EREM 75/2

Journal of Environmental Research, Engineering and Management
Vol. 75 / No. 2 / 2019
pp. 36-46
DOI 10.5755/j01.erem.75.2.22253

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Received 2018/12 | Accepted after revision 2019/04

http://dx.doi.org/10.5755/j01.erem.75.2.22253

Geoecological Situation in Land Use

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The new principles for the construction of the scale of a geoecological situation in land use were substantiated. This situation is based on the parameter of the landscape anthropisation extent. The parameter was called a geosituation index. Such an index is the area proportion for geoecological positive (or geo-positive) and geoecological negative (or geo-negative) land use and/or land cover (LULC) systems. The first systems are still called in essence nature-accentuated, near-to-nature or simply natural systems. The percent of geo-positive LULC system area is also used as a separate parameter additional to the geosituation index. The original scale of geosituation concerning land use in model landscapes or other territorial units was developed. Such a scale for the first time has the logic-parametric consistency with the previously developed scheme of the landscape anthropisation extent. The geosituation is classified in the scale by categories. They vary from excessively favourable to catastrophic. The developed geosituation scale was first implemented for the selected megaregion. It includes Ukrainian physical-geographic zones of mixed and broad-leaved forests and forest-steppe and their regions, areas and districts. The digital choropleths were modelled for the geosituation in land use in the areas and districts.

All obtained results indicated the validity and further implementation suitability of proposed geosituation indexes and their scale. The developed new approaches can be applied in territorial schemes and projects of modern environmental management and landscape planning.

Keywords: land use, anthropisation, landscape, geoecological situation, near-to-nature systems.

Introduction

The assessment modelling of landscape anthropisation is the actual scope of contemporary environmental research, engineering and management. The source review confirms that a methodology for assessment of an anthropogenic impact on different geosystems was proposed and realised in a number of the most recent publications. They include international resumptive developments of Paracchini and

Capitani (Paracchini & Capitani, 2011), implemented in Eurostat Statistics for all EU countries (Eurostat Statistics, 2012), research of Frank (Frank, 2014), investigation of Walz and Stein (Walz & Stein, 2014), realised in web-service IOER Monitor of Leibniz Institute of Ecological Urban and Regional Development (IOER Monitor, 2015) as well as our own developments (Samoilenko et al., 2017, 2018a). In particular, the procedure of anthropisation extent modelling for landscapes and/or taxons of physical-geographic zoning was developed with its implementation (Samoilenko et al., 2018b). The procedure generalises all the above-mentioned existing approaches and uses primary the classified scheme presented in Table 1. Here the anthropogenic impact is specified by the combined degrees. These are the degrees of hemeroby, impact intensity, geoecological positivity and/or negativity and naturalness of land use and/or land cover (LULC) systems. The scheme grades categories of the landscape anthropisation extent and corresponding categories of LULC systems'

Table 1

Classified scheme of the landscape and/or physical-geographic taxons' anthropisation extent [1)]

Code and name of landscape / taxon anthropisation extent category	Extent of anthropogenic impact for LULC systems:			Categorical ranges for values of anthropisation index I_{ANT}**, %	Mean categorical values of index I_{ANT}**, %
	Hemeroby degree and anthropogenic impact intensity [2)]	Geoecological positivity / negativity	Degree of naturalness [3)]		
1	2	3	4	5	6
1 – Very slight anthropisation	Ahemerobic, almost no impact	Very geo-positive	Natural	(0...15.8]	7.9
2 – Slight anthropisation	Oligohemerobic, weak impact	Geo-positive	Close to natural	(15.8...28.3]	22.1
3 – Moderate anthropisation	Mesohemerobic, moderate impact	Moderately geo-positive	Semi-natural	(28.3...39.2]	33.7
4a – L/c moderate-great anthropisation	L/c β-euhemerobic, l/c moderate-strong impact	L/c moderately geo-negative	L/c relatively far from natural	(39.2...44.8]	42.0
4b – H/c moderate-great anthropisation	H/c β-euhemerobic, h/c moderate-strong impact	H/c moderately geo-negative	H/c relatively far from natural	(44.8...50.4]	47.6
5a – L/c great anthropisation	L/c α-euhemerobic, strong impact	L/c geo-negative	L/c far from natural	(50.4...57.1]	53.8
5b – H/c great anthropisation	H/c α-euhemerobic, strong impact	H/c geo-negative	H/c far from natural	(57.1...63.7]	60.4
6 – Very great anthropisation	Polyhemerobic, very strong impact	Very geo-negative	Strange to natural	(63.7...79.5]	71.6
7 – Excessive anthropisation	Metahemerobic, excessively strong impact	Excessively geo-negative	Artificial	(79.5...100]	89.8

[1)] According to Samoilenko et al., (2018b). Abbreviation: L/c – low-categorical, H/c – high-categorical.
[2)] According to Walz and Stein (2014) and IOER Monitor (2015) with our modification.
[3)] According to Paracchini and Capitani (2011) and Eurostat Statistics (2012) with our modification.

geoecological positivity and/or negativity. The scheme in Table 1 also operates the categorical and mean values of anthropisation index I_{ANT}**. It is calculated in percent by the following formula:

$$I_{ANT}{**} = \sum_{i=1}^{n} I_{ANT,\,E,\,i} \cdot s_i \quad (1)$$

where: $I_{ANT,\,E,\,i}$ – the calculating anthropisation index; it is partial for the relevant (i) LULC system of a model landscape or another model territorial unit; the index is determined in percent from an operating scale of the anthropisation extent. Such a scale has to be developed specially for a selected region of modelling;

s_i – the total part of the mentioned LULC system's area with $I_{ANT, E, i}$. It is used in fractions of a unity, provided that the total area of a landscape, etc. is equal to 1; n – the number of calculating by an operating scale LULC systems within boundaries of a landscape.

This index is applicable during modelling as average-weighted by the areas of proper LULC systems for a specified landscape or another unit. The index marks the first principal set of model parameters of landscape anthropisation.

The sources review also shows that the second set of the mentioned parameters is presented by the area proportion for geoecological positive (or geo-positive) and geoecological negative (or geo-negative) LULC systems. The first systems are still called nature-accentuated systems in Walz and Stein (2014) and near-to-nature systems in Frank (2014). In the so-called urbanisation index in Wrbka et al. (2004), such systems are also called simply natural systems. In all cases, these researches apply the so-called proportion of certain natural areas. These are the percents of the mentioned nature-accentuated LULC systems in the total area of the investigated territorial unit. Similarly such researches also use strictly the proportion of nature-accentuated LULC systems and other far from natural or artificial systems. Taking into account such approaches (Wrbka et al., 2004; Frank, 2014; Walz & Stein, 2014), we proposed (Samoilenko et al., 2017, 2018a) to apply a new notion for anthropisation modelling. This is the notion on the so-called geoecological situation (or geosituation) in land use. Such a situation should be simulated using the index of a geosituation or the geosituation index (). It is calculated by the formula of proportion as follows:

$$I_{GS} = f(S_{1-3} / S_{4-7}) \tag{2}$$

where: S_{1-3} – the total area of geo-positive LULC systems in a model landscape or another model territorial unit; it can be used in percent as a separate parameter additional to. S_{4-7} – the total area of geo-negative LULC systems in the mentioned landscape or unit.

Both arguments of formula (2) should be presented in absolute terms, e.g., in square kilometres, etc. They also are used in fractions of a unity, provided that the total area of a model landscape is equal to 1.

Recent representative scientific publications concerning parameterisation of proportion (2) are characterised by grave disadvantages.

In particular, Ukrainian researchers use rigidly assigned attribution of LULC systems to geo-positive or geo-negative systems (see National Atlas, 2007, and our review in Samoilenko et al., 2018a). Quite often, this attribution is controversial. For instance, certain types of grassland-pasture and even arable and fallow land systems are identified as always geo-positive systems. However, in European hemeroby conceptions (Eurostat Statistics, 2012), LULC systems of hemeroby degree 1–3 in Table 1 are differentiated as geo-positive systems. These conceptions do not use rigidly assigned attribution of LULC systems. For example, grassland-pasture and even forestry systems may be both geo-positive and geo-negative systems. It depends on the actual intensity of their use, the structure and status of the systems, etc. (see Paracchini & Capitani, 2011, and Walz & Stein, 2014).

In the existing publications, normalised parameterisation of proportion (2) is missing or insufficiently valid. Thus, such proportion is not normalised at all as to hemeroby conceptions. However, the categorisation of the so-called landscape ecological stability index ($LESI_1$) by Ukrainian researchers is mentioned in a study by Samoilenko et al. (2018a). According to it, the landscapes are initially stable if the anthropogenic impact on them is characterised by the equality of the landscape area occupied by geo-positive and geo-negative LULC systems. For stable landscapes, the area of geo-positive systems must exceed the area of geo-negative systems by 3–4.5 times. In addition, under the approaches in National Atlas (2007), the percent of geo-positive LULC systems in the total landscape area is considered satisfactory, starting at about 40%. Generally, all scales of proportion (2) in the existing proposals practically are not combined in any way to the scales of anthropisation extent in such proposals.

Therefore, this paper had three tasks. The first one was to substantiate the principles for the construction of the scale of a geoecological situation in land use. The second task was directly to develop the scale of the mentioned situation concerning land use in landscapes and/or physical-geographic taxons. The third task was to implement the developed scale of proportion (2) for the selected implementation megaregion with interpretation of the appropriate model results.

Methods

The following principles were substantiated for the construction of the scale of a geoecological situation in land use.

Firstly, according to hemeroby conceptions, LULC systems with anthropisation extent categories 1–3 in Table 1 will be considered as geo-positive systems. Systems with all other mentioned categories will be identified as geo-negative systems. Moreover, a combination of specified LULC systems with the appropriate categories of the anthropisation extent will be not universal. It will be situational according to an operating scale of the anthropisation extent developed for the selected model landscapes or other units. The last scale should display regional peculiarities of land use in such landscapes.

Secondly, the prospective scale of a geoecological situation must have the logic-parametric consistency with the classified scheme of the anthropisation extent in Table 1.

Thus, according to the content of formula (2)

$$S_{1-3} = s_1 + s_2 + s_3; \quad S_{4-7} = s_4 + s_5 + s_6 + s_7; \quad S_{1-3} + S_{4-7} = 1 \tag{3}$$

where: s_1 ... s_7 – the total area parts of the LULC systems, categorized by Table 1 and an operating scale developed for the selected model region (i.e., s_i in formula (1)).

Scale categorical ranges for values of the geosituation index I_{GS} can be set by certain selected values of the average-weighted anthropisation index I_{ANT}**, i.e., $I_{ANT, SEL}$**. Then in accordance with the structure of formula (1)

$$I_{ANT, SEL}^{**} = I_{ANT, E, 1-3} \cdot S_{1-3} + I_{ANT, E, 4-7} \cdot S_{4-7} \tag{4}$$

where: $I_{ANT, E, 1-3}$ and $I_{ANT, E, 4-7}$ – partial anthropisation indexes. They are calculated, firstly, as sums of mean categorical values of index from Table 1 for anthropisation extent categories 1–3 and 4–7, respectively. Secondly, such sums are weighted by an increase of in every category (see in detail Samoilenko et al., 2018a). Calculated in this way, the partial anthropisation indexes are $I_{ANT, E, 1-3}$ = 19.6% and $I_{ANT, E, 4-7}$ = 69.6%.

Considering that according to formula (3)

$$S_{1-3} = 1 - S_{4-7} \tag{5}$$

and substituting expression (5) into formula (4), we get that

$$S_{4-7} = (I_{ANT, SEL}^{**} - I_{ANT, E, 1-3})/(I_{ANT, E, 4-7} - I_{ANT, E, 1-3}) \tag{6}$$

Then we take into account formulas (5), (4) and (2). We put into operation the values of I_{GS}, which will be selected for the future scale, i.e., $I_{GS, SEL}$. In the result, we obtain that

$$I_{GS, SEL} = (S_{1-3} / S_{4-7}) = 1/S_{4-7} - 1 = (I_{ANT, E, 4-7} - I_{ANT, E, 1-3})/(I_{ANT, SEL}^{**} - I_{ANT, E, 1-3}) - 1 \tag{7}$$

The structure of formula (7) causes two obvious constraints, namely

$$I_{ANT, SEL}^{**} - I_{ANT, E, 1-3} > 0 \text{ and hence } I_{ANT, SEL}^{**} > I_{ANT, E, 1-3} > 19.6\% \tag{8}$$

$\{(I_{ANT, E, 4-7} - I_{ANT, E, 1-3})/(I_{ANT, SEL}^{**} - I_{ANT, E, 1-3}) - 1\} > 0$
and hence

$$(I_{ANT, E, 4-7} - I_{ANT, E, 1-3}) > (I_{ANT, SEL}^{**} - I_{ANT, E, 1-3}) \text{ i.e. } I_{ANT, SEL}^{**} < I_{ANT, E, 1-3} < 69.6\% \tag{9}$$

The resulting constraint for the geosituation index values, which will be selected for the scale of this situation, can be combined by formulas (8)–(9). Such a constraint looks as

$$19.6\% < I_{ANT, SEL} < 69.6\% \tag{10}$$

Results and Discussion

The demands of the resulting constraint (10) are met by the relevant values in columns 5–6 of Table 1. These are the values of upper limits for the first-second (28.3%), third (39.2%), fourth (50.4%) and fifth (63.7%) categories of the anthropisation extent. Additionally, these are the mean values of the third (33.7%) and fourth (44.8%) mentioned categories. Such values can be substituted as selected $I_{GS,SEL}$ into formula (7) and used for realising the initial conditions of formula (4). As a result, the desired 7-categorical scale of a geoecological situation in land use was developed, including proper indexes of formula (2). This situation is classified in the scale by categories from excessively favourable to catastrophic.

Such a scale is presented in Table 2. It has the logic-parametric consistency with the scheme of the anthropisation extent in Table 1. Categorical percent of geo-positive LULC systems' area in the total area of model landscape (S_{1-3}, %) is additionally displayed in Table 2. Parameter S_{1-3} is parity with parameter I_{GS} by use. It was calculated according to the relations that follow from formulas (3)–(10).

Table 2

Scale of a geoecological situation in land use in model landscapes or other territorial units

Code of geosituation category	Geosituation category	Values of geosituation index I_{GS} in formula (2)	Percent of geo-positive LULC systems' area (S_{1-3}, %)	Colour of category at thematic choropleths
1	2	3	4	5
1	Excessively favourable	≥ 4.77	≥ 82.7	
2	Very favourable	(4.77…2.54]	(82.7…71.7]	
3	Favourable	(2.54…1.55]	(71.7…60.8]	
4	Moderately unfavourable	(1.55…0.98]	(60.8…49.6]	
5	Unfavourable	(0.98…0.62]	(49.6…38.3]	
6	Excessively unfavourable	(0.62…0.13]	(38.3…11.5]	
7	Catastrophic	< 0.13	< 11.5	

In accordance with Table 2, for example, a favourable geosituation is initially marked if the geo-positive LULC systems' area exceeds the area of geo-negative systems by 1.55 times. The last is a more reasonable solution in comparison with the similar solution for index $LESI_1$ (see previous text). According to $LESI_1$ scale, proportion (2) for stable landscapes is 3.00. In addition, the low limit of a favourable geosituation in Table 2 is determined by 60.8% of the area of the geo-positive LULC systems in the total landscape area. The similar value in National Atlas (2007) is about 40%. This suggests greater environmental requirements of our scale compared with the mentioned Atlas.

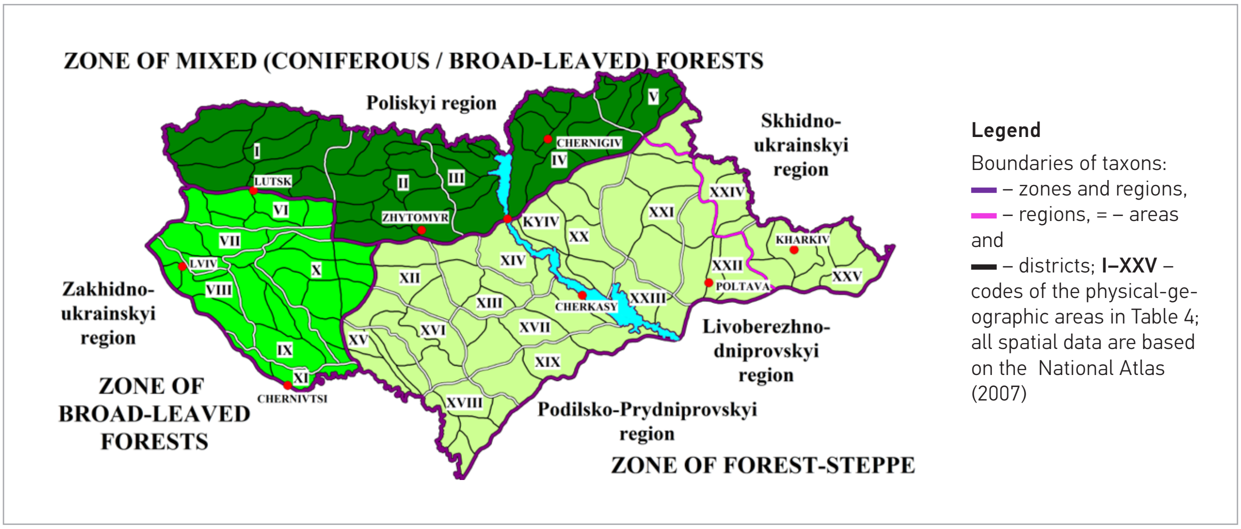
In all cases, the categorical values in Table 2 are more impartial than other proposals, examined above. This is due to the meta-systemic connectivity of these values with the scale of the anthropisation extent in Table 1. Such connectivity is not present in other existing developments.

Both integral parameters, I_{ANT}** by formula (1) and I_{GS} or S_{1-3} by formula (2), are not only interconnected. They are quite in parity with each other for modelling of the landscape anthropisation extent. However, the anthropisation index I_{ANT}** has certain content restrictions on its application. These restrictions are caused by the rank and size of model territorial units. For example, it is inappropriate to apply I_{ANT}** for modelling of the anthropisation extent for a physical-geographic zone or region. Geosituation index I_{GS} practically has no such restrictions.

According to the third task of this paper, the developed operating scale of a geosituation was implemented for the selected megaregion. Such an implementation megaregion is the same as we used in our previous publication (Samoilenko et al., 2018b). It consists of Ukrainian physical-geographic zones of mixed (coniferous / broad-leaved) and broad-leaved forests and forest-steppe and their physical-geographic taxons of lower level (Fig. 1). The last are 5 physical-geographic regions divided into 25 physical-geographic areas

Fig. 1

Digital map of the implementation megaregion: the physical-geographic taxons



with their 130 physical-geographic districts. The spatial databases concerning land use were organised for the mentioned megaregion by the appropriate geoinformation processing of the accessible modern sources of digital spatial data (ESA, 2015; NGCC, 2011; National Atlas, 2007; web-services OpenStreetMap, Google Earth and Google Maps etc.).

Under the principles developed in this paper, the suitable operating scale of the anthropisation extent for the modelling of a geosituation in selected physical-geographic taxons was also used. This operating scale was constructed in a study of Samoilenko et al. (2018b). Here it is used in the modified form in Table 3. Its principal purpose was to divide geo-positive and geo-negative LULC systems in the implementation megaregion according to their categories of the anthropisation extent. Hence, the ordinal numbers of the first systems in Table 3 are 1–7. The second systems have 8–17 numbers.

The obtained megaregional results of modelling of a geosituation in land use are presented in Table 4 and at the digital choropleths in Figs. 2–4.

The model results of the implementation indicate that the geoecological situation in land use in 3 of 25 physical-geographic areas is unfavourable, in 10 excessively unfavourable and in 12 catastrophic (see Fig. 2). At the level of the physical-geographic districts, such a simulated situation was evaluated as excessively favourable only in 1 district from 130 and as favourable in 5 districts (see Fig. 4). However, in 8 districts, the geosituation was identified as moderately unfavourable, in 12 as unfavourable, in 48 as excessively unfavourable and in 56 as catastrophic.

In the megaregional set of physical-geographic area ratings, constructed by the decrease of area percent (see Fig. 3), the first five positions are occupied by the areas of Poliskyi region. Thus, the best geoecological situation is in Kyivsko-Poliska, Volynsko-Poliska,

Table 3

Categories of landscape anthropisation extent caused by land use and/or land cover (LULC) systems of the first and second level

Ordinal number	Code and name of LULC systems *	Codes of anthropisation extent categories **
1	2	3
1	I – Nature-protection system	1, 2
2	XII – System of open spaces with little or no vegetation	1, 2
3	II – Wetland system	2
4	XIII.1 – Transitional woodland-shrub-herb system	2
5	III – Forestry system	2
6	IV – Shrubby-herbaceous natural system	3
7	V.1-2 – Grassland-pasture and haymaking system	3
8	XIII.2 – Agro-forestry system	4a
9	V.5-6 – Fruit trees and vineyard system	5a
10	XIII.3 – System of agriculture with significant areas of natural vegetation	5a
11	V.7 – Arable and fallow land system	(4b…6]
12	VI – Hydrotechnical-hydromelioration system	5a, 6
13	VII – Recreational system	6
14	VIII – Residential system	6, 7
15	IX – Industrial-construction system	7
16	X – Mining system	7
17	XI – Transport-communication system	4, 6, 7

* According to the operating scale in Samoilenko et al. (2018b); ** According to Table 1

Table 4

Categories of landscape anthropisation extent caused by land use and/or land cover (LULC) systems of the first and second level

Code and name of physical-geographic area (see Fig. 1) *	Percent S_{1-3} of area (its districts) **	Code and name of geosituation category for area (its districts) (see Table 2)
1	2	3
I Volynsko-Poliska[1)]	44.0; [61.6… 22.7]	5 – unfavourable (3 – favourable … 6 – excessively unfavourable)
II Zhytomyrsko-Poliska[1)]	40.4; [68.1… 7.0]	5 – unfavourable (3 – favourable … 7 – catastrophic)
III Kyivsko-Poliska[1)]	45.3; [84.5… 25.3]	5 – unfavourable (1 – excessively favorauble … 6 – excessively unfavourable)
IV Chernihivsko-Poliska[1)]	29.5; [51.4… 11.0]	6 – excessively unfavourable (4 – moderately unfavourable … 7 – catastrophic)
V Novhorod-Siversko-Poliska[1)]	37.8; [54.5… 32.6]	6 – excessively unfavourable (4 – moderately unfavourable … 6 – excessively unfavourable)
VI Volynska vysochynna[2)]	8.7; [16.0… 4.1]	7 – catastrophic (6 – excessively unfavourable … 7 – catastrophic)

1	2	3
VII Malopoliska[2)]	26.1; [54.0... 7.8]	6 – excessively unfavourable (4 – moderately unfavourable ... 7 – catastrophic)
VIII Roztotsko-Opilska horbohirna[2)]	27.9; [51.0... 10.5]	6 – excessively unfavourable (4 – moderately unfavourable ... 7 – catastrophic)
IX Zakhidnopodilska vysochynna[2)]	24.6; [36.5... 7.6]	6 – excessively unfavourable (6 – excessively unfavourable ... 7 – catastrophic)
X Seredniopodilska vysochynna[2)]	11.7; [46.6... 3.1]	6 – excessively unfavourable (5 – unfavourable ... 7 – catastrophic)
XI Prut-Dnistrovska vysochynna[2)]	10.3; [13.7... 4.3]	7 – catastrophic (6 – excessively unfavourable ... 7 – catastrophic)
XII Pivnichno-Zakhidna Prydniprovska vysochynna[3)]	6.3; [10.8... 3.7]	7 – catastrophic (7 – catastrophic)
XIII Pivnichno-Skhidna Prydniprovska vysochynna[3)]	8.4; [16.4... 3.4]	7 – catastrophic (6 – excessively unfavourable ... 7 – catastrophic)
XIV Kyivska vysochynna 3)	8.4; [19.1... 5.4]	7 – catastrophic (6 – excessively unfavourable ... 7 – catastrophic)
XV Prydnistrovsko-Skhidnopodilska vysochynna[3)]	7.3; [9.6... 5.1]	7 – catastrophic (7 – catastrophic)
XVI Serednobuzka vysochynna[3)]	12.8; [18.0... 9.9]	6 – excessively unfavourable (6 – excessively unfavourable ... 7 – catastrophic)
XVII Tsentralnoprydniprovska vysochynna[3)]	12.0; [36.9... 5.0]	6 – excessively unfavourable (6 – excessively unfavourable ... 7 – catastrophic)
XVIII Pivdennopodilska vysochynna[3)]	7.9; [14.8... 1.8]	7 – catastrophic (6 – excessively unfavourable ... 7 – catastrophic)
XIX Pivdennoprydniprovska vysochynna[3)]	6.8; [16.1... 2.3]	7 – catastrophic (6 – excessively unfavourable ... 7 – catastrophic)
XX Pivnichnoprydniprovska terasova nyzovynna[4)]	9.6; [28.8... 2.6]	7 – catastrophic (6 – excessively unfavourable ... 7 – catastrophic)
XXI Pivnichnopoltavska vysochynna[4)]	10.8; [41.8...4.8]	7 – catastrophic (5 – unfavourable ... 7 – catastrophic)
XXII Skhidnopoltavska vysochynna[4)]	9.5 [18.5... 5.7]	7 – catastrophic (6 – excessively unfavourable ... 7 – catastrophic)
XXIII Pivdennoprydniprovska terasova nyzovynna[4)]	6.8; [8.0... 4.3]	7 – catastrophic (7 – catastrophic)
XXIV Sumska skhylovo-vysochynna[5)]	19.1; [23.3... 10.0]	6 – excessively unfavourable (6 – excessively unfavourable ... 7 – catastrophic)
XXV Kharkivska skhylovo-vysochynna[5)]	11.7; [22.1... 4.6]	6 – excessively unfavourable (6 – excessively unfavourable ... 7 – catastrophic)

* The names of the physical-geographic areas, regions and zones are given according to the National Atlas (2007);** the percent of geo-positive LULC systems' area (S_(1-3), %).

[1)] zone of mixed (coniferous/broad-leaved) forests, Poliskyi region;

[2)] zone of broad-leaved forests, Zakhidnoukrainskyi region;

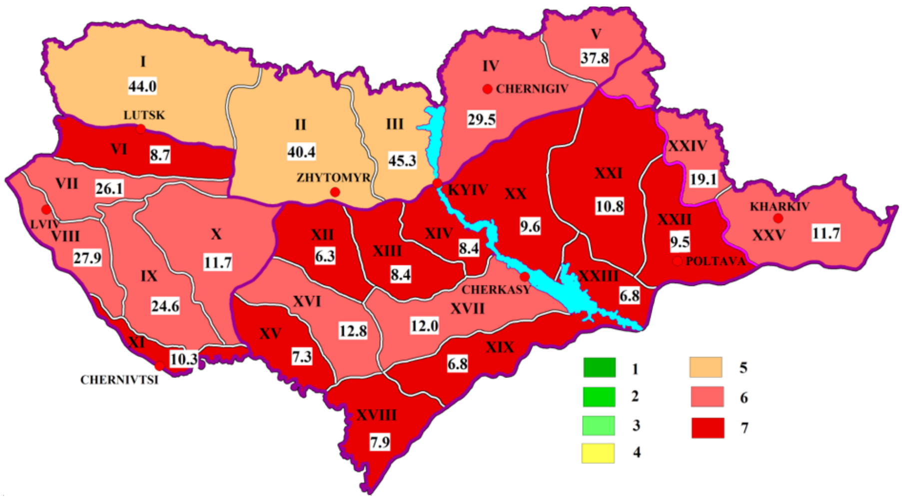
[3)] zone of forest-steppe, Podilsko-Prydniprovskyi region;

[4)] zone of forest-steppe, Livoberezhnodniprovskyi region;

[5)] zone of forest-steppe, Skhidnoukrainskyi region (see Fig. 1).

Fig. 2

Digital choropleth of the physical-geographic area' geosituation in land use



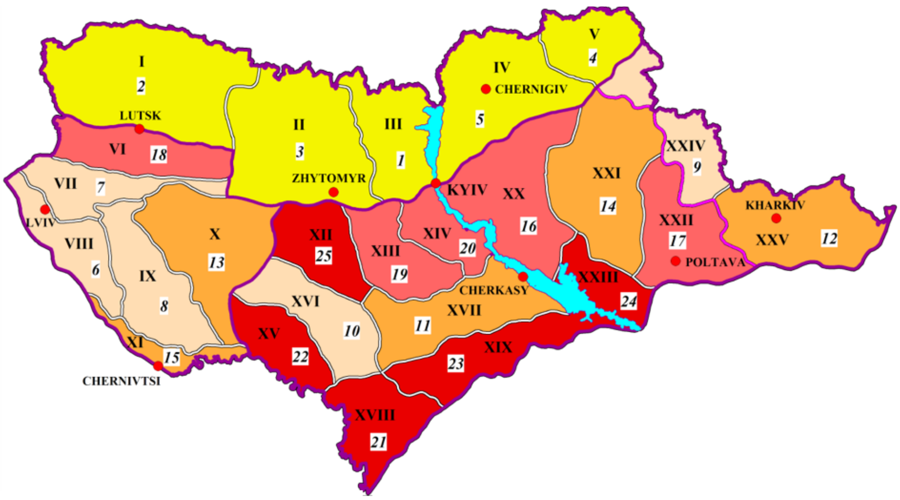
Legend

1–7 – codes and colours of geosituation categories in Table 2;

6.3–45.3 – percent S_{1-3} of the physical-geographic areas in Table 4

Fig. 3

Digital choropleth of the physical-geographic areas' geosituation ratings in the megaregion



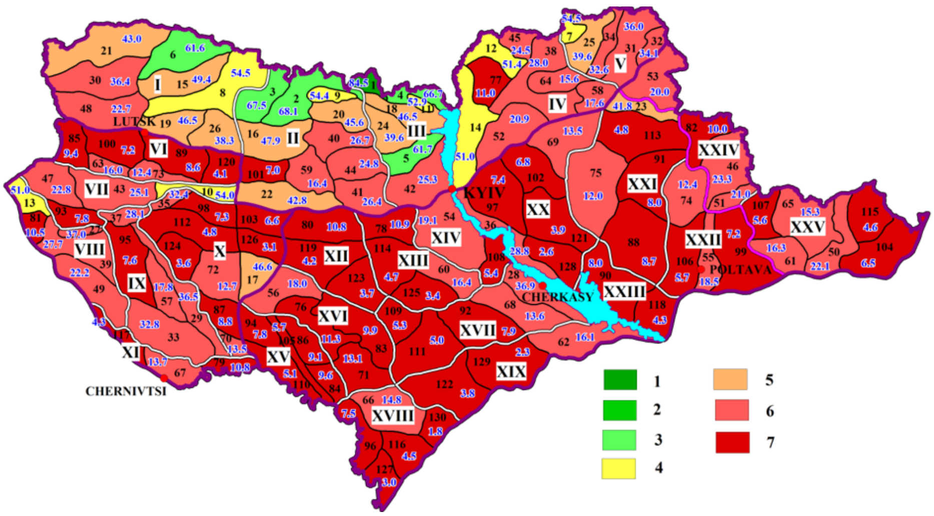
Legend

1–25 – ratings of the physical-geographic areas according to the decrease of their percent S_{1-3} (see Table 4)

Zhytomyrsko-Poliska, Novhorod-Siversko-Poliska and Chernihivsko-Poliska areas with S_{1-3} from 45.3% to 29.5% (see Fig. 3 and Table 4). The worst geosituation with S_{1-3} less than 8% is identified in land use in Pivdennopodilska, Prydnistrovsko-Skhidnopodilska, Pivdennoprydniprovska and Pivnichno-Zakhidna Prydniprovska vysochynna physical-geographic areas of Podilsko-Prydniprovskyi region. In the similar set of physical-geographic district ratings, one district of Kyivsko-Poliska area has the best rating

Fig. 4

Digital choropleth of the physical-geographic districts' geosituation in land use



with excessively favourable situation and S_{1-3} = 84.5% (see Fig. 4). However, one district of Pivdennopodilska vysochynna area has the worst rating, i.e., 130, in the megaregion with S_{1-3} = 1.8%.

The simulated results presented above and concerned the geoecological situation partially differ from the resulting modelling of average-weighted anthropisation indexes in the same megaregion (see Samoilenko et al., 2018b). This has objective reasons due to the different content of the parameters used for the modelling (see previous text).

In general, all the results indicated the validity and further implementation suitability of the first time proposed geosituation indexes and their scale as well as the first generated maps of scale realisation. The developed new approaches can be applied in the territorial schemes and projects of modern environmental management and landscape planning. Such management and planning has to be aimed to improve land use by the implementation of effective environmental protection measures, first of all reforestation and further creation of nature-protection objects, such as natural reserves, national natural and regional landscape parks, etc., with identification of their location, composition and priority.

Conclusions

The new principles for the construction of the scale of a geoecological situation in land use were substantiated. This situation is based on the parameter of landscape anthropisation extent. The parameter was called a geosituation index. Such an index is the area proportion for geoecological positive (or geo-positive) and geoecological negative (or geo-negative) LULC systems. The first systems are still called in essence nature-accentuated, near-to-nature or simply natural systems. The percent of geo-positive LULC systems' area is also used as a separate parameter additional to the geosituation index.

The original scale of a geosituation concerning land use in model landscapes or other territorial units was developed. Such a scale for the first time has the logic-parametric consistency with the previously developed scheme of the landscape anthropisation extent. The geosituation is classified in the scale by categories. They vary from excessively favourable to catastrophic.

The developed geosituation scale was first implemented for the selected megaregion. It includes Ukrainian physical-geographic zones of mixed and broad-leaved forests and forest-steppe and their lower level components such as regions, areas and districts. Modern digital spatial data and the existing operating scale of the megaregional anthropisation extent were used during the implementation. The digital choropleths were modelled for the geosituation in land use in the megaregional physical-geographic areas and districts.

All the obtained results indicated the validity and further implementation suitability of proposed geosituation indexes and their scale. The developed new approaches can be applied in the territorial schemes and projects of modern environmental management and landscape planning.

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