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Assessment of the ecological stability of the landscapes of the Pavlodar region

Abstract. *There are presented main results of the assessment of the ecological stability of the landscapes of the Pavlodar region, performed by GIS. The assessment of the ecological stability of the study region was carried out using a series of indicators: the area of water resources, the area of specially protected natural territories, the average NDVI value, the area of buildings, the average population density, the length of transport routes, the area of arable land, as well as the area of man-made territories that have an impact on the natural environment, both positive and negative. There has been compiled map of the ecological stability of the landscapes of the study region.*

Keywords: *landscape, ecological stability, indicators of ecological stability, coefficient of ecological stabilization, structure of nature management.*

Introduction

At the end of the twentieth century, there appeared new theoretical problems related to the acceleration of the processes of degradation of natural complexes, environmental pollution, and a decrease in environmental stability. In landscape science, there has come a new stage of development. It is ecological stage.

It is necessary to avoid disturbing the balance of natural processes that regulate energy exchange with the environment when conducting anthropogenic activities. Problems of assessing the stability of geosystems described in the works of A. D. Abalakov (2010, 2014), M. I. Lopyrev (1995, 2005, 2012), V. A. Baranov (1995, 2001, 2006, 2012), etc. Calculating the degree of stability of the functioning of geosystems is an urgent issue, the solution of which is particularly important at the present time. Environmental stability – an ability of geosystems to withstand internal abiotic and biotic environmental factors, as well as anthropogenic impact. The use of this parameter makes it possible to implement the selection of measures and actions to balance the environmental factors of different territories scientifically and systematically [1-5].

The developed optimal structure of environmental management makes it possible to link and regulate economic activities spatially, regulate the location of objects of economic activity, and determine the specifics of environmental management. At the same time, it is considered that the optimal structure of nature management does not lead to negative consequences, does not reduce the environmental and resource - forming properties of geosystems, and, conversely, an imperfect structure of nature management, formed without taking into account the ecological stability of the territory, leads to disruption and degradation.

Materials and methods of research

In our work, landscape is the operational unit of the study to assess the ecological stability of the Pavlodar region. The basis was a medium-scale (1:500,000) landscape map of Pavlodar region [6] that

we made earlier. There were identified 74 separate landscapes, presented in Figure 1 and Table 2. They are divided into different classification categories: classes (plains and mountains), types (forest-steppe and steppe) and subtypes (north-steppe and south-steppe). Evaluation of the definition of the coefficient of ecological stabilization of the landscape (Kesl), based on the ratio of the areas of landscape elements and various indicators that have an impact on the natural environment, both positive and negative [5, 7-11].

The coefficient of ecological stabilization is shown by the ratio, formula (1):

$$K esl = \sum_{i=1}^{n} F sp / \sum_{i=1}^{m} F nsp \qquad (1)$$

where:

F_{sp} - areas that have a positive impact on the landscape;

F_{nsp} - areas occupied by degraded landscape elements.

Using the calculated values of the (K_{esl}), the assessment of the stability of the landscape can be made on the following scale: very weakly stable ((K_{esl}), ≤0.50); weakly stable ((K_{esl}), =0.51-1.00); medium stable ((K_{esl}), =1.01-3.00); relatively stable ((K_{esl}), =3.01-4.50); stable ((K_{esl}), ≥4.50).

There were used the following indicators to assess the environmental stability: the area of water resources, the area of specially protected natural areas, the average value of NDVI, the area of buildings, the average population density, the length of transport routes (roads and railways), the area of arable land, as well as the area of man-made territories. Indicators that have a positive impact on environmental stability include the area of water bodies and protected areas, because these are natural ecological systems that reflect the presence of high biodiversity and are ecologically important for the geosystems within which they are located. In addition, the average values of the NDVI coefficient of each geosystem were added to the positive indicators. All these indicators make the greatest contribution to the development of ecological stabilization of the studied geosystems.

There were determined the following factors to account for the significance of the negative impact - the area of buildings, the average population density, the length of transport routes (roads and railways), the area of arable land, and the area of man-made territories. The above indicators are the main destabilizing factors that can be obtained in quantitative form from open sources.

Results and discussion

There were considered available statistical and cartographic data to assess the ecological stability of landscapes, such as: the area of arable land, forests, specially protected natural areas; the length of transport routes, etc. An assessment of the environmental sustainability of landscapes in the Pavlodar region was calculated and an environmental sustainability assessment map was produced based on the collected information (Figure 1).

Based on the results obtained, it can be concluded that most of the region's territory, i.e. 79.2% of the total area of the Pavlodar region (76 out of 96 landscape types), has a rating lower than 0.5. It belongs to the category of ecologically fragile landscapes. These landscapes include almost all types of relief found on the territory of the Pavlodar region, such as shallow-sand dunes, lake-alluvial, alluvial, denudation and deluvial-proluvial plains. The low stability of these landscapes, for the most part, is associated with a high percentage of arable land areas relative to the entire area of individual allotments and the lack of areas that have a positive impact on the landscape.

Landscapes 7, 14a, 20, 61, 73-belong to the category of stable landscapes. These types of landscapes do not experience a strong anthropogenic load. Within this landscape there is a small number of transport routes, no arable land, and there is also a nature reserve "Kyzyltau" (landscape 73).

Landscapes 28, 38, 49f, 63, 65, 71, and 72 fall into the relatively stable category. Such high ratings of these landscapes relative to others are explained by the presence of large areas of specially protected

ВЕСТНИК ЕНУ имени Л.Н. Гумилева. Серия Химия. География. Экология
BULLETIN of L.N. Gumilyov ENU. Chemistry. Geography. Ecology Series

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natural areas, for example, the natural reserve "Ertis ormany" (landscape 71) and most of the territory of the Bayanaul National Park (landscape 72). In addition, on the territory of these geosystems there is a small number of man-made and residential buildings and almost no arable land.
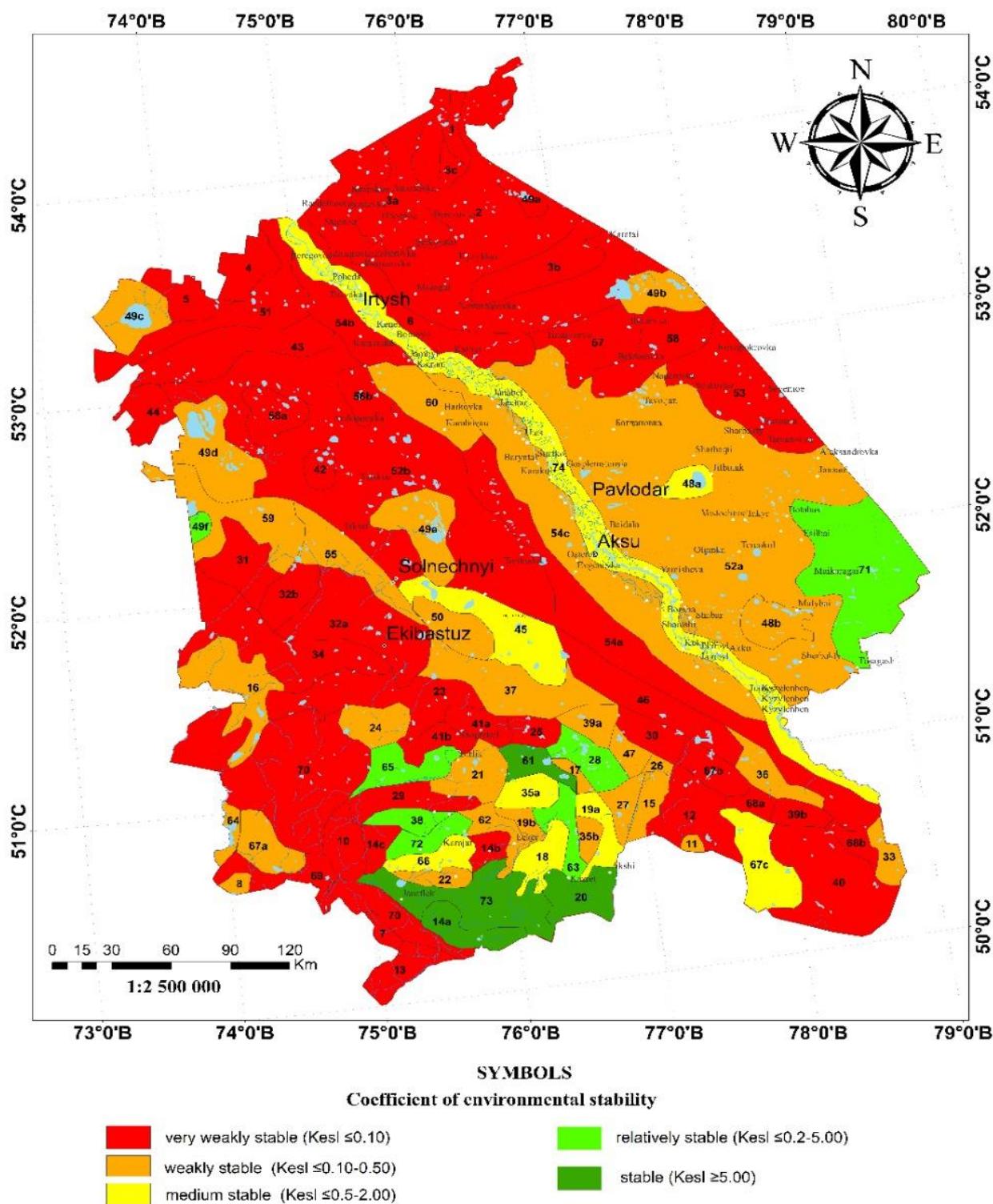

Figure 1. Zoning of the landscapes of the Pavlodar region according to the degree of ecological stability

Landscapes 18, 19a, 35a, 45, 48a, 66, 67c, 74 are included in the category of medium stable. These geosystems have relatively equal indicators of positive and negative factors. In addition, they are characterized by the presence of forests, as well as areas included in protected natural areas – such as

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Л.Н. Гумилев атындағы ЕҰУ Хабаршысы. Химия. География. Экология сериясы
ISSN: 2616-6771, eISSN: 2617-9962

the Bayanaul National Park (landscapes 18, 35a, 66), as well as the nature reserve "Floodplain of the Irtysh River" (landscape 74).

There are 30 landscapes classified as weakly stable. The situation with the presence in these geosystems of areas of water bodies and protected areas in this category is almost similar to the situation in geosystems with very weak stability. However, the main difference for the better is the lower population density, the absence of industrial facilities and hence the absence of man-made buildings. In addition, some of these landscapes record relatively small areas of arable land.

There are 46 geosystems belong to the group of very weakly stable landscapes. These landscapes are characterized by a high average population density. Respectively, a large area of residential and man-made buildings, large areas of arable land, that is, a large total area of territories that negatively affect stability. In contrast, there are very few or no areas of water resources and protected areas on the territory of these geosystems.

Based on the obtained assessments of all types of landscapes of the Pavlodar region, it can be concluded that the region needs a radical revision of the basic principles of land use, as well as the development of a separate strategy to improve environmental stability in the region.

Conclusion

The territory of the Pavlodar region belongs to forest-steppe, steppe (north-steppe, south-steppe), mountain (forest, steppe) and valley landscapes. The landscapes of the region have a combination of natural factors that enhance the processes of landscape pollution. All this reduces centralization, orderliness and self-organization, and the stability of the landscape.

Thus, studying the problems of ecological stability of landscapes, we assessed the ecological stability of the Pavlodar region using various indicators. The assessment of the degree of ecological stability of natural complexes made it possible to identify landscapes with different stability potentials (from very weak to stable). The study has confirmed that landscapes with a high degree of ecological stability are mainly confined to specially protected natural areas. While other landscapes have a low degree of stability, having smaller favorable impact areas and being subjected to strong anthropogenic impact.

The assessment of landscape diversity made it possible to identify areas with different environmental stability potentials. The results obtained allow us to identify spaces of monofunctional and diverse use, including finding specific places for the organization of protected and recreational areas.

The results of environmental stability assessments are of central importance in justifying economic activity and are a necessary component of modern environmental management planning.

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Павлодар облысы ландшафтарының экологиялық тұрақтылығын бағалау

Аңдатпа. ГАЖ көмегімен орындалған Павлодар облысы ландшафтарының экологиялық тұрақтылығын бағалаудың негізгі нәтижелері келтірілген. Зерттеу аймақтың экологиялық тұрақтылығын бағалау бірқатар көрсеткіштер көмегімен жүргізілді: су қоры объектілерінің ауданы, ерекше қорғалатын табиғи аумақтардың ауданы, NDVI орташа мәні, ғимараттардың ауданы, халықтың орташа тығыздығы, көлік жолдарының ұзындығы, егістік жерлер, сондай-ақ табиғи ортаға оң да, теріс те әсер ететін техногендік аумақтардың ауданы.

Түйін сөздер: ландшафт, экологиялық тұрақтылық, экологиялық тұрақтылық көрсеткіштері, экологиялық тұрақтандыру коэффициенті, табиғатты пайдалану құрылымы.

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Оценка экологической стабильности ландшафтов Павлодарской области

Аннотация. Приведены основные результаты оценки экологической стабильности ландшафтов Павлодарской области, выполненной с использованием ГИС. Оценка экологической стабильности региона исследования проведена с помощью серии показателей: площадь объектов водного фонда, площадь особо охраняемых природных территорий, среднее значение NDVI, площадь строений, средняя плотность населения, протяженность транспортных путей, площадь пашен, а также площадь техногенных территорий, имеющих как положительное, так и

отрицательное влияние на природную среду.

Ключевые слова: ландшафт, экологическая стабильность, показатели экологической стабильности, коэффициент экологической стабилизации, структура природопользования.

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