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Multicriteria evaluation of forestry development by regions (by the example of Ukraine)

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Abstract

The investigation aims at elaboration and practical application of multicriteria evaluation methodology to compare the forestry development levels in the context of regions based on index method. Elaborated methodology provides 5 assessment criteria: intensity of forest reproduction and regeneration, profitability of logging, forestry financial return, forestry protection and security level, and legislation observance. Three main indices were selected to ensure evaluation proportionality. The individual indices of each indicator by regions are calculated and the group integral indices by each criterion along with the reconciled integral index by all groups of criteria are defined. Application of this methodology by the example of Ukrainian forestry allowed conducting ranking and grouping of regions by indicators of integral indices for certain years and the period of 2011–2013. The diagrammed map is plotted to demonstrate the results visually. It revealed that certain highly forested regions did not ensure appropriate forestry development level as individual steppe zone regions. Elaborated methodology can be used for analogical evaluation of forestry development for other countries and their regions or for a set of countries in a certain territory.

Key words

evaluation criteria, forest resources, forest zones, metrics, group and integral indices, regional grouping

Introduction

Forestry is a main chain of Ukrainian forest sector. Although as compared to the European countries, Ukraine does not dispose of high forest resources potential. Actual level of forest country in Ukraine is 15.9%, but optimal level is considered to be equal to 20%. For reference: the percentage of forestland in Europe varies from 25% to 65%. According to the State Forest Resources Agency of Ukraine (2016), the total area of timberland in Ukraine is 10378.7 thousand hectares, of which 9573.9 thousand hectares is covered by forest vegetation (92.2%). Regard must be paid to the fact that 1600.7 thousand hectares (16.7%) are covered by ripe and overripe forests.

The forests in Ukrainian territory are planted non-uniformly. The bulk of forests are located in the northern and western part of the country, where woodiness of the territory varies depending on the administrative-

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territorial unit from 21% in Chernihiv region to 51% in Transcarpathian region.

More detailed analysis of the distribution patterns of forest areas and sites by categories in Ukraine shows that the largest area is occupied by exploitable forests – 3937 thousand hectares (37.9%) and protective forests – 3416 thousand hectares (32.99%); while the proportion of conservation, scientific, historical and cultural purpose forests is only 1440 thousand hectares (13.9%), whereas recreation and health forests occupy 1586 thousand hectares (15.3%). Thus, an acceptable balancing of forest areas by categories is maintained (Khvesyk et al. 2012).

Forests of Ukraine are formed by more than 30 kinds of wood species, dominated by pine (*Pinus sylvestris*), oak (*Quercus robur*), beech (*Fagus sylvatica*), spruce (*Picea abies*), birch (*Betula pendula*), alder (*Alnus glutinosa*), ash (*Fraxinus excelsior*), hornbeam (Carpinus betulus), fir (Abies alba). Coniferous plantations occupy 42% of the total area, including Pine – 33%. Hardwood plantations occupy 43%, including oak and beech – 32% (State Agency of Forest Resources of Ukraine 2016).

Analysis of the forest resources total area distribution by departmental subordination in Ukraine shows that the State Forest Resources Agency of Ukraine being the central public authority in the field of forestry in Ukraine subjects to 73% of forests. The share of forests exploited by local authorities remains considerable – 12%, but a part of these is subject to legal rectification as to lawfulness of transfer into municipal ownership. About 5% of forests are not subordinated to other ministries, but can also be transferred under the authority of the State Forest Resources Agency of Ukraine. The share of forests ready to be transferred for use is 8%.

Thus, Ukraine has sufficient forest resources potential for sustainable forestry development in the long term. However, the availability of considerable resources in the form of potential forest in a particular region does not guarantee that it will be used effectively. Therefore, it is important to conduct more detailed research to compare the level of development of forestry in separate regions of Ukraine. Nevertheless, we must take into account that the development of forestry can be characterized by many indicators, each of them being important and revealing certain aspects of business. The forestry development level depends on the reafforestation and afforestation intensity, harvesting profitability, financial return of forestry, forest security and protection level, forest legislation observance. Thus, the level of forest management is to be studied by many criteria. Each of the criteria may correspond to a set of indicators that best characterize the level of forest development in this respect. Therefore, there is a need for multicriteria evaluation to compare forestry development level by regions. For this purpose, it is expedient to use the method of index comparative evaluation, based not on the comparison of separate indicators but their indices. This will allow to reduce to a common denominator the indicators' values that have different units of measure and relate to different evaluation criteria and to hold generalized evaluation and regional grouping.

Material and methods

Theoretical foundations multicriteria evaluation

The basic fundamentals of application of this multicriteria evaluation methodology to compare the socio-economic development of Ukrainian regions were grounded by Poburko (2004). The authors also had previous experience of analogical nature in using the multicriteria evaluation methodology applications in terms of Ukrainian regions (Khvesyk and Golyan 2007; Shubalyi 2008; Khvesyk et al. 2011).

The analysis of many scientific papers in this field revealed that most scientists use methods of multicriteria evaluation to select the best scenarios of forestry development, justification of development strategies options, planning of sustainable forest management, developing of approaches to sustainable forest management.

Scientific researches in this field can be divided into two groups. The first group of researches concerns the study of problems of criteria and selection of indicators to assess the sustainable forestry development. The second group of researches concerns the choice of methods for multicriteria evaluation based on elaborated criteria and indicators.

The first group includes the researches of Mendoza and Martins (2006) who were involved in the elaboration of methodology to choose the criteria and indicators of sustainable forest management. They justified

the use of multivariate analysis of criteria (MAC) to evaluate the criteria and indicators adapted to specific forest management unit. The methods include rating, evaluation and pairwise comparisons. These methods were used to assess the participation of encirclement in decision-making by the example of Kalimantan (Indonesia), where a team representing various concerned parties and experts used their expert opinions and judgements when assessing the various criteria and indicators (C & I), on the one hand, and how suitable and applicable are they in forest management, on the other hand. The results of the research showed that the methods of multicriteria evaluation are an effective tool that can be used as a structured means to support decision-making for evaluation, prioritizing and selecting the C & I for a particular forest management unit. According to feedback obtained from the participants of evaluation, it is concluded that multicriteria evaluation methods are transparent, easy to implement and they provide a comfortable environment for joint decision-making.

Prabhu et al. (1999) in their manual defined the guidelines for developing, testing and selection of criteria and indicators for sustainable forest management. They presented the methods aimed at development of sets of C & I of impact evaluation of forest management units (FMU) upon the state of natural forests in the tropics. The main attention is focused on the explanation of preparation and analysis of C & I testing results, the conceptual basis of C & I development is revealed, the possible sets of C & I that can be available for users for evaluation and testing in their countries are suggested.

Hall (2006) considered the criteria and indicators of sustainable forest management in Canada. According to him, to evaluate the state or the progress of implementation of sustainable forest management principles, it is expedient to evaluate the groups of broad core values (criteria) supported by a number of measures (indicators). The measuring and monitoring of indicators are to demonstrate progress in achieving sustainable development at the national and international levels. The criteria he defined take into account the traditional concept of timber significance and include economic, environmental and social values as well as the criteria of national infrastructure development.

Problems faced in developing the criteria and indicators for multicriteria sustainable forestry development were also discussed at the conference 'Sustainable forest management: fostering stakeholder input to advance development of scientifically based indicators' held in Melbourne (1998). Raison et al. (1998) identified many approaches to the development of criteria and indicators (C & I) for sustainable forest management: the study of benefits that can be obtained from the use of C & I; investigation of the extent of problem of application of C & I at the lowest level of the control unit; the role of the scientists in the implementation of C & I is studied; the key issues and actions necessary to promote the development of indicators for each criterion (significance of socio-economic values, productivity, health and bioenergy, soil and water, maintaining the balance of carbon and biodiversity) are observed.

Mendoza and Prabhu (2004) grounded the expediency to use the theory of fuzzy sets to evaluate the criteria and indicators of sustainable forest management. They suggested criteria and indicators (C & I) that are to become tools for forest stability evaluation. The main elements and notions of fuzzy sets are outlined, including the membership functions and their interpretation in terms of sustainable forest management. Moreover, the fuzzy operators that can be united into operational concepts of sustainable development are described, that is to say criteria and indicators.

Balanaa et al. (2010) suggested applying multiple criteria to analyse the decisions on the example of collective forests in Northern Ethiopia. Three multi-criteria analysis methods (MCA) – ranking, pair-wise comparison and scoring were used to form a set of criteria and indicators to evaluate alternative scenarios of forest management. It is concluded that MCA-methods are the means to solve local problems of forest resource management. They are effective to determine the criteria and indicators of sustainability at the local level and to assess management schemes based on broad participation of all the concerned parties.

Jalilova et al. (2010) developed the criteria and indicators for the evaluation of sustainable forest management on the example of walnut and fruit forests of Kyrgyzstan. The opinion of concerned parties at the level of forest management separate units was taken into account when forming the set of C & I. The final set of C & I identified to evaluate sustainable forest management (SFM) in walnut and fruit forests consist of 7 criteria and 45 indicators. The maintenance health and vitality as well as the support of biodiversity of forests

were considered as the most important criteria. Subsequent to the results of multicriteria evaluation, the strategies of forestry management based on attraction of local concerned parties in course of decision-making were grounded.

Within the second group of researches, Anandaa and Herathb (2009) held a critical review of methods of multicriteria decision-making (MCDM) with particular emphasis on forestry management and planning. More than 60 separate researches were reviewed and classified according to the way, country of origin, type and number of criteria and options. The review serves as a guide for those interested in how to use a specific MCDM approach.

Bergh (1996), in the process of investigation of theory, methods and programs of ecological economy and sustainable development elaborated the indicators, suggested approaches for accounting of natural resources, described statistical methods of integral evaluation, methods of dynamic and spatial modelling used for multicriteria evaluation of expenses and profits of Dutch forests' sustainable management. He also elaborated a methodology of multicriteria evaluation of Australian forests' sustainable management.

Sheppard and Meitner (1996) offered to use methods of multicriteria analysis and visualization for planning of sustainable forest management taking into account the interests of concerned parties' groups. They conducted an experimental investigation using multicriteria analysis of forest management scenarios in accordance with national priorities. Based on the survey of concerned parties, criteria and indicators for sustainable forest management were received and alternative scenarios were worked out. The scenarios in modelling process were considered in accordance with priorities of concerned groups by the results of expert evaluation. The researchers concluded that the use of multicriteria analysis methods will ensure accountability and transparency of decision-making in forestry, will allow to involve all concerned parties in the process as well as to consider their interests with the aim of sustainable forest management.

Wolfslehner et al. (2005) compared two different approaches of analysis using a number of criteria: Method of analysis if hierarchies (MAI) with hierarchical structure and analytical network process with network structure. The comparison was conducted to evaluate the strategies for sustainable forest management by individual units using the criteria and indicators based on EU-wide principles of sustainable forest management. Methods of MAI and ANP were used to compare four different variants of strategic management with a set of 6 criteria and 43 indicators. The differences in the results of evaluation by AHP and ANP methods allowed identifying the strengths and weaknesses of both approaches to sustainable forest management. We arrived at a conclusion about the expediency to apply methods of multicriteria evaluation for decision-making in forestry.

Mendoza and Prabhub (2003) describe the advantages of multiple criteria analysis method application, which is used as a tool for decision-making for the analysis and evaluation of C & I for sustainable forest management. The application of method allows generating C & I, evaluating their relative importance, evaluating each indicator's activity as regards to its required condition and evaluating the aggregate influence or influence upon indicators reaching. A soft methodology named cognitive mapping was also elaborated, which may be used to evaluate the interaction of cross-indicators, relations and coherence of indicators. The advantage of this method is a possibility to evaluate the aggregate cumulative influence of all the indicators as well as an individual influence of each factor, investigation of their direct or side effect upon stability through their interaction with other indicators.

According to the results of presented scientific discussion, it is possible to confirm the importance of solving the problems of criteria and indicators for sustainable forest development choice as well as the usage of multicriteria evaluation methods to develop solutions that will take into account the interests of all concerned parties.

Study area

Actually, Ukraine is a unitary state consisting of 27 administrative-territorial units. The objects of further study are the 25 regions of Ukraine that correspond to administrative and territorial units. However, to simplify the analysis of spatial data, Kyiv is included in Kyiv region, whereas Sevastopol belongs to the Autonomous Republic of Crimea. According to the natural and climatic characteristics, the following zones are distinguished in Ukraine: Polissia forest region, the Carpathi-

ans, Forest steppe, Steppe, covering the complex of certain regions. Polissia covers the Volyn, Rivne, Zhytomyr and Chernihiv regions. The Carpathian zone covers the Zakarpattia, Ivano-Frankivsk, Lviv and Chernivtsi regions. Forest steppe covers the Ternopil, Khmelnitskyi, Cherkasy, Sumy, Kharkiv, Poltava and Kyiv regions (including Kyiv). Steppe covers the Dnipropetrovsk, Kirovohrad, Zaporizhia, Kherson, Mykolaiv, Odesa, Donetsk and Luhansk regions and the Autonomous Republic of Crimea (including Sevastopol).

This study provides a comparative evaluation of the forestry development level by pre-selected regions of Ukraine and forest zones.

Methodology

Elaborated methodology of multicriteria evaluation of forestry development level by the regions of Ukraine includes identifying the totality of criteria and grouping together by these criteria of indicators that characterize the development of forestry in this respect. Then we will calculate the indices that will allow to reduce the indicators that have different units of measure to a common denominator and to summarize the results of evaluation by the selected criteria and then by all the criteria.

It is expedient to select the evaluation criteria considering the fact that the development of forestry is affected by many different natural, economic, environmental and social factors. Given the specificity of Ukrainian forestry development, it is proposed to include the following as a part of the evaluation criteria: intensity of forest reproduction and regeneration, profitability of logging, forestry financial return, forestry protection and security level and forest legislation observance. Surely, each researcher can increase and decrease the whole criteria and indicators to hold multicriteria evaluation according to the specifics of forest development in a particular country. The objects of a study may not be the regions within a country but particular countries within a given administrative area, for example, the European Union countries.

To ensure the proportionality of evaluation, it is appropriate to choose the same number of indicators for each criterion. For our research, it is sufficient to select three major indicators for each evaluation criterion. However, if researchers believe that the characteristics of forestry need more indicators, then there will be no problem to increase the number of indicators for each criterion.

According to the authors, all the indicators selected for multi-criteria evaluation criteria are important and equal. Therefore, the method provides for determination of weights among the criteria and indicators. The use of weighting factors would be appropriate when the state or regional level will prioritize the development of the forestry sector that will meet the individual criteria, indicator or group of indicators. The justification of values of weight coefficients can be carried out based on a survey of experts and summary of results scoring. It is advisable to determine that the weighting factors are directly proportional to the total number of points in the context of the selected criteria or indicators.

The complete list of criteria and groups of indicators for multicriteria evaluation of forestry development level by the regions of Ukraine is presented in Table 1.

Regions of Ukraine have different area of territories, area of forests and volume of wood that in absolute assessments provides advantage to the regions that are well-provided with forest resources. Therefore, to ensure the objectivity and comparability of results of multi-criteria evaluation, it is suitable for the scorecard to include absolute and relative performance per unit area, the area of forest land, volume of timber or the values of specific weight. The choice of this system of criteria and indicators due to the limitations of information base about the development of forestry in Ukraine, which was available to the authors from the official statistical reports (State statistics service of Ukraine – State Statistics Service of Ukraine) and forms of internal management accounting (State Agency of forest resources of Ukraine – State Agency of Forest Resources of Ukraine). Researchers from other countries while conducting similar multi-criteria evaluation of forest development can clarify the system of criteria and indicators based on the available information base.

After grouping of major indicators by defined criteria, the elaborated methodology provides calculation of individual indices of each indicator by regions and the definition of group integral indices by each criterion along with the reconciled integral index by all groups of criteria based on the calculation. Then the ranking and grouping of regions will be held according to the indicators of integral indices. This approach involves the transition from investigation of indicators' values to the

Table 1. Criteria and metrics of multicriteria evaluation of forestry development by the regions of Ukraine

Evaluation criteria	Indicators	Incentive (+), disincentive (–)
Reafforestation and afforestation intensity	Area of reafforestation by means of forest-growing on 1 hectare of territory area, hectares	+
	Area of forest recreation per 1 hectare of forest sites area, hectares	+
	Area of forest recreation per 1 hectare of harvesting area, hectares	+
Logging profitability	The volume of products, works and services of forestry per 1 hectare of forest sites area, thousands of UAH	+
	The share of merchantable wood in gross volume of cut timber, %	+
	Volume of products of timber per 1 m^3 of cut merchantable timber, thousands of UAH	+
Forestry financial return	Special forest using fee paid in average per 1 hectare of forest sites area, UAH	+
	Special forest using fee paid in average per 1 m^3 of cut timber (forestry fiscal return), UAH/m^3	+
	Special forest using fee paid to local budget per UAH 1 of government funding for forest management, protection and security of forests, UAH	+
Forest security and protection	Damages caused by forest fires per 1 hectare of forest lands, affected by fires, thousands of UAH	–
	Area of forest pests and diseases nuclei, liquidated during the year to their the total area at the end of the year, %	+
	The share of conducted works to protect of forests from pests and diseases in the total area of forest plots, %	+
Forest legislation observance	Number of illegal cuttings per 1 hectare of forest plots covered with forest vegetation, units	–
	Volume of destroyed or damaged wood per 1 hectare of forest plots covered with forest vegetation, m^3	–
	Damage to forestry per 1 hectare of forest plots thousand, thousands of UAH	–

analysis of their indices' values based on comparison with the maximum and minimum values. It is used in the statistics of the UN during such comparative evaluations in different domains (United Nations 2015).

Individual indices of each indicator within each group (Y_{ij}) are proposed to be determined using the formulas that depend on whether the indicator is an incentive (its augmentation is considered positive), or disincentive (diminution is considered positive).

For indicators-incentives that have a positive impact on the object of research development level, they are normalized using the formula (1), whereas for indicators-disincentives the following formula is used (2):

$$Y_{ij} = \frac{X_{ij} - X_{j\min}}{X_{j\max} - X_{j\min}} \quad (1)$$

$$Y_{ij} = \frac{X_{j\max} - X_{ij}}{X_{j\max} - X_{j\min}} \quad (2)$$

where:

X_{ij} – value of *i*-indicator in *j*-region;

$X_{j\min}$ – minimal value of *i*-indicator among *j*-x regions;

$X_{j\min}$ – maximal value of *i*-indicator among *j*-x regions.

In the next stage, the group index is calculated for each region using the formula of mathematical averaging simple from the values of individual indices of indicators for analogical years, which are a part of the relevant group within certain evaluation criteria.

Then the integral index of forestry development for each region will also be defined as a mathematical averaging simple from the values of group indices for analogical years.

The use of calculation of group indices and integral formulas of simple arithmetic average is explained by the possibility of further comparison of the index values of a particular region according to the criteria or indicators for certain years or a certain period with their average level. Comparison of average indicators

by time periods, geography with plans or values for previous periods will allow for a deep, reasoned analysis and evaluation of forestry development. This will also help identify patterns and reserves for increase in the efficiency of forestry development.

Elaborated methodology will also allow determining the group indices for each region and integral indices not only for certain years, but also in general for the period of 2011–2013 using the formula of mathematical averaging simple from the values of these indices for all the years of this period.

The usage of mean value to summarize the results of evaluation within the criterion and by all criteria is explained by the need to ensure proportionality and uniformity of contribution for all the factors that influence the development of forestry. The formula of mathematical averaging simple is most suitable to provide equal importance of indicators for each year of the period under analysis.

Regional grouping according to forestry development level based on defined group and integral indices in the process of comparative analysis and assessment is of high importance. It is proposed to allocate three groups with equal intervals in the process of grouping by values of group and integral indices. Grouping interval is determined by the formula:

$$L = \frac{Y_{\max} - Y_{\min}}{3} \tag{3}$$

where: $Y_{\max}$ and $Y_{\min}$ – the maximum and minimum value of individual (group or integral) index accordingly.

Regional grouping by forestry development level according to the values of individual, group and integral indices will be based on the following criteria:

– relatively low level of forestry development:

$$Y_{\min} \le I_i < Y_{\min} + L \tag{4}$$

– average level of forestry development:

$$Y_{\min} + L \le I_i \le Y_{\max} - L \tag{5}$$

– relatively high level of forestry development:

$$Y_{\max} - L < I_i \le Y_{\max} \tag{6}$$

At the final stage of multicriteria evaluation and the grouping of Ukrainian regions by forestry development level will allow to identify the very sectors for each region, where there is a need to improve the work and elaborate main measures for long-term to eliminate negative trends.

It is also expedient to represent the results of multicriteria evaluation on the administrative map of Ukraine. It is offered to highlight the results of regional grouping by the values of integral index for all the period of 2011–2013 and to represent the changes of forestry development integral indices for each region for certain years of this period in figures. It will allow the investigation of the patterns and trends of forestry development on spatial basis.

Results

The individual indices of indicators and group indices which correspond to defined evaluation criteria are determined at the primary stage as well as the Ukrainian regional grouping by the values of these indices. Then, based on the values of group indices for each Ukrainian region, the integral indices of forestry development for certain years and for all the period of 2011–2013 are defined (Table 2).

As we can see from the table, there is a certain pattern. Polissia regions are characterized by relatively high level of forestry development, Forest steppe regions have average level of forestry development, whereas Steppe and the Carpathian regions are characterized by relatively low level. However, among certain regions of Ukraine, only Zhytomyr and Chernivtsi regions demonstrated relatively high level during the whole period, while Ternopil, Odesa, Kherson, Ivano-Frankivsk, Lviv regions and the Autonomous Republic of Crimea were marked by the relatively low levels of forestry development.

The results of more detailed cartographical analysis (Figure 1) based on the resource approach shows that in a number of highly forested zones of Polissia and the Carpathians, an adequate level of ecological and economical relations is not ensured. It applies to Volyn, Lviv, Ivano-Frankivsk, Zakarpattia regions, which having considerable forest resource potential were characterized by relatively low level of ecological and economical relations in forestry in the period under analysis.

Table 2. Group and integral indices of forestry development by the regions and forest zones of Ukraine in 2011–2013

Regions	Group index of reafforestation and afforestation intensity				Group index of logging profitability				Group index of forestry financial return				Group index of forest security and protection				Group index of forest legislation observance				Integral index of ecological and economical relations development in forestry sector			
	2011	2012	2013	2011 –2013	2011	2012	2013	2011 –2013	2011	2012	2013	2011 –2013	2011	2012	2013	2011 –2013	2011	2012	2013	2011 –2013	2011	2012	2013	2011 –2013
Volyn	0.224	0.208	0.233	0.222	0.410	0.391	0.408	0.403	0.433	0.429	0.450	0.437	0.409	0.360	0.394	0.388	0.761	0.673	0.649	0.695	0.447	0.412	0.427	0.429
Zhytomyr	0.355	0.365	0.429	0.383	0.444	0.392	0.428	0.421	0.681	0.763	0.795	0.746	0.381	0.374	0.375	0.376	0.923	0.699	0.651	0.758	0.557	0.519	0.536	0.537
Rivne	0.306	0.310	0.380	0.332	0.603	0.573	0.601	0.592	0.683	0.757	0.707	0.716	0.321	0.356	0.341	0.339	0.644	0.710	0.675	0.677	0.511	0.541	0.541	0.531
Chernihiv	0.189	0.199	0.230	0.206	0.374	0.361	0.385	0.373	0.790	0.822	0.832	0.815	0.545	0.516	0.325	0.462	0.923	0.644	0.670	0.746	0.564	0.509	0.488	0.520
POLISSIA	0.278	0.468	0.393	0.380	0.456	0.425	0.450	0.443	0.617	0.680	0.697	0.665	0.407	0.428	0.358	0.398	0.822	0.684	0.661	0.723	0.516	0.537	0.512	0.522
Vinnytsia	0.170	0.135	0.161	0.155	0.389	0.342	0.346	0.359	0.391	0.401	0.389	0.394	0.660	0.676	0.681	0.672	0.660	0.371	0.651	0.561	0.454	0.385	0.446	0.428
Kyiv	0.201	0.202	0.225	0.210	0.360	0.317	0.345	0.341	0.446	0.479	0.498	0.474	0.337	0.360	0.382	0.360	0.876	0.649	0.703	0.743	0.444	0.401	0.431	0.425
Poltava	0.264	0.241	0.272	0.259	0.329	0.299	0.303	0.310	0.452	0.466	0.528	0.482	0.351	0.493	0.477	0.440	0.864	0.674	0.720	0.753	0.452	0.435	0.460	0.449
Sumy	0.201	0.186	0.196	0.194	0.490	0.440	0.427	0.452	0.706	0.812	0.794	0.771	0.332	0.347	0.030	0.236	0.899	0.659	0.637	0.732	0.526	0.489	0.417	0.477
Ternopil	0.104	0.078	0.081	0.088	0.331	0.272	0.274	0.292	0.240	0.254	0.199	0.231	0.468	0.407	0.448	0.441	0.537	0.665	0.640	0.614	0.336	0.335	0.329	0.333
Kharkiv	0.043	0.048	0.059	0.050	0.220	0.159	0.153	0.178	0.557	0.558	0.543	0.553	0.457	0.391	0.384	0.411	0.763	0.646	0.611	0.673	0.408	0.360	0.350	0.373
Khmelnitski	0.181	0.137	0.150	0.156	0.435	0.377	0.415	0.409	0.497	0.528	0.595	0.540	0.511	0.537	0.504	0.517	0.956	0.678	0.667	0.767	0.516	0.451	0.466	0.478
Cherkasy	0.147	0.139	0.148	0.144	0.402	0.381	0.389	0.391	0.465	0.501	0.553	0.506	0.425	0.362	0.494	0.427	0.966	0.641	0.665	0.757	0.481	0.405	0.450	0.445
FOREST STEPPE	0.153	0.140	0.155	0.149	0.376	0.331	0.341	0.350	0.475	0.497	0.505	0.492	0.386	0.389	0.379	0.384	0.871	0.849	0.641	0.787	0.452	0.441	0.404	0.433
Dnipropetrovsk	0.245	0.154	0.043	0.147	0.191	0.148	0.177	0.172	0.306	0.340	0.205	0.284	0.415	0.413	0.342	0.390	0.951	0.613	0.648	0.737	0.422	0.334	0.283	0.346
Donetsk	0.277	0.101	0.111	0.163	0.256	0.235	0.245	0.245	0.155	0.161	0.199	0.172	0.336	0.580	0.264	0.394	0.389	0.334	0.611	0.445	0.283	0.282	0.286	0.284
Zaporizhia	0.667	0.667	0.667	0.667	0.518	0.488	0.475	0.493	0.000	0.000	0.000	0.000	0.212	0.361	0.157	0.244	0.817	0.623	0.652	0.697	0.443	0.428	0.390	0.420
Kirovohrad	0.259	0.281	0.327	0.289	0.340	0.291	0.317	0.316	0.530	0.493	0.531	0.518	0.466	0.470	0.464	0.467	0.920	0.623	0.677	0.740	0.503	0.432	0.463	0.466
The Autonomous Republic of Crimea	0.113	0.067	0.083	0.088	0.320	0.247	0.236	0.268	0.036	0.022	0.035	0.031	0.429	0.449	0.529	0.469	0.712	0.734	0.689	0.712	0.322	0.304	0.314	0.313
Luhansk	0.383	0.347	0.340	0.357	0.230	0.199	0.208	0.212	0.087	0.111	0.116	0.105	0.485	0.470	0.419	0.458	0.834	0.621	0.639	0.698	0.404	0.350	0.345	0.366
Mykolaiv	0.604	0.485	0.158	0.416	0.504	0.395	0.399	0.433	0.085	0.063	0.045	0.064	0.358	0.381	0.371	0.370	0.946	0.712	0.587	0.748	0.499	0.407	0.312	0.406
Odesa	0.345	0.344	0.303	0.331	0.320	0.245	0.319	0.295	0.162	0.182	0.164	0.169	0.374	0.324	0.302	0.333	0.595	0.722	0.344	0.554	0.359	0.364	0.286	0.336
Kherson	0.264	0.270	0.254	0.263	0.136	0.183	0.151	0.157	0.066	0.056	0.158	0.094	0.352	0.344	0.467	0.388	0.596	0.565	0.530	0.564	0.283	0.284	0.312	0.293
STEPPE	0.301	0.256	0.230	0.262	0.260	0.221	0.234	0.238	0.188	0.187	0.190	0.188	0.390	0.414	0.363	0.389	0.742	0.624	0.604	0.656	0.376	0.340	0.324	0.347
Zakarpattia	0.313	0.325	0.358	0.332	0.172	0.109	0.130	0.137	0.531	0.480	0.515	0.509	0.436	0.369	0.381	0.395	0.474	0.360	0.626	0.487	0.385	0.328	0.402	0.372
Iv.-Frankivsk	0.277	0.324	0.358	0.320	0.232	0.188	0.196	0.205	0.315	0.325	0.317	0.319	0.394	0.362	0.350	0.369	0.673	0.656	0.700	0.676	0.378	0.371	0.384	0.378
Lviv	0.246	0.254	0.262	0.254	0.331	0.263	0.315	0.303	0.426	0.464	0.433	0.441	0.358	0.345	0.340	0.348	0.021	0.362	0.455	0.280	0.276	0.338	0.361	0.325
Chernivtsi	0.503	0.533	0.578	0.538	0.635	0.610	0.603	0.616	0.606	0.673	0.653	0.644	0.670	0.546	0.668	0.628	0.797	0.568	0.621	0.662	0.642	0.586	0.625	0.618
THE CARPATHIANS	0.299	0.318	0.346	0.321	0.312	0.259	0.278	0.283	0.431	0.447	0.444	0.441	0.385	0.354	0.351	0.363	0.430	0.465	0.595	0.497	0.371	0.369	0.403	0.381
TOTAL AMOUNT	0.189	0.182	0.201	0.191	0.367	0.325	0.342	0.344	0.436	0.445	0.442	0.441	0.392	0.395	0.364	0.384	0.726	0.607	0.638	0.657	0.422	0.391	0.397	0.403
Criteria of regional grouping by development level:										– relatively low;						– average;					– relatively high;			

It should be noted that the positive results achieved in the scarcely forested Zaporizhia region, which by the levels of reafforestation and afforestation intensity as well as logging profitability was among the leaders, surpasses similar indicators of many highly forested regions of Ukraine. We should also note that Chernivtsi region, which based on the analysis results, appeared to be in the leading group by all the specified criteria of multicriteria evaluation and ultimately was characterized by the largest value of the integral index for the period of 2011–2013.

There is a need to improve work in forestry sector in some regions of Steppe zone (Donetsk, Kherson, Dnipropetrovsk regions and the Autonomous Republic of Crimea) that were characterized by the lowest values of integral index for the period under analysis. These regions should use positive experience in the area of Zaporizhia region.

The results of a more detailed analysis of dynamics of the integral index for some years of the period under analysis show that its positive changes were specific to Kherson and Lviv regions only. The negative dynamics of integral index was typical during the period under analysis for certain regions of Polissia zone (Chernihiv region), Forest steppe (Sumy and Kharkiv regions), Steppe (Dnipropetrovsk, Zaporizhia, Luhansk and Mykolaiv regions).

The results obtained by the application of methodology of multicriteria evaluation of forestry development by the example of Ukrainian regions will help select the most appropriate strategies and programs for each region in the long run.

Discussion

The choice of criteria and indicators is of high importance in the elaborated methodology of forestry multicriteria evaluation. The system of criteria and indicators presented in this paper is formed based on the forestry sector statistical data available to the public. Of course, it cannot claim to be comprehensive of all aspects of this important part of the forest sector. Elaborated methodology reflects how the authors ad-

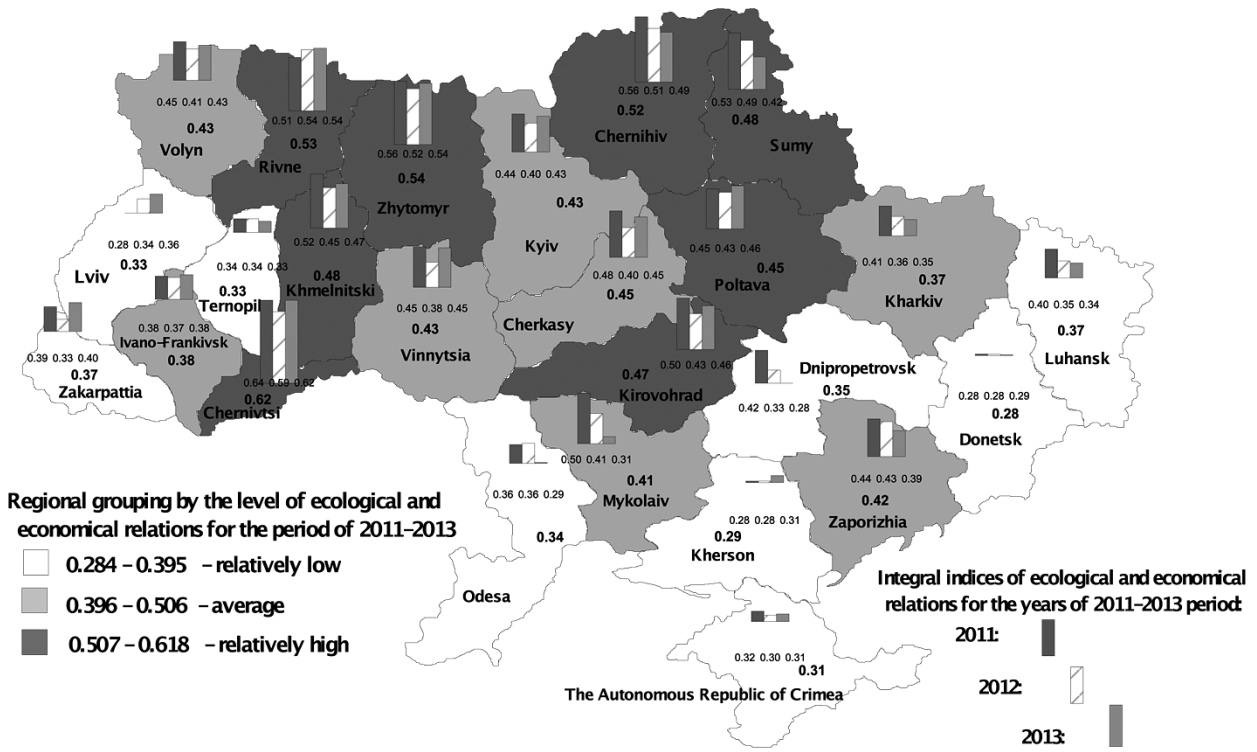

Figure 1. Results of multicriteria evaluation of forestry development level by regions of Ukraine in 2011–2013

dress the problem of finding approaches to economic and mathematical justification of promising areas of forestry development in the regions of certain country, in accordance with the principles and priorities of sustainable development.

The results of multi-criteria evaluation and the grouping of regions of Ukraine may, in the future, become the basis for justifying the choice of the type of functional strategies of forestry development for each regional management forest and hunting economy, and of public authorities at the regional level.

For regions that are in the group with relatively low level of forestry development, it is proposed to take a type of functional strategy, which involves the necessity of crisis management. Especially important is to start the implementation of the anti-crisis strategy in the Donetsk and Kherson regions, which by the results of multi-criteria evaluation have reached the lowest levels of forestry development in Ukraine.

For most regions, which provided the average level of forestry development (mainly regions in Central Ukraine) characteristic of a type of functional strategy, it involves the need to maintain stability and ensure a moderate growth. Although for some of the functional areas of forestry development, it is proposed to implement an offensive strategy that involves the need to strengthen the position and expand its sphere of influence.

The regions that are assigned to the group with relatively high levels of forestry development (Zhytomyr, Rivne, Chernihiv and Chernivtsi region), for most functional activities need to be based on the strategy, which implies the need to strengthen the position and expand its sphere of influence. Although for most areas − by the recovery rate, breeding, and protection of forests, it is proposed to focus on a strategy of crisis management, as they have provided a high standard of performance at the specified evaluation criterion.

Thus, Ukraine has a great potential in terms of forest resources that can ensure stable development of the forest sector in the long run. For this purpose, there is a necessity to ensure sustainable use and expanded reproduction of forest resources, to step up the efforts to secure and protect forests, and to increase revenue from forest resources usage. However, not all regions of the country are marked by a relatively high potential of forest resources. Thus, Ukraine must ensure its most efficient use and enhanced safety.

On the basis of multicriteria evaluation and regional grouping, and by representing their results on the administrative map, it is possible to make a conclusion that in Ukraine, in certain regions of different vegetation zones, a level of forestry development adequate to their potential is not ensured. This concerns most regions of Polissia and the Carpathian regions. This situation has arisen due to shortcomings in the system of redistribution of funds for the development of forestry in Ukraine. Highly forested regions get a limited amount of forestry budget financing (10% of the total demand) and are not interested in spending the extra money for an extended reforestation, forest security and protection as well as forest legislation observance. The unforested regions marked by powerful industrial potential require fewer amounts of funds for forestry development. Reafforestation in these regions takes place in accordance with certain budget and is financed from the state budget, which does not contribute to the search for alternative sources of funding and expansion of the tax base.

Conclusions

For the purpose of conducting multiobjective indexing for evaluating the development of ecological and economic relations in forestry in the regions of Ukraine, a set of criteria (intensity of reforestation and afforestation, yield logging, the financial return of forest management, forest protection, forest law compliance) and system of metrics has been defined. Also, based on the common experience of ONN, a method of comparative estimates has been developed. The set of criteria, system of metrics and comparative estimates together provide the transition from the study of values of indicators to the analysis of values of their indexes, on the basis of comparison with the maximum or minimum values. It is proved that for the authorities of several regions of the zone of Polissya and Carpathians, it is necessary to revise the approaches to the organization of ecological and economic relations in forestry, and regions with scarce forest of the Steppe zone to study the positive experience in Zaporizhia region. The obtained results

can be the basis for prioritization of transformational change in each region.

The results of multicriteria evaluation may serve as a basis for further determination of the basic provisions of forestry development regional policy for each region, based on the results of their grouping by values of group and integral indices. This will allow to determine the priority areas of forestry development for each region as well as to monitor the effectiveness of measures to be implemented by regional authorities.

Elaborated methodology of multicriteria evaluation can be used for analogical evaluation of forestry development for other countries and their regions, or for a set of countries in certain territory. The advantage of this methodology is simplicity of calculations and a possibility to see the intermediate results of the evaluation and regional grouping by selected criteria. In addition, researchers can increase or decrease the number of criteria and indicators of evaluation corresponding to them, depending on the specificity of forestry development in a particular country or region.

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