

Validation of a methodology for forest industry sector sustainability assessment

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Abstract. The research is devoted to the development and testing of a methodology for assessing the level of sustainability of the forest industry. The work presents the general specifics of the methodology, the formula for calculating the sustainability index, the justification of the original approach, taking into account the specifics of the forest industry. The method is based on a system of economic, environmental and social indicators. The evaluation is based on the example of the forest sector logging sector. As a result of the approbation, it was determined that sustainability of forest industry development is below average in most regions of the country. The proposed methodology can be used as a justification for the necessity of transformations in the forest industry sector. This direction of industry is recognized as one of the underestimated and perspective in the sphere of modern requirements of the society to development of economy. The activity of the forest industry is associated with both timber production (deforestation) and reforestation. This makes it a unique industry. By using renewable resources in production, the industry can be seen as truly capable of adopting and implementing sustainable development. As a consequence, studies aimed at evaluating the various projects related to sustainable development in the forest industry are highly relevant. **Keywords:** Sustainability of Development, Forest Industry Sector, Sustainability Index, Timber Production, Modelling.

1 Introduction

The forestry sector is one of the most interesting sectors for the development of the modern economy. It has several unique characteristics that allow it to meet the trends of society. Quite a number of studies have been devoted to the forest industry and its individual aspects [1-3]. One of their important results is the definition of the main raw material of the industry - timber - as a valuable resource that allows the production of a variety of products. At the same time, the added value and price of goods increase significantly as the depth of wood processing increases. At the same time, it is generally accepted that the basic industry for the entire forest industry is the logging industry [4]. It is associated with the harvesting of timber in the forest area, its certain primary processing, and transportation to the end consumer.

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One of the most important requirements and trends in economic development is the transition to the principles of sustainable development, the development of a "green economy" [5]. The main idea of such approach consists in the observance of the balance between economic, ecological and social needs in the development of industry. This task is quite difficult under the conditions of the necessity to increase industrial production more and more to meet the urgent needs of the population.

As a result of this work, many authors point out that sustainable development is only possible in industries that use renewable raw materials [5, 6]. This approach focusses on the forest sector, where wood is a renewable resource. And its regeneration takes place both naturally and artificially. Thus, the forest industry has a powerful tool to actively use the principles of sustainable development.

However, of course, sustainable development does not only imply withdrawal and restoration of forest resources, but also a set of other measures and principles of organization. In this regard, the following aspects can be highlighted: taking care of the personnel and population, reducing emissions and waste generation, preserving biodiversity and many others [7].

At the moment, there are various approaches to assessing the sustainability of individual objects (enterprises, regions, countries) [8]. However, as the author's research shows, all of them are fragmented, use heterogeneous databases for analysis, and are very complicated for calculations and interpretation of the results. Nevertheless, we can identify three groups of factors (indicators) traditionally used in obtaining sustainability models (indices): economic, environmental and social [9]. Thus, it is the indicators of these groups that should be used to assess the sustainability of specific objects. In this case, the development of an adequate and practically applicable methodology for determining the level of sustainability of various objects is an extremely urgent task.

Turning to Russia, the country with the largest timber reserves, it is worth paying attention to the fact that its territory is extremely differentiated by its natural-climatic and resource conditions. The territory of this country differs in climatic zones, natural zones, relief, urbanization level, etc. These factors have an impact on the size and quality of the forests and their accessibility. The forest industry is one of the oldest in the country. This leads to depletion of timber resources in some areas. Considering the structure of the country, it is most suitable to analyse the level of sustainability by region. They have a certain unity, availability and quality of wood resources, specifics of forest policy, level of development of forestry industry, etc.

Taking into account the above-mentioned features, the purpose of the current study is to develop and test a methodology for assessing the level of sustainability of the forest industry in the regions of the country on the basis of economic, environmental and social parameters.

2 Materials and Methods

The paper contains the results of a desk study. It uses analytical and statistical methods. The development of the methodology for assessing the level of regional sustainability is based on scientific works in the sphere of sustainability analysis, as well as the development of regions and countries [10-13]. An assessment algorithm is proposed, the use of which allows applying a set of different indicators characterizing economic, environmental and social processes in the objects under study for the analysis.

The developed methodology was tested on the basis of statistical data contained in the Unified Interdepartmental Statistical Information System (UISIS). The objects used for testing were logging in the forestry sector. The data were processed using Statistica software.

3 Results and Discussion

A methodology for assessing the level of sustainability of the regions in the country has been developed as a result of the study of approaches to the subject matter of this work. It is based on a system of economic, environmental and social indicators. The principal algorithm of the methodology is as follows:

- Formation of an approach for assessment.
- Development of a set of utilized indicators.
- Formation of a database on the objects under study.
- Assessment of the level of sustainability of the objects under study.
- Analysis of the obtained results.

The first step of the algorithm is the most important from the fundamental point of view. To determine the level of sustainability of objects we need to calculate the sustainability index. It is defined as follows:

$$I_i = \sqrt[m]{\frac{x_{i1}}{x_{max1}} \cdot \frac{x_{i2}}{x_{max2}} \cdot \dots \cdot \frac{x_{ij}}{x_{maxj}}}, \quad (1)$$

here: I_i – Sustainability level index of the i -th object of the study (in a group of objects), $i = 1 \dots n$;

x_{ij} – value of the j -th indicator for the i -th object of the study, $j = 1 \dots m$;

x_{maxj} – is the maximum value of the j -th indicator among the study objects;

n is the number of study objects;

m - number of indicators used to investigate the level of sustainability.

For the objects of this study - the regions of the country - a certain adjustment should be made. Due to the fact that Russia is a huge country with significantly different regions by various parameters, it is correct to calculate x_{max} for each of the used indicators for a similar group of regions. In the author's opinion, it is most correct to use maximum values for federal districts as a basis for comparison. So, as far as the proposed model is concerned x_{maxj} is the maximum value of j -th index in federal district the region in question belongs to. Table 1 represents the scale for assessment of sustainability level of forest industry in the regions of the country. It should be clarified that the presented scale reflects only general aspects of assessment of results. Detailed results can be obtained in the analysis of the practical results of the study of the level of sustainability of the forest industry in the regions of the country.

Table 1. Scale for assessing the level of sustainability of the forestry sector in the regions of the country.

Value of the regional sustainability index	Sustainability level	Brief description
0.8-1.0	Absolute sustainability	A reasonable balance between the interests of society, production and the environment. The regions pay due attention to sustainable development, the forest industry is characterised by a holistic approach to the use of wood resources and is a leader in terms of production volumes.
0.6-0.79	Standard sustainability	Appropriate approach to the sustainability of the forest industry, the region is a major producer. Environmental and social issues are adequately addressed.

0.4-0.59	Low sustainability	Insufficient attention has been paid to the sustainability of the forestry sector, with the region as a whole ranking average among its competitors in many respects.
0.2-0.39	Unsatisfactory sustainability	Sustainability issues receive limited attention, significantly lagging behind other regions.
< 0.2	Absolute instability	Virtually all of the research indicators are at a minimum and the region pays little or no attention to many of the most important issues. The scope of activity of the forestry sector is at minimal levels.

The next stage of the study is to form a set of indicators to be used. Based on the results of the analytical study of the author's team, it is suggested that a group of indicators characterizing economic, environmental and social aspects of the forest industry should be used to analyse the level of sustainability. The list of specific indicators used for analysis can vary greatly depending on many factors. They can be: goals of the analysis, existence of actual values of the indicators, depth of research, specific objects of forest industry research etc. However, it is the author's opinion that the following indicators are most appropriate:

- economic: profitability, volume of output, net profit, revenue, cost of production;
- environmental: depth of wood processing, reforestation area, share of environmental costs in production costs;
- social: the number of people employed in the industry, wages and salaries, the share of labour costs in the cost of production, etc.

The indicators presented generally correspond to different categories but, at the same time, are aimed at assessing the positioning of the objects under study in terms of sustainable development. It is optimal that, when selecting indicators, the number of indicators should be equal in each of the groups mentioned. This will avoid a focus on any one aspect of the forest sector. If this is not possible, weighting coefficients for the indicators should be used. These can be determined by expert judgement or by mathematical methods, distributing weight among the indicators of one group in order to achieve an overall balance among the three groups of criteria.

Next, it is necessary to form a database for the selected indicators and assess the level of sustainability of forestry regions.

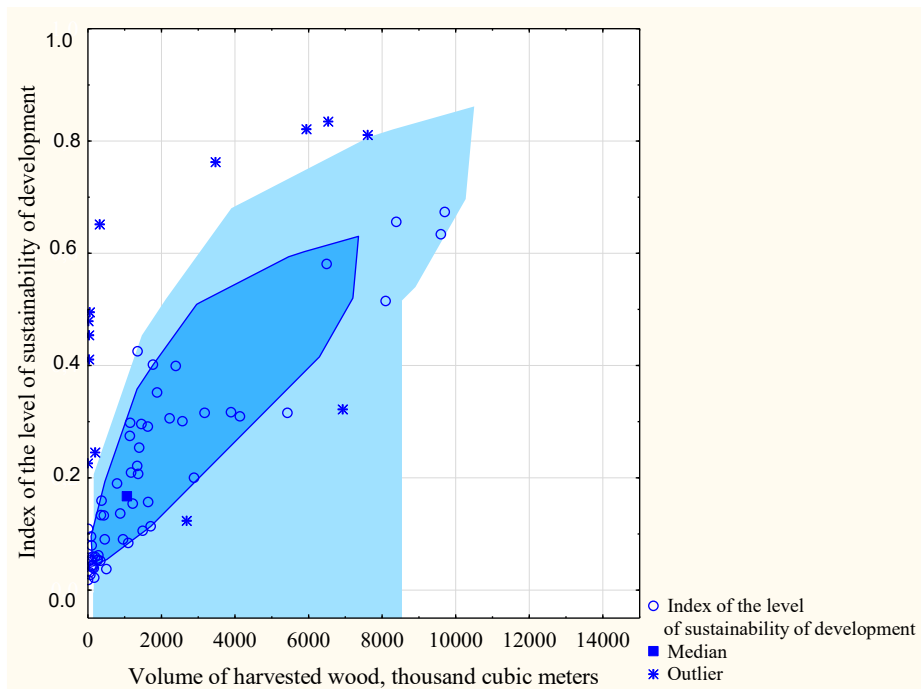
The author's team tested the proposed methodology on the example of the forestry sector. As evaluation indexes the following ones have been chosen: volume of harvested wood, thousand m³, average monthly salary per employee, rubles, forest regeneration area, ha. The use of a limited number of indicators was made to simplify and demonstrate the principal positions of the regions of the country in the context of sustainable development. Based on formula (1), we have calculated an index of the level of regional sustainability in terms of logging.

A fragment of the database with the results of the calculation of the sustainability index is presented in Table 2.

Table 2. Fragment of the database with the results of the Sustainability Index of the forestry sector in the regions of the country.

Region	Reforestation area, ha	Volume of produced timber, th. m ³	Average monthly wage per employee, RUB	Sustainability index value
Belgorod Oblast	70.64	65.96	27347.0	0.03
Bryansk Oblast	3261.53	1394.06	22538.3	0.25
Vladimirskaia Oblast	6 075.00	1 770.81	37709.0	0.40
...				
Khabarovsk Krai	64585.80	6 490.30	43575.6	0.58

The next stage of the study is the results analysis. Figure 1 shows the distribution of sustainability indices for the forestry sector in the regions of the country. Based on the data presented, it is clear that the level of sustainability for most regions is low, unsatisfactory and unsustainable. To a certain extent this is due to the fact that there are few regions that are actually actively engaged in sustainable development. At the same time, the indicators used in the analysis have the highest values for a limited number of regions.

**Fig. 1.** Concentration diagram for the Index of the level of sustainability of development and Volume of harvested wood.

The regions analysed include the following: Arkhangelsk, Vologda, Sverdlovsk, Irkutsk oblasts, Krasnoyarsk Krai, Khanty-Mansi Autonomous Okrug and a number of others. It is in these regions that the highest values of the index of the level of sustainability of forest sector development are observed. It is important to note that these regions are leaders simultaneously in all three studied indicators, which predetermines their overall high value

of the sustainability index.

Obviously, the results of the final index are determined by the quality of the initial data. An important aspect of the study is the adequacy of the results and models. In the course of this work, models reflecting the dependence of the final index on the indicators used have been derived for the final sustainable development index value. An example of the relationship is shown in Figure 2. The shape of the resulting response surface indicates significant dependence of sustainability on logging and reforestation volumes. Validation of the resulting models indicates a high value of coefficients of determination ($R^2 = 0.68-0.75$). This corresponds to quite acceptable models.

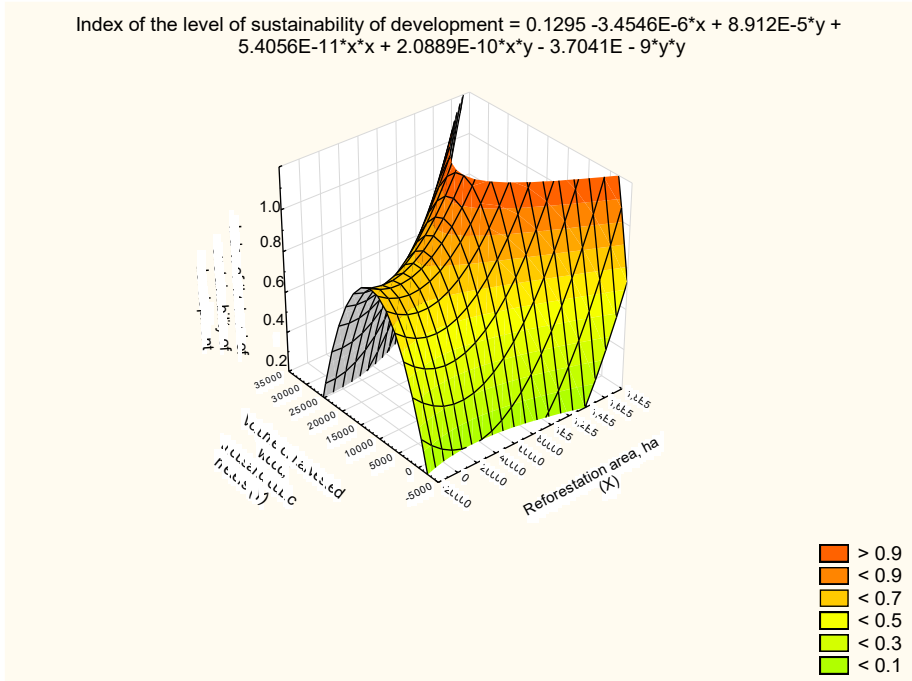


Fig. 2. A three-dimensional model of the relationship between the sustainability index and the volume of production and reforestation.

The results are largely dependent on the volume of activity (production, reforestation, etc.), which is one of the important outcomes of testing the methodology. However, regions with little production capacity are not a priori able to achieve high sustainability. To a certain extent, this negative point is mitigated by using the maximum indicators for the federal district rather than for the country as a basis for comparison in calculations (1). However, in order to obtain an even more accurate and adequate assessment, relative indicators, together with absolute ones, should be used in the calculations. Examples are the ratio of reforestation to logging, the growth rate of wages, profitability, etc.

The study carried out by the authors in the light of this recommendation made it possible to slightly adjust the results obtained. At the same time, it should be noted that the deviation of the level of sustainability of the forest industry by regions from the initial results of the approbation was 15-20%. In general, the new values obtained are in line with the overall picture for the country. Regions with traditionally developed logging and forestry as such are characterised by a higher level of sustainability. This is due to the attempts made to improve the sector's activities in various aspects, including sustainability.

4 Conclusion

The research has resulted in a methodology for assessing the level of sustainability of the forest industry in the regions of the country on the basis of economic, environmental, and social parameters. The research algorithm and formula for calculating the sustainability index are presented, and the rationale for its application to the forest industry is given. The testing of the developed methodology has revealed that there is not enough attention to the problem of sustainability in most of the regions of the country. At the same time, the leading regions are distinguished by dominance in their federal districts by all the indicators used in the calculations.

A logical continuation of the collective work is to identify the most appropriate indicators that can be used to assess the level of sustainability of the forest industry. Another important continuation of the work will be to obtain dependency models of the level of sustainability of the forest industry in the regions and enterprises of the country on the complex of parameters that can be selected. This will allow more rapid monitoring of changes in the forest industry. Another promising area of work is forecasting changes in the sustainability of the forest industry in the country.

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