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METHODIC APPROACH TO ASSESSMENT OF THE TYPES OF BALANCED LAND USE OF RURAL AREAS

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ABSTRACT

The article studies a methodic approach to the assessment of the types of balanced land use of rural areas based on the analytic hierarchy process in the context of sustainable development. In particular, the authors of the research present the assessment and trends of changes of the indicators of land use greening, which is the most sensitive element of sustainable development. To identify the directions of land use greening, the authors make a comparative assessment of the actual and standard (maximum) ecological parameters of land use on the territory of Trybukhivtsi amalgamated territorial community. Ploughness of the territory exceeds the norm by 22.5%; the share of perennial plants, hayfields and grassland in the total area of agricultural lands is by 12.5% below the norm; the share of forest cover is 9.5% lower than the norm required by law. Therefore, the authors propose a hierarchy structure of alternative types of planning the balanced development of land use for the studied territory. Based on the results of interrogated specialists and the conducted expert estimates, the researchers got a score of assessment criteria/subcriteria and priority alternatives of the land use types. The assessment of criteria/subcriteria and alternative types of the balanced land use development was used to compose comparative assessment matrixes and to identify and wyznaczthe priority vectors of land use planning by territorial communities. It is marked. Please note that the mentioned methodic approach can be used for determining the priorities of rural area development, which can be achieved by different measures. Rational combination of the priorities will shape the policy of sustainable development of rural areas.

Introduction

In Ukraine, administrative reforms and establishment of amalgamated territorial communities have caused great difficulties with reforming land use within their boundaries. In 2021, Ukraine had 1469 communities, established by amalgamation of villages, settlements, and towns.

Territorial communities face a rather complicated situation concerning the use of land and other natural resources, primarily due to:

1. underestimated complexity and character of land transformations during the land and economic reforms in Ukraine;
2. the newly established territorial communities have almost no information on their right to land and other natural resources, their potential, conditions of use and protection;
3. nonsystemic and incompetent delivery of the tasks related to land reforming on the territories of local councils, especially shunning responsibility of the management of land within their territories, no differentiation between the state and communal property, uncompleted reform of land relations and land use system, particularly in agriculture;
4. unsatisfactory legislative and information supply and protection of the property rights of rural population to land and other natural resources;
5. neglecting problems of economic turnover of land as capital, the resource-integrated approach to development of rural areas in the process of land relations transformation, unsustainable state land policy on land use planning and land organization of territorial communities, as well as mechanisms of their implementation;
6. inconsistent state policy of comprehensive development of land legislation, implementation and funding of the state and municipal land organization, cadaster, difficulties to organize land use that is attractive for investments;
7. extremely low infrastructure of the real estate market, especially the market of agricultural and non-agricultural lands;
8. lack of information support for rural population on the opportunity to use land and other natural resources of their territories in market conditions.

Therefore, the process of community establishment, particularly under the opened land market in Ukraine, requires scientific substantiation of the prospects of land use development within their boundaries due to land use planning considering the principles of sustainability for the social (rural, urban) welfare of the population and territorial communities. In particular, it deals with the substantiation of the methodic fundamentals of planning development of the land use in rural areas with the forecast of the economic, ecological, and social consequences of that process. Maintenance of the balanced development of newly established territories, organization of the rational use of their lands and other natural resources that are located on it, greatly depend on the system of planning land use and management of that process.

Scientists from different countries focus on studying the balance between rural area development, environmental protection and land use planning (Netherlands) (Van der Vlist, 1998) by balancing animal production, protection of biological diversity and sequestration (Mexico) (Williams et al., 2017), by sustainable land use and regional development of rural areas (China) (Wang et al., 2019) and general optimization of the land use structure (Moldova) (Kapitalchuk, 2018). This is because rational land use directly influences sustainable development of the territory (Abreu et al., 2021; Ryborski and Gojko, 1988; Moilanen et al., 2011).

Therefore, it is necessary to develop approaches that would help to comprehend the economic, ecological and social impact of changes in changes in land use on sustainable development. To satisfy the need to properly integrate the economic, environmental and social problems in different spheres of politics in the broader spatial scope, the interdisciplinary team working within the framework of the SENSOR project has developed an innovative conceptual basis to assess the impact of politics on sustainability of lands at different levels of spatial aggregation, namely the structure of the land use functions (LUFs). The concept of LUFs provides an opportunity to clearly identify analytical relations between multifunctional land use and sustainable development (Pérez-Soba et al., 2008). In Ukraine, scientists have also proposed some approaches to ensure effective use of land resources in regions based on the supply of effective market-oriented and environmentally balanced rural areas (Voronkova and Sycheva, 2017; Nuzhna et al., 2019; Shkuratov, 2018; Tretiak et al., 2016).

Therefore, an issue of developing the approach to assessment of the types of sustainable land use of rural areas is relevant that is confirmed by numerous domestic and foreign researches.

Materials and Methods

Theoretical and methodological foundation of the research is basic scientific fundamentals and principles of the economy of land and nature management, which are outlined in the works of domestic and foreign scientists discussing the improvement of the ecological and economic aspects of land organization and land management in terms of planning and development.

To reach the set goal and tasks in the process of the research performance, the authors applied a set of general and special methods of scientific cognition:

- theoretical generalization – to disclose the essence of planning land use of rural areas
- the abstract-logical method – to define the research goal and tasks, to make theoretical generalization of the results and to make conclusions on the research findings
- the monographic method – to study fundamentals of the land use development on a specific object
- the statistical method – to consolidate statistical data, to study changes of use and distribution of lands by the forms of ownership, land owners and land users, and to assess tendencies of ecological stability
- the economic method – to assess efficiency of planning the land use of rural areas
- the analytic hierarchy process – to define alternative types of planning the balanced development of land use.

In the process of research, an information base was created, listing the normative and legal acts of Ukraine, official data of the Main Department of Statistics in Ternopil region, Main Department of the StateGeoCadaster in Ternopil region, scientific works of foreign and domestic scientists on balanced development of territories, a forecast of economic, ecological and social effects of the land use of rural areas, as well as the results of authors' personal studies.

Thus, in Trybukhivtsi ATC, in the conditions of ecological vulnerability, the highest score was achieved for the ecological criterion, i.e. the factor of ecological score that allowed for the comparative assessment of the criteria for evaluation of the direction of development of the rural area use planning, expert estimates were used.

Factor of ecological stability of the area (land use) is determined by the formula:

$$\mathrm{F_{ec.s.}} = \frac{\sum \mathrm{F1_i} \times S_{\mathrm{i}}}{\sum S_{\mathrm{i}}} \times \mathrm{Ct} \tag{1}$$

where:

- $F_{ec\cdot st}$ – factor of ecological stability of the area (land use),
- $F1_i$ – factor of ecological stability of lands of the i-th type,
- S_i – the area of land of the i-th type,
- C_t – coefficient of morphological stability of the terrain (C_t = 1 for unstable areas).

Factor of anthropogenic footprint is calculated by the formula:

$$\mathrm{F_{a.b.}} = \frac{(\sum S_{\mathrm{i}} \times B_{\mathrm{i}})}{\sum S_{\mathrm{i}}} \tag{2}$$

where:

- $F_{a.b}$ – factor of anthropogenic footprint,
- S_i – land area with the i-th of anthropogenic footprint, (ha)
- B_i – score of the i-th area with a certain level of anthropogenic footprint (measured on a 5-point scale).

Factor of land development is determined by the formula:

$$\mathrm{F_{l.d.}} = \frac{S_{\mathrm{i}}}{S} \times 100 \tag{3}$$

where:

- $F_{l.d.}$ – factor of land development, (%)
- $S_{a.l}$ – area of agricultural land, (ha)
- S – total area, (ha)

The ploughness index is calculated by the formula:

$$\mathrm{I_p} = \frac{S_a}{S} \times 100 \tag{4}$$

where:

- I_p – the ploughness index, (%)
- S_a – arable land, (ha)
- S – total area, (ha)

Coefficient of territory forest cover is determined by the formula:

$$\mathrm{C}_{f.} = \frac{S_f}{S} \times 100 \tag{5}$$

where:

- C_f – coefficient of forest cover, (%)
- S_f – area of forests, (ha)
- S – total area, (ha)

The averaged expert estimates, presented in the Table 3, were used to range the factors influencing the choice of planning of sustainable development of the land use of rural areas. The most important criteria (factors) should be valued higher and get the highest score of comparison. It is presented in the form of a comparative matrix of the criteria, which are considered to identify the alternative types of planning of sustainable development of the land use (Table 4). Totals of the ratio of the criteria scores are calculated. Thus:

$$\sum h_i = \sum h_j = 16.592 \tag{6}$$

where:

$h_{i;}\, h_j$ – members of the matrix with the index identifying the line and column number.

Eigenvalues of the matrix were calculated by applying the appropriate matrix function of eigenvals using MathCAD software.

Results and discussions

Implementation of the principle of land use greening requires development of a broad system of normative documents on the use of land as a production resource and its protection as an environmental element. Social and economic goals of any land owner or land user include their priorities, but these priorities will be useless if they deteriorate the environment. Therefore, it is very important that the measures, focused on agricultural land use greening become the foundation of the land reform and the prerequisite to forming new land relations. It is an extremely important argument for the economic approach to land, increasing its productivity, and the protection of soil fertility (The Verkhovna Rada of Ukraine, 2001).

Therefore, it is necessary to reconsider the outdated approaches to land transformation, which were characterized by the tendency of maximum inclusion of lands to agricultural use. The practice shows that ploughing slope land and transforming vegetation for healthy water-bodies have brought more harm than benefits. Therefore, the measures to create ecologically sustainable landscapes, ecological normalization of anthropogenic footprint on land resources should primarily include those, which contribute to achieving realistic (actual) parameters of land characteristics and soil fertility in compliance with the standards (Hensiruk, 1992).

Integrity of the ecological potential, as well as mutual transformation of economic and ecological effects determine expansion of the spectrum of measures and estimates for an indefinite period. Rational nature management can be characterized by the structure of land use, as well as quality of ecological potential of land resources.

To assess ecological conditions of agricultural land use and agricultural landscapes in Ukraine, the following indicators are used:

- ecological stability of territories (land use) (Ryborski and Gojko, 1988; Tretiak et al., 2001);
- anthropogenic footprint (Ryborski and Gojko, 1988; Tretiak et al., 2001);
- level of land development;
- the ploughness index;
- coefficient of forest cover of the area;

– other indicators, characterizing ecological diversity and stability of territory (micro-reserves, ecological niches, length of migration corridors, areas protected with forest belts) (Druhak et al., 2012).

Table 1 presents assessment and tendencies of changes of the indicators of land use greening on the example of Ternopil region, Buchach district and Trybukhivtsi amalgamated territorial community (ATC).

Table 1.
Tendencies of changes of the land use greening indexes.

Administrative formations	Factor of land development	Ploughness	Coefficient of forest cover	Factor of ecological stability	Factor of anthropogenic footprint
2010					
Ternopil region	81.4	75.8	14.4	0.31	3.45
Buchach district	81.3	76.5	15.8	0.324	3.44
Trybukhivtsi ATC	90.5	84.2	0.07	0.24	3.65
2019					
Ternopil region	81.9	75.7	14.6	0.31	3.46
Buchach district	81.4	76.3	15.9	0.325	3.45
Trybukhivtsi ATC	87.8	83.2	0.07	0.25	3.68
± 2019 against 2010					
Ternopil region	0.5	-0.1	0.2	0.0	0.01
Buchach district	0.1	-0.2	0.1	0.001	0.01
Trybukhivtsi ATC	-2.7	-1.0	0.0	0.01	0.03

Source: own calculations, based on data of the Main Department of StateGeoCadaster in Ternopil region.

The data in Table 1 show that some little changes occurred in the structure of lands in the region in 2019 compared to 2010 that confirms inefficiency of managerial actions on the in land use greening of those territories. In 2019, the level of ecological instability was high caused by excessive agricultural development and relatively small forest cover of the territory, which was observed in the administrative-territorial units studied. In particular, the factor of environmental stability of Ternopil region (0.31), Buchach district (0.325) and Trybukhivtsi amalgamated territorial community (0.25), shows an increasing tendency and is less than 0.33. According to the calculation methodology (Tretiak et al., 2001), it confirms that the territories are environmentally instable. The factor of anthropogenic footprint also showed a negative tendency to increase and was characterized by the medium level of anthropogenic footprint, which exceeded the permissible level of a significant degree of anthropogenic footprint. In 2010, in Ternopil region, the factor was 3.45, while in 2019, it was 3.46. In Buchach district, the indicators were similar, i.e. 3.44 and 3.45, whereas in Trybukhivtsi amalgamated territorial community, they were 3.65 and 3.68 respectively.

To define the direction of land use greening, the authors of the research performed a comparative assessment of the actual and standard (maximum) ecological parameters of land use on the territory of Trybukhivtsi amalgamated territorial community (Table 2). Analysis of its results proves a significant excess. In particular, land development exceeds the norm by 22.5%; the share of perennial plants, hayfields, and grasslands in the total area is by 12.5% less; the share of forest cover is by 9.5% less than the set norm.

Table 2.
Assessment of ecological parameters of land use on the territory of Trybukhivtsi amalgamated territorial community

Indicator	Parameters		Standards in relation to actual ones, +/-
	Actual (data in 2020)	Standards\(maximum)	
Assessment of anthropogenic footprint			
Ploughness of territory, (%)	87.5	< 65	22.5
Level of anthropogenic footprint, score	3.69	2	-1.69
Assessment of the efficiency of useful land properties recovery			
Factor of area development	0.87	x	x
Share of perennial plants, hayfields and grassland in the total area of agricultural lands, (%)	12.5	>25	-12.5
Assessment of the efficiency of balanced land use			
Factor of ecological stability of land use	0.25	0.67	-0.42
Share of hayfield and grassland in the total area of agricultural lands, (%)	10.2	>30	-19.8
Share of forest-covered territory in the total area of agricultural lands, %	5.5	>15	-9.5

Sources: own elaboration.

Therefore, in land use planning, an important role is performed by the ecological and landscape aspects, because the ecological and landscape organization of land use considers the properties of land and other natural resources, as well as certain landscape in the process of formation of the kinds and types (subtypes) of land use (zoning), evaluation of their resistance to some kinds of burden, estimation of the degree of transformation, assessment of the environment-forming resources and ecological network, including environmental territories, identification of the landscape functions, analysis of the degree of geosystem adaptability, application of the methods of adaptive land use in all kinds (Tretiak, 2012).

Ecological and landscape organization of land use (planning) is called by A.M. Tretiak as an ecological framework of the territory (Tretiak et al., 2016). Some scientists (Budziak, 2016; Budziak et al., 2017; Hutsuliak, 2010; Hutsuliak, 2009) consider that ecological and landscape planning of territory or its land use involves projecting of such spatial organization, which will maintain sustainable (balanced) land and nature management and protection of the main functions of the natural framework of the corresponding territory as a system of support for the human living environment. In its turn, due to the implementation of the principle of rational use of land resources, balanced land use aims to create a strong basis for economic development of agricultural production under simultaneous improvement of the

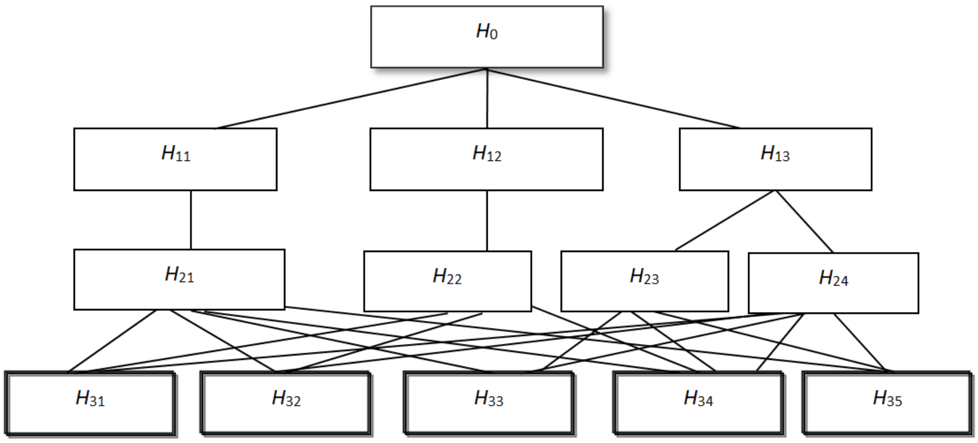
the living standards of population. Balanced land use is the vector that determines the capacity to achieve sustainable development of agricultural land use and the agrarian sector, particularly due to the resource factor (Martyn, 2001; Palianychko, 2012).

Today, environmentally-oriented arable farming, such as ecological, biodynamic, and organic one are getting more and more popular. However, the alternative and innovative way of agricultural development with the focus on greening and capitalization in Ukraine should be fulfilled by introducing non-traditional land use. Non-traditional land use is considered as a process of organization of economically effective, ecologically clean and socially oriented use of agricultural lands as means of the main production in close interaction with environment and land property (where people and their intellect are of principal importance for land capital formation).

The main directions of development determine the land use of rural areas, causing changes in the structure of land use. Therefore, the authors propose a methodic approach that is based on the analytic hierarchy process, which was developed by T.L. Saaty. The analytic hierarchy process is a mathematical apparatus, which suggests the application of a pairwise comparison of the criteria and alternatives to choose the best one of the competitive alternatives considering several criteria. It involves decomposition of problems into the simplest components as well as processing of the consistency of judgements of a person making decisions, which are viewed as pairwise comparison (Kovalyshyn and Pendzei, 2020; Kovalyshyn and Kryshenyk, 2018). The analytic hierarchy process is a general method of solving a wide range of weakly structured problems of decision making, which combines a relatively simple mathematical apparatus and the experience and intuition of the decision maker, and means a gradual fulfilment of the following stages:

– structuring of problems and identification of relations between its constituents (development of a multi-level hierarchy);
– formation of the criteria of assessment and comparison of available vectors of local priorities;
– synthesis of priorities and choice of a priority alternative.

The hierarchy model of the decision-making process, proposed by the authors of the article, has three such levels (Fig. 1): 1) the research goal; 2) criteria and conditions, which should be considered (social – level of supply with agricultural lands; economic – assessment of the natural and resource potential; ecological – factor of ecological stability and factor of anthropogenic footprint); 3) alternative ways to achieve the set goal (decision) (non-traditional land use by agricultural enterprises; farming enterprises and private farms; forest land use; use of the lands of the water fund; recreation land use). The methodic approach to determination of the alternative types of planning based on balanced development in land use of rural areas is applied to Trybukhivtsi amalgamated territorial community. Calculations were carried out using the MathCAD 14 software.



Note: H_0 - optimization goal. Criteria: H_{11} – social; H_{12} – economic; H_{13} – ecological. Subcriteria: H_{21} – social – level of supply with agricultural land; H_{22} – economic – assessment of the natural and resource potential; H_{23} – ecological – factor of ecological stability; H_{24} – factor of anthropogenic footprint. Types of land use and the corresponding land use: H_{31} – non-traditional land use of agricultural enterprises; H_{32} – non-traditional land use by farming enterprises and private farms; H_{33} – forest land use; H_{34} – water land use; H_{35} – recreation land use.

Figure 1. Hierarchy structure of the problem

Source: own calculations

To make calculations, the researchers made comparative assessment of each criterion for the types of balanced land use (in the present research, for Trybukhivtsi amalgamated territorial community). It should be noted that to make comparative assessment of the criteria, the authors used expert estimates, obtained due to interrogation, conducted according to the Land Governance Assessment Framework methodology. This system of assessing was developed by the World Bank to respond to the necessity to a complex solution of land problems. In particular, such research provides the opportunity for countries to achieve a set of important results: first, to shape personal opinion and to set goals regarding land use management; second, to assess current situation in the country, region, community, its strengths and weaknesses; third, to develop a definite plan of measures to improve the system of land use management and to identify measures to monitor the achieved progress (Khvesyk et al., 2019). The group of experts included representatives of the StateGeoCadaster, local authorities, scientists and managers and specialists of some enterprises. They were interrogated and the following results were obtained: the most important – 71-100%, important – 41-70%, significant – up to 40%, average weighted values of the score (Table 3). Thus, experts consider that for Trybukhivtsi amalgamated territorial community ecological instability, the highest score was demonstrated by ecological criterion (factor of ecological stability and anthropogenic footprint).

Table 3.
Expert estimates of the criteria/subcriteria for Trybukhivtsi amalgamated territorial community

Criteria/subcriteria	Expert estimates, score
Social: level of supply with agricultural lands, H_{21}	60
Economic: assessment of productivity of the natural and resource potential, H_{22}	80
Ecological:	
factor of ecological stability, H_{23}	100
factor of anthropogenic footprint H_{24}	90

Source: own calculations, based on expert estimates.

Similarly, based on the interrogated specialists and made expert estimates, the researchers obtained the score of alternative types of land use on the territory of Trybukhivtsi amalgamated territorial community by each of criteria/subcriteria, presented in the Table 4.

Table 4.
Assessment score of different types of land use for each of the criteria/subcriteria.

Type of balanced development of land use on rural area	Level of supply with agricultural lands, H_{21}	Assessment of productivity of the natural and resource potential, H_{22}	Factor of ecological stability, H_{23}	Factor of anthropogenic footprint, H_{24}
Non-traditional land use by agricultural enterprises, H_{31}	43	65	5	17
Non-traditional land use by farming enterprises and private farms, H_{32}	33	57	8	19
Forest land use, H_{33}	5	28	30	31
Water land use, H_{34}	6	24	26	24
Recreation land use, H_{35}	3	19	18	21

Source: own calculations, based on expert estimates.

Based on average expert estimates, the authors ranked the factors influencing the choice of planning balanced development of land use in the rural area. In particular, the next stage is to compose a pairwise comparison matrix to quantitatively demonstrate the relative significance of the criteria and available alternatives concerning the accepted criteria (in general case in relation to the highest level of hierarchy). The pairwise comparison matrix is marked as H = (h_{ij}), where the element h_{ij} in the matrix stays for the relative value of *i* object of the hierarchy (alternative, criterion) compared to *j* object. For any pairwise comparison matrix h_{ii}=1; h_{ij}=1/h_{ji} (matrix, which satisfies the conditions, is called antisymmetrical). For each pairwise comparison matrix, a vector of local priorities is found, i.e. on the set of objects of hierarchy of some level in relation to the studied criterion, the authors set the function $w(x_i)\epsilon[0;1]$, which should satisfy the conditions of rationing: $\sum w(x_i)=1$. The best mathematically substantiated method for developing vectors of local priorities is the method of eigenvectors, which suggests that local priorities are determined based on a standard eigenvector that corresponds to the highest eigenvalue of the pairwise comparison matrix.

Thus, the MathCAD software and the score of assessment of criteria/subcriteria and alternative types of the balanced development of land use are used to make comparison matrices of assessments, where members of the matrix are presented as a fraction.

Thus, the pairwise comparison matrix for higher levels (H_{21}, H_{22}, H_{23} та H_{24}) is presented in Table 5. The data of the matrix are composed to define the advantages of the elements of the hierarchy level with respect to the elements of the higher level. Therefore, the next step is to determine the standard eigenvector of the matrix with its maximum eigenvalue. The standard eigenvector W=(0.182; 0.242; 0.303; 0.273).

Table 5.
Comparison matrix of the criteria/subcriteria.

	H_{21}	H_{22}	H_{23}	H_{24}	$\sum H_i$
H_{21}	1	60/80	60/100	60/90	3.017
H_{22}	80/60	1	80/100	80/90	4.022
H_{23}	100/60	100/80	1	100/90	5.028
H_{24}	90/60	90/80	90/100	1	4.525
$\sum H_j$	5.500	4.125	3.300	3.667	16.592

Source: own calculations.

The authors determined priority vectors w_i concerning the last level of hierarchy (H_{31}, H_{32}, H_{33}, H_{34}, H_{35}), (H_{31}, H_{32}, H_{33}, H_{34}, H_{35}). To do it, the pairwise comparison matrices were built and maximum eigenvalues (to assess the homogeneity of judgments) and main eigenvector (priorities) were calculated for each of the matrices (Table 6).

Table 6.
Comparison matrix of the alternative types of balanced development

	H_{31}	H_{32}	H_{33}	H_{34}	H_{35}	$\sum H_i$
	Level of population supply with agricultural lands, H_{21}					
H_{31}	1	43/33	43/5	43/6	43/5	32.4030
H_{32}	33/43	1	33/5	33/6	33/3	24.8674
H_{33}	5/43	5/33	1	5/6	5/3	3.7678
H_{34}	6/43	6/33	6/5	1	6/3	4.5213
H_{35}	3/43	3/33	3/5	3/6	1	2.2606
$\sum H$	2.0929	2.7272	18.00	15.00	30.0000	67.8201
	Assessment of the natural and resource potential, H_{22}					
H_{31}	1	65/57	65/28	65/24	65/19	10.5911
H_{32}	57/65	1	57/28	57/24	57/19	9.2876
H_{33}	28/65	28/57	1	28/24	28/19	4.5622
H_{34}	24/65	24/57	24/28	1	24/19	3.9104
H_{35}	19/65	19/57	19/28	19/24	1	3.0957
$\sum H$	2.9691	3.3858	6.8927	8.0415	10.1578	31.4469
	Factor of ecological stability, H_{23}					
H_{31}	1	5/8	5/30	5/26	5/18	2.26173
H_{32}	8/5	1	8/30	8/26	8/18	3.6187
H_{33}	30/5	30/8	1	30/26	30/18	13.5704

H_{34}	26/5	26/8	26/30	1	28/18	11.2452
H_{35}	18/5	18/8	18/30	18/26	1	8.1423
$\sum H$	17.4000	10.8750	2.8998	3.3461	4.3172	38.8383
Factor of anthropogenic footprint, H_{24}						
H_{31}	1	17/19	17/31	17/24	17/21	3.9608
H_{32}	19/17	1	19/31	19/24	19/21	4.4269
H_{33}	31/17	31/19	1	31/24	31/21	7.2230
H_{34}	24/17	24/19	24/31	1	24/21	5.5919
H_{35}	21/17	21/19	21/31	21/24	1	4.8929
$\sum H$	6.5852	5.8946	3.6128	4.6667	5.3332	26.0955

Source: own calculations, based on expert estimates.

Results of the vectors of priorities w_i of the last hierarchy level are presented in the Table 7. Control of calculations shows that the total of each column is = 1.

Table 7.
Results of the priority vectors w_i of the last hierarchy level

Type of balanced development of land use of rural areas	Standard eigenvector w_i for matrices:				Integrated assessment of alternative directions of land use development, $\sum W$
	Level of supply with agricultural lands, H_{21}	Assessment of natural and resource potential, H_{22}	Factor of ecological stability, H_{23}	Factor of anthropogenic footprint, H_{24}	
Non-traditional land use by agricultural enterprises, H_{31}	0.478	0.337	0.058	0.152	1.025
Non-traditional land use by farming enterprises and personal farms, H32	0.367	0.295	0.093	0.170	0.925
Forest land use, H33	0.056	0.145	0.349	0.277	0.827
Water land use, H34	0.066	0.125	0.290	0.214	0.695
Recreation land use, H35	0.033	0.098	0.210	0.187	0.528
$\sum W$	1	1	1	1	4

Source: own calculations.

The calculated figures of Table 7 show that in Trybukhivtsi amalgamated territorial community, development of land use will be supported by a significant spreading of non-traditional land use (agricultural enterprises, farming enterprises and private farms) that is confirmed by the highest integrated assessment W = 1.025 and W = 0.925.

However, each of the priority vectors has its set of alternative types of balanced development. For example, ecological vector suggests an alternative type of balanced development in the forest land use.

To control the most important parameter, the authors made a hierarchy synthesis for the presented hierarchy model. The priority vector of the alternatives W_E^A is gradually determined for the elements H_{ij} that are at all hierarchy levels. Calculation of priority vectors is conducted in the direction from lower levels to the upper ones, considering specific relations between the elements that belong to different levels. The calculations are made by multiplying the corresponding vectors and matrices and by summing them.

$$\begin{pmatrix} 0.478 & 0.337 & 0.058 & 0.152 \\ 0.367 & 0.295 & 0.093 & 0.170 \\ 0.056 & 0.145 & 0.349 & 0.277 \\ 0.066 & 0.125 & 0.290 & 0.214 \\ 0.33 & 0.098 & 0.210 & 0.187 \end{pmatrix} \begin{pmatrix} 0.182 \\ 0.242 \\ 0.303 \\ 0.273 \end{pmatrix} = \begin{pmatrix} 0.228 \\ 0.213 \\ 0.227 \\ 0.189 \\ 0.144 \end{pmatrix}$$

In the matrix, the maximum element is 0.228, i.e. the most important parameter of choice is non-traditional land use by agricultural enterprises (H_{31}), whereas the element of forest land use (H_{33}) is close by its value, i.e. 0.227.

Considering the high current anthropogenic footprint of land use and its ecological instability, it is necessary to optimize the land structure that can be implemented by using non-traditional crops, e.g. perennial plants (cherry trees, plum trees, apple trees, etc.)

Thus, the present research provides the most important conclusion that for Trybukhivtsi amalgamated territorial community it is reasonable to implement the defined directions of balanced development of land use. Moreover, the authors of the research consider that the proposed methodic approach can be used as a basis for shaping priorities of rural areas, which can be secured by different measures. A rational combination of measures will determine the policy of sustainable development policy of rural areas.

Conclusions

In the process of research, the authors received the following main indicators. The social and economic goals of any land owner or land user, which are considered priorities, are useless if no greening measures are taken. Therefore, the authors applied the methodic approach to assess the types of balanced land use of rural areas based on the analytic hierarchy process in the context of sustainable development. In the work, the authors present their evaluation and trends for land use greening indexes exemplified by Ternopil region, Buchach district and Trybukhivtsi amalgamated territorial community. To determine the directions for the greening of land use, the authors made a comparative evaluation of actual and standard (maximum) ecological parameters of land use in the territory of Trybukhivtsi amalgamated territorial community, which showed that the plowing of the territory exceeded the norm by 22.5%, the share of perennial plants, hay fields, and grasslands in the total area of agricultural land was 12.5% smaller; the share of forest cover was 9.5% less than the set legislative norms. The authors proposed a hierarchy structure of problems with the identification of alternative types of planning, balanced development of land use for the mentioned territory. Based on the results of expert investigation and estimation, the authors composed comparative matrices of assessments and defined priority vectors of the criteria and alternatives to planning balanced land use, as well as made integrated assessment of alternatives. Thus, the integrated assessment W proves that development of land use will be secured by significant spreading of non-traditional land use that is confirmed by the highest integrated estimate W = 1.025. Moreover, it is also proved by the hierarchy synthesis, where the maximum element in the matrix is demonstrated by non-traditional land use of agricultural enterprises, i.e. 0.228. Considering the obtained data and the high current anthropogenic footprint of land use and its ecological instability, the authors of the research mark that optimization of the land structure can be implemented by using non-traditional crops, e.g. perennial plants (cherry trees, plum trees, apple trees, etc.)

The authors consider that the proposed methodic approach can be used as a basis to shape the priorities of rural areas, which are fulfilled by different measures, and the rational combination of them will shape the policy of sustainable development of rural areas.

References

Abreu, I., Mesias, F. J., Ramajo, J. (2021). *Design and validation of an index to measure development in rural areas through stakeholder participation* (No. 2109.12568).

Budziak, O.S. (2016). Formation of environmental land use on agricultural lands of Ukraine. *Balanced use of natural resources, 3,* 180-187.

Budziak, O.S., Budziak, V.M. (2017). Problems of land use in conditions of reforming property relations. Problems of nature management in the process of property relations reforming: Kyiv, Ukraine.

Druhak, V. M. Kuryltsiv, R. M., Tretiak, N. A. (2012). New paradigm of management of land resources and land use in Ukraine. *Land law of Ukraine, 2,* 14-21.

Hensiruk, S. A. (1992). *Rational use of natural resources*. Svit: Lviv, Ukraine.

Hutsuliak, H.D. (2010). *Sustainable development of land use: methodological aspects of management*. Prut: Chernivtsi, Ukraine.

Hutsuliak, Yu. (2009). Optimization of natural environment: its criteria, problems and directions of their solution. *Land management bulletin, 1,* 34-39.

Kapitalchuk, I. (2018). Optimization of land use structure in the Republic of Moldova on the basis of the method ofecological-economic balance of the territory. *Present Environment and Sustainable Development, 12*(1), 239-247.

Khvesyk, M.A. et al. (2019). *Financial and economic fundamentals of nature management regulation*. State institution "Institute of Nature Management Economics and Sustainable Development of the National Academy of Sciences of Ukraine": Kyiv, Ukraine.

Kovalyshyn, O.F., Kryshenyk, N.I. (2018). Improvement of methodic approaches to formation of legal restrictions while using land plots in the system of state land cadaster. *Scientific bulletin of UNFU of Ukraine, 28*(4), 78-82.

Kovalyshyn, O., Pendzei, L. (2020). Determination of the main directions of balanced land use by the analitic hierarchy process. *Journal of Agri-Food Industry*. *20(2),* 83-90.

Martyn, A.H. (2001). *Economic aspects of optimization of the structure of land use with application of mathematical modeling methods*. Institute of Land Organization of UAAS: Kyiv, Ukraine.

Moilanen, A., Anderson, B.J., Eigenbrod, F., Heinemeyer, A., Roy, D.B., Gillings, S., Thomas C.D. (2011). Balancing alternative land uses in conservation prioritization. *Ecological Applications, 21*(5), 1419–1426.

Nuzhna, O., Tluchkevych, N., Semenyshena, N., Nahirska, K., Sadovska, I. (2019). Making managerial decisions in the agrarian management through the use of ABC-Analysis tool. *Independent Journal of Management & Production, 10*(7), 798-816.

Palianychko, N.I. (2012). Organizational constituent in supply of sustainable land use. In *Economics of nature management and environmental protection, 163-169*, Kyiv, Ukraine.

Pérez-Soba, M., Petit, S., Jones, L., Bertrand, N., Briquel, V., Omodei-Zorini, L., ... & Groot, R. D. (2008). Land use functions – a multifunctionality approach to assess the impact of land use changes on land use sustainability. In *Sustainability impact assessment of land use changes*, 375-404. Springer, Berlin, Heidelberg.

Ryborski, I., Gojko E. (1988). *Impact of land uses on the sustainability area. Land management in special conditions*. Tatranska Lomnica, Slovakia.
Shkuratov, O. (2018). Methodology for Estimation of Ecological Safety in the Agricultural of Ukraine. *Management, Economic Engineering in Agriculture and rural development, 18*(3), 379-389.
The Verkhovna Rada of Ukraine (2001). *The Law of Ukraine «Land Code of Ukraine»*. Available at: https://zakon.rada.gov.ua/laws/show/2768-14#Text (Accessed 1 June 2021).
Tretiak, A.M. (2012). Ecology of land use: theoretical and methodological principles of formation and administration: monograph. Hrin D.S.: Kherson. Ukraine.
Tretiak, A.M., Tretiak V.M., Hunko L.A., Lobunko Yu.V. (2016). *Organization of land use of the structural elements of ecological network of Ukraine at the local level*. S.E. Komprynh: Kyiv, Ukraine.
Tretiak, A., Tretiak, R. Shkvir, M. (2001). *Methodical recommendations for assessing the ecological stability of agricultural landscapes and agricultural land use*. Kiev, Ukraine.
Van der Vlist, M. J. (1998). Land use planning in the Netherlands; finding a balance between rural development and protection of the environment. *Landscape and urban planning*, *41*(2), 135-144.
Voronkova, O. Yu., Sycheva, I. N. (2017). Application of Environmental Criteria. In Economic-Mathematical Modeling for The Development of Organic Agricultural Production. *Ukrainian Journal of Ecology*, *7*(4), 151–156.
Wang, J., Li, Y., Wang, Q., Cheong, K. C. (2019). Urban–rural construction land replacement for more sustainable land use and regional development in China: Policies and practices. *Land*, *8*(11), 171.
Williams, D. R., Alvarado, F. G., Rhys E. M., Phalan, B., & Balmford, A. (2017). Land-use strategies to balance livestock production, biodiversity conservation and carbon storage in Yucatan, Mexico. *Global Change Biology*, *23*(12), 5260–5272.

OCENA METODYCZNA TYPÓW ZRÓWNOWAŻONEGO ZAGOSPODAROWANIA PRZESTRZENNEGO OBSZARÓW WIEJSKICH

Streszczenie. W artykule zbadano metodyczne podejście do oceny typów zrównoważonego zagospodarowania przestrzennego obszarów wiejskich w oparciu o analityczny proces hierarchiczny osadzony w kontekście zrównoważonego rozwoju. Autorzy badań skoncentrowali się na ocenie i przedstawieniu trendów zmian wskaźników związanych z uwrażliwieniem na kwestie środowiskowe odnośnie użytkowania terenu, co stanowi najbardziej wrażliwy element zrównoważonego rozwoju. W celu określenia kierunków rozwoju tych trendów autorzy przeprowadzili ocenę porównawczą rzeczywistych i standardowych (maksymalnych) parametrów ekologicznych użytkowania terenu na terytorium ukraińskiej gminy Trybuchowce. Poziom gruntów ornych w gminie przekracza normę o 22,5%; udział roślin wieloletnich, pól uprawnych i łąk w ogólnej powierzchni gruntów rolnych jest o 12,5% niższy od normy wymaganej przez prawo, a udział pokrywy leśnej – o 9,5% niższy. Dlatego autorzy proponują hierarchiczną strukturę alternatywnych rodzajów planowania zrównoważonego rozwoju użytkowania gruntów dla badanego terenu. Na podstawie wyników rozmów z ekspertami i przeprowadzonych badań autorzy ustalili punktową ocenę kryteriów/podkryteriów oraz priorytetowych wariantów rodzajów jego użytkowania. Ocena kryteriów/podkryteriów i alternatywnych typów zrównoważonego zagospodarowania terenu posłużyła do stworzenia macierzy oceny porównawczej i określenia priorytetowych wektorów planowania zagospodarowania terenu przez gminy. Zaznaczono. Należy pamiętać, że wspomniane podejście metodyczne można wykorzystać do określenia priorytetów rozwoju obszarów wiejskich, realizowanych za pomocą różnych środków. Racjonalne połączenie priorytetów będzie kształtowało politykę zrównoważonego rozwoju obszarów wiejskich.

Słowa kluczowe: gmina, ochrona środowiska, planowanie przestrzenne, nietradycyjne zagospodarowanie terenu, analityczny proces hierarchiczny