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ANALYSIS OF THE OPTIMALITY OF THE KLAIPEDA COUNTY LANDSCAPE STRUCTURE

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The aim of this study was to perform an analysis of the optimality of the landscape structure of Klaipeda County.
Various scientific methods were used in the study, namely: comparative, grouping, analytical, statistical data, graphical representation analysis. After calculating the formulas, the ratio of relatively natural and cultivated land in Klaipeda County and municipalities was determined, the relative deviation of the landscape structure from the optimal value of the ratio was estimated and the optimality class was determined.
The article presents an analysis of the changes in the natural, anthropogenized and anthropogenic landscape of the Klaipeda County during the time period between the years 2002 and 2021. It was found that in the analyzed period the area of natural landscape increased by 4.89 percent, that of anthropogenic - increased by 26.70 percent, that of anthropogenized - decreased by 4.99 percent. Assessing the structure of the county's landscape, it can be seen that in 2021 the largest part of the country's landscape was occupied by anthropogenized landscape (55.45 percent), the smallest - by anthropogenic landscape (6.57 percent), and the natural landscape accounted for 37.98 percent of Klaipeda County's territory.
Calculations were also performed, which established that the ratio of relatively natural land and cultivated land in Klaipeda County R_{ns} = 1.65. After estimating the relative deviation of the Klaipeda County from the optimal ratio value (D_r), it was obtained that D_r = 1.01, which means that the county's optimality class is A1.

Keywords: landscape structure, optimal landscape, optimality class.

INTRODUCTION

European Landscape Convention (European, 2000) describes the landscape as people perceived area, as determined by the nature and (or) the factors of human action and interaction.

In the contemporary meaning the landscape is treated as a multi-dimensional and multi-feature system changing in time and space. Inherent in the landscape is the man, so the landscape is subject to various anthropogenic influences (Flis, 2012).

A.Farina (2010) notes that Landscapes are not static. Landscapes can be impressed by climate changes, land-use changes and human activities as well. It can be changed mosaic structure, shape and size of patches in a landscape. All these changes could be seen different spatial sizes and frequencies.

Landscapes are dynamic systems. Human affects them continuously. Depending on intensive human effects, pressure was increased on landscapes. Consequently, landscapes were altered over time. Landscape structure evaluates land mosaic as measure, number, size and shape (Ozyavuz, 2013).

Landscape-level metrics can be used to measure changes in landscape structure over time (DiBari, 2007).

E.S. Gergel and G.M.Turner (2002) describes the structure of a landscape as the spatial pattern of landscape elements and the connections between the different ecosystems or landscape elements. Landscape structure assesses relationship between ecosystems as measure, number, size and shape.

An important assumption of many environmental decisions is that some patterns or combinations of land cover are optimal or more preferable to others. Management plans frequently seek to change the structure of a landscape to realise particular management goals, because it is recognized that the spatial arrangement of elements in a land cover mosaic control the ecological processes which operate within it (Haines-Young, Chopping, 1996).

T. Lamy, K.N. Liss, A. Gonzalez and E. M. Bennett (2016) note that understanding how landscape structure, the composition and configuration of land use/land cover types, affects the relative supply of ecosystem services, is critical to improving landscape management.

S.A. Cushman and K. McGarigal (2008) state that effective implementation of the "multiple path" approach to managing green landscapes depends fundamentally on rigorous quantification of the composition and structure of the landscapes of concern at present, modelling landscape structure trajectories under alternative management paths, and monitoring landscape structure into the future to confirm whether management is having the expected effects on landscape structure. Indeed, quantification of current conditions, anticipation of future changes and monitoring these changes as they occur are the three foundational elements of adaptive management and the key foundation for the multiple path approach to landscape design**.**

Land-use optimisation in the process of evaluation is a confrontation of landscape-ecological conditions and socio-economic demands for use. It is necessary to consider the limitations resulting from three key of landscape-ecological carrying capacity criteria: landscape vulnerability, present load and landscape ecological significance (Zauskova, 2014).

So, landscape structure reflects the results of policies and practices, and is well-suited as a target for management actions (Dramstad *et. al*., 2001).

***The problem and actuality*.** Land-use change modifies the spatial structure of terrestrial landscapes, potentially shaping the distribution, abundance and diversity of remaining species assemblages. Various human activities increase the rate at which natural processes, such as weathering and erosion, shape the landscape. The cutting of forests exposes more soil to wind and water erosion. Pollution such as acid rain often speeds up the weathering, or breakdown, of the Earths rocky surface. Changes to landscape structure also affect habitat suitability for certain species of animals. Changes in landscapes, often have considerable cumulative effects on the environment. At present, it is extremely important to maintain a stable landscape and strive for its optimality.

The object of the investigation is the optimality of the Klaipeda County landscape structure.

The aim of the investigation is to perform an analysis of the optimality of the landscape structure of the Klaipeda County.

Goals of the research:

1. To analyze the change of natural, anthropogenized, and anthropogenic landscape of the Klaipeda County in 2002-2021.
2. To calculate the ratio of relatively natural and cultivated land in Klaipeda County (R_{ns}).
3. To evaluate the optimality of the landscape of the Klaipeda County and municipalities as well as its classes.

RESEARCH METHODS

First of all, during the research of determining the optimality of the Klaipeda County landscape structure, the analysis of the articles published in scientific publications on the examined topic was performed.

The article presents a comparative analysis of the change in the area of the natural, anthropogenized and anthropogenic landscape in 2002–2021. Using the grouping method, the components belonging to the natural, anthropogenized and anthropogenic landscape are divided. The change in the areas of the analyzed landscape components was also examined. The data of the Land Fund of the Republic of Lithuania for 2002–2021 were used for the analysis. The percentage and hectare distribution of the county's landscape types in 2021 was estimated.

The analysis of the ratio of relatively natural and cultivated land in Klaipeda County was performed and the R_{ns} of the county and seven municipalities were calculated. The municipalities data were compared and the municipalities with the most optimal ratio of relatively natural and cultivated land was determined.

Taking into account the diversity of land uses, it is possible to calculate the ratio of relatively natural and cultivated land (R_{ns}) for any sufficiently large (regional level) area with specific boundaries using the formula:

$$R_{ns} = \frac{P+M+0.5\,A+0.8\,V}{U+T+0.5A+0.2\,V}, \qquad (1)$$

where R_{ns} is the ratio of relatively natural land (fraction in the numerator) and relatively cultivated land (fraction in the denominator) of the land of the territory: *P* - wetlands; *M* - forests; *A* - agricultural land; *U, T* - urban and technological components; *V*- water bodies.

The relative deviation of the landscape structure of the Klaipeda County and municipalities from the optimal ratio value (D_r) was also calculated and the optimality class was estimated based on the table *Determination of the territory optimality class according to the distance of its natural and artificial land use* from the optimal value. The optimality of the landscape structure of the territories can be assessed by the following formulas:

$$Dr = \frac{R_{ns}}{Ro}, \text{ when } R_{ns} > Ro \qquad (2)$$

or

$$Dr = \_\ \frac{Ro}{Rns}, \text{ when } R_{ns} < Ro \qquad (3)$$

here D_r is the relative deviation from the optimal ratio value (R_o); R_{ns} - the ratio of relatively natural land and relatively cultivated land in the territory; R_o is the optimal value of the ratio.

After calculating D_r (*formulas 2 and 3*) and based on Table 1, the landscape structure optimality class is determined.

Table 1. Determination of the site optimality class according to the deviation of its natural and artificial land use ratio from the optimal value (Lietuvos Respublikos aplinkos..., 2015)

Ratio of natural and cultivated land (R_{ns})	R_{ns} deviation from optimal value (sometimes) (D_r)	Optimality classes
>78.25	>48.00	A6
13.37...78.24	8.01...48.00	A5
3.27...13.36	2.01...8.00	A4
2.46...3.26	1.51...2.00	A3
1.97...2.45	1.21...1.50	A2
1.631...1.96	1.00...1.20	A1
1.629...1.36	-1.00...-1.20	B1
1.35...1.09	-1.21...-1.50	B2
1.08...0.82	-1.51...-2.00	B3
0.81...0.20	-2.01...-8.00	B4
0.19...0.03	-8.01...-48.00	B5
<0.03	<-48.00	B6

Thus, in writing the article, not only the above-mentioned methods were used, but also the methods of analytical and logical analysis. The article presents graphic representation methods (6 figures in total). Figures 5 and 6 were made using ArcGIS program.

RESULTS OF RESEARCH

The change of landscape area in Klaipeda County

Natural landscape in Klaipeda County. Forests, water bodies and wetlands are components that make up the natural landscape.

The tendencies of changing the naturalness of the landscape are to some extent expressed by the development of the country's forest cover. In Klaipeda County, forest area covers 136,951.39 ha or 26.23 percent. Comparing 2002 with 2021, the forest area in Klaipeda County increased by 9,645.19 ha, i.e. 7.58 percent.

In 2021, water bodies in the country occupied 54,842.15 ha and accounted for 10.50 percent of the territory of Lithuania. After the analysis of the change of water bodies in 2002 - 2021, it was established that their area increased by 1,812.22 ha or 3.42 percent.

Wetlands are one of the most natural components of the natural landscape. Wetlands in Klaipeda County in 2002 occupied 8,748.33 ha, in 2021 – 6,527.86 ha, which means that in 2002–2021 the area of wetlands decreased by as much as 2,220.47 ha or 25.38 percent.

The analysis of the components of the relatively natural landscape shows that the area of forests and water bodies increased between 2002 and 2021, but unfortunately the area of wetlands decreased.

Examining the change of the natural landscape in Klaipeda County, it was found that the area increased by 9,236.94 ha or 4.89 percent during the analyzed period (Fig. 1).

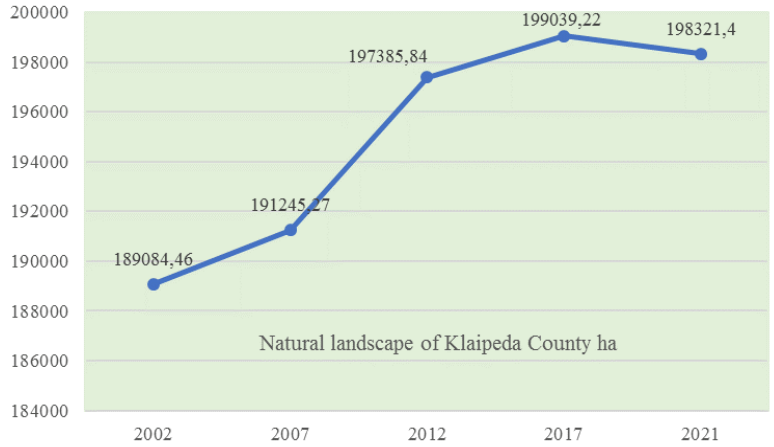

Figure 1. Natural landscape area change in hectares in Klaipeda County 2002-2021

The natural landscape area has increased due to the development of forests and water bodies.

Anthropogenized landscape. The following components can be included in the anthropogenized landscape: agricultural land (arable land, orchards as well as meadows and natural pastures), tree and shrub plantations, unused land.

The area of agricultural land in Klaipeda County decreased by 55,136.87 ha or 19.52 percent in 2002–2021. Human economic activity influences the change of land use, as the composition of land use changes with the change of purpose.

Greenery of trees and shrubs in the analyzed period increased as much as 4,549.32 ha or 95.61 percent. The reason for the increase of this land use is the development of green areas and the implementation of afforestation programs.

In 2002-2021, the areas of unused land in Klaipeda County decreased by 12,468.25 ha or 70.85 percent.

The analysis of the change in the areas of the components of the anthropogenized landscape shows that in the Klaipeda County in 2002–2021 the areas of agricultural land and unused land decreased, and the areas occupied by trees and shrubs increased.

Between 2002 and 2021, the area of the anthropogenized landscape decreased by 15,197.64 ha or 4.99 percent (Fig. 2).

The reason for the decrease in the area of anthropogenized landscape is the decrease in the area of agricultural land (19.52 percent) and unused land (70.85 percent).

Anthropogenic landscape. Anthropogenic landscape includes: built-up areas, roads and damaged land.

In the period of 2002–2021, the area of built-up territories in Klaipeda County increased by 8,640.43 ha or 59.08 percent, and in 2021 it occupied 23,265.70 ha.

Based on the data of the Land Fund of the Republic of Lithuania (Nacionalinė, 2002-2021), it was established that in 2002-2021 the road area in Klaipeda County decreased by 1,724.17ha or 16.90 percent. In 2021, the road area covered 8,480.13 ha.

In 2002–2021, the area of damaged land in Klaipeda County increased by 309.44 ha or 13.85 percent.

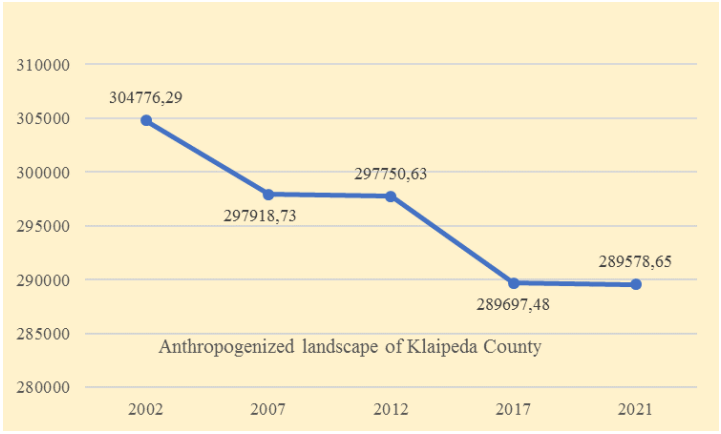

Figure 2. Anthropogenized landscape change in Klaipeda County in hectares during the period between the years 2002 and 2021

After analyzing the change in the area of the Klaipeda County anthropogenic landscape in 2002–2021, it was established that the above area increased by 7,225.70 ha or 26.70 percent. (Fig. 3).

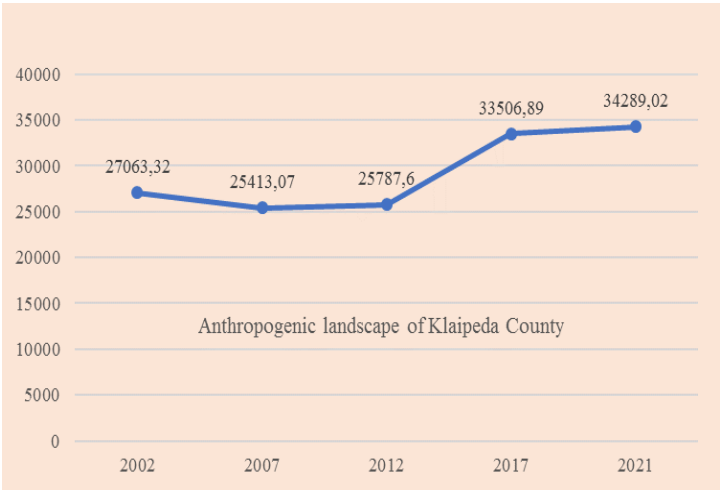

Figure 3. Anthropogenic landscape change in Klaipeda County in hectares during the period between the years 2002 and 2021

The reason for the increase in the area of anthropogenic landscape is the development of built-up areas (59.08 percent) and damaged land (13.85 percent).

After the analysis of the landscape of Klaipeda County, it was established that in 2021 the anthropogenized landscape occupied the largest part of the country's landscape (55.45 percent or 289,578.65 ha), the smallest part of the

landscape was occupied by anthropogenic one (6.57 percent or 34,289.02 ha). The natural landscape in Lithuania occupied 198,321.40 ha and accounted for 37.98 percent of the Klaipeda County's territory (Fig. 4).

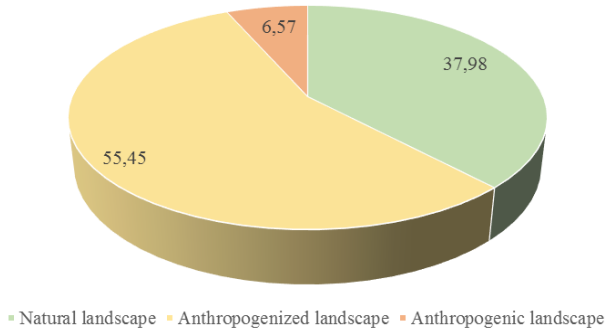

Figure 4. Distribution of Klaipeda County landscape in 2021, in percent.

Analysis of the ratio of relatively natural and cultivated land in Klaipeda County

The methodology of landscape formation (landscape benchmarks to be achieved) (Kavaliauskas *et al*., 2013) states that the optimal landscape structure of a country is assessed on the basis of geoecological compensation index, when the active part of anthropogenic (anthropogenized) land occupies 38 %, passive part or natural (relatively natural) land occupies 62 % (Skorupskas, Kavaliauskas, 2007).

Thus, the landscape cannot be considered optimal if the minimum percentage of natural areas required to compensate for anthropogenic impacts is not reached.

From the above analysis and Figure 4 it can be seen that in 2021, the natural areas of Klaipeda County occupied 37.98 percent, while the anthropogenic together with the anthropogenized landscape accounted for 62.02 percent

After performing the calculations according to the formula *(1)*, it was established that the ratio of relatively natural land and cultivated land (R_{ns}) of Klaipeda County is equal to 1.65.

The structure of the landscape is natural when $R_{ns} = R_o$. R_o is the optimal ratio value, which is equal to 1.63.

There are ten seven municipalities in the territory of Klaipeda County. After analyzing the ratio of relatively natural land and relatively cultivated land, it was found that the optimal ratio of relatively natural land and relatively cultivated land is in Klaipėda county (R_{ns} = 1.65) (Fig. 5). It can be stated that the optimal ratio of the mentioned land use is also in Kretinga district municipality (R_{ns} = 1.80) and Silute district municipality (R_{ns} = 1.79).

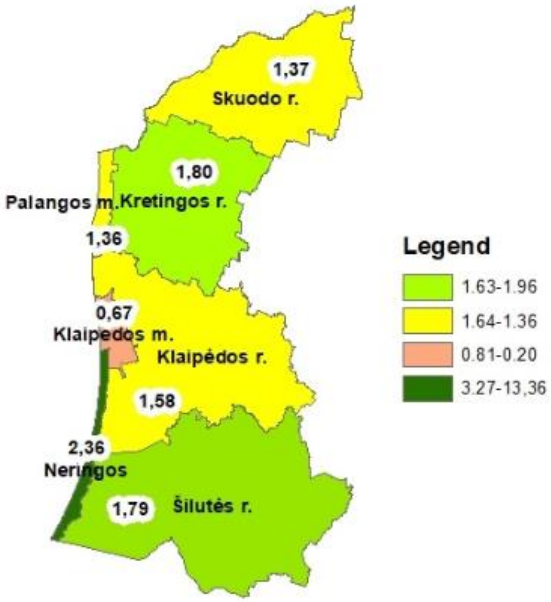

Figure 5. The ratio of relatively natural land and relatively cultivated land in the municipatities of the Klaipeda County

After calculating the counties D_r (*formulas 2 and 3*) and determining the optimality classes (*Table 1)*, it can be seen that the optimal structure - A1 class was determined in Klaipeda County (D_r=1.01), Kretinga district (D_r=1.10) and Silute district (1.09) municipalities (Fig. 6).

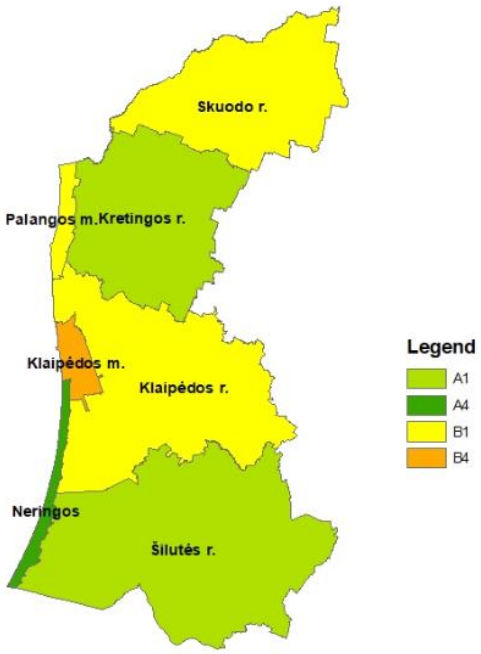

Figure 6. Optimality classes of landscape structure in the municipalities of the Klaipeda County

Class B1 is an almost optimal structure, with a small predominance of cultivated land. This class is established for for Klaipeda district (D_r=-1.03), Palanga city (D_r=-1.19) and Skuodas district municipalities.

Optimality class A4 was determined for Neringa municipality (D_r=2.36). Class A2 shows that the above-mentioned municipality landscape is formed almost exclusively by natural components. In Neringa municipality natural components cover 86.38 percent.

Class B4 was determined in Klaipeda City municipality (D_r=-2.43). Class B4 shows that the above-mentioned municipality landscape is dominated by anthropogenic components.

The landscape optimality structure must be formed taking into account the general optimality of the land use structure of the whole country, territorial structures provided for in the General Plan of the Republic of Lithuania (natural framework, protected areas, functional priority areas, presuming the respective land use structure, etc.), ecological compensation.

CONCLUSIONS

1. After the analysis of landscape change in the Klaipeda County during the period between the years 2002 and 2021, it was established that the area of natural landscape increased by 9,236.94 ha or 4.89 percent, the area of anthropogenic landscape increased by 7,225.70 ha or 26.70 percent, the area of anthropogenized landscape decreased by 15,197.64 ha or 4.99 percent.
2. In 2021, the largest part of the Klaipeda County's landscape made up anthropogenized landscape (55.45 percent), the smallest - anthropogenic (6.57 percent). The natural landscape accounted for 37.98 percent of the county's territory.
3. After calculating the ratio of relatively natural land and cultivated land (R_{ns}) in the Klaipeda County in 2021, it was established that it is equal to 1.65. Out of seven municipalities of the Klaipeda County, the most optimal ratio of relatively natural land and relatively cultivated land is in Silute district (R_{ns}=1.79) and Kretinga district (R_{ns}=1.80) municipalities.
4. The relative deviation of the Klaipeda County from the optimal ratio value (D_r) is equal to 1.01, which means that the county's optimality class is A1, which indicates that there are the optimal structure of landscape. Class B1 was set for Palanga district, Klaipeda district and Skuodas district municipalities, A4 optimality class was set for Neringa municipality, and B4 - for Klaipeda City.

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