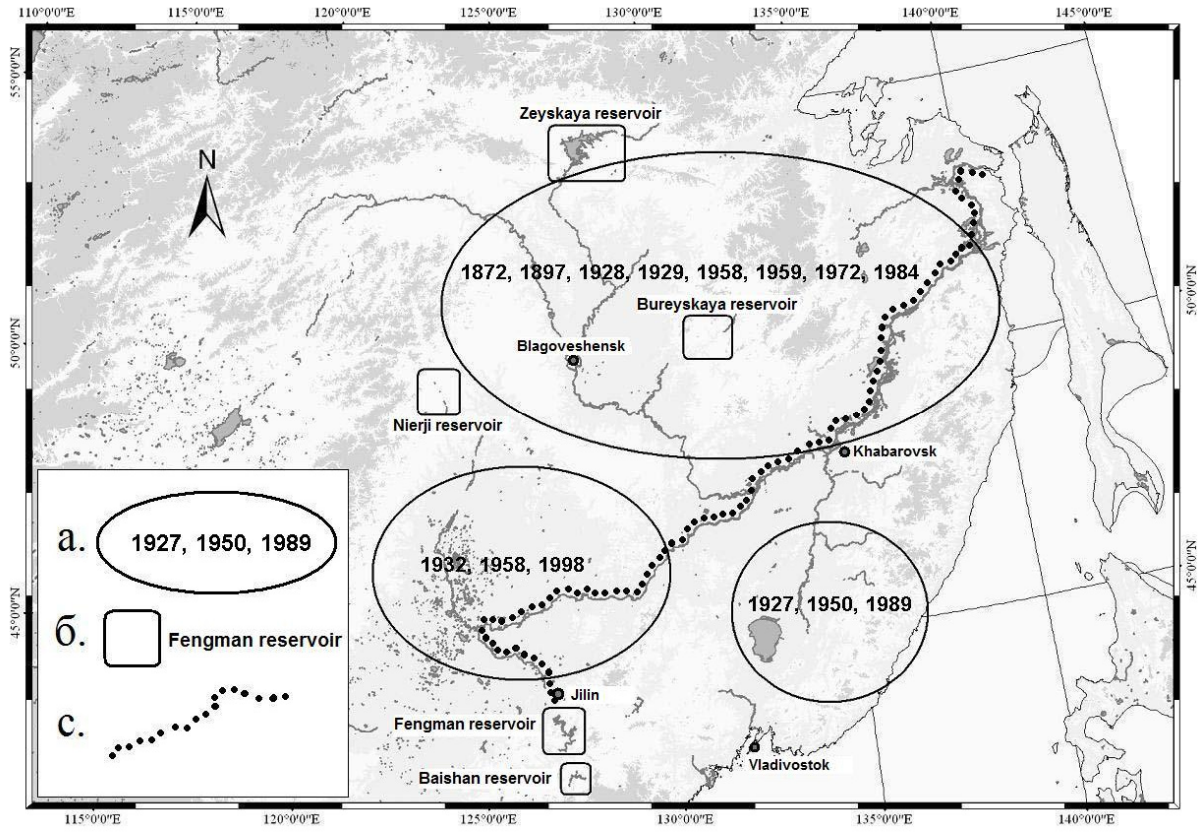

Fig. 3. Hazardous hydrological events and water-management situations in Amur River basin.
a. Years and approximate areas of territory covering with remarkable floods.
b. Large water storage basins in the Amur River basin.
c. Path of motion of the pollutant "spot" in case of volley of sewage in November, 2005.

Floods at small and medium rivers and Amur River caused by summer-autumn rains are repeated practically every year. A threat is noticeably reduced after construction of water storage reservoirs. However, in case of their possible operating troubles, the threats of great floods can arise. For example, such threat has arisen at Zeya water reservoir in 2007 when water inflow has exceeded a design flood. The possible water supply deficits during dry seasons constitute certain threats in a number of basin areas.

The sustainable nature management in the region suffers also from tree felling and forest fires. At that, nearly 100% of cleared spaces in some areas undergo fires eventually. Littered with refuse wood, cleared spaces are strong stimulators of pyrogenic processes as a result of which the fires, after forming and gaining the strength, move subsequently to adjoining trees and shrubs. As a result, losses of forest resources and areas are quite great. In the last 100 years, the forest lands in the Russian part of the basin have decreased by only 20% (with essential drop in quality and capability of forests) [5] whereas in the Chinese part by more than 70% [6, 9]. It should be noted that the fires in the Amur River region are equally characteristic of open landscapes - meadows, bogs and highlands. They result in complex destructions of ecosystems involving in these processes practically all of their components but adversely affecting, mainly, their biological diversity, to a greater extent, than tree felling or agricultural transformations of lands.

On the pyrogenic territories, the ground-water levels, hydrological and temperature regimes of watercourses and water bodies change significantly and the chemical composition of their waters varies, first of all, at the expense of surface wash to the water systems of enormous amounts of ash constituents. Up to 300 kg of ash constituents including potassium, calcium, phosphor etc. come from 1 ha of burned-out forests [1, 11]. After that, a considerable part of such water bodies and, not infrequently, watercourses undergo an eutrophication. For the time being, the fires (depending on fire type and territory features) may destruct the ecosystem completely destroying soil, vegetation and up to 95% animal population [4]. Allow for the fact that about 1500 fires covering, on the average, approximately 800 thousand hectares arise in Amur River region every year, the scales of pyrogenic effect on the natural complexes are quite essential.

A profound influence on the condition of aquatic and, as a whole, floodplain ecosystems of Amur river and some its tributaries is exerted by erection of waterside structures. Zeya and Bureya hydropower stations operate in the Russian part of the basin and smaller Fenman, Baishan, Hongshun (Хонгшуньская), Jingbohun and Lianghuan stations in the Chinese territory as well as there are large quantity of other great and small waterworks. At that, account must be taken of the circumstance that more than 70 cross sections suitable for construction of great and medium hydropower stations and about 200 cross sections for small ones are only counted on the Russian territory of the basin. Several hydropower stations are considered to be first-priority. On the Chinese territory, the prospects of erecting the waterside structures are lower but the Xihuguo power project will be placed in operation in the coming years and other projects with realization over the long term are discussed. Thus, the effect of waterworks on the Amur basin ecosystems will become stronger. Suffice it to say that single Zeya hydropower "takes" from Amur River about 40 cm of the summer water level but, at the same time, increases by factor of six to eight its winter water discharges. As a result, areas of spawning grounds of ordinary fishes decrease considerably, water temperature regime and fish capacity vary during spring-summer period in the tail water of regulated rives and high-water bed of Amur. At once, the winter stream bank erosion became a practice and a dilution capacity of the Amur River waters increased during winter season. The chemical composition of waters in the storage basins has changed considerably, low values of mineralization and increased contents of biogenic and organic matters have become established which has reflected in the Amur water quality and color (color of water values increased appreciably). The concentrations of ammonium nitrogen and total iron have also increased. Provision of water storage basins resulted in significant changes in living conditions of many species of animals and plants, first of all, in the tail-water and some microclimatic changes. That is, an effect of waterworks facilities on the ecosystems begins to acquire a complex character causing changes in the condition of hydrobionts including their productivity in Amur River as well as in components of coastal landscapes.

The declining ecological situation in the Amur River basin is a result of risks of its biological pollution. So, in the last decades, a large grouping of adventive flora or so-called imported species of plants has here formed. Currently, it constitutes more than 20% of the whole of the Amur River region flora.

A situation with Amur fishes is almost the same. In the last 30-40 years, their species composition has increased by nearly 30% at the expense of active infiltration to the Amur basin of imported species which are less valuable but adapted to habitation under present-day unfavorable conditions. At that, they quite often displace indigenous species and take their ecological niches while reserves of valuable species of ordinary fishes, sturgeons and salmon fishes decrease.

A biological diversity in the terrestrial ecosystems of Amur River region is also decreasing. A deterioration of living conditions of a wide variety of plant and animal species, reduction in their food reserve, stations for shelter and reproduction, pursuit by poachers have lowered the populations of a large number of species rearranging them from category of common species to category of rare and endangered ones and whereby increasing considerably lists in the regional Red Books for plants and animals. Together with total reduction in the biological diversity (species and ecosystem, first of all), numbers of game animals, reserves of wild medical plants, plants for technical use, edible plants and other useful forest products (nuts, berries, mushrooms) which, along with fishes, form the basis of food ration and are critical objects of traditional forms of housekeeping (fishing, hunting, gathering) of native minorities and, as a whole, majority of taiga and rural population decrease. The existing unfavorable ecological situation resulted in fall of productivity of natural ecosystems and their recovery potential. At the same time, an attractiveness of landscapes has decreased as a result of their all-powerful transformation. In the end, overall reduction in the living comfort level of local population is here observed. Negative demographic processes affect not only urban population but also rural one which is a threat to the sustainable nature management in the region.

On the whole, one can identify different scales of ecological threats including the following transboundary ones:

1. Measurable disturbances, pollution of individual components of geosystems.
2. Disturbances, pollution – within MPC, MAD and other environmental norms.
3. Disturbances, pollutions exceeding ecological norms.
4. Pre-critical disturbances and pollutions which do not result in irreversible alterations of geosystems.
5. Critical disturbances and pollutions which cause irreversible alterations of the geosystem components.
6. Catastrophic disturbances and pollutions which cause a destruction of ecosystems and geosystems.

By now, the Amur River basin has lost a large part of its natural-resource potential (productive and suitable for commercial development forests, fish resources, natural reserves of game animals, medical, technical and food raw materials, tourist resources including an attractiveness of landscapes, resources of the clean natural waters, reserves of some mineral resources etc.), its ecological capacity has reduced and ecological tension in the region has grown. There is a quite real risk of maintenance of these negative tendencies unless a policy

in respect of regional NM and international coordination under transboundary conditions changes.

On the whole, a specificity of the nature management within the Amur basin is determined by both transboundary conditions of large-scale geosystem with greatly differentiated economies of neighboring countries and their different effects on the individual geosystem components and its basin nature.

One can identify the following outstanding features of influencing the transboundary conditions on the nature management in the Amur River basin geosystem [2, c. 72].

1. Preservation of community and interrelation of the natural-geographical structures and processes in different parts of the basin geosystem and in different countries.
2. Preservation of a certain connectedness of the natural-resource structures in different links of the basin geosystem.
3. Asymmetry of territorial structures of the nature management expressed in their differences on both sides of the boundary. The similar differences of homogeneous economical, social and ecological indices can be measured by transboundary gradients.
4. An asynchrony of the nature management processes and tendencies expressed in the fact that these processes and tendencies in the same periods of time on both sides of the boundary differ.
5. Performing by the river the peculiar function of the ecologo-geographical axis in the basin geosystem where the ecological state of the river reflects, to a considerable extent, the same of the whole of basin ecosystem.
6. Formation in the basin geosystem of two-section natural-economical structures in the form of possible integrations of natural-resources and economic entities on both sides of the boundary.
7. Especially close and complicated interrelations arise in the use of water resources in the transboundary basin geosystems.

Thus, a necessity becomes evident to be switched to a new system of regional economic and nature management which is able to provide the long-term and ecologically sustainable development of the region.

The primary efforts should be concentrated on the balance maintenance between the social-economical interests of the region population and resource-ecological capabilities of its territory, ecosystems and their components. At that, it is necessary to take into account the scientifically grounded provisions forming the basis of the creation of the sustainable and ecologically adapted NM aimed at both rational use of the natural-resources potential and general progressive development of all region.

1. The processes of production and use of natural resources should be preceded by the qualitative and quantitative assessment of the territory's resources-ecological potential, its natural and anthropogenic dynamics, current and predicted state. At that, the assessment of the natural-resources potential and its dynamics is necessary for the transboundary basin as a whole based on general technical approach.

2. All the analytical information of the basin including characteristics and estimates of the natural and natural-resources systems, ecological state of the territory and water objects, basic parameters of the territorial structures of economy and nature management should be presented in the form of hierarchical geoinformation system (GIS). Its upper level should generalize and coordinate information within the whole transboundary basin of Amur River. The more detailed GISs are created for national levels: Russian, Chinese, Mongolian portions of the basin. One more GIS level can cover the basins of Amur tributaries: Sungari, Zeya, Bureya, Ussuri etc. At last, more detailed GISs are possible for individual administrative districts, zones of cities, municipal formations, waterworks facilities of most vulnerable elements of geosystems etc.

3. Based on results of estimating the condition and dynamics of the territory's resource-ecological potential, the priority types and structures of the NM as well as limitations in the regional NM are determined.

4. The important condition of forming the adapted and sustainable NM is taking into account the peculiarities of the social-economical base and ecologo-psychological environment which can contribute to or prevent from developing one or other types of the NM. The social-economical condition of the region, ability to invest or attract the investments, availability of labor resources, their educational level (including the ecological problems) and readiness to one or another kind of activity, positive or negative perception of the nature and long-term objectives of the territory development determine, to a considerable extent, a policy, sustainability and effectiveness of the NM.

5. When determining the prospects of developing the existing and planned regional types of the NM, it is needed to evaluate the capabilities of their modern and perspective (long-term) research-and-engineering and innovative provision. The investment projects of new construction and modernization of objects should be bases on the latest environmentally safe and sound technologies.

6. The major challenge is to coordinate the regulatory-legal base supporting one or another type of the NM in different countries as well as application of the appropriate adapted technologies and engineering solutions under particular conditions.

7. A realization of any type of the NM and their combinations in the region should be preceded by evaluation and establishment of necessary infrastructure (transport, energetic and information communications, bases for processing, storage and distribution of production, treatment complexes, sanitary zones etc.) an availability or absence of which can contribute to the stability of the nature management processes or prevent from it.

8. Any type of the NM should be preceded by its ecological expertise at the levels of development schemes, feasibility reports (FR), business-plans, feasibility studies (FS) and realization projects. The expert reviews are performed for expected NM type as well as for territory on which it is realized or planned to be realize and the whole its system with this type of the NM.

According to results of the ecological expertise valuating the existing and possible consequences of the NM process realization for ecosystems of different levels and people, the variants of compensations, neutralization and reduction of current and apprehended damages

are considered and, in addition, the environmental-legal standards, monitoring principles and NM process regulations are agreed. These provisions under present-day conditions must become the scientific base for development and realization of the sustainable nature management strategy for the Amur River basin.

In the long run, based on the appropriate intergovernmental agreements it is profitable to work out international program of the sustainable development for all transboundary region of Amur River basin. For the purpose of the subsequent coordination of realizing such program, it is necessary to establish the international commission including representatives of all basin countries as well as to set up a permanent system of the international monitoring of the nature management.

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