Geoinformation mapping of landscape spatial modification

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Abstract. The research shows the importance of geoinformation environmental mapping for the purpose of evaluating the landscape environmental state and dynamics. The current state of landscape environmental mapping, as well as the principles of landscape boundary mapping, has been studied, and the methodology of geoinformation environmental mapping for the purposes of the landscape modification study has been developed. The position of the landscape environmental maps within the classification system of complex environmental maps has been defined with reference to their readiness degree, purpose and interrelationship in the conventional system of geographical maps.

1. Introduction

The new technologies in geoinformation mapping make it possible to register a territory’s spatial structure characteristics in terms of the geoinformation systems theory. Evaluation of the territories’ current environmental state requires geometrically accurate data with a high information capacity (e.g. data obtained by earth sounding from space). Such data enables us to update the geographical maps and evaluate the physical (real) state of the landscape. The landscape environmental maps represent the territory’s analytical and evaluative environmental characteristics as well as the related data on the territory’s economy structure. Thus, cartographic research and environmental evaluation projects are important for the implementation of the state environmental programs including the ones of the Irkutsk region (e.g. state program “Environmental protection” for 2014–2020).

2. Materials and methods

The research methodology is based on a complex evaluation concept and a systems’ approach to cartographic modeling of the landscape modification, including complex computer-aided satellite data interpretation methods and geoinformation mapping techniques.

The main aim of landscape environmental mapping is to detect, classify and represent the natural and anthropogenic systems of the Earth crust undergoing the influence of the economic and environmental factors with time [1].

When developing landscape environmental maps (LEM), the following methodological principles should be observed [2]:

– Mapping of the objects and phenomena should be based on the geographic and indicative localization;
– Different types of the objects- and phenomena interrelationship should be represented;
– When mapping the objects and phenomena, correct registration and representation of different-type natural and anthropogenic boundaries is required;
Ecological aspects and anthropogenic changes of the territory should be represented.
At the current stage of landscape environmental mapping (and of mapping in general), computer technologies are widely used for the source data collection and storage as well as for the design and updating of cartographic products.
Besides, non-simultaneous polyzonal satellite photography and geoinformation systems are of importance as they show the environmental impact dynamics and the landscape environmental state in space-and-time terms.

3. Research results and analysis
The landscape environmental state is a result of the influence of diverse external factors (including anthropogenic ones) on the environment. This influence causes changes in the landscape structure and composition, as well as in the interrelationship of the landscape natural components, depending on the landscape stability. These changes are integrated with the common notion of ‘landscape modification’ which means an aggregate of positive and negative landscape changes.

In accordance with the modification degree, the environmental time-and-space landscape state (ETSLS) is formed as a sample landscape modification taking place over a specific period of time.

It is known that the dynamic landscape components (first of all, the vegetation cover) are most prone to adverse environmental changes [3, 4, 5, 6].

Landscape environmental mapping of the vegetation modification degree is spatial modeling of the qualitative and quantitative indices for the vegetation productivity dynamics in a sample landscape (Figure 1) with the use of non-simultaneous polyzonal satellite images and geoinformation technologies.

In order to obtain quality information on the vegetation biomass and for the purpose of the further geoinformation analysis and modeling, non-simultaneous vegetation index images are built and comparative schemes are made, those are then represented in the maps and used for the definition of the vegetation state based on the modification classes.

Using an overlay option in GIS analysis, random sampling is done in order to define the NDVI modification class composition for every sample landscape, while the use of arithmetic and geometric functions gives the quantitative indices of the area sums of all modification classes for every sample landscape.

Based on the obtained results, geoinformation modeling of the landscape vegetation cover modification is implemented.

![Vegetation modification dynamics modeling for a sample landscape.](image)
Applying the general mean principle, percentage ratio of the areas of every modification class [7] in the structure of all landscape units is calculated by the known formula (1):

$$ S_{\% k} = \frac{S_k \times 100\%}{S_l}, \quad (k=1,\ldots, m), \quad (l=1,\ldots, t) $$

where $S_{\% k}$ is a percentage ratio of the $k$ class modification area to the total area of the sample landscape; $S_k$ is the area of the $k$ class modification in the structure of the sample landscape; $S_l$ is the total area of the $l$ sample landscape; $k$ is the modification class number; $l$ is the number of the sample landscape.

Then, using the formula (2) [8] for every landscape, the weighted average value of the percentage modification is calculated:

$$ S_{\% cr} = \frac{S_{\% k} \times P_i + S_{\% n} \times P_n}{\sum_{i=1}^{n} P_i}, \quad (k=1,\ldots, m), \quad (i=1,\ldots, n) $$

where $P_i$ is the digit weight; $i$ is the number of the sample landscape.

As a result of the processing of the non-simultaneous polyzonal satellite images (Landsat), GIS analysis and geo-modeling, analytical maps have been charted for the west shore of Lake Baikal (Priolkhonje and Olkhon Island) [7, 9] (Figure 2).

![Weighted average scale percent's](image)

**Figure 2.** The map weighted average of percentage values of variation of landscapes in the Priolkhonje and Olkhon Island.
4. Conclusion

Landscape environmental mapping is one of the main types of complex ecological mapping. LEM ranking high among the complex ecological maps in Russia. The inventory-evaluation character of LEM determines LEM’s significance for management purposes, scientific and research work, environmental education and environmental awareness-building.

Natural landscapes and their boundaries are characterized by spatial and temporal changeability. The landscape configuration and state directly depend on the dynamic properties of the landscape components as well as on the external factors. Thus, correct representation of the landscape pattern as well as of the properties of the landscape boundaries is an important task for thematic cartography.

The present-day landscape studies and cartography require valid boundary mapping techniques that would allow different researchers to obtain the same results when using the same source data. The geoinformation analysis methods can give a strong impulse to the development of such techniques: with a sufficient amount of the source information and the information processing algorithms available, it is possible to use computer-aided classification systems enabling an objective discrimination of the landscape spatial elements that are homogenous by a set of the established parameters [10].

Thus, being a variety of complex environmental maps, LEM comprise a series of maps: ‘external influences on the landscape’, ‘landscape component modification’, ‘landscape weighted average modification’, «landscape environmental state».

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