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Specificity of the anthropogenic landscapes in part of the catchment area of Luda Yana River

Kamen Nam, Ilia Tamburadzhiev
Sofia University „St. Kliment Ohridski", Faculty of Geology and Geography, Department of Landscape Ecology and Environmental Protection, 1504 Sofia, Bulgaria, 15 Tsar Osvoboditel blvd.

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ABSTRACT

The present research covers the lowland part of the catchment area of Luda Yana River. This is those part of the catchment area of the river, which is in the range of Pazardzhik-Plovdiv field. Object of research are the contemporary landscapes in the lowland part of the catchment area of Luda Yana River. Subject of research are the processes of differentiating and classifying the anthropogenic landscapes in the considered area and determining the degree of anthropogenization of the landscapes. The differentiation of the landscapes is carried out by the interaction between the landscape-forming factors – the natural components and the types of land use. The classification of the landscapes used in the present research is based on the information in the European Landscape Character Areas. There are differentiated 17 types of landscapes in the studied area. The determining of the degree of anthropogenization is realized by implementing the "Distance to Nature" compiled indicator, which is calculated by the combination of the individual indicators „Degree of Naturalness" and „Distance to Natural Habitat". A map of the contemporary landscapes in the lowland part of the catchment area of Luda Yana River, representing the degree of naturalness of the types of landscapes, is generated in GIS.

Introduction

The anthropogenization of the landscapes in the Upper Thracian Plain passes with great intensity since the Ancient history. Nowadays, the Pazardzhik-Plovdiv area, as a western part of the lowland, is one of the most densely populated and most significantly anthropogenized regions of the country. The active agrarian, industrial and transport activity in the area have led to significant transformation in the structure of the natural landscapes and their transformation into qualitatively new anthropogenic and anthropogenized complexes.

The lowland part of the catchment area of the Luda Yana River has been chosen as a representative area, characterized by a considerable variety of contemporary anthropogenic landscapes, that have occurred and developed under the influence of multi-year and versatile human activity. The main focus of the present study is aimed at establishing the interrelationship between the types of anthropogenic activity and the existing landscapes in the considered part of the catchment area of the Luda Yana River, as well as determining the degree of anthropogenization of the individual landscape units.

Methods and Methodology

The object of the research are the landscapes in the lowland part of the catchment area of the Luda Yana River. In the present study, as a lowland part is perceived that part of the catchment area of the river, which is characterized by slopes up to 3°, i.e. to the border between the lowland and the lower crease of the foot of the hills in the transitional foot zone of Sredna Gora. The total area of the investigated area is 7244,193 ha. Landscapes that show a significant degree of alteration in their structure are analyzed. As such, there can be mentioned the agricultural landscapes, urban, industrial and others.

The types of anthropogenic activity, the horizontal structure of the anthropogenic landscapes in the studied region and their classification, as well as the degree of anthropogenization of the landscapes in the lowland part of the catchment area of the Luda Yana River are subject of research.

The present study aims to reveal the interrelation between the types of anthropogenic activity and the characteristic peculiarities of the landscapes in the studied area, subjected to anthropogenization to one or another degree. The specific spectrum of landscapes existing within the scope of the studied territory is a result of the differentiating role of the landscape-forming factors, including land use types. Establishing the degree of anthropogenization of the contemporary landscapes in the investigated area is another major focus in the research.

In order to reveal the specifics of the contemporary landscapes in the lowland part of the Luda Yana River basin, an analysis of the landscape-forming factors and the types of land use, as well as of the concrete manifestations of anthropogenic activity in the region, is carried out. Differentiation and classification of the contemporary landscapes are realized. The classification of Wascher (2005), involved in the generation of LANMAP2, is used, making some additions according to the requirements of the present study.

E-mail: Ilia Tamburadzhiev, iliia1991@abv.bg

Landscape-forming factors

Natural features

Basically, the studied territory is part of the complicatedly compounded structure of the Pazardzhik-Plovdiv field. The graben depression is filled with pliocene and quaternary alluvial deposits (Yordanova et al., 2002). Regarding the relief features, the studied area falls mainly in the lowland and to a lesser extent in the plain-hilly hypsometric belt. The terrain is characterized by a slight horizontal and vertical indentation and a slope of 0° to 3°. Characteristic contemporary relief-forming processes are the erosion-accumulative.

The natural processes in the studied territory go under the conditions of a transitional continental climate with average annual temperatures of about 12° C and average annual rainfall amount of about 530-570 mm.

Groundwater within the scope of the studied area occur at a depth of 1 m along the Maritsa River and along the Luda Yana River and up to 20 m in the interstream areas. According to the Hydrological Guidebook of the Rivers in PR Bulgaria, vol. I (Marinov, 1957), the water quantity used for irrigation during the irrigation season can reach tentative up to 160 million cubic meters. The Luda Yana River is the main water artery in the studied area. Near the village of Rosen the river enters the Upper Thracian Plain. The average annual runoff at the village of Sbor is 3160 cubic meters / s. The amount of the Luda Yana deposits at the village of Sbor is between 0.026 g / l (measured on 22.III.1953) and 26.012 g / l (measured on 14.VI.1951) (Marinov, 1957). The difference in the amount of deposits carried by the Luda Yana River is directly related to the spring high water and the summer low water of the river, determined by the specifics of the respective climatic region. The bed of the Luda Yana River before its influx into Maritsa is amended.

Soil diversity data in the area under consideration is taken from the Soil Map of PR Bulgaria M 1:200 000 (Koinov and Tanov, 1956). The main soil types within the scope of the investigated area are Fluvisols, Luvisols and Vertisols (FAO). The Fluvisols are distributed along the Luda Yana River as well as in the southern parts of the studied area, where they are attached to the Maritsa River terraces. The Luvisols occupy the interstream area watersheds to the west and east of the Luda Yana River, contacting a wide front with the Fluvisols. The Vertisols are distributed in confined areas northwest of the village of Chernogorovo and in the northern part of the studied area from the lowland part of the catchment area of the Luda Yana River. The Fluvisols, the Luvisols and the Vertisols in the studied area can be divided into different varieties based on some soil specifics. The different varieties of the main soil types are not taken into account in the process of landscape differentiation in the area due to the essence and the specifics of the present study.

The studied territory is part of the Upper Thracian biogeographical region (Asenov, 2006). Characteristic of the vegetation in the studied area is almost completely destroyed natural vegetation and dominance of agrophytocenoses. Only in particular places along the Luda Yana River, as well as in abandoned or long ago non-cultivated agricultural areas, there are representatives of the natural tree and shrub vegetation (predominantly secondary). Dominance of natural grasslands is observed in the pastures.

Types of land use

Several settlements or parts of them are located within the scope of the investigated territory. The villages of Dobrovnitsa and Krali Marko completely come under the research area, while the villages of Rosen, Chernogorovo, Pishtigovo and Ognyanovo partially belong. All settlements are of the "Discontinuous urban fabric" type, according to the Corine Land Cover 2012 classification. In the outline of the settlements are included not only the living areas, but also the areas occupied by farm buildings. The independent industrial sites are located in a limited area in the southern part of the investigated territory.

The agriculture is the main anthropogenic activity in the lowland part of the catchment area of the Luda Yana River. The areas with non-irrigated arable lands, on which are cultivated some annual crops, such as grain and technical crops, as well as fruit crops predominate. The terrains occupied by vegetables, rice and vineyards are represented by a smaller area. The areas with vegetable fields are located in close proximity north and south of the village of Chernogorovo, north-west of the village of Pishtigovo, as well as in the northern parts of the studied territory. The rice production is developed on a consolidated area between the villages of Dobrovnitsa and Krali Marko. In some places along the Luda Yana River, vineyards are grown.

The extraction of mineral resources is not characteristic to the concrete territory of the present study. In the immediate proximity of the lowland part of the catchment area of the Luda Yana River there is one of the largest mining complexes in Bulgaria - the quarries at the villages of Tsar Asen and Rosen. Because these quarries fall into the hill and foothills belt of the Ovchi hills and the Sashtinska Sredna Gora Mountains, they are not an object of the present research, but exert indirectly influence on the anthropogenization.

Important roads of national and international significance pass through the territory of the research area - Trakia motorway and the first-class road Pazardzhik-Plovdiv. These transport arteries play a significant role in the landscape fragmentation and in the complicating the horizontal landscape structure. Similarly significance, but to a lesser extent, have the roads of the municipal infrastructure.

Landscape differentiation and classification

The differentiation of the landscapes is done by analyzing the landscape-forming factors. These factors are determined by the interaction between the natural components and the types of land use in the studied area. Land use data was obtained from Corine Land Cover 2012 (http://eea.government.bg/bg/projects/korine-14/osn-inform). Landscapes on sedimentary deposits and Luvisols, sedimentary deposits and Vertisols and sedimentary deposits and Fluvisols are differentiated. The adding of the land use type as a factor for landscape differentiation leads to a higher degree of landscape heterogeneity.

Landscapes of the transitional tree-shrub vegetation are differentiated; agricultural lands with significant plots of natural vegetation; pastures; non-irrigated arable lands with annual crops; vegetable gardens; rice fields; vineyards; settlements; industrial sites; major transport arteries; waterbodies characterized by strictly determined specificities of the constituent natural components.

The contemporary landscapes are formed by the interaction of the factors of the natural environment and the anthropogenic factor, manifested in the type of land use.

GIS tools are used to specify the landscape differentiation process. Base rock layer, soil layer and land cover layer are generated. Then the individual layers are crossed and merged into a single layer expressing the complex essence of the contemporary landscapes in the investigated area. The unified landscape layer is distinguished

by the linking of the data from the individual layers of landscape-forming factors, while at the same time has its own specific spatial configuration of its constituent units.

The landscape classification used is based on the information in the European Landscape Character Areas (Wascher, 2005), part of the European Landscape Character Assessment Initiative (ELCAI) project. Some additions and clarifications were made in accordance with the specific of the environment conditions and the character of the anthropogenic activity in the research area. The classification system used includes several typological levels reflecting the environmental zone, part of which are the respective landscape units, the relief features of the territory, the character of the lithological basis and the type of land use. In addition to the classification system, typological characteristics of the soil component in the landscapes have been added. Some changes are also made to the visualization of the landscape unit names on the landscape map. For this purpose, both numeric and alphabetic symbols are used, not just alphabetic symbols, as in the European landscape typology map LANMAP2 is. The individual landscape types are classified based on their degree of anthropogenization, using the four-step scale represented by Rüdisser et al. (2012). The first category of the scale is divided into two subcategories to specify the present study. Map of the contemporary landscapes in the lowland part of the catchment area of Luda Yana River, representing the degree of naturalness of the types of landscapes, is shown on Fig. 1.

Implementation of the Landscape indicator set

The combined "Distance to Nature" index can be used in analysis of the anthropogenic landscape transformations. The focus of this landscape indicator is turned to determine the degree of transformation of the structure and the biodiversity characteristics of the respective landscape types. Vranken (2015) proves the successful use of the indicator for assessment of the effect of human impact on landscapes and at a local scale. The present study also applies this indicator to large-scale landscape investigation.

The "Distance to Nature" index is determined by the combination of the individual indicators „degree of naturalness" and „distance to natural habitat". "Degree of naturalness" is defined by the formula:

$$N_d = \sum_{i=1}^{n} p_i m_i ,$$

where *n* is the number of landscape types in the studied territory, pi is the ratio between the area of the particular landscape type and the area of the studied territory, and mi is the degree of naturalness reflected in the scale of naturalness by Rüdisser et al. (2012). "Distance to natural habitat" is obtained by determining the Euclidean distance to the nearest natural habitat within the investigated space. In the present study, the landscapes of the forests, the landscapes of the shrubs and the grasslands along the Luda Yana River, as well as the waterbodies, are perceived as landscapes comprised natural habitats.

The Euclidean distance is calculated using the ArcToolBox of the ArcGIS program, and for the purpose a raster model of the landscape map of the investigated territory is generated. On the basis of the already generated raster model of the landscape map, the tool for determining the Euclidean distance was implemented. As some of the landscape types fall into zones with different values of the Euclidean distance, the average values of the Euclidean distance from the respective landscape type to areal of the natural habitat are calculated. The values for the N_d and D_n indices are normalized according to the requirements of the algorithm of D_2N landscape indicator. The normalization of the values is done by a standard mathematical formula, as the specific values of the both N_d and D_n indicators are referenced and equalized to values from the 0 to 1 numerical range.

The results of the calculations of the normalized values of N_d and D_n indicators, as well as the values of the combined indicator D_2N are shown in Table. 1. The classification scheme of Rüdisser et al. (2012) is used to determine the degree of anthropogenization of the individual types of landscapes. Landscapes with D_2N values of 0 to 0.06 are natural or near natural; with D_2N values of 0.06 to 0.35 (but with D_n <750 m) - cultivated landscapes with substantial amount of natural elements; with D_2N values of 0.06 to 0.35 (but at D_n > 750 m) - extensively cultivated landscapes with few natural elements; with D_2N values of 0.35 to 1 - urbanised or intensively cultivated landscapes (in the case of the present study these are agricultural landscapes with intensive land use and no or very few amounts of natural habitats).

The calculation of the naturalness indicator is not carried out for the industrial landscape type. It would not be properly and logically justifiable to determine an indicator of transformation of biodiversity into a almost totally devoid of vegetation type technogenic landscape. Also, the D_2N indicator is not calculated for the landscapes that consist of natural habitats and on the basis of which the Euclidean distance between them and the other types of landscapes, subjected to anthropogenic transformation, is

Table 1. Values of the N_d D_n and the compiled D_2N indicators for the non-natural types of landscapes in the studied area.

Landscape type	N_d (normalized)	D_n (normalized)	D_2N
Vineyards of continental lowlands on sediments and Luvisols	0,02	0	0
Heterogeneous agricultural areas of continental lowlands on sediments and Luvisols	0,04	0,125	0,05
Arable lands of continental lowlands on sediments and Luvisols	1	1	1
Rice fields of continental lowlands on sediments and Luvisols	0,1	1	0,1
Heterogeneous agricultural areas of continental lowlands on sediments and Vertisols	0,01	0,125	0,01
Arable lands of continental lowlands on sediments and Vertisols	0,26	0,25	0,07
Pastures of continental lowlands on sediments and Vertisols	0	0	0
Pastures of continental lowlands on sediments and Fluvisols	0	0	0
Arable lands of continental lowlands on sediments and Fluvisols	0,56	1	0,56
Settlements	0,14	0,05	0,07

calculated. These are the Waterbodies, the Forests of continental lowlands on sediments and Luvisols, the Forests of continental lowlands on sediments and Vertisols, the Shrubs and herbaceous vegetation of continental lowlands on sediments and Luvisols, the Shrubs and herbaceous vegetation of continental lowlands on sediments and Vertisols, the Shrubs and herbaceous vegetation of continental lowlands on sediments and Fluvisols. Therefore, these are landscapes with natural forests (predominantly secondary), as well as shrub and grass vegetation. In them, the degree of naturalness is as close as possible to the natural one, and that is why these types of landscapes in the present study are considered as natural landscapes and are involved in the process of calculating the N_d indicator as a natural habitats.

Results and Discussion

It becomes clear from the data in Table.1. and from the preliminary definition of the landscapes, characterized by the presence of natural habitats, that the most types of landscapes fall in the category of natural or near natural landscapes (D_2N from 0 to 0.06) - 11 types. In the present study, the natural or near natural landscapes category (D_2N from 0 to 0.06) is divided into two subcategories - 1) natural landscapes and 2) near natural landscapes. To the natural landscapes subcategory fall the mentioned above landscapes, which contain natural habitats. These are the Waterbodies, the Forests of continental lowlands on sediments and Luvisols, the Forests of continental lowlands on sediments and Vertisols, the Shrubs and herbaceous vegetation of continental lowlands on sediments and Luvisols, the Shrubs and herbaceous vegetation of continental lowlands on sediments and Vertisols, and the Shrubs and herbaceous vegetation of continental lowlands on sediments and Fluvisols. To the near natural landscapes subcategory fall the landscapes of the Vineyards of continental lowlands on sediments and Luvisols, the Heterogeneous agricultural areas of continental lowlands on sediments and Luvisols, the Heterogeneous agricultural areas of continental lowlands on sediments and Vertisols, the Pastures of continental lowlands on sediments and Vertisols, and the Pastures of continental lowlands on sediments and Fluvisols. For landscapes, which are characteristic with land use associated with the cultivation of vineyards, the degree of naturalness is significant, because the vineyard culture does not require an annual deep ploughing of the soil on which it grows, nor intensive irrigation during the period of vegetation. In addition, this type of landscapes in the studied territory are located in close proximity to landscapes with natural habitats. The landscapes of the heterogeneous agricultural lands also have a high degree of naturalness, because they are also located near landscapes with natural habitats. The variety of agricultural activity and cultivated agrophytocenoses in this type of landscape correlates with the natural conditions of the environment, which is characterized by a relatively high degree of biodiversity, based on the favorable soil and climatic conditions in the research area, even though the lowland character in terms of the relief.

The pastures are characterized by a high degree of proximity to the natural state of the natural environment due to the lack of active, intensive and permanent anthropogenic interference in their natural state.

In the category of cultivated landscapes with substantial amount of natural elements (D_2N from 0.06 to 0.35 at D_n <750 m), none of the landscape types in the studied area fall.

In the category of extensively cultivated landscapes with few natural elements (D_2N from 0.06 to 0.35 at D_n > 750 m), the landscapes of the Rice fields of continental lowlands on sediments and Luvisols, the Arable lands of continental lowlands on sediments and Vertisols, and the Settlements fall.

The rice fields and some types of agricultural landscapes (orchards, vegetable fields characterized by the relatively higher degree of species diversity in the cultivated agrophytocenoses) are distinguished by the presence of individual natural plant communities, especially on the field boundaries and in the areas between the tracts of land. This reduces the degree of remoteness from the natural state of these types of landscapes.

For the settlements is characteristic a free building up of the areas and large yard areas, in which the degree of biodiversity, both of natural species (especially in the abandoned and uncultivated yard areas) and agrophytocenoses, is significant. Therefore, these landscapes ("rural settlements") are characterized by significantly greater proximity to the natural state of the environment compared to the urbanised town areas and the industrial landscapes. Because of this these landscapes fall into the specific category and not in the category of the urbanised territories.

In the category intensively cultivated landscapes (urbanised) (D_2N from 0.35 to 1), the landscapes of the Arable lands of continental lowlands on sediments and Fluvisols and the Arable lands of continental lowlands on sediments and Luvisols fall. The landscapes of the arable lands have mainly an one-year character of the land use. I.e. on them are mainly cultivated annual crops such as cereals, technical crops, vegetables, and etc. Intensive agro-technical activities in the agricultural cultivation in the land use of these landscapes, such as annual deep ploughing of the soil, annual crop-rotation, irrigation, fertilization and etc., lead to a significant transformation in the state, structure, functioning and dynamics of this type of arable landscapes. This type of landscapes occupy a large area of the studied territory and respectively the average distance between them and landscapes with natural habitats in the studied area is significant. This fact, together with the specifics of the land use, attributes this type of landscapes to the category intensively cultivated landscapes. To the category urbanised landscapes can also be added and the industrial landscapes.

Conclusion

Based on the differentiation and classification of the contemporary landscapes, 17 types of landscapes are differentiated within the scope of the studied area. The differentiation of the landscapes is conducted on the basis of the landscape-forming role of the natural components and the land use. The concrete manifestations of the anthropogenic activity in the area of research and the impact of this activity on the type of land use are directly included as a major factor in the process of differentiation of the existing contemporary landscape types in the area under consideration. After an analysis of the types of land use and the implementation of the landscape differentiation and classification, it was reported that 9 of 17 types of landscapes are identified as agricultural landscapes and only one type as an industrial landscape. This reaffirm the fundamental role of the agricultural production in determining the type of land use and the specific features of the contemporary landscapes in the area of research.

The classification of the landscapes is added with data on their degree of anthropogenization. The complex „Distance to Nature" indicator is used, showing the degree of naturalness of the individual landscape units from the point of view of the transformation in the state of the biodiversity in them. „Distance to Nature" is calculated on the basis of "Degree of Naturalness" and "Distance to Natural Habitat" indices. Some additions and clarifications have been made

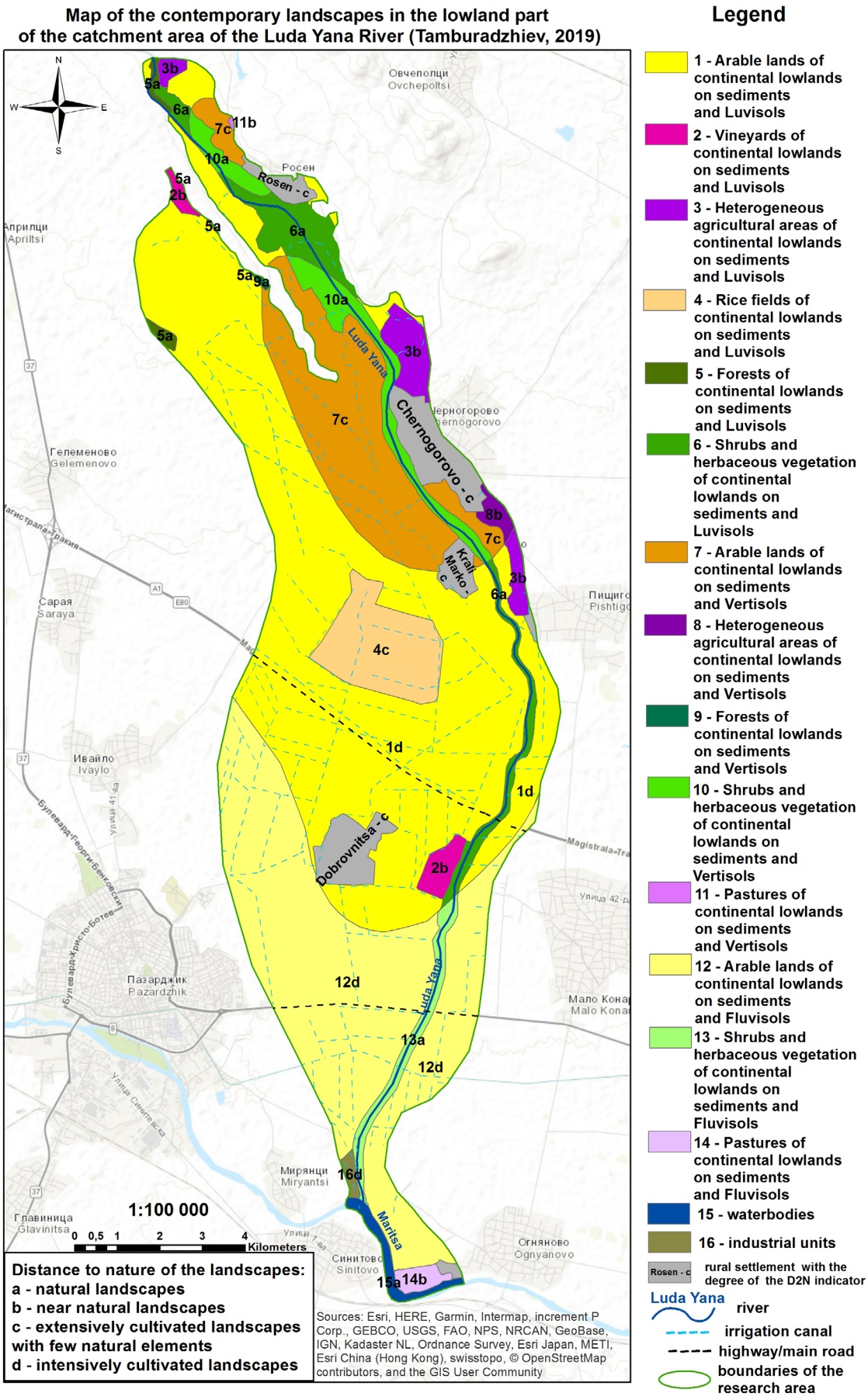

Figure 1. Map of the contemporary landscapes in the lowland part of the catchment area of Luda Yana River

in the process of application of the indicator according to the structural and functional features of the landscapes in the studied territory. Four categories of landscapes are differentiated. Most landscape types fall into tinto the category of natural or near natural landscapes - 11 types. This category is divided for the purposes of this study into two subcategories - natural landscapes (6 types of landscapes) and near natural landscapes (5 types of landscapes). Three types of landscapes fall into the category of extensively cultivated landscapes with few natural elements, and in the category of intensively cultivated landscapes - 3 types of landscapes too. The landscapes of arable lands with annual grain crops, technical crops and vegetables, located at a relatively greater distance from the natural landscapes and occupying the largest areas among the landscape types in the studied territory, stand out by the highest degree of anthropogenic transformation. The industrial landscapes, which in the studied area represent anthropogenically conditioned technogenic complexes, fall into the category of the highest degree of anthropogenic transformation by presumption. The landscape types and their degree of naturalness are represented by a landscape map, generated in GIS.

The present study represents a complex analysis of the landscapes in a representative in terms of the agrarian activity lowland territory of the country. The analysis of the landscape anthropogenization is a major step in the processes of planning and management of the territory in the context of the concept of sustainable development and finding a balance in the system interactions between the nature and the society.

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