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Global and regional landscape studies in Russia: scientific traditions and the actual state of research

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ABSTRACT: Principal results of scientific research of the Russian landscape school at the global and regional level in the second half of the XX century are connected with the development of landscape classification. The main classification units at this territorial level are the zonal type of landscapes (the term was introduced in the 1960-ies) and the present-day landscape (since the 1980-ies). At present the wide application of geospatial data allows to supplement this classification with indicators which characterize changes of the zonal types of landscapes during the last decades. This type of study is already performed for the forest-steppe zone of Russia.
The development of complex geoecological regionalization became another important line of research at this spatial level. A group of methodologies offered by the ArcMap software package was used for identification of the geoecological regions of Africa. The general model was divided into three thematic submodels, namely natural factors, anthropogenic influence and the state of environment. As a result of modeling Africa was divided into 52 areas which are characterized by the same type of land cover transformation. In the areas with long and rich civilization history cultural landscapes of different stages are also used for regionalization**.**

Key-words: zonal type of landscapes, present-day landscape, model, global and regional level, landscape palimpsest.

The scientific direction dealing with the studying of structure and dynamics of natural and present-day landscapes at the different hierarchical levels is well-developed in the Russian physical geography. It stems from the classics of Russian geography (V. V. Dokuchayev, L.S. Berg, etc.) dating back to the beginning of the XX century and it gained rapid development in the 1960-70ies (Lukashova, 1966). The system of classification of natural landscapes at the global and regional levels was elaborated at that time. Typological regionalization of landscapes was based on the large taxonomical groups of zonal and azonal units: geographical belt → longitudinal sector → natural zone / subzone → zonal type of landscapes. This principle became the basis for a small-scale map for higher schools "Geographical belts and zonal types of landscapes of the world", created by geographers of the Lomonosov Moscow State University and published in Moscow in 1988 (Geographical belts…, 1988). Its matrix legend represents complicated combination of natural zones and 96 zonal types of the landscapes within them, grouped in 13 geographical belts. The belts are subdivided into sectors (maritime, transitional, continental, and severely continental) with characteristic sets of natural zones.

The concept of geographical zonality which is the cornerstone of the Russian concept of landscape studies is of particular importance not only for physical geography, but also for geoecological research. Zonality in many respects determines the natural and resource potential and a set of ecological services of landscapes, and, therefore, the trends of their economic development and the intensity of anthropogenic transformation. Therefore it is possible to claim that many properties of present-day (cultural) landscapes also depend on the natural zonality law.

In the 1980th several maps of natural landscapes at the scale of 1: 4 Mln were developed for the territory of the USSR (Legend..., 1987, Landscapes..., 1988). The latter characterizes landscapes according to their types, subtypes, classes and more detailed classification units. The functional and dynamic approach is widely used to describe the landscapes and special attention is paid to the dynamics of landscapes and their biological productivity.

Further history of the Russian physiographic school was connected with the development of the concept of "present-day landscapes" (in the 1990-2000ies). These are complex natural and anthropogenic (natural and economic) geosystems which resulted from the centuries-long process of society-nature

interactions. The principles of classification of modern landscapes of the world were developed which are based on the extent of changes of natural geosystems under economic influence and in fact reflect the dynamic sequences of landscape development and also social-economic trends of their transformation (Kurakova, Romanova, 1989). Depending on the extent of changes all present-day landscapes are subdivided into modal ones (which correspond to a natural invariant and experience minor local/incidental economic influence) and natural-anthropogenic ones. The latter are those landscapes which were to a different degree transformed by economic activities. For the purpose of the small-scale mapping natural-anthropogenic landscapes could be subdivided into three groups depending on the extent of change of their natural subsystem, i.e.: derivative landscapes, anthropogenic modifications of landscapes, and technogenic complexes.

The extent of landscape changes depends on the intensity and territorial distribution of economic influence which is well indicated by the transformation of vegetation (or land) cover. The map of present-day landscapes of the world at the scale of 1:15 Mln elaborated in the MSU and published with the support of UNEP in 1993 is based on this principle (Report..., 1991). Each mapping unit was characterized by the complex index representing the detailed description of this or that landscape (Fig. 1).

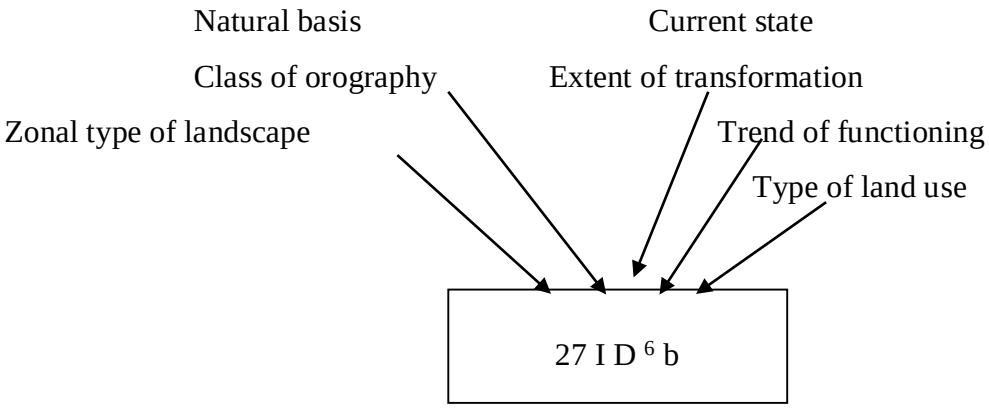

Figure. 1. Key parameters characterizing the structure of present-day landscapes (World Map of Present-Day Landscapes. Moscow, 1993).

Thus, the methodology of creation of maps of the present-day landscapes developed by Russian geographers combines the integration of natural and anthropogenic factors of landscape differentiation. Information embedded in the "zonal type of landscape" index reflects its climatic conditions (location in particular belt/sector), and also gives an idea of potential vegetation and soil cover. The class of orography reflects the altitudinal position of landscapes (from lowlands to highlands), with typical sets of hydromorphic and automorphic geosystems. The extent of transformation (from modal to technogenic) characterizes the degree of landscape changes; the trend of functioning describes the biotic evolution of a landscape (for example, secondary forests or desertificated landscapes); and the type of land use reflects the dominating land cover.

Later on, actually the same principle became the basis for classification and mapping of the landscapes of Europe based on modern technologies of segmentation and classification of geospatial data. The European Landscape Map (LANMAP) at the scale of 1:2 Mln (Mucher et al, 2010) was a result. The structure of biotic, abiotic and anthropogenic (cultural) components of landscapes is reflected on this map. The map was compiled with the account of four classification parameters: topography (absolute heights), climate, basement rocks, and land cover. It is obvious that this approach supports the analysis of primarily biophysical parameters (easily measured and mapped) without development of hierarchical classification of landscapes. The similar principle of layer combination was used for the compilation of a new global map of ecological territorial units (Sayre et al, 2014).

Thus, the accomplished transition from the coupled analysis of various sources (series of maps) and expert estimates to (semi) - automatic methods of landscape mapping is obvious. However many issues of typology, definition of criteria of the differentiation of hierarchical units, interpretation of spatial characteristics are not conclusively resolved, as well as a lot of methodical problems. Unlike foreign systems of classification and mapping of landscapes or semantically similar territorial units, the Russian concepts

always give much attention to hierarchy and typological classifications which were usually constructed "top to down" for the purpose of small-scale mapping.

At present the development and use of basic algorithms of mapping which deals with creation of thematic spatial databases and models of various levels become especially actual considering the wide application of various geoinformation media and remote sensing data. Such research is among the main lines of today's small-scale mapping of landscapes of the world.

Under the global changes of land cover the regional studies allowing the estimation of specific features of an individual response of various natural areas and parts of the countries are particularly important. Spatio-temporal changes of land use analysis are significant for identifying dynamic changes in a certain period. The general analysis of the quantity, structure and environment of land-use change is useful to perceive the trend and character of land-use spatio-temporal change (Xin Chang et al., 2008). The transformation of landscapes is an inevitable step of their development. Globally, land cover today is altered principally by direct human use: by agriculture and livestock raising, forest harvesting and management and urban and suburban construction and development (Meyer, 1995). Both at global and regional levels the anthropogenic impact which radically influences structure and functioning of environment is observed now (Mucher et al., 2006). Therefore it becomes necessary to identify and evaluate the main types of land cover changes. Using Explicit Cross Tabulation function in GeoMedia Product (Intergraph Corp.) we have obtained the GIMMS images classified with GLCF parameters. Afterwards it was possible to apply the schema of transformation to the four NDVI data sets. Consequently, land cover images for four periods of time (1981, 1992, 2000 and 2006) were derived. There were four categories of landscape which were used (according to GLCF classification):

1. Croplands - the lands with more than 80% crop coverage. The areas of perennials could be classified as shrublands;

2. Grasslands – the lands with continuous grass cover and less than 10% coverage of trees or bushes;

3. Wooded grasslands/Shrublands – the lands with more than 10% grass coverage and less than 40% of trees. The maximum height of trees is 5 meters, the tree cover can consist of both deciduous and coniferous species;

4. Deciduous Broadleaf Forest with Mixed forest – more than 60% are covered with trees more than 5 meters high; a mosaic of deciduous, coniferous and mixed forests.

Using methods of cross classification in GeoMedia Professional (Intergraph Corp.) software other images were processed, and four images with prevailing types of land cover for 1981, 2000, 1993 and 2006 were received as a result.

The method of changes identification allowed the compilation of an integrated image displaying main types of changes characteristic for the territory under study:

Croplands into Shrublands (16,64%)

Croplands into Grasslands (11,43%)

Croplands into Mixed forests (8,81%)

Grasslands into Shrublands (13%)

Grasslands into Croplands (7,64%)

Mixed forests into Croplands (4,63%)

No changes (37,7%)

The re-growing process is characteristic for the whole territory: croplands are replaced by shrublands or grasslands and grasslands are also replaced with shrublands. The first type is more typical for the southern areas with warmer conditions during the spring-summer period, chernozem soils, gentle slopes and generally lower absolute heights. The second type is the most widespread in northern and northeast parts of the territory under study where average monthly temperatures in spring and summer are lower, and dark gray forest and meadow-chernozem soils prevail on steeper slopes.

The analysis of four temporary sets of remote sensing data revealed the general tendency of reduction of croplands which are replaced by shrublands and forests in the eastern part of the forest-steppe zone, while the growing fragmentation of a mosaic of croplands, grasslands and shrublands is characteristic for its western part.

Regionalization is traditionally considered to be a major task in Russian geographical research

(Saushkin, 2001). It is defined as a procedure of identification of integral territorial systems and, unlike typology, it concentrates the attention of a researcher on the distinctions between them, on the determination of their identity (Tikunov, 1997). Geoecological regionalization is a rather new type of this procedure aimed at the identification of the areas of similar geoecological situations, or groups of landscapes similar in their geoecological quality (Romanova, 2004). At the same time at the macroregional level (continents, subcontinents, civilization regions, and large countries) an individual geoecological area is characterized with specific trajectory of nature-society interactions which is defined by its natural, historical-cultural and social-economic features. Identification of such geoecological areas which could be both compact and compage is a result of complex multi-criteria analysis using more stringent and rather "free" indicators.

This type of regionalization poses a specific problem of the reasonable balance between the use of various criteria of regionalization defined on the basis of objective and subjective approach to the identification of individual areas. Therefore the elaboration of algorithms of geoinformation mapping in case of already “hand-made” geoecological regionalization is of particular interest. Such procedure provides for the partial verification of the results of regionalization (taking into account possible incompleteness of data), and facilitates weighting of particular factors basing on the already accomplished regionalization.

This type of research was carried out for the territory of Africa. Geoecological regionalization of the continent was based on natural and historical-cultural features and the anthropogenic impact. As a result 52 individual geoecological areas were identified according to the combination of the leading factors of regionalization (natural, civilization, ethnolinguistic, social-economic). Delimitation of areas was carried out by imposing the boundaries of natural, ethnolinguistic, historical and cultural areas and the areas of anthropogenic influence; the critical factor of regionalization was chosen by the expert analysis. All boundaries of areas were digitized, and the resulting cartographical model was the basis for further research.

The resulting regionalization was verified using the group of methodologies offered by the ArcMap software package for modeling of the complex spatially distributed phenomena connected with the analysis of polytypic and diverse input data. Taking into account specific features of anthropogenic impact on the territory of the African continent, and also the availability of information sources, we gave the preference to the indicators characterizing agricultural impact, and the impact of the urbanized areas. Some factors of regionalization are obviously interconnected (for example, population density and level of urbanization). Other ones are interconnected as well, but the links are rather implicit or difficult to formalize (for example, absolute heights and slope inclination), while some factors act independently (for example, types of animal husbandry and large drainage basins). Therefore the general logical model of geoecological regionalization was divided into thematic submodels: natural factors of area formation (1), anthropogenic pressure on landscapes (2) and geoecological state of landscapes and their separate components (3).

The result of the geoinformation modeling reflects the differentiation of the African territory in terms of three groups of factors: natural features, anthropogenic load and the state of environment. The third submodel, proper geoecological one, is the poorest in the information support. It is because of the lack of data on the extent of the environmental impact, first of all the technogenic emission of pollutants. However, social-economic development of the countries of Africa suggests that the most polluted areas, as a rule, coincide with the urbanized areas. Their localization was taken into account in the third submodel.

At the same time more detailed division is possible for a number of areas which have to be analyzed in each particular case. This is most obvious in the southern parts of the geoecological regions of Sahara where heterogeneity is caused by the increase of population density in the zone of deserted savannas in comparison with the true desert zone, and thus by the change of cattle density and types of economic use.

Considering the total character of areas, it is necessary to notice that they are really more diverse if the level of their generalization is higher. The diversity is the highest within savanna and woodland zones on the plains of Sahel and Sudan where the mosaic of population density, forms of anthropogenic influence and geoenvironmental pressure is the most pronounced. Unlike the subjective regionalization the application of geoinformation modeling allows to identify the center of an area where the characteristic properties are the most obvious and its periphery.

Another technique of geoecological regionalization is applied to areas with a long history of civilization development. The model including civilization features of the territory should be added to the model described above. Such research was carried out for the Mediterranean. The areas of different civilizations in the Mediterranean until the falling of the Roman Empire (V century AD) were overlaid to reveal the territories with similar civilization changes. As a result 15 individual types of such changes are identified. Each type of civilization change corresponds to the territory where cultural landscapes of various

eras are superimposed and forms an area of landscape palimpsest. The areas of two- and three-layer palimpsests are formed under the relevant type of civilization change, i.e. two or three civilizations. It is known that the Ancient Rome civilization became the first to cover the whole territory of the Mediterranean. In peripheral parts of the region its cultural landscapes did not inherit and practically didn't include the earlier elements. Moreover, it was these landscapes that became a basis for the later landscape palimpsests. As a rule the most complex palimpsests are typical for the areas of the most ancient development, namely the south of the Balkan Peninsula, the North Africa, the south of the Iberian Peninsula, the Aegean coast of Asia Minor and Levant.

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