Geoinformation methods of geoecological features of the territory study

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Abstract. The paper considers the analysis of dynamics changes in the Ilmenno-Bugrovy lowland of the Caspian region to evaluate the accuracy of detecting changes in the geoecological peculiarities of the region. The method of remote sensing is used for a more detailed study of the Ilmenno-Bugrovy lowland region. A complex of various methods of fixing the natural situation using photographic, scanner, and other special equipment is used. The authors also apply visual observations and methods for calculating quantitative indicators in landscape ecology. The unique landscape of these regions is represented by the tracts of the Baer knolls and inter-mound plains, which are occupied by lake-like reservoirs, ilmens, of varying degrees of salinity which have preserved the water surface due to their connection with the arms of the Volga River. The natural water regime of these regions is disturbed, and in the process of extensive environment, the Baer knolls are destroyed, natural territories are polluted as a result of the Volga river flow regulation. The information was collected on the geoecological state of the site in this landscape region using modern geoinformation research methods. These methods made it possible to identify the features of anthropogenic influence in these regions, to develop a set of measures to prevent the environmental deterioration and preserve the biological diversity of these regions. The analysis of the obtained results made it possible to identify an unstable ecological situation in these unique natural territories. The structure and texture of the landscapes of the Ilmenno-Bugrovy lowland is changing under the conditions of active anthropogenic and technogenic impact.

1. Introduction
The Caspian depression located in the southern part of the temperate climatic zone, is characterized by a continental climate with a relatively low level of air humidity. The Ilmenno-Bugrovy lowland region is in sharp contrast to the semi-desert and desert landscapes adjacent to the Volga-Akhtuba floodplain and the Volga river delta. The modern landscape was being emerged and changed under the influence of transgression and regression of the Caspian Sea, climatic conditions, and deltaic processes and under conditions of close occurrence of mineralized groundwater.

The Baer knolls are rectilinear, parallel elevations of the relief are occupied Different lakes, ilmen (of varying degrees of salinity; fresh, slightly salted, salty) occupy inter-hillock lowlands. Their water content decreases with increasing distance from the Volga. In some places dry territories have formed...
sections of plains. The Baer knolls, named in honor of academician K.M. Baer, who first described them. They consist of rocks formed in the Khvalynian period and genetically associated with the Volga River delta.

Geologically, the knolls are composed of clay (mainly brown-yellow), loam, sandy loam and sand. The rock sediments of the ilmen lakes are organomineral silt sediments up to 1.5 m thick, fine-grained sedimentary mineral rocks, aleurite, river sediments. The depth of the lakes in low water ranges from 1 to 3 meters. Almost all the hillocks are spatially oriented from east to west [1].

Semi-desert and desert plants are widely distributed on the brown soils of the Bera mounds. The species diversity of the flora of these territories is very scarce, for example, camel thorn (Alhagi), sand wormwood (Artemisia arenaria), etc. Eriks connect the main channel of the Volga River and inter-hillock lakes, i.e., ilmen, during the flood period. On the shores of the lakes, thickets of reed-ctail vegetation grow, which are being replaced, on less moist soils, by cereal-forb meadows, and then by semi-desert and desert plants.

The main border and regulator of water resources supplied with river runoff to the territory of the Volga River delta is the Volga Hydroelectric Station. In the process of a significant increase in the intensity of agriculture and as a result of a decrease in the watering of territories, characteristic of the last decades, most of the lake system of the Western steppe ilmen is artificially watered, through pumping the Volga water through a system of canals. On the territories bordering the coast of the Caspian Sea, sea water can flow into the ilmen lakes during the surge winds.

As a result of active evaporation, constant water intake for the needs of agriculture and peaks of high water, fluctuations in the water level in the seasons of the year can reach up to 1.5 meters in the lake system, and the indicators of water salinity in them will change four times. Thus, both fresh and salty water bodies are widespread in the study area. The peak of flooding occurs at the end of May - beginning of June, and the minimum indicators of watering of the territory are observed in the autumn-winter period.

On the territory of the Ilmenno-Bugrovy lowland region, there are many different animals listed in the Russian Red Book, for example, from representatives of the avifauna: osprey, stilt, spoonbills, etc. Examples of a fairly figurative ichthyofauna can be called perches, pikes, spoonbills, etc. The irrigated agriculture, including the cultivation of rice and melons and gourds, is developed in the territories of the Western steppe ilmen. A method of periodic drainage of the lake bottom is used under crops for a more efficient agricultural industry. And then lakes are filled with water again. Moreover, in the Ilmen region, sites for pastures for cattle and small livestock are widespread besides plant growing. Also, these areas are applied as hayfields. Sometimes domestic ducks are bred on reservoirs. [2].

In recent years, there has been a sharp decline in the volume of water flow in the rivers of the Caspian lowland. It negatively affected the hydrological regime of some ilmen.

Significant changes in the qualitative and quantitative characteristics of land use affect not only the landscapes, but also the water resources located in these territories. Therefore, it can be argued that a close relationship is formed of the features of land use and territorial water resources [3].

2. Materials and research methods
Landscapes are constantly changing in modern conditions of anthropogenic global influence. It is difficult to apply traditional methods at studying large territories. It is logical to explore individual sites of the studied landscapes. For the detailed investigation of the studied Ilmenno-Bugrovy lowland region, the ERS method (Earth Remote Sensing method) was applied, i.e., visual observation, scanning and photographic equipment is used to record natural conditions and objects.

Cartographic methods for studying the anthropogenic influence on the relief make it possible to gain visual highly informative evidence that reflects the current state of natural-territorial complexes. It proves especially objective design of actions for the protection and expedient use of these natural resources [4].

For the comprehensive investigation of the area, the experience of foreign researchers was studied in analyzing changes in the structure of the landscape using satellite images, which are mainly focused on
the study of soil and flora cover. The remote sensing method is combined with GIS techniques such as quantitative methods in landscape ecology [5].

The need for a systematic approach to the study of the landscape is expressed by the fact that a series of thematic maps is being compiled for cartographic interpretation of the problem under study. Thus, these maps form a cycle that can be considered as a necessary system of monitoring measures (table 1).

| Map group         | Map content                                                                 | Map purpose                                                                 |
|-------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Base              | Natural conditions of the territory.                                         | Reflect the environmental capabilities of the environment, the main natural laws, potential natural resources |
| Recommend         | Recommended measures for the protection and rational use of landscapes       | Graphic representation of the most environmentally effective measures for the protection and rational use of landscapes, recommended on the basis of the environmental forecast. Designed to facilitate the selection of the optimal solution by the planning authorities |
| Prognostic        | The main trends in landscape changes are the dynamics of natural and anthropogenic | Graphic reflection of ecological forecast is reflection of possible changes of natural environment at the existing level of influence or at its purposeful change. Designed for the design of environmental measures |
| Property survey   | Current state of landscapes and measures for the protection and use of resources; analysis of the magnitude and direction of anthropogenic impact on the landscape | Current state of landscapes and measures for the protection and use of resources; analysis of the magnitude and direction of anthropogenic impact on the landscape |

The maps included in the cycle reflect the existing natural conditions and the current ecological situation of the studied territory, characterize the modern features and the general state of natural resources, including their quantitative and qualitative data, express the forecast of the transformation of natural resources and natural conditions as a result of anthropogenic influence, contain information on a set of recommendatory measures aimed at the formation of rational environment.

The mapped units are initially distinguished from general to specific for the compilation of thematic natural maps of the Ilmenno-Bugrovy lowland region. Thus, the units of the highest taxonomic rank and general patterns were indicated [6].

The development of cartographic research methods makes it possible to compile various groups of thematic maps: ecological, hydrological, and recreational. It is cartographic methods that help to reveal the full potential of geographical research of the territory [7].

3. Results and their discussion
The use of space materials and geoinformation programs made it possible to compile a series of thematic natural maps of the studied areas of the region. They presented landscape textures with great detail, in particular, the division of species and subspecies of landscapes into smaller natural-territorial complexes (facies, natural districts, areas). The obtained data helps to supplement the landscape map of the Astrakhan region, compiled on the basis of multispectral satellite imagery and field observations.
At the next stage, the necessary material was prepared for conducting a more detailed mapping of the ilmen-hillock region. In the process of conducting field expeditions, markers were tracked at all control points using GPS navigation. [8].

Recently, a dynamic anthropogenic change in relief forms and species of flora has been taking place in this territory. It has become more difficult to detect contours of observation by visual and descriptive characteristics. In turn, the direction-finding points on the ground helped to detect the desired object precisely. About 200 contours were passed and over 1000 points were tracked.

Geographic Tracker helps users to import position data from a GPS receiver and load waypoints into MapInfo (figure 1).

In the delta of the Volga River, knolls almost do not form continuous layers, but they occur either in groups or separately. The islands in the southern part of the delta and at the seaside, most often, consist of these knolls. Thus, it was necessary to generalize complex ecosystems, consisting of combinations of optically homogeneous elementary areas at interpreting optical effects at the regional level [9].

It is possible to trace changes in landscape complexes to one degree or another, both monotypic tracts, facies, and the relief as a whole within the studied region (figure 2).

The agricultural activity is the main reason for the natural landscapes change. Plowing lands and organizing regular pastures make leading pattern of aerospace images so called “a patchwork quilt” of rectangles and squares [10].

The MapInfo program was used to evaluate the accuracy of detecting changes. Random biphasic sampling with 250 pixels sampled in regions of permanent land cover and 250 pixels sampled within change areas defined by continuous change detection and classification (CCDC) algorithms. The accuracy evaluation shows that the CCDC results were accurate for detecting changes in the Earth's surface, with a producer's accuracy of 98% and a user accuracy of 86% in the spatial domain and a temporal accuracy of 80% [11].
Figure 2 indicates the following:

- Nature monuments “Medical lake”.
- Landscape reserve “Ilmenno – Bugrovy”.
- Landscape reserve “Kryaninsky”.
- Nature monuments “Sntnyagovo - pyreyny field”.
- Nature monuments “Reed field”.
- Nature monuments “Zelenginsky breeding ground”.
- Nature monuments “Zabuzansky breeding ground”.
- Nature monuments “Svinoropyny field”.
- Nature monuments “Dianovskiy breeding ground”.
- Nature monuments “Trostonikovo skrytnitsevy field”.
- Nature monuments “Kalinin breeding ground”.
- Nature monuments “Pribrezhnitsevo - mortukovy field”.
- Nature monuments “Dvukistrochnikovo - sitnyagovy field”.
- Nature monuments “Skrytnitsevo-solerosovy field”.
- Nature monuments “Snake Hillock”.
- Nature monuments “Pyreyno - pribrezhnitsevy field”.

Satellite images of various time frames were interpreted to analyze the dynamics of changes in the Ilmenno-Bugrovy lowland region of the Caspian Sea region. The sampling method was used. Sampling is a process of marking objects to calculate statistics.

Figure 3. Images obtained at different periods of time, interpreted them with objects (left 2008, right to 2018).
One of the most stable controlling factors for changes in the optical and radiation characteristics of ecosystems is a change in the structure of the cover and phytomass of vegetation. It occurs under the influence of overgrazing, felling, burnt areas, plowing, transport, construction, and secondary anthropogenic soil erosion (figure 3).

The 2008 image is characterized by a larger area of the ilmen water surface. In the 2018 image, the plowed areas and areas of hayfields and pastures were easily deciphered. These anthropogenic activities are absent in the early picture.

The GVI (Green Vegetation Index) is used for geoinformation analysis of the lack of water supply. This index is based on the fact that differences in the vegetation brightness in different areas characterize the state of vegetation. (Szilassi et al., 2018) A decrease in water supply leads to a deterioration in the vegetative development of vegetation and a decrease in the GVI index (figure 4).

![Figure 4](image-url) Analysis of the index of GVI in the territory of Ilmen-hillock area of the Caspian lowland (on the left 2008, right 2018.).

It is also easy to determine soil salinity with readily soluble salts through the indicator function of vegetation. With an increase in soil salinity, the phytomass of vegetation decreases, and, in turn, the Green Vegetation Index of saline soils decreases [12].

It was possible to mark all related objects based on the selection of a similar color structure applying the maximum similarity classification method. So, in two images at different times (2008 and 2018), schematic maps were deciphered and compiled for a comparative analysis of the distribution area of the ilmen. The dynamics is clearly visible at comparison. So, the number of the salted ilmen areas increased by 15%. The number of fresh ilmen areas decreased by 10%. Natural formations, the Baer hillocks, were also deformed and destroyed (figure 5).

![Figure 5](image-url) The map chart created by a sampling method on multi-temporal images of the area (left 2008, right 2018g.).
4. Conclusion
The active nature environment is carried out; agricultural and recreational activities are developed in these territories.

A high level of anthropogenic impact and high rates of these territories development lead to the fact that vast territories are located in zones of natural and economic conflicts.

In general, the given study showed that the geographic information method is suitable for mapping landscape heterogeneity in natural and semi-natural landscapes. The method can be used to inform the gradient analysis in landscape ecological studies of landscape ecological mapping [13].

This study showed the superiority of the combined geoinformation approach based on the greenish tone acquired with aerospace video cameras of the RGB property for biomass modeling [14].

A decrease in the surface runoff of ilmen, stimulation of erosion of territories, an increase in the actions of deflation and salt accumulation, as well as degradation of soil and vegetation cover, are very common in the study area. A single or complex influence of these factors leads to a decrease in the water level in the ilmen, and, accordingly, a decrease in areas. Changes in hydro-conditions lead to a change in successions, i.e., the overgrowth of the shores and the bottom with macrophytes.

The landscapes of the Ilmenno-Bugrovy lowland region, as well as other landscapes of the region, are greatly influenced by agricultural and technical human activities. Also uncontrolled, aggressive tourist flow influences the landscape. Monitoring and analysis of the results obtained show an unstable ecological situation in these unique natural-territorial complexes. The exploitation of landscapes and the study of the consequences of these actions are of a prolong nature.

According to the results of the study it is possible to discuss the process of desertification. It is a consequence of the violation of the ecological and resource balance of the area under study. This is a result of the transformation of the landscapes from the organized to the primitively arranged complexity.

The authors consider desertification as the main result of the anthropogenic process against the background of climatic changes. For this reason, it is necessary to take into account the influence of anthropogenesis on the environmental situation, formed in the study area of the Ilmenno-Bugrovy lowland region. It is necessary to avoid restraining the natural mechanisms of self-regulation of landscape complexes to eliminate irreversible changes in the hydrological structure [15].

Geographic information and geodetic monitoring, over the past 15 years, has risen to a higher level of accuracy.

The space imagery opens up prospects for the development not only structural-genetic landscape maps, but also structural-dynamic ones. It provides the necessary information for landscape-geotechnical mapping. Their object is natural-anthropogenic landscapes, i.e., agricultural, urban, industrial, recreational, etc.

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