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Environmental Assessment of the Territories in the Region of Activity the Oil and Gas Complex for Sustainable Development: Mapping and GIS Approach

Oleg Petrovich Yermolaev

Kazan Federal University, Kremlevskaya, 18, 420008, Kazan, Russia

Abstract: The given paper considers the methodological aspects of the Atlas mapping for the purposes of Sustainable Development (SD) in the regions of Russia. The Republic of Tatarstan viewed as a model territory where a large-scale oil-gas complex "Tatneft" PLC works. Methods for to the structure and requirements for the Atlas's content were outlined. The approaches to mapping of "an ecological dominant" of SD conceptually substantiated following the pattern of a large region of Russia.

Key words: Sustainable Development · GIS · Mapping · Atlas · Environmental assessment · Oil-gas complex

INTRODUCTION

During the first half of the XX century, the negative effect on economic activity on biosphere was smooth out by the natural process of homeostasis occurring in it. In the next ten-year period, a large-scale society's activity has led biosphere on the brink of the pre-crisis state of the environment. Moreover, the forces of resistance and compensative reactions of the abiotic environment sometimes appear to be insufficient to withstand the determination and to weaken the negative factors of an external influence. At present, the ecological capacity of the environmental in many regions of the earth exceeds the standards, especially where the ecological growth is determines by involving into the economic activity of a human the influx of natural raw resources and their profound processing. Thereby, the purpose to assure an ecologically safe SD of the world's community favoring to meet the essential needs of people in conjunction with the environment protection and its reproduction, assumes ever-greater importance. The UNO Conference on the Environment and Development at which the conception of SD formulated (Rio de Janeiro, 1992) took a decisive step to approve a new transnational paradigm. The ecological aspect of the paradigm of SD is the leading one when defining the strategy of the development of the world's community economics. Whereas, it requires the elaboration of appropriate programs that could be adapted to definite regions.

For Russia and its regions, the problem of the SD stipulate by such factors as the territory's and diversity of natural and social-economical conditions. In accordance with the principles of SD as far back as 1996 in Russia there was approved "The Concepts of Transition of the Russian Federation to the Sustainable Development". This concept assumes the recognition of three components: the balanced application of ecosystems, the effective economics and the social welfare (a fair society) that gain to meet the needs of present and future generations. This approach supposes a through regard of ecological factors that determine the parameters and the rate of a human's economic activity, which directly or indirectly exert anthropogenic influence of one other force on the environment [1-4].

The realization of the SD concept requires to solve not only political-legal decisions, but also to provide the obtained decisions with multi-aspect, objective and properly spreading information. In addition, all existing interactions in the supersystem "community-economy-ecology" formed into definite groups. These groups from the point of flows structuring information while developing the concept of the SD can be determined to the resources consumption, pollution and waste products escape, ecosystems application and the influence on a human's health.

Corresponding Author: Yermolaev, Kazan Federal University, Kremlevskaya, 18, 420008, Kazan, Russia.

MATERIALS AND METHODS

The Concept of the Atlas: In our view, the uniform system of complex scientific-reference ecological-geographical should act as a base for the maintenance of the SD concept in the territories of the Russian federation subjects or certain regions. In this case, the assessment of the ecological situation in the regions can be solved by the conjugation of the two interrelated system-the mapping and the Geoinformational [5, 6]. Moreover, the Geoinformational systems and GIS-technologies in the period when a society is transiting into the SD model might play a significant role. However, due to quite number of reasons, there is no a single meaning on the contents idea (subject matter) of such specialized GIS which created for the condition of balanced development of the environment surroundings, population and economics. Firstly, the mechanisms to achieve the SD are not quite understandable and have only just general far from being correct opinion which is difficult to follow strict logic and formalization. Secondly, the principles of the SD that are declared cannot always correlate with the specificity of certain regions.

The investigations that carried out to determine a level of generalization while working out the models of the SD show the regional level of researches to be the most perspective one [7-11]. On this level, the inertia of the processes is lower as compared with the microsystems having great opportunities to reach the efficient management decisions. Stabilization of the continental biosphere clarifies the ecological safety of large territories depends on the state of the ecosystems zonal-regional types [2, 12, 13 and others]. That is why the laying down a regional GIS is the most substantial and actual task both for science and practice, respectively.

Thus, the regional thematic and complex atlases (including their electronic analogues) which solve the problem of informational-geographical maintenance for fundamental science, applied science, national economics under the conditions of the transit period might be basic for the development of the SD. The attractiveness of approach also substantiated by the fact that the information in the atlases initially given in the systematized, formalized and uniformed; it has the characteristics of the Geoinformational system and was the prototype of the GIS-technology. The expectancy of the Atlas mapping of the ecological dominant in SD has considered in some of papers [7, 12, 14 and others]. We suggest creating a science-reference Atlas for a large region of Russia (within Tatarstan), where a diversified in force and intensity, the national economy exerts its influence on the environment surroundings.

The high intensity of national economy activity that especially strictly reveled for the last 200 years is follow by the considerable reorganization of geosystems (Fig.1). There occurred the transportation of geosystems from the basic (natural) state into the nature-anthropogenic and anthropogenic analogues. The first grave pressure on the part of a human, the regions nature has undergone as a result of the mass lands ploughing up which caused deforestation and virgin meadow lands steppe vegetation destroying [15, 16]. This has led to the radical reorganization of erosion-accumulative process. The earlier prevailing riverbed erosion has enlarged in dozens, hundred and even in thousands times [17]. Extensive cultivation is responsible for accelerated soil erosion and suspended sediment yield. For this reason, the study region is figuratively called the "erosion pole" of Russia. In the

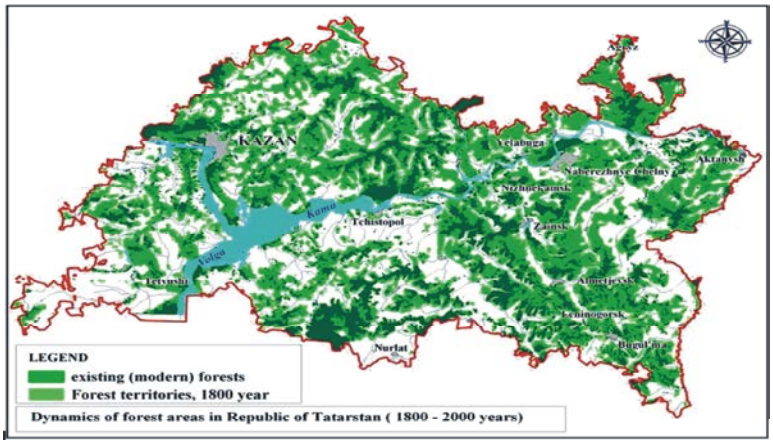

Fig 1:

main of different structure river-basin erosion, represented by erosion belts formed on the ploughed up hills [8, 18-20].

All these processes radically changed bionic and damaged the most conservative component of landscape-lithogenic component. Completely new geosystems type appeared in landscape structure. The radical vegetation of forestry and forest-steppes zone almost completely substituted for either agrocenosis of forestry afforestation.

The second stage of the influence on the landscapes in the region deals with the industry's development, which unlike the agricultural industry based and exerts the influence on the environmental surroundings locally in main. However, the industry's effect on the landscapes had an adversely affect in pollution of different natural surroundings (air basin, surface and underground waters), damage of landscapes components (soil and forest cover). That why the question is about a large-scale oil-gas extracting complex-"Tatneft" PLC functioning in Republic of Tatarstan for more than 60 years. Oil fields occupy an area of more than 38 thousand km^2. Here are the largest city of Tatarstan (so-called the "urbanized belt" of east of Tatarstan): Naberezhnie Chelny, Nizhnekamsk, Almetjevsk, Bugulma, Leninogorsk, Yelabuga and others, hundreds of villages and rural areas with the population exceeding 1 ml of people. The enterprises of "Tatneft" PLC placed in its territory about 40 thousand oil wells, more than 55 thousand km of pipelines, hundreds of different installations, thousands kilometers of highway. During that period more than 3 billion tons of oil was extracted.

At present, the Company's activity keeping pace, respectively: it is turning to other areas, using new technologies and is extracting the oil difficult to access. Finally, a wide range of the company's activities in so large territory is aimed at preserving, keeping up and regenerating the ecological functions of all nature's components.

The Atlas "Tatneft and the Sustainable Development" proposed to be development, can be considered by its spatial scope as the regional one and by the content as the fundamental complex science-reference mapping guide which characterizes the environment situation in the east of RT, the conditions and factors that determine it, the tendencies to the change of the ecological state in the territory and in the centers, the measures to reach an ecological equilibrium. Besides, the Atlas's stuff are to serve as the basic to make decisions concerning the plans on the industry's (branch) location, i.e. the foundation of Strategic Ecological Assessment and also pursue a policy of establishment of partnership with local, republican and federal government bodies. In that way, the main objective while compiling the Atlas proposed, is the mapping of 'the ecological dominant' of the SD with perspective to apply its stuff for the creating a system of support to implement decisions on the SD. The researches findings carried out by a large group of the scientists of Kazan Federal University do serve as the informational basis of the Atlas. Because of that work for the first time a unique in its scope and saturation, the specialized GIS constructed for such a large territory.

RESULTS AND DISCUSSION

The following data confirm that: the general information volume accounts more than 200 electronic analytical, complex and synthetic maps (131 in MapInfo and 80 in SURFER); the number of raster grid knots, i.e. territorial units while making components and integral evaluation of the Environmental State exceeds 1 million. We analyze more than 1000 small rivers basins, 6000 landscapes contours depending on the types of terrain and integrate stows, 500 anthropogenic pollutions source, etc. As far as we know, at present neither Russia nor neighboring countries do not possess a similar GIS generalization on the regional level to meet the challenges of the SD in the large territories. The GIS that constructed exceeds far beyond sectoral objectives and can apply to create territorial development programs for Tatarstan and Russian Federation.

It should be necessary to note that the enlisting diverse information, the applying GIS and GIS-technologies have made it possible to modify the methods of spatial ecological evaluations considerably and get a real picture of the present ES.

We suggest presenting the three levels of mapping in the Atlas:

- The regional-the territory of "Tatneft" PLC activity (the main; the maps in dual pages);
- The local-the most ecologically dangerous regions in the territory of "Tatneft" PLC activity (maps of dual pages and insert maps);
- The municipal-certain industrial units and cities (subjection meaning; the series of insert maps).

The Atlas should cover the main trends of the ecological mapping: the natural conditions, anthropogenic exertion and natural surroundings change, assessment of ecological state of the environment surroundings

elements, medical-ecological situation, economic and social consequences after its worsening, ecological safety strategy. The ecological factors and conditions, trends for their development produced concerning all geospheres: litho-atmo-hydro-bio-pedo-techno-and sociosphere. The Atlas considered as the kernel of the whole complex of the mapping provision to solve the problems of the ecology in the region of "Tatneft" PLC activity. In particular, the negative exertion on the environment by other pertains to national economy complexes.

The Atlas is to represent by itself the system that includes analytical, complex and synthetically maps. This mean that they must be inventorized, evaluation, predictable and recommendational ones. The purpose it could serve and its type will determine the Atlas's structure, by peculiarities of the nature of a region under investigation, to what extent it studied, anthropogenic transformations and informational provision. It will have the maps of natural, of social-economical themes and complex ecological maps of regional and local levels. Several trends of thematically mapping were suggested to be distinguished in the Atlas's structure:

- The background history of oil-fields mine working;
- The nature preservation technologies while oil extracting;
- The assessment of natural conditions of a humans vital activity;
- Unfavorable and dangerous natural processes and phenomena;
- The anthropogenic effect and environmental surroundings change;
- The social-economical processes and phenomena;
- The medical-ecological and geochemical processes and phenomena.

A few basic layers of the operational territorial units of the spatial analysis are used in the Atlas. For example, the first section of the Atlas is devoted to the nature's characteristics and small rivers ecological state, the rivers basin of the stream order is the main type of operational territorial units. In the landscape section-these are the terrains types and stows.

In the section of the regional assessment on the anthropogenic exertion on the environments surroundings and in the integrated maps-all sorts of the operational territorial units, - including the enterprises, municipal districts, bounds of oil-gas extraction companies, forestry, hunting grounds, raster grids enclosure.

The inner unity of the Atlas realized owing to the following facts: the minimum numbers of map projections (Gauss-Krüger); the minimum short-scale row (1:1 150 000; 1:1 120 000); maps construction in accordance with the uniform basic geographical principles; by mutual agreement on different maps legends, scales and gradations with the uniform level of generalization; the observing the common principles of shaping and the style of design.

Within these groups the other numerous groups can distinguished. The maps of unfavorable and dangerous processes and phenomena subdivided in accordance with the types of processes-of endogenous and exogenous origin [8, 18, 19]. Among the maps of the anthropogenic effects on the natural surroundings one can differentiate the maps of the influence on different nature's spheres-atmosphere, hydrosphere, lithosphere, biosphere, etc.

In this way, all thematic groups brought together into four main sections:

- The introduction (the maps of a general condition and social-economical state, a region's rating in Republic;
- The components of natural, social-economics systems that form the conditions for the ecological situations;
- The integrated maps of exertion and change of the environment;
- The strategy to reach an ecological equilibrium.

Figure 2 show the maps of various contents themes we consider to be the most important synthetically evaluation ones. It should be noted that when we making these maps we developed the method to estimate the present state of that or other component. As the example, we can illustrate the evaluation scale on the state of soil cover (Table 1). The lower is the point the worse is the state of component.

CONCLUSIONS

Atlas, in our opinion, will contribute to choose a way to optimize environmental management, environmental surroundings, improvement of living conditions and people's health and to define the strategy and tactics of the ecological policy in the region. The methods of mathematical-mapping and computer modeling presume to compute spatial correlations and mutual conformity of phenomena and to estimate the homogeneity of the ecological

Table 1: The indices used while estimating the soil cover state.

Indicators	Point	Indices
Soil erosion	1	Heavy wasted off
	2	Average washed off
	3	Weakly washed off
	4	Indelible off one
Gully erosion	1	>1 (distribution density, km/km^2)
	2	0.6-1
	3	0.2-0.6
	4	0.01-0.2
	5	<0.01
Duration of agricultural loadings	1	Lands occupied by ploughed field more than 200 years
	2	Lands occupied by ploughed field less than 200 years
	3	Lands under meadow
	4	Land under forest
Level of geochemical soil's contamination	1	>128 units of total contamination
	2	32-128
	3	16-32
	4	8-16
	5	<8

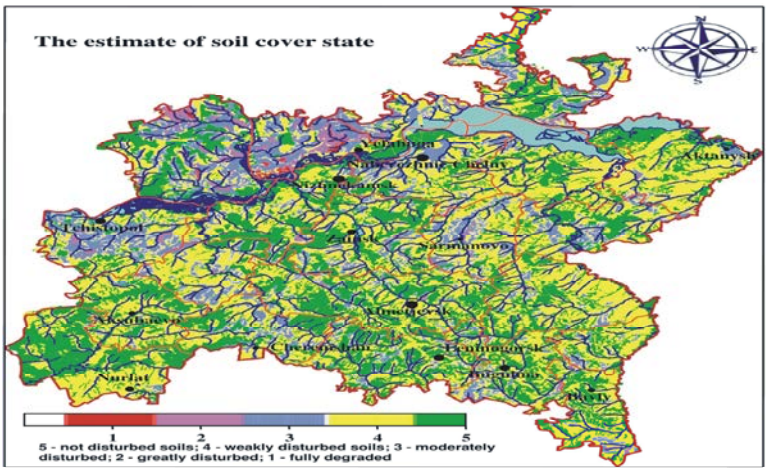

Fig 2: The estimate of soil cover state

conditions, to reveal the leading factors of distribution and phenomena and processes development using the means of multidimensional statistical analysis. Based on the Atlas's map analysis one can get the additional data including those that might provide to reach the management decisions.

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