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MODERN PROCEDURE OF LANDSCAPE ANTHROPIZATION ANAYSIS

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The modern principles/approaches and procedure of anthropization extent analysis for Ukrainian landscapes were substantiated and developed. The procedure is universal for all-European and Ukrainian approaches and consists of four components: common-matter, parametric, logic-mathematical and verification-implementation component. The procedure embodies the scheme and the scales of landscape anthropization extent depending on anthropogenic impact extent of land use and/or land cover systems. This impact is specified by corresponding degrees of hemeroby, impact intensity, geoecological favorableness / unfavorableness and naturalness of mentioned systems.

Keywords: landscapes, anthropization, hemeroby, land use, land cover

СЪВРЕМЕННА МЕТОДИКА ЗА АНАЛИЗ НА АНТРОПИЗАЦИЯТА НА ЛАНДШАФТИТЕ

Виктор Самойленко, Владимир Пласкални

Обосновани са и са разработени съвременните принципи/подходи, както и методика за анализ на степента на антропизация на ландшафтите в Украйна. Методиката е универсална и съответства на общоевропейските и украинските подходи и се състои от четири компонента: общосъдържателен, параметричен, логическо-математически и верификационно-реализационен (проверка-реализация). Методиката включва схема и скали със степените на антропизацията на ландшафтите в зависимост от стойността на антропогенното влияние върху системите на земеплозване и/или земно покритие. Това влияние се определя чрез съответните нива на хемеробност, интензивност на влияние, геоекологична благоприятност/неблагоприятност и естеството на тези системи.

Клучови думи: ландшафти, антропизация, хемеробност, земеползване, земно покритие

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INTRODUCTION

The study of the dynamics and ways to identify the consequences of anthropogenic (human) impact on the landscape complexes is one of the most important tasks of contemporary geography. This thesis is confirmed as by the European Landscape Convention and as well by the objectives of the new Sustainable Development Program of the United Nations, adopted for the 2015-2030 years.

Four European and Ukrainian conceptions for the identification of landscape anthropization extent are differentiated now, viz. the conceptions of naturalness, wilderness, hemeroby and geoecological-nature-management analysis (Samoilenko, Plaskalnyi, 2015). Considering the suitable actual geoinformation basis, which is available for the verification and realization, the conceptions of hemeroby and geoecological-nature-management analysis are for the present the most applicable and opened for their further improving modification, including a possible integration of these conceptions (Samoilenko, Plaskalnyi, 2016a).

Moreover, the current challenges related to global and regional threats for the landscape and biotic diversity require the development of new conceptual bases and approaches for determining and analyzing the anthropization extent of the landscapes aggregations. These bases and approaches must to meet Europe-wide universality, the context and terminological systematization, the sufficient level of model formalization and the usage of correct parametrical-mathematical tools under expert evaluation of stated anthropization. That’s why the substantiation and development of the mentioned above modern principles/approaches and procedure of landscape anthropization extent analysis is the primary purpose of this paper.

PRINCIPAL RESULTS

There were defined five principles and/or approaches to substantiation and future realization of the procedure for analysis of Ukrainian landscape anthropization extent, which will have all-European interoperability.

The first of such principles/approaches is synergetic combination of all useful achievements concerning the mentioned conceptions of hemeroby and geoecological-nature-management analysis, including an aspect of universalization.

The second principle/approach expects the application of such model-parametric tool for a landscape transformation assessment as the classified scheme of landscape anthropization extent depending on anthropogenic impact degree of land use and/or land cover (LULC) systems (the last as systems of land use consequences) and corresponding to this scheme average-weighted by appropriate areas indexes of anthropization.

The content of the third principle/approach is a notion on geoecological favorable LULC systems (nature-accentuated or near-to-nature systems) and opposite to them geoecological unfavorable systems.

According to the fourth principle/approach the landscape anthropization is identified as the process of their generation and/or transformation through the anthropogenic impact with specific intensity and consequences of this process – as existence of different level anthropized landscapes. At the same time the degree of naturalness is defined as a level of the landscape ability for self-organization and self-regulation primarily by sequencing the matter-energy flows into the integrated system.

The fifth principle expects the creation of new scale of anthropization extent for Ukraine based on comparative analysis of European and Ukraine experience for connection of anthropogenic impact's definite intensity with determined land use and/or land cover systems. This scale has to be non-linear parameterized.

Based on such assumptions, the actually developed procedure of landscapes anthropization extent analysis consists of four components: common-matter, parametric, logic-mathematical and verification-implementation component.

1. *The common-matter procedure's component* is represented as the classified scheme of the landscape anthropization extent (Table 1) depending on the anthropogenic impact extent of land use and/or land cover (LULC) systems, which is specified by the corresponding degrees of hemeroby, anthropogenic (human) impact intensity, geoecological favorableness / unfavorableness and naturalness of indicated systems.

Table 1

Common-matter classified scheme of landscape anthropization extent depending on extent of anthropogenic impact for land use and/or land cover (LULC) systems

Code and name of landscape anthropization extent category	**Extent of anthropogenic impact for LULC systems:**		
	Hemeroby degree and anthropogenic impact intensity *	**Geoecological favorableness / unfavorableness**	**Degree of naturalness ****
1 – Very slight anthropization	Ahemerobic, almost no impact	Very favorable	Natural
2 – Slight anthropization	Oligohemerobic, weak impact	Favorable	Close to natural
3 – Moderate anthropization	Mesohemerobic, moderate impact	Moderately favorable	Semi-natural
4 – Moderate-great anthropization	β-euhemerobic, moderate-strong impact	Moderately unfavorable	Relatively far from natural
5 – Great anthropization	α-euhemerobic, strong impact	Unfavorable	Far from natural
6 – Very great anthropization	Polyhemerobic, very strong impact	Very unfavorable	Strange to natural
7 – Excessive anthropization	Metahemerobic, excessively strong impact	Excessively unfavorable	Artificial

* According to Walz U., Stein C. (2014).
** According to Paracchini M.L., Capitani C. (2011) and Eurostat Statistics (2012)

2. *The parametric procedure's component* is the result of the correct mathematical-statistical generalization of the most representative available expert parameterizations for the landscape anthropization extent caused by the anthropogenic impact of defined LULC systems. Such representative expert parameterizations are:

1) Under the conception of the hemeroby analysis – *approaches*:

a) *Hemeroby-1 approach* (HB-1), stated in the resumptive work of Walz and Stein (2014) on Germany land covers and implemented in the web-service IOER Monitor (2015);

b) *Hemeroby-2 approach* (HB-2), proposed in the regional study of Hungary by Csorba and Szabó (2009) and involved for our examination at the hypothesis level because of the proposition to use the weighted values of hemeroby categories, which differs from all other developments on hemeroby conception (see Samoilenko, Plaskalnyi, 2015, 2016a);

c) *Hemeroby-3 approach* (HB-3), stated in the resumptive publication of Paracchini and Capitani (2011) and implemented in the system of Eurostat Statistics (2012), why this approach can be deemed as all-European (for the EU countries)

2) Under the conception of geoecological-nature-management analysis – *approaches* (all concern primarily Ukraine):

a) *Constructive-geographic approach* (CG), involved for the examination by generalized to approach publication of Shyshchenko and Gavrilenko (2014);

b) *Hydro-environmental approach* (HE), developed in the monographs of Samoilenko and his scientific colleagues (Samoilenko et al., 2006-2015);

c) *Agro-ecological approach* (AE), founded by publications of Ryborski and Hoike (1988) and Klementova and Geynige (1995) and actively implemented at present by a number of Ukrainian researches (see survey by Samoilenko, Plaskalnyi, 2015, 2016A).

All mentioned above parameterizations operate with the specific parametric scales of anthropization index and were needed to be modified to find the joint solutions. Thus hemeroby approaches (HB-1, HB-2 and HB-3, which is agreed by parameters with HB-1) use the scales with 7 categories (simultaneously both initial-estimating and final-estimating), which were resulted to interval presentation and normalized with anthropization index from 0 to 100%. Besides, HB-2 scale was additionally modified by the new 'weights' of its 7 categories (with multiplying factors (1), 1, 2, 4, 8, 10, 15) according to the proposals of this approach authors (Csorba, Szabó, 2009).

However expert values, put to the base of CG, HE and AE approaches' scales, were different in quantitative and category distribution of anthropization index. Moreover, these approaches use 2 kinds of scales – initial-estimating and final-estimating scale. So they required mathematical-statistical processing primarily for a comparison with scales of hemeroby (HB-1, HB-2 and HB-3). That`s why, the scale of CG, HE and AE approaches were, for the first, parametrically modified to the interval format with determination of the mean values for each scale interval. For the second, such scales were also proportionally normalized by anthropization index (from 0% to 100%) as hemeroby scales.

Carried out joint analysis of all mentioned scales (Samoilenko, Plaskalnyi, 2016B) proved that the most perspective for the next parametric development are initial-estimating 12-category scales of the geoecological-nature-management conception, because the hemeroby approaches are low-informative due to trivially even (close to linear) distribution of their parameters (HB-1 and HB-3) or the non-conformity of parameterization to its initial conception (HB-2).

So, the sets of mentioned mean values for the 12 initial-estimating categories of CG, HE and AE approaches were used as three empirical samples of generalized and parametrically coordinated percentage middle-category index of anthropization $\boldsymbol{I_{ANT,C}}^*$ (%). Herewith the identity was used such as

$$I_{ANT,C}{}^*{}_{,i} \equiv x_{e,i} \qquad (1)$$

Then, values of the three mentioned above empirical samples ($x_{e,1,i}$ by CG approach, $x_{e,2,i}$ by HE approach and $x_{e,3,i}$ by AE approach) were ranked in the ascending order, connected with their empirical non-exceeding probabilities and averaged in order to obtain an empirical distribution of averaged for them middle-category values ($x_{e,*,i}$), i.e. $x_{e,*,i} = f\,(F_e(x))$ as the result of

$$\{(x_{e,1,i} + x_{e,2,i} + x_{e,3,i}) \,/\, 3 = x_{e,*,i}\} = f\,(F_e(x))\ ; \qquad (2)$$

$$F_e(x) = \{(N_i - 0{,}3) \,/\, (n + 0{,}4)\} \cdot 100\%\ , \qquad (3)$$

where N_i – sequence number for each sample member $x_{e,i}$, ranked in ascending order; n – total amount of sample members (in this case n=12).

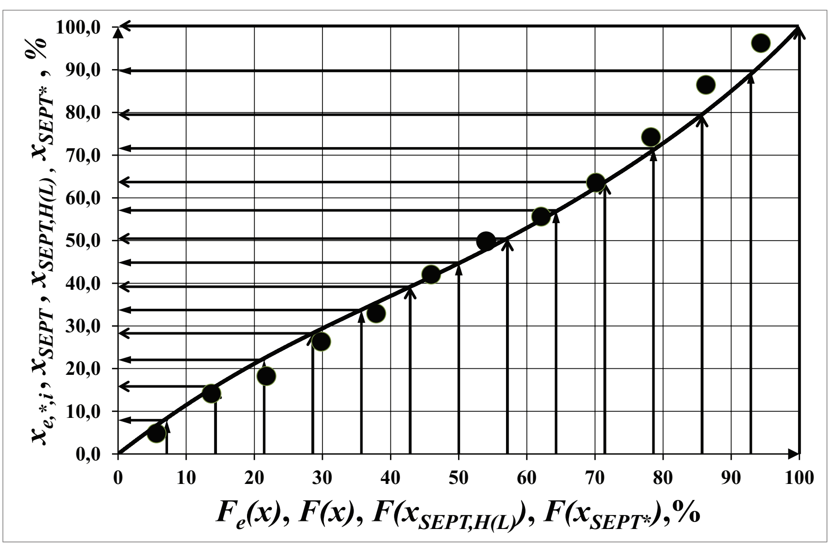

Fig. 1. Approximation by log-normal distribution law averaged empirical distribution for representative middle-category values of anthropization index (see (1)) with determination of limits (properly septiles) and mean value of septile intervals (categories of landscape anthropization extent) for this theoretic distribution: ●●● – points of $x_{e,*,i}$ empirical distribution according to (1)-(3); full curve – plot of log-normal x distribution function with asymmetry coefficient $C_{s,x}$ = 0,43 ($F(x)$ – theoretical probability of non-exceeding); full perpendiculars – limits of septile intervals (properly septiles $x_{SEPT,L(H)}$) with non-exceeding probabilities $F(x_{SEPT,L(H)})$; stippled perpendiculars – mean values of septile intervals x_{SEPT}* with non-exceeding probabilities $F(x_{SEPT}*)$, see Table 2)

The given averaged empirical distribution (2)-(3) was approximated by a log-normal distribution law with the use of graphic-analytical method and the software module "SIC WEMOW" (see Samoilenko, 2002, 2011). As a result theoretical distribution $x = f(F(x))$ was obtained (where $F(x)$ – a theoretical probability of non-exceeding) with the asymmetry coefficient $C_{s,x}$ = 0,43 (Fig. 1).

For such generalized theoretical distribution of the mentioned anthropization indexes $x = f(F(x))$ quantization (division into equal parts) of the distribution, viz. septile (sevenfold) quantization was applied. This was consistent with the goal of transition from the initial-estimating 12-category distribution to desired 7-category distribution, adequate to universal (both initial-estimating and final-estimating) non-linear 7-category scale of landscape anthropization extent (see for details Fig. 1 and Table 2, where not only 7 principal categories but also their sub-categories, such as 4a, 4b, 5a and 5b, are also given for the understanding of the scale constructive principles).

Table 2

Non-linear parameterized by septiles scale of landscape anthropization extent (see Fig. 1 and equations (4)-(5))

Septile interval code (code of landscape anthropization extent category by Table 1)	**Ranges of non-exceeding probabilities $F(x)$ within limits of septile intervals (categories of landscape anthropization extent) from lower to upper limit $\{F(x_{SEPT,L})$ ... $F(x_{SEPT,H})\}$, %**	**Ranges of x (categorical ranges of anthropization index) from lower to upper limit $\{(x_{SEPT,L})$ ... $(x_{SEPT,H})\}$,%**	**Non-exceeding probability of midpoints for septile intervals (categories of landscape anthropization extent) $F(x_{SEPT}*)$,%**	**Mean value of septile intervals (categories of landscape anthropization extent) $x_{SEPT}*$, %**
1	(0…14.3]	(0…15.8]	7.1	7.9
2	(14.3…28.6]	(15.8…28.3]	21.4	22.1
3	(28.6…42.9]	(28.3…39.2]	35.7	33.7
4	(42.9…57.1]	(39.2…50.4]	50.0	44.8
4a	(42.9…50.0]	(39.2…44.8]	46.5	42.0
4b	(50.0…57.1]	(44.8…50.4]	53.6	47.6
5	(57.1…71.4]	(50.4…63.7]	64.3	57.1
5a	(57.1…64.3]	(50.4…57.1]	60.7	53.8
5b	(64.3…71.4]	(57.1…63.7]	67.9	60.4
6	(71.4…85.7]	(63.7…79.5]	78.6	71.6
7	(85.7…100)	(79.5…100]	92.9	89.8

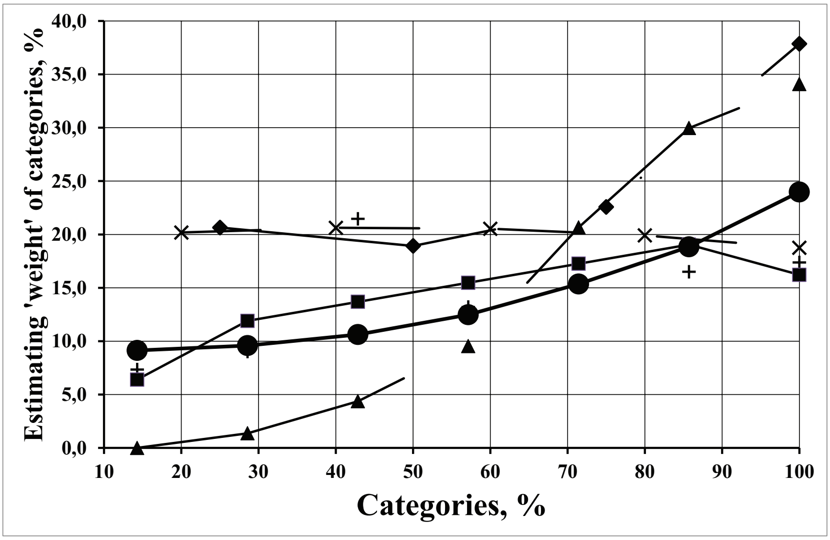

Fig. 2. Comparison of category estimating ‘weights’ for modeled at Fig. 1 and Table 2 septile scale (mark ‘●’) and examined representative final-estimating scales of landscape anthropization extent (by approaches: CG – mark ‘**x**’; HE – mark ‘+’; AE – mark ‘♦’; HB-1 & HB-3 – mark ‘■’; HB-2 – mark ‘▲’)

The modeled septile scale of landscape anthropization extent was compared with all examined representative final-estimating scales (see the example at Fig. 2, where estimating ‘weights’ of presented in percent categories are equal to normalized to 100% sums of the category gains and the middle-category values). Such comparison (Samoilenko, Plaskalnyi, 2016 B) demonstrated relevancy, impartial nature and mathematical-statistical correctness of modeled here the non-linear scale and, that’s why, its wide applicability. Such scale realizes the thesis ‘the greater degree of LULC system non-naturalness (artificiality) entails the steady non-linear increase of the estimating ‘weight’ of these systems in the common anthropization extent scheme of Table 2’ (see Fig. 2).

3. *The logical-mathematical procedure’s component* operates with the generalized scale of anthropization extent, caused by land use / land cover systems for terrestrial (conventionally including wetland) Ukrainian landscapes (Table 3). This scale is integrated for examined above representative all-European and Ukrainian conceptions / approaches and combined with the second, parametric procedures’ component. The scale of Table 3 uses the appropriate anthropization indexes (with their possible changes from 0 to 100%), which reflect the anthropogenic impact of ranged by such indexes 13 first-level LULC systems with their elements.

The similar to Table 3 scale, but for the assessment of anthropization extent concerning the aqua-terrestrial landscapes of a different water bodies requires separate detailed development, the proposals on what were substantiated in our paper (Samoilenko, Plaskalnyi, 2016b) as well as the proposals on parameterization of a proportion for geoecological favorable and unfavorable LULC systems.

Table 3

Generalized scale of terrestrial landscape anthropization extent, caused by land use and/or land cover (LULC) systems for 1st and 2nd level, integrated by representative conceptions / approaches (RC_{ANT} – generalized range of possible anthropization extent categories; AI_{ANT} – anthropization index, averaged according to RC_{ANT} and Table 2, %; AC_{ANT} – category of anthropization extent, averaged by AI_{ANT} and Table 2)

Code and name of LULC systems for 1st and 2nd level	Anthropization extent categories, caused by LULC systems, coordinated with conceptions of *:						RC_{ANT} / AI_{ANT}, % / AC_{ANT}
	Hemeroby analysis by approaches:			Geoecological-nature-management analysis by approaches:			
	HB-1	HB-2	HB-3	CG	HE	AE	
I – Nature-protection system	–	–	1	1-2	1-2	–	***1-2* / 13.6% / 1**
II – Wetland system (incl. marshes, bogs, strictly wetlands etc.)	2	2	2	2	2	1-2	***1-2* / 20.0% / 2**
III – Forestry system, in particular:	2-3	2-3	1-5a	2	1-2	1-2, 5	***1-5* / 27.3% / 2**
III.1 – Broad-leaved forest system	2	2	1-5a	2	1-2	1-2, 5	*1-5* / 26.4% / 2
III.2 – Coniferous forest system	2-3	3	1-5a	2	1-2	1-2, 5	*1-5* / 27.7% / 2
III.3 – Mixed forest system	2-3	3	1-5a	2	1-2	1-2, 5	*1-5* / 27.7% / 2
IV – Shrubby-herbaceous natural system	3	2	2	–	–	5	***2-5* / 33.7% / 3**
V – Agricultural system, incl.:	3-5	2-4	2-5b	3-5	3-5	2-6	***2-6* / 45.8% / 4b**
V.1 – Grassland-pasture system	3-4	2-3	2-4b	3-4	3-4	2-3	*2-4* / 35.2% / 3
V.2 – Haymaking system	3-4	2-3	2-4b	3-4	3-4	3-4	*2-4* / 36.8% / 3
V.3 – Hop-garden, flowerbed etc. system	–	–	4a-5a	5	4	4	*4a-5* / 48.4% / 4b
V.4 – Berry plantation system	5	5	4a-5a	5	4	–	*4a-5* / 51.4% / 5a
V.5 – Fruit trees system	5	5	4a-5a	5	4	5	*4a-5* / 52.1% / 5a
V.6 – Vineyard system	5	5	4a-5a	5	4	5-6	*4a-6* / 5 4.2% /5a
V.7 – Arable and fallow land system	5	4	4b-5b	5	5	5-6	*4-6* / 56.3% / 5a
VI – Hydrotechnical-melioration system, in particular:	4-5	3-4	4a-5b	6	6	–	***3-6* / 56.3% / 5a**

VI.1 – Drainage-irrigation system	4-5	3-4	4a-5b	6	6	–	*3-6* / 52.8% / 5a
VI.2 – Drainage system	5	–	5b	6	6	–	*5-6* / 65.2% / 6
VII – Recreational system (incl. sport, leisure, health-improving facilities etc.)	4-5	6-7	6	–	–	–	***4-6* / 67.0% / 6**
VIII – Residential system, in particular:	6-7	7	7	5-6	5-6	6-7	***5-7* / 78.6% / 6**
VIII.1 – Village (discontinuous built-up) system	6	7	7	5	5	6-7	*5-7* / 75.2% / 6
VIII.2 – City-town (continuous built-up) system	7	7	7	6	6	6-7	*6-7* / 82.0% / 7
IX – Industrial-construction system	6-7	6-7	6-7	7	7	6-7	***6-7* / 82.5% / 7**
X – Mining system	6	7	6	7	7	7	***6-7* / 83.7% / 7**
XI – Transport-communication system	7	7	7	6	7	6-7	***6-7* / 84.6% / 7**
XII – System of open spaces with little or no vegetation, in particular:	–	–	–	–	–	–	–
XII.1 – Bare rock system	1	2	1	–	–	–	*1-2* / 12.6% / 1
XII.2 – Sand system	2	–	2	–	–	–	*2* / 22.1% / 2
XII.3 – Sparsely vegetated system	3	2	2	–	–	–	*2-3* / 26.0% / 2
XII.4 – Burnt area system	3	–	5a	–	–	–	*3,5a* / 43.8% / 4a
XIII – Heterogeneous and other systems, in particular:	–	–	–	–	–	–	–
XIII.1 – Transitional woodland-shrub-herb system	3	2	2	–	–	–	*2-3* / 26.0% / 2
XIII.2 – Agro-forestry system	–	–	3-4b	–	–	–	*3-4b* / 41.1% / 4a
XIII.3 – System of agriculture with significant areas of natural vegetation	4	4	4a-5a	–	–	–	*4-5a* / 47.1% / 4b
XIII.4 – Complex agricultural system	5	4	4a-5a	–	–	–	*4-5* / 49.1% / 4b

* According to Walz, Stein (2014) and IOER Monitor (2015) (considering Bossard et al. (2000), Paracchini, Capitani (2011) and Eurostat Statistics (2012), Csorba, Szabó (2009), Shyshchenko, Gavrylenko (2014), Samoilenko et al. (2006-2016), Ryborski, Hoike (1988), Klementova, Geynige (1995)

There was also envisaged the possibility of detailing and/or certain aggregation for the categories of generalized scale in Table 3, depending on an available research geoinformation basis and taking into account a possibility to introduce defined corrective procedures and modified methods of parameterization aimed to create the real regional operating scales of anthropization extent.

In all cases presented in Table 3 generalized scale and/or its any operating modification have to use for estimation the average-weighted (by the areas of proper LULC systems) index of terrestrial landscape anthropization (I_{ANT}**, %) for a definite study object by equation

$$I_{ANT}^{**} = \sum_{i=1}^{n} I_{ANT,E,i} \cdot s_i \ , \qquad (4)$$

where $I_{ANT,E,i}$ – estimated anthropization index, which is partial for relevant (i) LULC system of study object and is determined by Table 3 and/or its operating modifications; s_i – total part of this LULC system's area with $I_{ANT,E,i}$ (in unity fraction, when total area of modeled terrestrial landscapes is equal to 1); n – number of estimated LULC systems within study object's boundaries.

According to the above stated, estimated anthropization index in (4) can be adequate to parameters in accordance with the notation (see Tables 2-3)

$$I_{ANT,E,i} \equiv x_{SEPT}^{*};\ I_{ANT,E,i}\ \hat{I}\ \{(x_{SEPT,L}) \ldots (x_{SEPT,H})\};\ I_{ANT,E,i} \equiv AI_{ANT} \text{ etc.} \qquad (5)$$

4. *The verification-implementation procedure's component* can be realized through formalized model constructions, based on a spatial analysis by GIS tools. These constructions have to foresee the intersection of LULC systems' random and determined fields, transformed by the corresponding anthropization indexes etc., with the landscape aggregation within the geographical-determined fields to begin with the physical-geographical regions of Ukraine. Such intersection will be aimed to evaluate an integral anthropization extent of the mentioned regions and this extent distribution by the regions' area and, further, to analyze factors, which caused such extent using suitable ways of result interpretation. Also it is intended to compare the procedure implementation results for Ukraine with analogical computations, which will be executed for relevant (physical-geographical or other) model units of Bulgaria, Hungary and Germany. All these specify the future prospect of our research which will be aimed at a development of operating version of the landscape anthropization extent's scale, identical to a geoinformation basis available for selected region of examination.

CONCLUSIONS

The modern principles/approaches and procedure of anthropization extent analysis for Ukrainian landscapes were substantiated and developed. The procedure is universal for all-European and Ukrainian approaches and consists of four components: common-matter, parametric, logic-mathematical and verification-implementation component.

The first procedure's component embodies common-matter classified scheme of the landscape anthropization extent depending on the anthropogenic impact extent of land use and/or land cover (LULC) systems. This impact is specified by the corresponding degrees of hemeroby, impact intensity, geoecological favorableness / unfavorableness and naturalness of LULC systems.

The new non-linear parameterized by septiles scale of landscapes' anthropization extent is the tool of the second procedure's component. This scale was developed as a result of the impartial mathematical-statistical summing up for representative parameterizations of anthropization extent, obtainment of the generalized anthropization indexes' distribution and the quantization of this distribution, taking into accounts seven degrees of scale.

The third procedure's component operates with the generalized scale of anthropization extent, caused by land use / land cover systems for terrestrial Ukrainian landscapes. This scale is integrated for the examined representative all-European and Ukrainian conceptions / approaches and combined with the second, parametric component. Such scale uses the appropriate anthropization indexes, which reflect the anthropogenic impact of ranged 13 first-level LULC systems with their elements. Among these systems are nature-protection, wetland, forestry, shrubby-herbaceous, agricultural, hydrotechnical-melioration, recreational, residential, industrial-construction, mining and transport-communication system and also system of open spaces with little or no vegetation, heterogeneous and some other systems.

In the fourth procedure's component there were defined the ways for verification and implementation of the procedure concerning, first of all, the physic-geographic regions of Ukraine with a possible comparison of gained in future results with analogical results for relevant units of Bulgaria, Hungary and Germany.

REFERENCES

Bossard, M. et al. 2000. CORINE land cover technical guide – Addendum 2000. Technical report No 40. – Copenhagen: EEA, 105 pp.

Csorba, P., S. Szabó. 2009. Degree of human transformation of landscapes: a case study from Hungary. *Hungarian Geographical Bulletin*. Vol.58. No2, pp. 91-99.

Eurostat Statistics. 2012. Eurostat Statistics Explain: Agri-environmental indicator – landscape state and diversity. Web source: http://ec.europa.eu/eurostat/statistics-explained

IOER Monitor. 2015. Monitor of Settlement and Open Space Development. – Leibniz Institute of Ecological Urban and Regional Development. Web source: http://www.ioer-monitor.de

Klementova, Y., V. Geynige. 1995. Assessment of the environmental sustainability of the agricultural landscape. *Melioration and Water Management*. № 5, pp. 24-35. / Клементова, Е., В. Гейниге. 1995. Оценка экологической устойчивости сельскохозяйственного ландшафта. Мелиорация и водное хозяйство. № 5, с. 24-35. (Rus)

Paracchini, M.L., C. Capitani. 2011. Implementation of a EU wide indicator for the rural-agrarian landscape. – JRC scientific and technical reports (EUR 25114 EN-2011). – Luxembourg: Publications Office of the European Union. 89 pp.

Ryborski, I., E. Hoike. 1988. Impact of land use structure on the area ecological stability (in Slovak). Land management in special conditions. – Tatranska Lomnica, 1988. / Риборські І., Е. Гойке. 1988. Вплив складу угідь на екологічну стабільність

території (словацькою мовою). Землевпорядні роботи в спеціальних умовах. – Татранська Ломніца, 1988. (Slovac).
Samoilenko, V.M. 2002. Probabilistic mathematical methods in geoecology: Manual. – Kyiv: Nika-Center, 404 pp. / Самойленко, В.М. 2002. Ймовірнісні математичні методи в геоекології: Навчальний посібник. – К.: Ніка-Центр, 404 с. (Ukr)
Samoilenko, V.M., N.P. Korogoda. 2006. Geoinformation modeling of ecological network: Monograph. – Kyiv: Nika-Center, 224 p. / Самойленко, В.М. 2006. Корогода Н.П. Геоінформаційне моделювання екомережі: Монографія. – К.: Ніка-Центр, 224 с. (Ukr)
Samoilenko, V.M., K.O. Veres. 2007. Modeling of urban-landscape basin geosystems: Monograph. – Kyiv: Nika-Center, 296 pp. / Самойленко, В.М., К.О. Верес. 2007. Моделювання урболандшафтних басейнових геосистем: Монографія. – К.: Ніка-Центр, 296 с. (Ukr)
Samoilenko, V.M . O.M. Topuzov. 2011. Statistical and stochastic mathematical methods in geography: Electronic textbook. – Kyiv: Nika-Center, CD, ISBN 978-966-521-580-6. / Самойленко,В.М., О.М. Топузов. 2011. Статистичні та стохастичні математичні методи в географії: Електронний підручник. – К.: Ніка-Центр, CD, ISBN 978-966-521-580-6. (Ukr)
Samoilenko, V.M., D.V. Ivanok. 2015. Modeling of basin geosystems: Monograph – Kyiv: SE “Print Service”, 208 p. / Самойленко В.М., Іванок Д.В. Моделювання басейнових геосистем: Монографія. – К.: ДП “Прінт Сервіс”, 208 с. (Ukr)
Samoilenko, V.M., V.V. Plaskalnyi. 2015. Conceptions for identification of landscapes’ anthropization extent: retrospective survey and prospects. *Physical Geography and Geomorphology*. V.4(80). pp. 6-29. / Самойленко, В.М., В.В. Пласкальний. 2015. Концепції ідентифікації міри антропізації ландшафтів: ретроспектива та перспективи.– Фізична географія та геоморфологія. Вип.4(80), с.19-38. (Ukr)
Samoilenko, V.M., V.V. Plaskalnyi, 2016 A. Classification of conceptions for identification of landscapes’ anthropization extent. *Hydrology, Hydrochemistry and Hydroecology*. V.1(40), pp. 6-29. / Самойленко, В.М., В.В. Пласкальний. 2016 А. Систематизація концепцій ідентифікації міри антропізації ландшафтів. – Гідрологія, гідрохімія і гідроекологія. Т.1(40), с. 6-29. (Ukr)
Samoilenko, V.M., V.V. Plaskalnyi. 2016 B. Interoperable procedure of anthropization extent’ analysis for Ukrainian landscapes. *Hydrology, Hydrochemistry and Hydroecology*. V.2(41), pp. 6-31. / Самойленко, В.М., В.В. Пласкальний. 2016 В. Інтероперабельна методика аналізу міри антропізації ландшафтів України. – Гідрологія, гідрохімія і гідроекологія. Т.2(41) с. 6-31. (Ukr)
Shyshchenko, P.G., O.P. Gavrylenko 2014. Geoecological rationale of environmental management projects: Textbook (el. version). – Kyiv: Alterpress, 414 p. / Шищенко, П.Г., О.П. Гавриленко. 2014. Геоекологічне обгрунтування проектів природокористування: Підручник (ел. версія). – К.: Альтерпрес, 414 с. (Ukr)
Walz U., C. Stein. 2014. Indicators of hemeroby for the monitoring of landscapes in Germany. *Journal for Nature Conservation*. Vol.22, pp. 279-289.