

Classification and fragmentation of natural-anthropogenic landscapes for the purposes of the balanced spatial organization of territory

Iryna I. Schastnaya

Belarussian State University, Minsk. Belarus
schastnaya@tut.by

Abstract. Active anthropogenic impact on natural complexes has resulted in dominance of “natural-anthropogenic landscapes” (NAL) in Belarus. They include both elements of natural components and outcomes of anthropogenic activity. NAL follow in their development first of all to natural laws. At the same time attributes of their functioning and dynamics are closely connected with social and economic circumstances. Economic activities of the population in different branches of a national economy essentially alter structure of land use. The direction of economic activity is a main indicator of classification of NAL in Belarus. Furthermore, classification of NAL is a source for detection of fragmentation of landscape structure.

The system of classification units of NAL includes three ranks: class - subclass – species (vid). The highest unit of classification - a class NAL – is defined according to such indicator as the main direction of economic activities in different branches of national economy. We defined forest, agricultural, recreational, protected, urban and typical for a zone of the mixed forests – agro-forest class of landscapes. The proportion of various land use type is an indicator to determine subclass of PAL (arable, forestry-arable and so on). The species of a landscape considers a type of economic activities within natural complex. The set of species is defined (arable secondary-moraine, forestry alluvial terracing and so on). The degree of fragmentation of natural-anthropogenic landscapes is calculated on the basis of developed classification. For assessment of fragmentation of NAL the following coefficients were used: an index of division, coefficient of complexity, a degree of similarity, a level of fragmentation of landscape contour. The research has been made using CorelDraw10, ArcView GIS 3.2, Excel software, that has allowed to receive complex parameters, which characterize contours of different land use (quantity, average size and the relative abundance within a contours of NAL). The number of maps has been made. The areas with various degree of fragmentation are defined (maximum, high, satisfactory, and minimum). These results are a source of data for creation of development strategy for territory.

Classification of natural-anthropogenic landscapes and assessment of their fragmentation gives diverse information which can be used for development of alternatives for an optimum improvement of each species of NAL. It forms a basis for the balanced organization of territory.

Key words: natural-anthropogenic complexes, landscape diversity, landscape metrics, fragmentation, spatial planning

Introduction

The scarcely a landscape anywhere in the world can be found which has not been modified by human activity. Anthropogenic, natural-anthropogenic and cultural landscapes are the most widely used terms for modified natural landscapes in the result of human impact. According to Milkov (1973) anthropogenic complexes should be considered as “new landscapes created by human and also all those natural complexes in which any of their components including vegetation with fauna had influenced by humans”. According to this definition every area in any place of Earth can be considered as anthropogenic. However, the considerable part of the land was

not exposed to deep transformation though the certain influence of economic activity has been tested. Such landscapes, which structure and quality is basically defined by natural preconditions, do are called natural-anthropogenic (NAL). Natural-anthropogenic landscapes dominate within the territory of Belarus. NAL include both elements of natural complexes and anthropogenic elements. Natural-anthropogenic complexes follow in their development first of all to natural laws. At the same time attributes of their functioning and dynamics are closely connected with social and economic circumstances (Martsinkevich 2002). The creation of natural-anthropogenic complexes results in fragmentation of natural areas.

The fragmentation of natural territories is a spatial problem resulted in division of territory on smaller patterns. Urbanization, agriculture, industry and transport infrastructure are the major factors which enhances fragmentation. Fragmentation process often results in adverse ecological processes, such as loss of habitats for animals; loss of particular species of flora and fauna; occurrence of the barriers reducing possibility of freely moving for animals between various habitats and etc. Thus, the fragmentation results in reduction of habitats, increase in barriers and raise spatial heterogeneity. The consequences of the process are the following: negative effect on habitats increases and also quantity of suitable habitats for animals and plants is reduced.

The goal of the study is to investigate the particular features of structure of natural-anthropogenic complexes for sustainable organization of the area. The object of the study is administrative region of Belarus (Brest region). The main aims of the research are to develop classification of natural-anthropogenic landscapes and to produce the map of natural-anthropogenic complexes; to make assessment of fragmentation according to different indexes; to define NAL characterized by various levels of fragmentation and finally, to produce some recommendations how to use natural-anthropogenic complexes in tourism.

Data and methods

The classification of natural-anthropogenic landscapes of Belarus is based on the standard approaches, but also includes some differences that reflect regional attributes of territory. The system of classification units of NAL of Belarus includes three steps: class - subclass – species (vid). A class NAL is defined according to such indicator as the main direction of economic activities in different branches of national economy. We defined *forest, agricultural, recreational, protected, urban* and typical for a zone of the mixed forests – *agro-forest* class of landscapes. The classification feature of class of NAL is proportion of agricultural and forest areas within landscape (tab. 1).

Economic activities of humans within classes of NAL proceed in several directions. The basic employment of the population within agricultural landscapes – agriculture and livestock farming, forest – forestry and forest regeneration, protected landscapes – the organisation of protected natural territories and realisation of regulations of their protection, recreational landscapes – creation of conditions for rest of the population and preservation of traditional types of nature management for people who for a long time live in these territories. As a result in each class of NAL the certain structure of land use is organized. The relative abundance of various type of land use within landscape (arable, forest-arable, etc.) is the indicator for determination of NAL subclasses (tab. 2). For example, the arable NAL includes areas, where a share of an arable land is more than 70%, meadow-pasture – arable lands occupy 10%, meadow – 70-90%, and etc. The species of a landscape considers a type of economic activities within natural complex. The set of species is defined (arable secondary-moraine, forestry alluvial terracing, forest-arable moraine-sandr and so on).

Table 1. The structure of class of NAL (Schastnaya 2004)

The structure of land use(%)	The class of NAL		
	Agricultural	Agricultural-forestry	Forestry
Agricultural areas	No less than 80	30-50	
Forestry areas	No more than 20	20-40	70 and more

Table 2. The criteria of subclasses of NAL according to structure of land use, % (Schastnaya, 2004)

Agricultural landscapes					
The structure of land use	Subclasses				
	Arable	Arable-cultural meadows	Meadow-arable	Pasture-meadow-swamps	Meadow-pasture
Arable areas	>70	30 – 60	50 – 70	< 15	10
Forest	< 20	< 20	< 20	< 20	< 20
Meadow	< 10	< 10	10 – 40	10	70 – 80
Swamps	< 10	15 – 20	5 – 15	< 80	< 15
Agro-forestry landscapes					
The structure of land use	Subclasses				
	Forestry-arable	Meadow-forestry-arable	Arable-forestry		
Arable areas	50 – 70	< 60	20 – 50		
Forest	20 – 50	25 – 50	50 – 70		
Meadow	< 10	10 – 30	< 10		
Swamps	< 10	< 10	< 10		
Forest landscapes					
The structure of land use	Subclasses				
	forestry	Forestry bog			
Arable areas	< 20	< 15			
Forest	>70	70			
Swamps	< 10	15 – 30			
Recreational landscapes					
The structure of land use	Subclasses				
	Forestry-arable-recreational	Forestry-water-recreational	Arable-forestry-recreational	Forestry-recreational	Forestry-meadow-recreational
Arable areas	>51	55-75	25-45	65-85	40-80
Forest	< 49	< 20	51-70	15-25	< 20
Meadow	< 5	< 10	< 2	< 10	20-40
Water objects	< 1	15 – 20	-	< 5	2-5
Swamps	-	-	0.2-0.5	-	1-3

The developed system of classification units allows mapping the natural-anthropogenic landscapes of territories at a different of scales. The basic spatial unit to delimit the natural-anthropogenic landscapes of Brest region is based on the map of natural landscapes (fig. 1a). All calculation of structure of land use has been made within these units.

Calculation of indexes of a landscape diversity of NAL includes many indexes, first of all (Puzachenko 2002, Martsinkevich et al. 2005, Jaeger 2000):

- 1) Area and perimeter of patches,
- 2) Patch numbers within landscape,
- 3) Number of land use types,
- 4) Proportion of different land use type within landscape:

$$P_i = \frac{S_i}{S} \quad (1)$$

- S_i – area of particular land use type,
5) Mean area of patches within landscape:

$$S_o = \frac{S}{n} \quad (2)$$

n – number of patches.

All previously described indicators have formed a basis for the later calculations of indexes of a fragmentation of NAL, such as index of division, coefficient of complexity, degree of similarity, level of fragmentation of land use patches within NAL.

The index of division:

$$K = \frac{n}{S} \quad (3)$$

where: n – numbers of patches,

S – area of particular species.

The index characterises a fragmentation of landscape structure, through calculation of quantity of patches within the area of a landscape. A variation of values of the index of division depends on two indicators: number of patches and area of every patch. Thus, the values of index increase if the area of landscape is getting smaller and more quantity of patches of different land use is increasing.

The index of complexity allows defining a degree of similarity between quantity of patches and the average area of patches within a landscape. High values of index of complexity characterise landscapes with a considerable quantity of contours and small average area of contours. The index of complexity also allows to estimate a fragmentation of landscapes. Low values of an index characterise a high fragmentation of landscapes.

The index of complexity:

$$K = \frac{n}{S_0} \quad (4)$$

where: S_0 - average area:

$$S_0 = \frac{S}{n} \quad (5)$$

The degree of similarity:

$$C = \sum_{i=1}^n \left(\frac{A_i}{A_t} \right)^2 \quad (6)$$

where: n – number of patterns within landscape contour,

A_i – area of particular pattern,

A_t – area of NAL contour.

The level of fragmentation of landscape patches is calculated according to the following formula:

$$D = 1 - \sum_{i=1}^n \left(\frac{A_i}{A_t} \right)^2 \quad (7)$$

The level of fragmentation is reciprocal value of the index of similarity. High values of an index indicate high degree of fragmentation of landscape.

The research has been made using CorelDraw10, ArcView GIS 3.2, Excel software that has allowed to receive complex parameters, which characterize patches of different land use (quantity, average area and the relative abundance within NAL).

The number of maps has been made. The areas with various degree of fragmentation are defined (maximum, high, satisfactory, and minimum). These results are a source of data for making development strategies at regional level.

Results

The maps of NAL for Belarus and the set of maps of key regions, including Brest region, has been made (fig.1).

Agricultural, agro-forestry and forest landscapes are widely extended in the Brest region. Agricultural and agro-forestry landscapes dominate in the study region. Agricultural landscapes are characterized by the large set of subclasses (5) and species (vid) (9). Agro-forestry landscapes also have difficult horizontal structure (3 subclasses and 12 species). Within forest landscapes extended in the south-west of the territory, one subclass

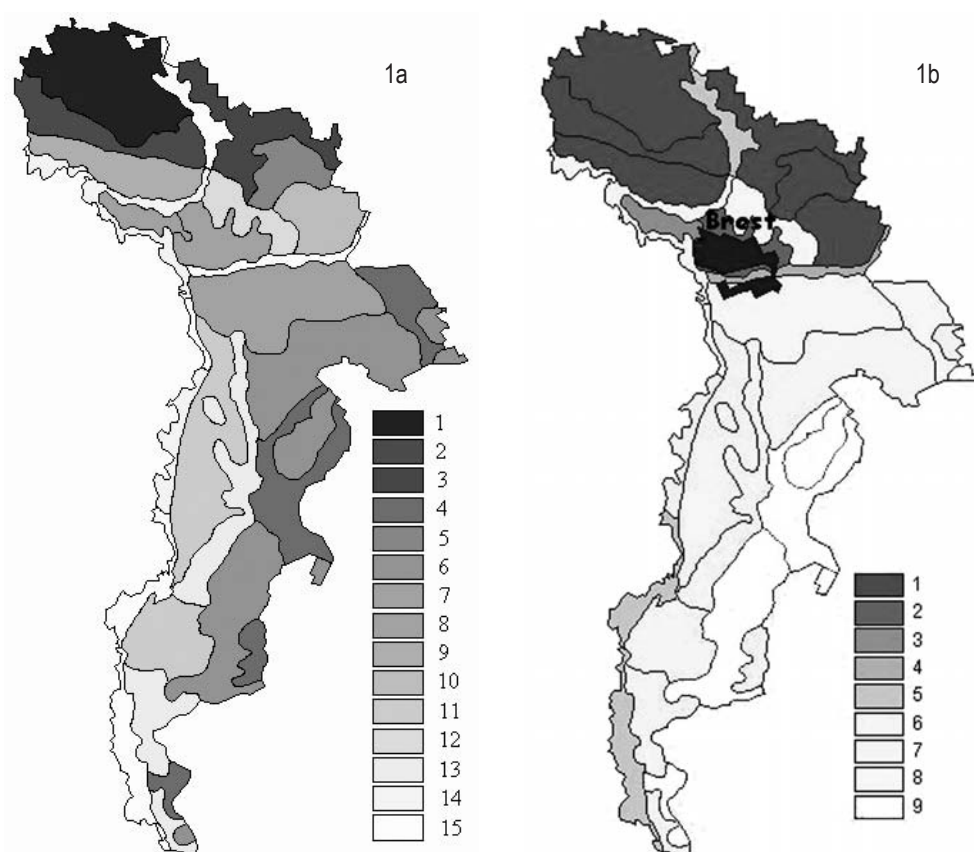


Fig. 1. The maps of natural and natural-anthropogenic landscapes of Brest region in Belarus

1a. Natural landscapes of the Brest region in Belarus ((rod): secondary-moraine landscapes (1,2); fluvial-glacial landscapes (3,4,5,6); landscapes of alluvial terraces (7,8,9,10,11,12,13); landscapes of flood plane (14,15) (Schastnaya, 2006).

1b. Natural-anthropogenic landscapes of the Brest region in Belarus. Subclasses of NAL: agricultural – 1. arable, 2. arable-urban, 3. arable-cultural meadows, 4. pasture meadow-swamps, 5. – meadow-pasture, agro-forestry – 6. forestry-arable, 7. arable-forestry, 8. meadow-forestry-arable, forest – 8. forestry.

and 12 species are distinguished.

The classification of natural-anthropogenic landscapes can be used as a basis for the assessment of fragmentation (fig. 2).

The assessment of fragmentation of landscapes helps to define NAL with optimal structure. These NAL are the following – agricultural-forestry class of NAL (forestry-arable, arable-forestry, grassland-forestry-arable subclasses of NAL). The comparative analysis of all received maps and charts on fragmentation indexes has shown that there are areas of an optimum fragmentation which can be used for the organisation of protected and recreational territories in territory of the Brest area. These are agro-forestry complexes.

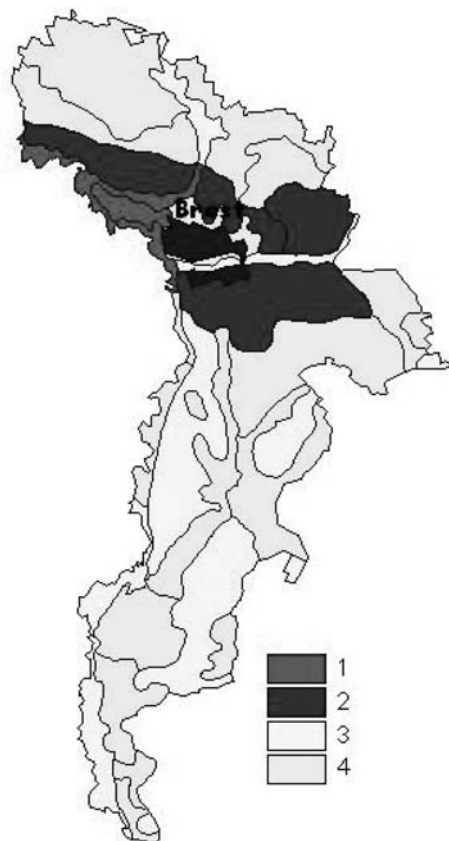


Fig. 2. The assessment of landscape fragmentation of NAL of the Brest area according to index of complexity
The level of fragmentation: 1 – maximum, 2 – high, 3 – sufficient, 4 – minimum

Discussion and Conclusion

The assessment of land use of landscape is widely used in landscape science (Richling 1988, Kolyka 1999). Classification of landscape is important task for study and mapping of anthropogenic landscapes. Many classification of anthropogenic landscape has been developed. The classification of natural-anthropogenic landscapes of Belarus is based on the standard approaches, but also includes some differences that reflect regional attributes of territory. Since modified under anthropogenic impact landscapes are dominant nowadays, it is worth to make assessment of landscape diversity not only for natural landscape but also for anthropogenic ones. Therefore, Grodzinsky (1999) proposed the term “anthropogenic landscape diversity”. He understands this term as diversity of land use types. Nowadays there are many approaches are developed for landscape

diversity assessment, however the most popular – calculation of landscape indexes (Gustafson 1998). Each of the landscape indexes reflects certain property of spatial structure of a landscape that allows to describe a landscape structure from various aspects. The assessment of landscape diversity is made within watershed, administrative regions and other spatial units. We have made assessment of landscape diversity within natural-anthropogenic complexes. We focus on the assessment of fragmentation of NAL. Final results of landscape assessment together with data about network of settlements and also indicators of tourism and recreational capacity of the region can be used as a basis for development of the scheme of spatial organization of tourism at the regional level. Areas of the maximum and high level of fragmentation, as elements of natural patches of territory, it is possible to use for the creation of protected and recreational territories. It is possible to develop ecological, scientifically-informative and partially recreational and sanitary (health-improving) tourism on these territories. The areas with lower levels of fragmentation can be used for the organization of rural and business, recreational and sanitary (health improving) tourism with elements of agricultural tourism.

Thus, the classification and assessment of fragmentation of natural-anthropogenic complexes provide data to receive more information about the structure of landscapes. These data can be used in landscape planning to define certain options for sustainable development of the territories within each subclass and specie of NAL. Therefore the results of analysis allow to create maps of suitability of territories for a certain kind of activity and to reveal areas of the conflict of interests of various types of land use. Landscape indexes can help to make a prompt choice of a certain strategy for the region development. However, the set of indexes should be defined according to problems addressed within the region. Hence, natural, social and economic indicators of territory should be carefully analysed to produce the strategy of balanced spatial organization of territory.

References

- Grodzinski M. D., 1999. Diversity of landscape diversity. Landscape as an integrated concept of 21 century, Kiiv: 34-35. (in Ukrainian)
- Gustafson E. J., 1998. Quantifying landscape spatial pattern: What is the state of the art? *Ecosystems*, 1. 143-156.
- Jaeger J. A. G., 2000. Landscape division, splitting index and effective mesh size: new measures of landscape fragmentation. *Landscape ecology*. Vol. 15. 115-130.
- Kolyka L., Lipsky Z., 1999. Maps of present landscape. *Geographie (Geography) Journal of the Czech Geographical Society*, Vol. 104. 161-175 (in Czech).
- Martsinkevich G. I., Klitsunova N.K., Schastnaya I.I., 2002. Principles of natural-anthropogenic complexes classification Dynamic of landscapes and problems and conservation and sustainable development of biodiversity, Belarusian State Pedagogic University Press. 90-91. (in Russian)
- Martsinkevich G. I., Schastnaya I. I., 2005. The landscape diversity assessment of natural and natural-anthropogenic complexes *Environmental Management*, 61. 98-205. (in Russian)
- Milkov F.N., (1973) Human and landscapes. *Mysl, Moscow*. 223. (in Russian)
- Schastnaya I. I., 2004. Natural-anthropogenic complexes of Mahilew district *Geography of Mahilew district*. Mahilew State University Press. Mahilew. 174-180. (in russian)
- Schastnaya I. I., 2006. Landscape diversity of Brest region. *Natural environment of Palesse region: specific features and perspectives of development*. Academy Press, Brest. 379-384. (in Russian)
- Natural-anthropogenic complexes of Mahilew district *Geography of Mahilew district*. Mahilew State University Press. Mahilew. 174-180. (in Russian)
- Puzachenko Y. G., Djakonov K. N., Alechenko G. M., 2002. The landscape diversity and methods of their assessment. 98. (in Russian)
- Richling A., Lewandowski W., 1988. The map of landscape use. *Miscellanea Geographica*. Warszawa.

