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Formation of the Regional Economy in the Context of Environmental Risks

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Abstract. The article is devoted to the analysis of the main modern challenges in the environmental sphere in Russia and its individual regions. The reasons for the formation of environmental challenges and threats are disclosed, and key challenges are identified for which ways to overcome them in the first place should be sought. Among them, emphasis is placed on the lack of the necessary conditions in the country for the development of industries using environmentally friendly technologies; a number of institutional conditions that would contribute to the improvement of modern state environmental policy; effective use of strategic planning and management as one of the ways to solve environmental problems. Environmental challenges are conventionally divided into general, which are characteristic of the regions of Russia of any type, and specific, characteristic of regions of a certain type. Particular attention is paid to identifying environmental challenges and threats in the resource regions of the new economic development, one of which is the Lower Angara region in the Krasnoyarsk Krai (Russia). The research methodology is based on linking environmental issues with the nature of the socio-economic conditions of a particular territory. Possible ways of mitigating and overcoming environmental challenges and threats are proposed, which are suggested to be guided in choosing the directions of economic development of the region under study. The long-term nature of environmental problems necessitates the using the strategic approaches to solving them. The results can be used to develop a strategy for the integrated development of territorial economic systems in the context of forecasting environmental activities to substantiate management decisions.

Keywords: environmental challenges and threats, environmental strategy, environmental compatibility of industries, the territorial environmental and economic system, the effect of synergies of pollution, additivity of the interaction of harmful substances.

Research area: social structure, social institutions and processes (socio-logical sciences); regional and sectoral economy.

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Формирование региональной экономики в контексте экологических рисков

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Аннотация. Статья посвящена анализу основных современных вызовов в экологической сфере России и отдельных ее регионов. Раскрыты основные причины формирования экологических вызовов и связанных с ними рисков, а также выделены ключевые вызовы, пути преодоления которых следует искать в первую очередь. Среди них акцент сделан на отсутствии в стране необходимых условий для развития производств с использованием экологически ориентированных технологий; необходимости решения ряда институциональных проблем в экологической сфере; обязательном использовании стратегического планирования и управления как одного из способов решения экологических проблем с учетом долгосрочной перспективы и др. Экологические вызовы условно можно разделить на общие, характерные для регионов России любого типа, и специфические, характерные для регионов определенного типа. Особое внимание уделено выявлению экологических рисков в ресурсных регионах нового экономического освоения, одним из которых является Нижнее Приангарье в Красноярском крае (Россия). Методология исследования основана на увязке экологических проблем с характером природно-климатических и социально-экономических условий конкретной территории. Предложены возможные пути смягчения и преодоления экологических рисков, которыми предлагается руководствоваться при выборе направлений экономического развития исследуемого региона. Долгосрочный характер экологических проблем обуславливает необходимость использования стратегических подходов к их решению.

Ключевые слова: экологические вызовы и угрозы, экологическая стратегия, экологичность производств, территориальная эколого-экономическая система, эффект синергии загрязнения, аддитивность взаимодействия вредных веществ.

Научная специальность: 5.4.4. Социальная структура, социальные институты и процессы (социологические науки); 5.2.3. Региональная и отраслевая экономика.

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Introduction

Modern environmental challenges from the point of view of their territorial coverage are usually subdivided into global, national and regional (Addressing, 2015; Biodiversity, 2017; Environmental challenges..., 2010; Matson, 2001; Tedsen, Kraemer, 2015). The challenges and threats to the environmental safety of Russia and its regions are largely due to institutional problems in the field of state environmental management and are largely associated with the existing technically backward structure of the economy (Aganbegyan, 2022), the country's insufficiently effective environmental policy, the lack of effective economic instruments for environmental regulation, insufficient financing of the environmental sphere, the constant weakening of the role of environmental legislation, the growth of offenses in the environmental sphere, low environmental responsibility of business and other reasons (Blokov, 2018; Environmental institutions..., 2010). All this creates serious challenges in the field of ensuring environmental safety in the country as a whole and its regions in particular.

Among the environmental challenges, one can conditionally single out region-wide challenges that are typical for regions of Russia of any type, and specific regional challenges inherent in regions of a certain type, including resource regions of new economic development. Thus, many resource-extracting regions and regions with a high territorial concentration of industrial production in Siberia are characterized by serious environmental problems associated with the preservation of the resource orientation of the economy, the intensification of environmental degradation processes and the deterioration of the health and living conditions of the population, the deterioration of the state of forest and water resources, and the growth of forest fires, a decrease in biological diversity up to the disappearance of certain species of plants and animals, a constant increase in the production of industrial and municipal waste and

the number of unauthorized landfills, etc. The solution of the listed problems is impossible without the formation of a flexible system of environmental management both at the federal, and at the regional and local levels of government, which prevents the strengthening of existing unfavorable environmental and economic trends and the emergence of new ones.

The purpose of the article is to identify possible environmental challenges and threats in the resource regions of new economic development on the example of the Lower Angara region in the Krasnoyarsk Krai (Russia).

Achieving this goal required solving the following tasks: to perform an analysis of regional environmental challenges, possible threats caused by them, and propose measures as adequate responses; to characterize the Lower Angara region as a resource region for new economic development, to show its investment attractiveness and significance for the development of environmental factors; to identify the main environmental challenges in the Lower Angara region and propose the best ways to overcome them, based on the results of applied research on the example of this region.

The scientific novelty of the study consists in the analysis of the possibilities and limitations of the development of a particular region from the standpoint of environmental challenges and threats and the search for ways to prevent and overcome them, recommendations are made regarding the prospects for the development of the Lower Angara region, taking into account environmental requirements.

Region-wide environmental challenges, possible threats caused by them, and the required responses

First, among the main regional challenges, *the lack of the necessary conditions in the country for the development of industries using environmentally friendly technologies* should be highlighted. The technological backwardness of industrial enterprises is directly related to the threat to environmental safety

and, accordingly, determines the economic inefficiency of the outdated technologies used.

The following measures, including long-overdue ones, could become worthy responses to such threats.

1. Transition to an innovative vector of greening the economy in the regions, creating conditions for the introduction of green technologies with a simultaneous growth of the regional economy, an increase in the well-being of people and a decrease in the negative impact on the environment. For Russian enterprises, this challenge seems to be extremely serious, since a worthy response to it is associated with great risks arising from the need for huge investments and the time of their implementation, during which it is possible to replace obsolete equipment with new ones, as well as with a reduction in profit during the corresponding period of reconstruction and modernization. It is evident that the transition to new technologies is impossible without thoughtful and consistent government support, measures of which would allow minimizing possible losses of companies during the period of their modernization of production or the creation of new high-tech industries.

2. Consistent and thoughtful implementation of the principle of the best available technologies (BAT) based on technological transformations of the economy. This measure, as shown by the experience of developed countries that have introduced a system of environmental regulation based on BAT, requires the creation of a number of important and necessary prerequisites that can not only increase the competitiveness of products and the investment attractiveness of business, but also simultaneously reduce the level of negative impact on the environment (Veselova, 2010). These include, first of all, the massive transition of industry to new resource-saving and environmentally friendly technologies and the introduction of the international system of environmental management standards ISO 14000 at enterprises. However, neither the one nor the other has yet become the norm for Russian practice.

3. Intensification of the development of sectors of the green economy as one of the main ways of movement towards sustainable

development generally recognized by the world community.

It is evident that all of the above measures to create the necessary conditions for the development of high-tech industries using environmentally friendly technologies are interrelated and complementary.

Second, a serious environmental challenge is associated with *the weakness of the modern state environmental policy*, which is not sufficiently focused on creating conditions for structural and technological transformations of the economy in favor of resource-saving and energy-saving and low-waste industries. This makes it difficult to secure and obtain economic and environmental benefits from conservation activities. Therefore, the need to develop and implement new effective management tools in the environmental sphere, which make it possible to stimulate the modernization and reindustrialization of production and the widespread use of environmental technologies, remains extremely urgent.

Third, an important challenge in the environmental sphere is the long-term nature of environmental problems that determine the safety of life of the population, which highlights *the need to develop strategic approaches to their solution*. Therefore, the development of strategic documents for the socio-economic development of regions requires taking into account possible security threats, including environmental ones, and makes it necessary to use a strategic approach in the formation of state environmental policy (Burmato, 2021).

The listed calls are common for regions of various types. However, in each region, specific regional environmental challenges may also arise, due both to the peculiarities of the production and spatial nature of the economy of individual regions, and to the natural conditions of each specific territory. Using the example of the Lower Angara region¹ in the Krasnoyarsk Krai (Russia), we will consider the

¹ The Low Angara region is usually understood as a region located in the Basin of the lower flow of the Angara River and the middle section of the Yenisei River. It consists of the territory of five districts within the Krasnoyarsk Territory (Boguchany, Kezhma, Motygin, Yeniseisk, North-Yeniseisk districts).

possibilities and limitations of its development from the standpoint of environmental challenges and threats.

Preconditions for the development of the Lower Angara region

The Lower Angara region is one of the most promising regions for new economic development in modern conditions of the country due to the high attractiveness of its territory for new large-scale investments for industrial and infrastructural development. The investment attractiveness of the Lower Angara region is due to the presence of a colossal resource and energy potential on its territory, as well as a certain backlog created in the field of production infrastructure (including railways and roads, a bridge across the Angara, power lines, electrical substations and other infrastructure facilities).

All these advantages of the region, on the one hand, were the reasons for attracting the attention of government bodies and potential investors to it for the assimilation of the region and development programs (Guidelines..., 1990; Lower Angara region..., 1996) and, on the other hand, determined the necessity and importance of the implementation of strategic developments in the field of exploration and further development of the region, including the ecological sphere.

The formation of the ecological situation in the Low Angara region depends largely on the influence of a number of factors that can be combined into the following aggregated groups:

- 1) natural and climatic conditions are generally unfavorable for the disintegration of pollution of various kinds in the region's environment;
- 2) high concentration of environmentally harmful industries in individual industrial nodes, preservation of the trend of creating super-large enterprises, etc.;
- 3) impact from existing and possible future hydroelectric facilities on the Angara and the Yenisei rivers;
- 4) approaches used to solve environmental problems at enterprises, including technological and organizational measures.

Methods

Based on the materials of the Low Angara region, the IEIE of the Siberian Branch of the Russian Academy of Sciences has solved a number of problems on the choice of possible scenarios for solving environmental problems in the framework of developing a strategy for the socio-economic development of the region, taking into account the mutual influence of the natural-climatic and socio-economic characteristics of the territory on the formation of the ecological situation and the identification of priority environmental problems (Burmatoва, 2021). The essence of the approach used to predict the development of a territory, taking into account socio-ecological and economic interactions, is to consider the region as a separate limited compact territory, which is characterized by the presence of a close interconnection of economic, social and environmental features from the standpoint of their joint influence on the formation of the ecological situation.

For the practical implementation of tasks for predicting environmental protection activities in the region, an economic and mathematical toolkit has been developed that allows analyzing the environmental and economic relationships that arise in the region when predicting the development of its spatial structure of the economy. The composition of this toolkit and the nature of the tasks solved with its help are shown in Fig. 1.

In this article, in contrast to our earlier studies, an attempt is made to combine the results obtained (using different models and methods) to form a general picture from the point of view of a comprehensive analysis of the ecological situation, which may develop in the region in the future under the influence of many different factors. Based on this, it seems possible to identify the main environmental challenges and propose the best ways to overcome them.

Results and Discussion (Environmental challenges in the Lower Angara region)

1. Significant scale of production at individual sites. The production structure of the region under consideration covers both created to date and planned in the future large-scale

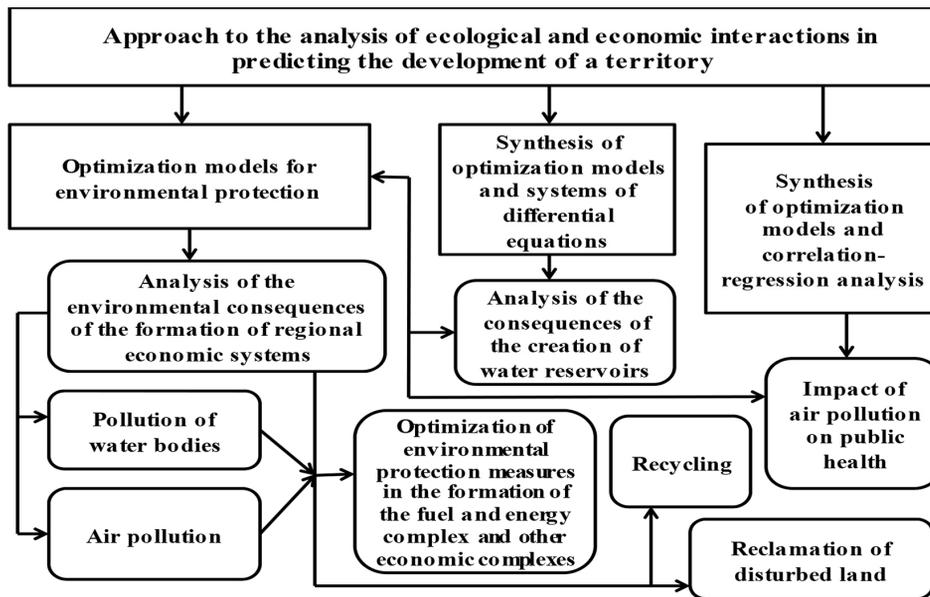


Fig. 1. Toolkit for the analysis of socio-ecological-economic interactions in the region and the main problems to be solved

Source: compiled by the authors

objects of ecologically significant types of activity, including mining, timber industry, hydro and thermal power plants, enterprises of the chemical, petrochemical and gas processing industries, large infrastructure elements (railways and highways, power lines, oil and gas pipelines, etc.). So, in 2016, an aluminum plant was put into operation in Boguchany with a design capacity of 600 thousand tons. In the near future, a new pulp and paper mill is planned here with a design capacity of 720 thousand tons of pulp per year as well as the Tagara mining and processing plant in the Kodinsk district with a capacity of 3.3 million tons of concentrate per year, the Boguchany hydrolysis and yeast plant with a capacity of 30–35 billion m³ per year and other production facilities.

These objects for the most part, on the one hand, create a significant load both scale and by the variety of types of environmental impact. On the other hand, the raw nature of the region's economy is fixed, it is difficult to achieve its sustainable development.

It seems to be important to note the fact of serious complication for the large-scale enterprises to solve the problem of neutralizing the

resulting volumes of pollutants. Such a complication is due, firstly, with the need to develop for them, as a rule, unique (and throughput, and by degree of cleaning) systems and cleaning methods, secondly, with increasing costs of developing relevant systems and methods. This necessitates extremely thoroughly choosing technological and environmental innovative solutions in the future production of the region in order to prevent the pollution of air and water basins and other violations in the environment. In addition, a more thorough analysis of the possibilities of reducing the capacity of future facilities and assess their joint impact on the environmental situation in places of their placement and operation are useful².

2. The uneven territorial development of the region. The economic development of Lower Angara region does not pursue development goals through full coverage of its entire territory. On the one hand, it seems justified

² Thus, the calculations performed by us were shown, in particular, that in the conditions of the Low Angara region, the size of the unit capacity of the pulp and paper plant should not exceed 300–350 thousand tons (instead of the planned 720 thousand tons), and the aluminum plant – 200–250 thousand tons (instead of 600 thousand tons).

with the considering the scale of the territory and limitation of funds. However, on the other hand, the intentions to focus on the small number of areas (primarily in Boguchany and at least – Kodinsk) will inevitably be accompanied by the enhancement of the load on the environment in these areas.

From the positions of the territorial concentration of production, the first new objects are placed in the Boguchany district (or industrial node). Here, the Boguchany hydroelectric station is already functioning, a large aluminum plant and a number of enterprises of the timber industry complex. In the future, in Boguchany, it is planned to supplement the existing timber industry complex with a new pulp and paper mill, as well as the creation of gas processing and gas chemistry industries. The construction of new production facilities is also planned in the Kodinsk area, in particular, we are talking about the commissioning of the Tagara mining and processing complex and a cement plant, and in the more distant future – a pulp and paper mill. Expansion of the production structure is also expected in the Motygin district by increasing the capacity of the Gorevsky lead-zinc mining and processing plant and the construction of the Motygin hydroelectric power station. In addition, in the long term, in these areas, it is possible to build a number of other industrial enterprises, as well as transport and energy infrastructure (Investment project, 2021; 2022).

3. Low regeneration potential of the natural environment of the region. The assimilation potential of the aquatic environment of the Lower Angara region is already close to depletion. The quality of water in the Angara River depends not only on the volume and composition of discharged industrial and domestic wastewater, but also on its regulation by dams and reservoirs (Krasnoyarsk Territory, 2022). The region has already achieved a fairly high level of pollution of water bodies with organic substances, primarily phenols and oil products (mainly due to pollution coming from the region of the upper and middle flow of the Angara River).

The situation is aggravated by forecasts of construction in the lower reaches of the Angara

River of new hydroelectric complexes with reservoirs (Motygin and Nizhneboguchanskoye), which will inevitably lead to further disruption of the natural hydrological regime of the river and the risk of increased water pollution.

From the standpoint of the assimilation potential of the atmosphere, the Lower Angara region has significant differentiation, characterized by the deterioration of many parameters of natural and climatic conditions from west to east. So, in the most unfavorable position in terms of dispersion of pollutants is the Kodinsk area (Scheme, 2008).

The listed features of the Lower Angara region, as well as frequent temperature inversions, fogs, calmness and uneven distribution of precipitation throughout the year, cause the possibility of weak dispersion of pollution in the atmospheric air and, accordingly, increase the risk of accumulation in the surface layer of the atmosphere of high concentrations of harmful substances.

Thus, the specificity of local (generally unfavorable) natural and climatic conditions of the territory is also makes it necessary to enter the region with technologically advanced industries equipped with advanced technologies and environmental systems.

4. Pollution of water bodies. At present, the main load on the water system of the Lower Angara region falls on facilities operating in the Boguchany and Kodinsk areas, as well as a result of the influx of pollutants carried downstream from the upper and middle sections of the river within the Irkutsk region. In the future, the Angara River on the plot from Kodinsk to the usting river will receive the flow of pollutants with wastewater from currently under construction or planned to create large-scale industrial facilities (first of all, aluminum plant and pulp and paper mill). In addition, the contaminants carrying substances carrying the river from the above situations will flow into this section of the hangars. As a result, this area of the river can become one of the most problematic water pollution by wastewater.

Studies have shown that important factors for the formation of water quality are also the processes of accumulation of pollution falling into the river with allocated drains, and the

natural transfer of harmful substances between adjacent ranges. These factors leading to worsening water quality in reservoirs should be reflected in the assessment of the state of water resources in reservoirs on the Angara River.

5. The synergistic effect of the interaction of pollutants. The synergistic effect in the atmospheric air is possessed, in particular, by such substances as sulfur dioxide and chlorine, sulfur dioxide and moisture, nitrogen oxides and hydrocarbons, hydrogen fluoride and methyl mercaptan, etc. (Petin, Syntsyns, 1998; Mauderly, Samet, 2009; Wu Dan, Ma Xunzhou, Zhang Shiqiu, 2018; Bandoli, von Ehrenstein, Ghosh, Ritz, 2016). The synergistic effect of exposure in the aquatic environment is characteristic, in particular, for copper and lead ions (the combination of which in wastewater can cause more harm than each of them separately); as well as petroleum products and pesticides, etc. (Combined (complex) action, 2022).

Based on the foregoing, in the Lower Angara region there is an acute problem of the possible connection of ecologically incompatible large-scale industries in one place. According to the results of the calculations, it is necessary to abandon the joint placement, first of all, of such combinations of industries as the aluminum and pulp and paper mills in the Boguchany area. Otherwise, there is a great risk for the Lower Angara region to repeat the fate of the city of Bratsk, where the functioning of such supergiants as the Bratsk Aluminum Plant and the Bratsk Pulp and Paper Mill led to intensive destruction of forests and an increase in the incidence of diseases of the population. The synergistic effect in this case is due to the interaction, firstly, of fluoride compounds emitted by the aluminum plant, and methyl sulfur compounds entering the atmosphere from the pulp and paper mill, and, secondly, the mixing of sulfur dioxide and chlorine emitted by these objects, respectively.

Thus, on the territory of the Lower Angara region, the formed and future structure of the regional economy should take into account the effects of synergy and additivity of the interaction of pollutants and the prevention of combinations of ecologically incompatible industries in a separate limited area. The introduction of

bans on the location of the relevant industries will prevent possible environmentally hazardous consequences of their joint functioning, primarily for human health and the state of natural systems.

6. Consequences of the construction of hydroelectric facilities with large reservoirs. Special environmental threats are associated with the construction of a cascade of hydroelectric power plants on the Angara River and flooding of significant areas of the territory, which led to negative changes in ecosystems and microclimate in the flood zone, destruction of banks, deterioration of water quality, and changes in habitat conditions for plants and animals.

The existing projects of RusHydro for the further development of hydropower in this region (in particular, as part of the creation of the Angara-Yenisei cluster) relate primarily to the possibility of constructing two more hydroelectric power plants in the lower reaches of the Angara River – Nizhneboguchany and Motygin. As a result, the Angara River will be regulated along its entire length from source to mouth, turning into the second Volga with all the ensuing negative changes and their consequences.

The reservoirs in the lower reaches of the Angara River will be not only the sedimentation tanks of pollution, but also the closing ones in the cascade. The studies carried out, in particular, have shown that the natural regime of the river will not only remain in the past, but the tendency for a consistent deterioration in water quality will intensify (Socio-ecological results, 2013).

Conclusion

The analysis of modern environmental challenges and the search for answers to them makes it possible to develop ways to overcome them and transform various environmental institutions in the right direction, including, first of all, the improvement of environmental legislation, the reanimation of the institution of state environmental expertise, the introduction of the principle of the best available technologies, etc. Ignoring any of the described challenges and the threats they entail is fraught with seri-

ous environmental risks. Based on the results of the study, measures were identified, the implementation of which could become a worthy response to regional and specific regional environmental challenges and threats.

Environmental challenges and threats in the Lower Angara region are largely stem due to the lack of a comprehensive approach to forecasting the formation of the spatial structure of the region's economy, taking into account environmental and economic interactions; insufficient study of the strategic aspects of the development of the regional economy; weak state environmental policies that are not focused on encouraging environmental protection and the introduction of new resource-saving and environmentally friendly technologies; the lack of linking of investment and financial priorities

with environmental interests and other reasons. The search for adequate responses to the formed challenges and threats in the environmental sphere should be seen primarily in the direction of solving these problems.

The results of the study and the formulated conclusions can be used in the development of a strategy for the integrated development of territorial economic systems in the context of forecasting environmental activities to justify management decisions. In general, the significance of the results of the study is determined by the possibility of using them to form proposals on topical areas for improving the effectiveness of management in the environmental sphere of the region and substantiating the economic decisions made within the territories of intensive economic development.

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