Approaches to anthropogenic loads on landscapes in heavily developed regions (On the example of the Chuvash Republic)

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Abstract. Economic activity led to significant transformations of natural landscapes of the Chuvash Republic. There is a change in certain components of geosystems and natural-territorial complexes as a whole. In order to rationalize environmental management, the analysis of the types and degree of anthropogenic load was carried out. The ratio of different lands was taken as parameters of the analysis. It was based on the share of farmlands, settlement zone, forests and natural landscapes. On the example of the model region of the Chuvash Republic 5 main types of areas were analyzed: upland, slope, terrace, floodplain and valley-river (valleys of small rivers). The factor of different stability of terrain types was taken into account. For uplands it is taken as a unit, and decreases in other types of terrain. On the basis of the analysis of the state of geosystems, the groups of districts were identified and measures were developed to reduce the anthropogenic load on landscapes.

1. Introduction
Intensive multi-dimensional use of land resources leads to high fragmentation of landscapes. The absence of spatial landscape-ecological analysis based on the description of the ratio of land and its comparison with critical indicators violates the integrity and stability of geosystems.

The description of landscape transformation based on the analysis of land use structure and types of management is reflected in the works of domestic (Kochurov B.I. [2], Orlova I.V. [8], Reimers N.F. and Schtilmark F.R. [13]) and foreign scientists (Robert W. Christopherson [6], A. Nowak [4]). The territories characterized by high fragmentation of landscapes and diverse economic activities are closely monitored [9]. Therefore, the object of this study is the territory of Chuvashia. The area is characterized by a high proportion of agricultural land (55.2 %), which is exacerbated by a thick network of rural settlements linked by developed infrastructure. According to the method of B.I. Kochurov (2008), for the studied region the ecosystem disturbance makes 54 % (for severely fragmented territories this indicator amounts to 30–55 %).

2. Methods and materials
To describe the extent to which geosystems are changing, there is a need to choose an elementary territorial unit. Administrative-territorial (administrative districts, rural settlements) and geosystems (landscapes, components of the natural environment, anthropogenic territorial) entities can be the linked units. The use of administrative-territorial units simplifies the collection of statistical data from official sources and optimizes the implementation of measures to stabilize the environmental situation through the authorities. Geosystems allow considering landscape-ecological peculiarities of the studied objects [3]. Therefore, it was decided to analyze landscapes for each administrative district of
the Chuvash Republic separately. In total there were 5 main types of terrain: upland, slope, terrace, floodplain and valley-river.

The anthropogenic impact on landscapes can be assessed by analyzing the volume of industrial and other emissions, analyzing the ratio of land types, describing the volume of withdrawn natural resources, etc. The work was based on the parameters identified by Orlova I.V. [8]. The analysis of the area-to-land ratio was applied and the compliance of these areas with the existing threshold values was studied (Table 1).

In order to optimize calculations, the following parameters were identified: the share of farmlands from the total area, the share of settlement zones from the total area, the share of natural landscapes from the total area, the ratio of agricultural land and pastures.

Different stability of landscapes was also taken into account. Analysis of literary sources [5, 11, 14] showed that the optimal ratio is the following: anthropogenic load on the upland type of terrain equals 1. Due to the decrease in stability in the terrace type, this indicator increases by 1.2; in slope – 1.5 times; in floodplain and valley-river – 2 times.

Table 1. Ecological parameters of balanced territory (according to Orlova I.V. [8])

| Parameter                                | Valid          | Optimal        |
|------------------------------------------|----------------|----------------|
| Share of natural landscapes              | From 40 %      | From 60 %      |
| Share of farmlands                       | Up to 60 %     | Up to 40 %     |
| Share of forage lands from agricultural lands | From 30 %      | From 50 %      |
| Share of forests                         | From 10 %      | From 20 %      |
| Share of settlement zones                | Up to 10 %     | Up to 3 %      |

3. Results

There are 5 types of terrain on the territory of the Chuvash Republic [1]. They were described separately for each administrative area according to the method of interfacing analysis of landscape maps by P. Xofis [10]. The impact of economic activities on biodiversity by landscape gradients was analyzed (according to J. Marull, E. Tello, G. Bugaria [10]). A total of 102 territorial units were identified, in which the ratio of land types to existing critical values was calculated.

The lowest indicators of anthropogenic loads are typical for the Prisursky forested physical and geographical area. The territories of Alatyrsky, Poretsky, Ibresinsky, Shumerlinsky, Vurnarsky districts, which are part of it, are characterized by low and satisfactory indicators of anthropogenic load. To the northeast of the Prisursky physical-geographical and in Alatyr Zazurye (symmetrical to the valley of the river Sura) there is an increase of anthropogenic load affecting all natural complexes.

The upland type of terrain in all administrative districts of the Chuvash Republic is characterized by the least loads, which is explained by high stability of landscapes.

The differentiation of anthropogenic loads on the terrace type of the area has a small amplitude: a satisfactory indicator is typical for Alatyrsky, Poretsky, Shumerlinsky and Cheboksarsky districts. The unsatisfactory indicator is observed in Yadrinsky, Krasnochetaysky and Tsivilsky districts, which is caused by the increase in the ploughing of studied territories.

The floodplains of the Chuvash Republic are more oppressed compared to terraces at the expense of less restorative ability. The situation is satisfactory in Shumerlinsky and Poretsky districts; unsatisfactory – in Alatyrsky, Krasnochetaysky, Yadrinsky, Morgaushsky districts.

Critical indicators are typical for Cheboksarsky, Mariinsko-Posadsky, Kozlovsky and Tsivilsky districts. The increase in anthropogenic loads in recent areas is caused by the increase in the area indicators of settlements, pastures and haylands.

The most of the slope type of the area of the Chuvash Republic is characterized by critical indicators of anthropogenic load. Satisfactory indicators are observed in 3 districts: Alatyrsky, Shumerlinsky, Ibresinsky due to the prevalence of forest plantations. The environmental situation is unsatisfactory in the rest of the administrative districts belonging to the Prisursky physical and geographical area: Krasnochetaysky, Vurnarsky, Poretsky, as well as in Mariinsky-Posadsky, Shemurshinsky, Batyrevsky districts, where there are also vast forest plantations. Administrative areas
with a critical indicator of anthropogenic load of the slope type of the area are extended by a wide strip from the north-west to the south-east of the republic, including Yadrinsky, Morgaushsky, Cheboksarsky, Alikovsky, Krasnoarmeysky, Tsivilsky, Kanashsky, Urmarsky, Yantikovsky, Kozlovsky, Komsomolsky, Yalchiksky districts. A considerable excess of the valid value of the area of farmlands (in Yalchiksky district the farmlands make 88 % of the area of slopes against the maximum permissible 60 %) leads to degradation and deterioration of the remaining natural complexes in these administrative areas.

The valley-river type of terrain is also characterized by high anthropogenic load. This is caused by a wide use of them as pasture and hay lands, the location of most settlements in small river valleys (33 % of the total area). Low stability of geocenosis of small river valleys exacerbates the situation. The above factors led to high anthropogenic load of this type of terrain: 18 out of 21 administrative districts of the Chuvash Republic are characterized by critical indicators of anthropogenic load; Alatyrsky, Ibrinsinsky and Shemurshinsky districts – by unsatisfactory condition.

There are no valley-river geosystems with low or satisfactory anthropogenic load. Critical anthropogenic load of the valley-river type of terrain is observed even in those administrative areas where other natural complexes are characterized by satisfactory anthropogenic load: Shumerlinsky, Poretsky districts.

On the basis of the obtained data and the methodology of land design, the groups of districts were identified as far as possible to intensify or reduce economic activities in them, to carry out reconstruction measures: (Yi Qu, Chunyu Luo [12]):

1. The Prisursky group of districts (including Alatyrsky, Ibrinsinsky, Poretsky, Shumerlinsky, Vurnarsky and Krasnochetaisky administrative districts) is characterized by the smallest indicators of anthropogenic loads in the Republic on all considered types of terrain, and the value of anthropogenic load increases as it moves away from the river Sura. The group has satisfactory indicators of landscape condition (except for the valley-river type of terrain in Vurnarsky and Krasnochetaisky districts). Therefore, it is possible to intensify economic activity on all types of natural complexes without the danger of their degradation.

2. The northern group of districts (Cheboksarsky, Morgaushsky, Yadrinsky) is characterized by maximum indicators of anthropogenic load on all natural complexes. It is characterized by high share of the settlement areas, a heavy transport network. The vast majority of geosystems are in unsatisfactory and critical condition. Increased economic activity in this group can lead to irreversible disruption of natural communities, most of which are already in critical condition. They require urgent measures to improve the environmental situation, in particular the transfer of some of the territories to more gentle land use modes (haylands, pastures, forest crops). On the slope type of terrain, it is recommended to create additional forest fields, ecological rest zones.

3. The eastern group of districts (Kozlovsky, Urmarsky, Komsomolsky, Yalchiksky administrative districts) is similar to the northern one in terms of anthropogenic loads. However, it is characterized by a smaller area of forest plantations, an increased share of agricultural land (in particular arable land). Here it is necessary to stabilize the environmental situation due to some reduction of the pasture area and creation of phytomeliorative forestry both in river valleys and in uplands and slopes. Additional steppe and forest reserves can be created. Intensification of business activities is not recommended.

4. The central group of districts includes Alikovsky, Krasnoarmeysky, Tsivilsky, Kanashsky, Yantikovsky districts. It is characterized by moderate indicators of anthropogenic load in uplands and a sharp increase of these indicators in the direction from watershed to river valleys. The restoration policy here should be implemented on the slope and valley-river types of the area by reducing the arable lands on the steepest slopes, creating forestlands, reduce pasture lands in river valleys.
Figure 1. Landscape Optimization

| Anthropogenic load | Areas                                                | Recommended activities                                                                 |
|--------------------|------------------------------------------------------|----------------------------------------------------------------------------------------|
| Low                | Alatyrskiy, Ilbresinskyy, Poretskiy, Krasnochetsayskiy, Vurnarskiy, Shumerlinskiy | Low man-made loads. Enhanced environmental management                                   |
| Satisfactory       | MARIINsKO-PoSADSIKY, ShemerShinsky, BatyreVskiY      | Moderate load prevails. River valleys should be converted to natural landscapes, protected areas |
| High               | Alikovskiy, Tsivii'skiy, Kanashskiy, Yantikovsky, Krasnoarmeyskiy | Average loads on flat areas. On the slopes and in river valleys - high. It is necessary to reduce the area of arable land and create forest belts |
| Critical           | Cheboksarskiy, Kozlovsky, Morgaushsky, Yadrinskiy, Urmarskiy, Ya'chiksky, Komsomol'skiy | Landscapes experience high and critical loads. An increase in forest belts and natural territories is required. Transfer arable land under hayfields |

Figure 1. Landscape Optimization
Separately, we shall highlight Mariinsky-Posadsky, Shemurshinsky and Batyrevsky districts. Due to the large area of forest land, the environment is stable here. Forest plantations are distributed quite evenly by type of area. Increased anthropogenic load is typical only for the valley-river type of terrain (Figure 1).

4. Conclusion
The study revealed that the optimal territorial unit for calculating anthropogenic loads at the regional level is the type of terrain within the administrative area. The positive sides of this choice include the following: accounting of landscape peculiarities and sustainability of geosystems, publicly available information on the structure of land areas of the districts, possibility of introducing a set of measures to green environmental management at the level of municipalities.

The calculation of anthropogenic load is possible through the analysis of the structure of the lands and its subsequent comparison with valid indicators. This method allows separately describing the changes in various types of environmental management and developing measures to improve the environmental situation.

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