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Vulnerability Assessment of Landscapes of the Kaliningrad Oblast for Environmental Management and Spatial Planning Optimization

Ivan I. Kesoretskikh[1]*, Sergey I. Zotov[2]

[1]Institute of Spatial Planning, Development and Foreign Relations, Klinicheskaya str. 27, 236016, Kaliningrad, Kaliningrad Region, Russia, [2]Department of Geography, Institute of Nature Management, Regional Development and Urban Planning, Immanuel Kant Baltic Federal University, Aleksandra Nevskogo str. 14, 236041, Kaliningrad, Kaliningrad Region, Russia.
*Email: ivan.k.loki@gmail.com

ABSTRACT

Regional applied research on comprehensive assessment of the territory for the purposes of optimization of environmental management and land use planning are now becoming increasingly popular among Russian researchers. The relevance of these studies is highlighted due to the necessity of introduction of environmentally oriented approaches to spatial planning system. This approach has found its application in the countries of Western Europe, where it takes place on legislative level, and in Russia it is not implemented fully. Aim of the study is to validate the methodology of integrated assessment of the Kaliningrad Oblast on the vulnerability of landscapes to anthropogenic influences. Result of the study is cartographic materials, which are the basis for the development of proposals for optimization of regional nature-use and existing scheme of spatial planning of the Kaliningrad Oblast.

Keywords: Landscape, Vulnerability, Kaliningrad Region, Geographic Information Systems, regional Nature Management, Spatial Planning
JEL Classifications: Q5, R1

1. INTRODUCTION

In recent years, a series of political and administrative steps have been taken in the Russian Federation to optimize environmental management and land use planning. The purpose of these initiatives is to assess the environmental impact and ecological consequences of the implemented land use planning and infrastructure projects. In this context, in several ecologically vulnerable Russian regions, such as the Altai and Lake Baikal area, model projects were implemented focusing on ecological aspects in land use planning. The results clearly demonstrate an urgent need for introducing environmentally orientated approaches to spatial planning in the Russian entities at both legislative and administrative levels. It highlights the relevance of the a well-proven and tested methodology of comprehensive assessment of territories in order to keep record of protected natural components and take account of ecological issues in land use planning.

One such approach consists in comprehensive assessment of geo-systems reflecting an all-embracing geo-ecological status of territories. It involves the assessment of vulnerability of landscapes to anthropogenic influences. At each stage, from design to operation of industrial and infrastructural units, addressing integrated indices helps to considerably reduce the impact on natural environment components and ensure sustainable development of the territory.

The development and approbation of this approach is of great importance for the Kaliningrad Oblast, as it tackles the region's unsatisfactory geo-ecological situation and promotes the implementation of large-scale construction projects.

2. THEORETICAL BACKGROUND

At the present moment, land use planning in Russia is more focused on investment leaving ecological requirements for land largely disregarded, which obstructs sustainable development of the territories. The current approach to zoning and use of protected natural complexes (protected natural units, water bodies, cultural objects, etc.) fails to draw a true portrait of the territories, which in its turn hampers creation of a mechanism for comprehensive environmental assessment and prioritization (NIIP Gradostroitelstva, 2014). Meanwhile, Russian land planning policies (Town Planning Code of the Russian Federation, 2004) do envisage elements of sustainable land use (Art.2 (1), Town Planning Code …), with due respect for ecological, economic, social and other factors (Art. 2 (2;9), Town Planning Code…). However, we eventually find ourselves in a situation where ecological issues do not become subject to land planning, but function only as construction constraints in urban planning.

Global practices show that spatial planning without comprehensive assessment of the territory leads up a blind alley. Experts deem it highly relevant for applied geo-ecological research to treat ecological components as essential elements in environmental protection and to make a transition to landscape territorial planning (Fedorov, 2014).

Scholarly publications outside Russia promote the term spatial decision analysis - A decision-making strategy aimed to make an informed decision, which involves decomposition of complex problems into smaller manageable sub-problems for subsequent analysis, and the re-composition of results from these analyses through processes of interpretative synthesis. Thus, spatial decision analysis is a component of the decision-making theory allowing the use of a whole body of geographical data. Advancements in geo-information technologies have made multicriteria decision-making the most optimal instrument of spatial analysis (Golobič and Breskvar, 2010; Malczewski, 2006).

Comprehensive assessment of territories for spatial planning carried out with the help of the multicriteria decision-making makes it possible to integrate entire groups of sampled data without resorting to complicated statistical tools. Public officials of all levels will use the estimates and cartographic materials built on such assessment principles as a universal tool to develop proposals and recommendations on specific environmental, urban, land-planning, developmental and zoning issues. The implementation of the proposed methodology will increase officials' efficiency in decision-making and facilitate communication between the academy and authorities responsible for spatial planning.

3. METHODOLOGY

The methodology of comprehensive assessment of landscape vulnerability in the Kaliningrad Oblast will comprise the stages as follows: Analysis of the concept of vulnerability for natural complexes and its role in the comprehensive evaluation of the territory under human impact; suggesting an algorithm to determine the integral index of vulnerability with the help of state-of-the-art techniques and geographic information systems (GIS) cartography; creation of the GIS "assessment of the Kaliningrad Oblast on the vulnerability of landscapes to anthropogenic influences" and of relevant cartographic materials. In order to suggest practical solutions, the final stage involved validation of the obtained analytical and cartographic materials on the assessment of landscapes vulnerability in the Kaliningrad Oblast to be used for the optimization of regional nature management and land planning.

The first stage in the development of the said methodology centered around two cognate terms, sensitivity and sustainability. While the concepts share similar features in describing structural characteristics of research subjects, they differ considerably when used for choosing and interpreting assessment criteria. A substantial body of research held by Isachenko (2003), Khaustov and Redina (2011), to name just a few, suggests two major interpretations of the term sustainability: Capability of a system to exist indefinitely maintaining its main properties; capability of a system to resist external influence maintaining its main properties. However, the term is not universally accepted as an indicator of ecological state and integrity of natural complexes (Dmitriyev, 2010).

The concept of sensitivity became current later than sustainability, emerging in a vast body of applied ecological research by such authors as Gundlash and Hayes (1978), Sivkov et al. (2004), Zhuravel and Chursina (2001), Dedkov and Fedorov (2006), etc. In a broad sense, ecological sensitivity is defined as a response of natural systems to outside influence, the degree of sensitivity reflecting the pace and scale of changes, and consequences resulting from the impact. Therefore, sensitive areas are active borderline zones and layers in which a slightest disturbance of equilibrium can noticeably affect the environment (Sivkov et al., 2004). In other words, sensitivity is understood as the ability of natural complexes to change their properties in response to external hazards (Dedkov and Fedorov, 2006).

In recent years, alongside the variously interpreted sensitivity and sustainability, yet another term has come into use, vulnerability - An independent feature of geo-ecology of natural complexes reflecting the degree of potential destruction of functional links between systemic components (Dmitriyev, 2010; Golobič and Breskvar, 2010). Eco-vulnerability, therefore, implies the potential changes in the components of ecosystems resulting from external influence and destroying its structure and functioning.

The three terms - Sensitivity, sustainability, and vulnerability - are differentiated depending on the structure of research subject and the choice of its assessment criterion. The concepts of sensitivity and sustainability come useful when applied to integral objects, such as organisms, populations, eco-systems, etc.; while vulnerability is used in research for discrete objects like seas, administrative units and others. The latter's geo-ecological status is assessed on the basis of their quantitative index fluctuations. This approach rests on the assumption that main features of natural complexes' biological structure can be generally described with a set of abiotic indicators (Sivkov et al., 2004).

Vulnerability assessment is viewed here as the process of identifying natural complexes highly sensitive to technological influence, in order to prevent or minimize their technogenic pollution. Therefore, two factors determine assessment results: The analysis of causes and sources of natural systems' transformation (technogenic factors), and the landscape morphology pattern of the subject. The analysis will make it possible to select key components and characteristics of natural complexes, which will be further synthesized into an integral parameter matrix.

Current approaches to the choice and substantiation of methods for comprehensive assessment of territories under human impact differ in the character of the assessed subject, types of technogenic impact and sets of assessed factors. Among many scholars involved in such research are Dmitriyev (2010), Dmitriyev et al. (2014), Sivkov et al. (2004), Opekunova (2001), Novikov (2007). The better part of this body of work is concentrated on the calculation of normalized scores determined on the basis of weighted sum of all assessment parameters; in rare cases semi-empirical formulae and weighting factors are used. Dmitriyev (2010), Dmitriyev et al. (2014) extends this approach to making multi-criteria vulnerability assessment conform to the conditions of information scarcity. The algorithm is as follows:

Stage 1: Selection m of the primary criteria $x_1,\ldots, x_m$, which form index clusters reflecting various parameters of the properties under study.

Stage 2: Normalizing indicators resulting in dimensionless numbers $q_1,\ldots,q_m$, $0 \le q_i \le 1$.

Stage 3: Introducing the function aggregating normalized values $q_1,\ldots,q_m$ into a single integral value $Q = Q(q)$.

$$Q = Q(q, w) = Q(q_1,\ldots,q_m; w_q,\ldots,w_m) = \sum q_i w_i \tag{1}$$

Stage 4: Calculation of weights $w = (w_1,\ldots,w_m)$ - non-negative weights setting the priorities of individual parameters for the estimated property, in view of reliable information on weights:

Ordinal - OI:

$$OI = \{w_r > w_s, w_u = w_v, \ldots r, s, u, v, \in \{1,\ldots m\}\}; \tag{2}$$

Interval - II:

$$II = \{0 \le a_i \le w_i \le b_i \le 1\{1,\ldots m\}\}; \tag{3}$$

Stage 5: Transition to integral assessment $Q\ (q;I) = MQ\ (q;I)$:

$$\overline{Q^{(j)}}(I) = \bar{Q}(q^{(j)}; I) = \bar{Q}(q^{(j)}, \bar{w}(I) = \frac{1}{N(m,n;I)} \sum_{t=1}^{N(m,n;I)} Q^{(t)}(q^{(j)}) \tag{4}$$

The relevant statistics and analysis (Kaliningrad Region in Figures, 2014) testify that mechanical and chemical impacts are the two major human-induced factors affecting the Kaliningrad terrestrial landscape. Chemical impact is defined as polluting environment or its components with soluble or water-infiltrating chemical pollutants: Hydrocarbons, surfactants, acids and alkali, heavy metals, and other substances (Oil and the Environment…, 2008). Mechanical impact stress includes sealing, destruction of subsurface land mass, accumulation of relief, etc.

Based on the above approaches, the algorithm for the comprehensive natural complexes' vulnerability assessment is as follows: Choice and justification of vulnerability assessment criteria; formation of parameter matrix of assessment criteria, gradation there of according to vulnerability classes; calculation of weighted averages; justified selection of an optimal territorial operational assessment unit for the studied subject. When determining the criteria, it is essential that both the structure of the research subject and the existing expertise in the field are taken into account, which suggests harmonizing hydrological, morphological, soil properties and other physical parameters, plus conventionally used assessment criteria.

In delineating the application areas for the assessment criteria, we proceeded from the assumptions as follows (Kesoretskikh and Zotov, 2012): (1) The major landscape functions are energy and moisture turnover and geo-chemical cycles. One of the crucial landscape functions is to ensure substances and energy exchange, (2) abiotic nature by and large conditions biotic life (Kolbovskiy, 2013). Main properties of the landscape biotic structure can be compared with a complex of abiotic values (Zotov and Desyatkov, 2006). The choice of assessment parameters is determined by the specificity of research subject and objectives.

In view of this theory, we suggest the Matrix of landscapes vulnerability parameters to anthropogenic influences for the Kaliningrad Region (Table 1).

Weighting values for the matrix were calculated with the help of the method of randomized consolidated indices, which consists in the transition from indefinite choice of weighted values to a random one, choosing from the multitude of all possible weighted coefficients (Khovanov and Fedotov, 2006). To that end, 20 information situations (variants) of assessment parameters value distribution were consequently analyzed; they are summed up in Table 2.

The final stage of elaborating the algorithm of assessment of the Kaliningrad Oblast on the vulnerability of landscapes to anthropogenic influences included the selection of the optimal operational territorial unit. Among the six (Kochurov, 2009) generally acknowledged approaches to the choice of territorial units of ecological mapping we selected the one based on geometrically accurate matrix of points. A 1 km - long leg (distance between two adjacent points) is sufficient to reveal the complexity of the constituent types and groups of landscapes in the Kaliningrad oblast, and to reflect their morphological patterns.

ESRI ArcGIS was used as a tool to create the GIS "assessment of the Kaliningrad Oblast on the vulnerability of landscapes to

Table 1: Matrix of landscapes vulnerability parameters to anthropogenic influences

Parameters	Levels of vulnerability									
	High		Increased		Modest		Lower		Low	
	From	To	From	To	From	To	From	To	From	To
Distance to the watercourse (M)	0	200	201	400	401	600	601	800	801	1000
Slope angles (°)	20	17	16	13	12	9	8	5	4	0
River network density (km/km²)	1.4	1.25	1.24	1.11	1.10	0.96	0.95	0.80	0.79	0.60
Spawning protection status	Yes				No					
PA	Yes				No					
Shallow ground water level (M)	0.5	2.0	2.1	4.0	4.1	6.0	6.1	8.0	8.1	10.0
Mechanical composition of soil	Sand		Sandy		Sandy-loamy		Loamy		Clay	
Land use	Swamp		Forest				Meadow			

Source Based on Zotov et al. (2012). PA: Protected area

Table 2: Weight values of vulnerability parameters of landscape vulnerability to anthropogenic influences

Parameter	Weight coefficient
Distance to the watercourse	0.25
Shallow ground water level	0.25
Mechanical composition of soil	0.25
Spawning protection status	0.05
Land use	0.05
PA status	0.05
River network density	0.05
Slope angles	0.05

PA: Protected area

anthropogenic influences." The GIS includes three sections: Data bases, intermediate and final maps (Kesoretskikh et al., 2014).

Sourced from cartographic materials and scientific literature (Geographical Atlas of the Kaliningrad Region, 2002), the first section comprises of a 1:500,000 scale digital coverage. Point sources of human-made impacts were digitalized separately (Figure 1).

Three groups are considered as major point sources of human-induced impact in the Kaliningrad Oblast: Exploited oil fields, sand and gravel deposits (SGD) under development, and solid waste landfills (SWL). They were selected for the reasons such as: Rate and scale of exploitation, prospective and existing ecological problems incurred by their exploitation, and their tangible presence on the territory of the region.

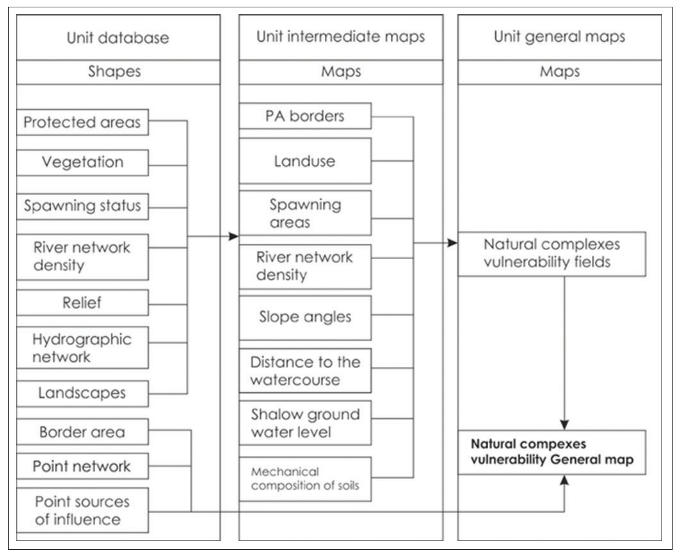
SGD quarries are intensively used in the Kaliningrad Region, with 37 quarries producing 4.3 million m^3 of solid minerals, given the 13.3 thousand km^2 of entire terrestrial area of the Kaliningrad Region (Kaliningrad Region in Figures, 2014).

3.1. Oil Deposits

35 onshore and 2 offshore rigs had yielded 943.000 tons of oil in 2013 (Kaliningrad Region in Figures, 2014). The risk of negative impact of oil fields on the regional ecology is high at all stages of oil extraction, projecting and conservation, as they may affect surface and ground water sources, disturb fauna and flora, and evoke local ecological catastrophes.

Objects of accumulated environmental damage. There are 21 officially registered SWLs in the region. In 2012, 15 of them were listed as the objects of accumulated environmental damage, with the polluted territory estimated at 118.2 ha; certain SWLs have been exploited for 20-50 years.

Figure 1: Assessment of the Kaliningrad Oblast on the vulnerability of landscapes to anthropogenic influences Geographic information systems structure



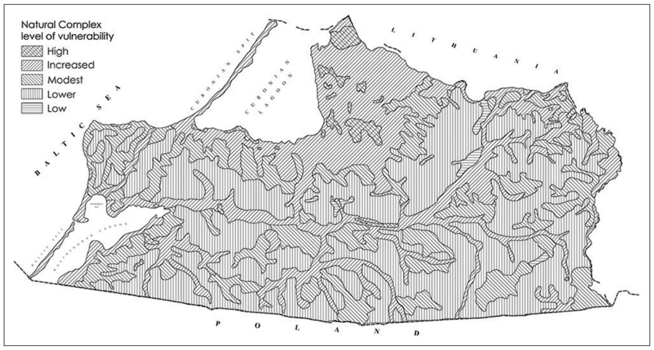
The second GIS section is a set of analytical and synthetic charts, designed in the course of revising attribute tables of basic layers, and their treatment with the help of ESRI ArcGIS tools. Thus, each point of the reference network is digitally represented in the attributive table according to each of eight parameters given in Table 1. The integrated index of vulnerability is calculated as the sum of productions of these values and corresponding weighted values.

The third section is represented by the comprehensive map of the areas of landscape vulnerability to human-induced impact. It shows the marked areas of assessment network points grouped into vulnerability grades according to the value of the integrated indicator (Figure 2).

4. RESEARCH RESULTS AND DISCUSSION

In figures and percentage, the ratio of variously rated vulnerable areas to the total territory of the region is as follows: High

Figure 2: Natural complexes vulnerability fields to the anthropogenic influence in Kaliningrad Region



vulnerability – 270 km^2 (2%), increased vulnerability – 4076 km^2 (31%), modest vulnerability – 3029 km^2 (23%), lower vulnerability – 5828 km^2 (43%), low vulnerability – 97 km^2 (1%).

Highly vulnerable landscapes are represented by the up to 10 km^2 large areas. They are located in the delta alluvial-marshy wetland in the Neman river estuary and the littoral-marine flat-floor valleys in the Polessk lowland. Higher vulnerability areas are found in the contemporary valleys of major waterways of the region: The Pregel, the Deima and others; in the littoral-marine flat-floor valleys and littoral wavy and bumpy sandy plains of the Vistula and Curonian spits, and of alluvial wetland of the Neman delta.

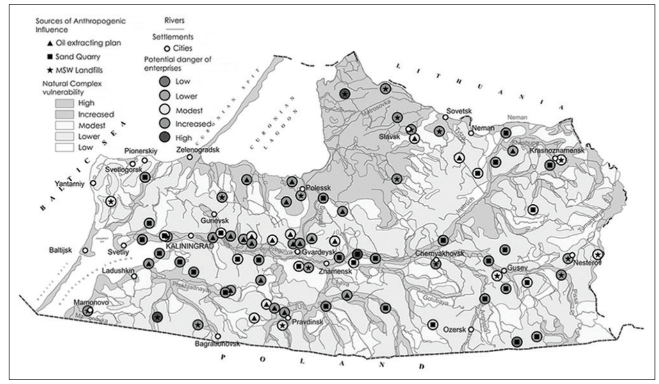
The areas of modest and lower vulnerability are found within the *wavy* and bumpy sandy plains between the Sheshupa and the Neman; rolling moraines and flat wavy lacustrine-glacial valleys of Polessk, Lava-Pregel and Sheshupe-Instruch lowlands; rolling moraine lacustrine upper plains are found near Sambia, Lake Vyshtynets, and Warmian highlands. The low vulnerability category is represented by certain areas in the landscapes of rolling moraines in the central, northeastern and southeastern parts of the region.

The analysis of the spatial distribution of vulnerability areas and landscape differentiation in the Kaliningrad Region demonstrates that diverse vulnerability classes may embrace several landscape units. Therefore, within one genetic landscape group, the value of the integral vulnerability indicator varies considerably. The resulting mapping of the vulnerable areas resulting from chemical and mechanical impact makes it possible to delineate the best and the least suited areas for allocating potentially polluting industries.

As a projection of the integral index, vulnerability area schemes provide grounds for a comprehensive assessment of territories according to the selected number of criteria. As a tool of spatial planning, these schemes can contribute to the existing methods of land planning in the whole region, as well as in individual municipal entities and towns (Kesoretskikh et al., 2014).

To verify the suggested approach, the authors compared their cartographic materials with previous holistic assessment instruments used in the Kaliningrad Region, such as: The scheme of ecologically-oriented objectives of land use (Dedkov and Fedorov, 2006), and the scheme for nature conservation in the Kaliningrad Region (Scheme for Conservation of Nature for Kaliningrad Region, 2004). When compared, the spatial distribution of cartographic data show considerable similarity, both in the patent areas like the Curonian and Vistula Spits, Vishtynets uplands, major waterway valleys (the Pregel river, the Angrapa, the Lava, the Prokhladnaya), and in the specific places like the Sheshupe and Nelma basins, some particular areas in Slavsk and Polessk districts and coastal areas of the Curonian and Vistula Lagoons.

Figure 3: Distribution of sources of anthropogenic influence within classification of potential danger for the landscapes of Kaliningrad Regions



By way of using the vulnerability assessment methodology in practice, an analysis was carried out regarding the deployment of current impact point sources, such as SWLs, SGD quarries, and oil fields. The use of the above data made it possible to draw a more precise picture of their potential threat to the environment (Figure 3).

Depending on the vulnerability area within which man-affected objects are found, they were rated according to the assessed threat potential, from first class (high vulnerability) down to fifth class (low vulnerability) (Table 3). By their distribution, 55% of man-made hazard sources classify as "high" and "higher," with 45% of them falling within "lower" and "modest" categories. These data prompt that additional environmental protection measures must be provided at the enterprises in the highest risk categories. They also testify to the urgent need for the implementation of eco-centered methods in land use planning, with the ultimate aim to lower or minimize the possibility of allocation of industrial enterprises in the highly vulnerable sittings.

In case of rigorous spatial localization of an industrial object, such as natural resources extraction sites, it is necessary to focus on a more detailed planning of the entire related infrastructure that may be located in less vulnerable territories.

The proposed methodology for the assessment of landscape vulnerability caused by anthropogenic interference and the obtained results could be used to optimize the existing assessment methods and to integrate eco-oriented approaches into the current Russian practices of land use planning, which will help to efficiently tackle the issues as follows:

Table 3: Distribution of sources of anthropogenic influence within classification of potential danger in Kaliningrad Regions

Category of sources of anthropogenic influence	Potential danger classes					Overall objects
	First class - High danger	Second class - Increased danger	Third class - Modest danger	Fourth class- Lower danger	Fifth class- Low danger	
Oil extracting plants	0	14	8	4	0	26
Sand quarry	1	16	9	7	0	33
MSW landfills	2	11	5	3	0	21
Overall objects within classes	3	41	22	14	0	80

MSW: Municipal solid waste

1. Elaboration of evaluative approach due to a more efficient implementation of ecological principles. Transition from the fragmentary evaluation of a territory based on zones with special conditions of use, to a comprehensive assessment of natural complexes and their components.
2. Implementation of the principles of preventing and minimizing the impact. Most ecological safety and security measures are usually implemented post factum, after the environmental damage has been revealed; therefore, those measures are taken to make up for the disturbed balance of natural components. Vulnerability assessment methodology is aimed to pre-empt the likelihood of such hazards and prevent negative human impact on the environment.
3. A broader conception of alternative sitings for economic entities makes it possible to demonstrate and quantify alternative locations at all stages of land planning, before taking a decision on enterprise placement. It provides a possibility to calculate potential sitings as well as structural and systemic alternatives.

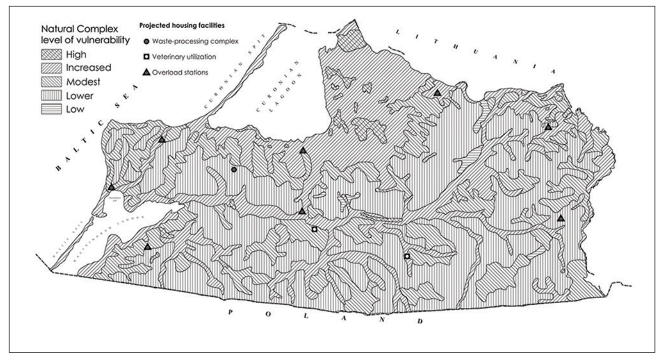
Let us consider these proposals using the case of the Kaliningrad Region and its land-planning documentation, such as the placement plan for the development of permanent facilities and functional zoning. The documents based on the RF legislation are designed in full compliance with all the necessary requirements and duly take into account the "special use" zoning, such as sensitive spawning areas, water protection, sanitary protection areas and others.

If we overlay the Kaliningrad Region's territorial planning schemes with its landscape vulnerability map, it will allow us to assess and evaluate real and potential "conflicted-ness" between economic facilities and the environment. The conflicted-ness between economic entities and environment is a human-made situation resulting in the destabilizing interference in the ecosystem's equilibrium and environmental management and inflicting damage on, or hampering development of a branch of environmental management.

Real conflicted-ness is assessed for existing objects, like urban settlements, municipal SWL, etc., while potential one is assessed for the planned objects.

According to territorial planning maps, the following point objects in the Kaliningrad province are worth considering as potentially subject to negative impact on natural components: Waste-treatment facilities (village Konstantinovka in Guryevsk district) veterinary waste disposal facilities (Elniky in Gvardeisk distr., Vloldarovka in Chernyakhovsk district,), waste hauling points (Gvardeisk,

Figure 4: Planning point-source objects of anthropogenic influence on environmental conditions



Polessk, Sovetsk, Krasnoznamensk, Nesterov, village Romanovo in Zelenogradsk district, Primorsk in Baltyisk municipal district, Bolshedorozhnoye in Bagrationovsk district) (Figure 4).

The analysis of spatial placement of point objects demonstrates that the better part of the latter are located in high vulnerability areas. This situation, apart from posing a greater environmental threat to the neighboring landscapes, jeopardizes the security of vast areas within several kilometres from the polluting source due to the transit of surface and subterrestrial water flows. Therefore, we conclude that existing regional spatial planning schemes do not fully meet the criteria of eco-security and therefore fail to ensure appropriate placement of economy entities.

REFERENCES

Dedkov, V.P., Fedorov, G.M. (2006), Spatial, Territorial and Landscape Planning in the Kaliningrad Region. Kaliningrad: Immanuel Kant Baltic Federal University Publishing.

Dmitriyev, V.V. (2010), Integrated assessment of complex systems in nature and society. Interdisciplinary Journal of Applied Science Biosphere, 2(4), 507-520.

Dmitriyev, V.V., Dmitriyev, N.V., Voskresenskaya, V.A., Frolova, A.D., Kozheko, U.R. (2014), Development of an integrated methodology for evaluating the environmental integrity of geosystems. International Journal of Applied and Basic Research, 8, 78-85.

Fedorov, G.M. (2014), Border position as a factor of strategic and territorial planning in Russian regions in the Baltic. Baltic Region, 3(21), 71-82.

Geographical Atlas of the Kaliningrad Region. (2002), Kaliningrad: Kaliningrad State University Publishing.

Golobič M., Breskvar L.Ž. (2010), Landscape Planning and Vulnerability Assessment in the Mediterranean. Ljubljana: Regional Activity Centre for the Priority Actions Programme.

Gundlash, E.R., Hayes, M.O. (1978), Classification of costal environments in terms of potential vulnerability to oil spill damage. Marine Technology Society Journal, 12(4), 18-27.

Isachenko, A.G. (2003), Introduction to Environmental Geography. Textbooks. St. Petersburg: St. Petersburg University Publishing.

Kaliningrad Region in Figures. (2014), Short Statistical Book, Federal State Statistics Service in the Kaliningrad Region. Available from: http://www.kaliningrad.gks.ru.

Kesoretskikh, I.I., Zotov, S.I. (2012), Methods of assessing the vulnerability of natural systems to anthropogenic influences. Bulletin of Immanuel Kant Baltic Federal University, 1, 51-57.

Kesoretskikh, I.I., Zotov, S.I., Voropayev, R.S. (2014), GIS for assessing the vulnerability of natural systems of the Kaliningrad region to anthropogenic influences. InterCarto/InterGIS-20: Sustainable Development of Territories: Cartography and GIS Software. Proceedings of the International Conference, p267-274.

Khaustov, A.P., Redina, M.M. (2011), Modernization of the system of environmental regulation on the basis of the European experience of quality management of underground hydrosphere. Sustainability of Water Bodies, Watersheds and Coastal Areas; the Risks of their Use. Kaliningrad: Kapros. p443-448.

Khovanov, N.V., Fedotov, U.V. (2006), Models accounting for uncertainty in the construction of summary performance indicators of complex production systems. Scientific Reports, 28, 1-37.

Kochurov, B.I. (2009), Geoecological mapping: Textbook. Russian Academy of Science, Institute for Geography, M.V. Lomonosov, Moscow: Akademiya.

Kolbovskiy, E.U. (2013), Outstanding issues of landscape science and landscape planning. Proceedings of Russian Academy of Science (Geography), 5, 19-29.

Malczewski, J. (2006), GIS-based multicriterial decision analysis: A survey of the literature. International Journal of Geographical Information Science, 20(7), 703-726.

NIIP Gradostroitelstva. (2014), Implementation of the environmental principles in the Russian Territorial Planning. Report on the 3rd Stage of the Project EkoRus. Available from: http://www.ioer.de/fileadmin/internet/IOER_Projekte/.

Novikov, M.A. (2007), Use of geographical expert-analytical systems for assessment of environmental and toxicological vulnerability Barents Sea. Ecological Systems and Devices, 5, 47-52.

Oil and the Environment of the Kaliningrad Region. (2008), Land. In: U.S.,, N.S.,itors Vol. 1. Kaliningrad: Yantarnyy Skaz.

Opekunova, M.G. (2001), Experience of the expert analysis of the ecological state of geosystems. Vestnik St. Petersburg University Series: Geography, Geoecology, 71-87.

Tsybin, U.A., editor. (2004), Scheme for Conservation of Nature for Kaliningrad Region. Kaliningrad: TENAX MEDIA.

Sivkov, V.V., Zotov, S.I., Kuzmina, E.V. (2004), Assessment of environmental sensitivity of coastal landscapes of the Kaliningrad region to chemical pollution. Nearshore: Morfolitodinamic and Geoecology. Proceedings of the Conference, p228-230.

Town Planning Code of the Russian Federation. (2004). Federal Law of Russian Federation, No. 190-FZ from 29.12.2004.

Zhuravel, V.I., Chursina, N.V. (2001), Development of the method of mapping environmental sensitivity for the planning and implementation of protective measures for oil spills in the Arctic Shelf Development. Russian Arctic - V International Conference Works, St. Petersburg. p342-350.

Zotov, S.I., Desyatkov, V.M. (2006), Results of monitoring of geo-ecological consequences of oil exploration and extraction of oil drilling in the area of Tselau swamp (Pravdinskoye). Geology, Geophysics and Development of Oil and Gas Fields, 8, 65-73.

Zotov, S.I., Kesoretskikh, I.I., Zotov, I.S., Lazareva, N.N. (2012), GIS support for vulnerability assessment of natural systems to anthropogenic influences. InterCarto-InterGIS-18: Sustainable Development of Territories: GIS Theory and Practical Experience. Proceedings of the International Conference, p318-322.