

Balancing of economic, ecological and social functions of forests: Case of Lithuania

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Abstract: According to the aims of this study, the balance of economic, ecological and social function groups of Lithuanian forests has been assessed. The study based on the methodology of European criteria and indicators for Sustainable Forest Management (SFM) and on the composite indicators construction methods. The balance of economic, ecological and social functions means their equal assessment in the SFM index in order to achieve maximum index of indicators and criteria (100%). Lithuanian forests economic, ecological and social functions are unbalanced. The lowest assessed is forests economic functions (index 39.8%), more is ecological (index 63.9%) and mostly is social (index 69.7%). In the SFM overall index, economic functions accounts for 23.0%, ecological functions for 36.8%, and social functions for 40.2%. This shows that in Lithuania all forest functions groups (economic, ecological and social) should be encouraged, especially - economic. The study develops a methodology for assessing the SFM by supplementing it with assessment the balances of forest functions.

Keywords: balancing, forest functions, criteria and indicators, sustainable forest management.

1. Introduction

Due to the competitiveness of some forest functions (such as wood supply and biodiversity or recreation), the SFM is linked to the goal of balancing the economic, ecological and social functions of forests. Many scientific articles and forest policy documents have highlighted the need to ensure a *balance* between the economic, ecological and social functions of forests. The European Union Forest strategy declared: SFM must ensure delivering multiple goods and services in a *balanced* way [1]. The multiple-use forestry should be promoted to achieve an appropriate *balance* between the various needs of society [2]. *Balancing* the inherent trade-off between satisfying immediate human needs and maintaining other ecosystem functions, requires quantitative knowledge about ecosystem response to land use [3]. It is vital that we find the *balance* between conserving and regenerating forest areas with economic growth for poverty reduction [4]. We have a responsibility to become more self-sufficient in our use of timber and relative products whilst at the same time maintaining a *balance* between the environmental, social, and economic benefits of a sustainability managed native forest landscape [5]. A sustainable development of mountain territory requires that economic and ecological issues are carefully considered and *balanced* [6]. Policies should better account for the multi-functionality of forests and should better optimize the *balance* between social, economic and ecological contributions [7]. Those environmental, social and economic values should be *balanced* by using forest practices that give priority to process had given priority to protecting and enhancing biodiversity [8]. Benefits from timber harvesting must be *balanced* with the implicit and usually non-monetary value provided by forest ecosystem services [9]. SFM is a term highlighting the management of forest that secure all required services in continuous and *balance* way [10]. Concepts and instruments that integrate the habitat requirements of forest biots into the management and production of other forest goods and services are mandatory for sustainable forestry that *balances* human commodity needs with the management of natural resources and ecosystem services [11]. Discussion between environmental ministers on the forest strategy is likely to focus on the *balance* between different uses of forests [12]. Although the goals of balancing forest functions widely declared the European SFM analysis system in which Lithuania participates does not assess the balance of forest functions. The first pan-European set of criteria and indicators for SFM was adopted at the Ministerial Conference held in Lisbon 1998

and then revised in 2003 and 2015 [13]. Five reports were issued by the Ministerial Conference on the Protection of Forest in Europe [13, 14, 15, 16, 17]. The overall aim of these reports was to provide policy and decision makers and stakeholders on the status and trends on forests and SFM in Europe for the indicators of the six criteria: forest resources and their contribution to global carbon cycles, forest ecosystem health and vitality, productive functions of forest (wood and non-wood), biological diversity in forest ecosystems, protective functions in forest management (notably soil and water), and other socio-economic functions and conditions. Indicators are not grouped according economic, ecological and social criteria. The level of SFM and balances of forest functions has not been assessed. Without assessing the balance of forest functions implementation of the SFM idea based on fulfil the economic, ecological and social functions of forests remains unclear.

Taking into account the challenges of balancing the functions of forests, the aim of this study was to assess the balance of economic, ecological and social functions of forests in Lithuania.

2. Materials and Methods

The SFM of Lithuania has been assessed on the basis of European criteria and indicators for SFM [13] applying composite indicators construction methods [18]. Steps of this assessment [13, 16, 19, 20-23]: 1. List of criteria and indicators. 2. Description of indicators and determination of their actual values. 3. Defining indicators threshold. 4. Indicators assessment (normalization). 5. Assessments of criteria. 6. Assessment of SFM and balance of forest functions.

List of criteria and indicators. The list of European criteria and indicators from the report State of Europe's Forests (SoEF) 2020 was applied [17]. It has been transformed into criteria economic, ecological and social. Economic indicators associated with multiple benefits of forests to society – include productive capacity, competitiveness of resource industries, contribution to the national economy, on non-wood values [24] Ecological indicators characterize the forest ecosystems integrity, productivity, resilience and biodiversity [25]. Socio-cultural values and conditions associated with quality of life, public access to non-market benefits and resources [26].

Description of indicators and its values. The indicators are described in the report State of Europe's Forests (SoEF) 2020 [13]. The source of actual values of Lithuanian indicators was the Lithuanian data of this report.

Defining indicators threshold. The threshold values for assessing indicators were not presented in the SoEF 2015, and 2020. Therefore, the SoEF 2011 maximum and minimum values for indicators: 1.1-1.5, 1.7, 1.8, 2.1-2.4, 2.7, 2.8, 2.10-2.15, 3.1, 3.3-3.6 (numbering according Table 1) [16] were used in this study. Thresholds values were calculated as the average of three European countries top performance for indicators not included in the SoEF 2011 Report: 1.6, 2.6, 2.16-2.19, 2.21, 3.2. The maximum value of the indicator $\max(x)$ corresponds to 100% index, minimum value $\min(x)$ – 0% index.

Indicators assessment (normalization). The indexes of indicators were calculated according to values normalization formula [18, 19]:

$$I_{ij} = \frac{x - \min(x)}{\max(x) - \min(x)} * 100, \quad (1)$$

where I_{ij} – index of i indicator of j criteria, %; x – actual value of indicators; $\max(x)$, $\min(x)$ – maximum value, minimum value, respectively.

Aggregation. The index of the criteria was calculated as the average of the indicators index:

$$I_j = \frac{1}{n_{ij}} \sum_i^n I_{ij}, \quad (2)$$

where I_j – index of j criteria, %; n_{ij} – number of i indicators of j criteria; I_{ij} – index of i indicators of j criteria, %.

The country overall SFM index calculated as the average of the criteria indexes:

$$I_o = \frac{1}{m} \sum_j^m I_j, \quad (3)$$

where I_o – country overall SFM index, %; m – number of j criteria.

Balance. The balance of forests functions has been assessed comparing SFM indexes of economic, ecological and social functions. The balance means an equals economic, ecological and social criteria indexes in order to achieve maximum index of indicators and criteria (100%).

3. Results

Lithuanian SFM overall index was assessed at 57.8%. The lowest assessed forest economic function (39.8%), more- ecological (63.9%) and mostly -social (69.7%) (Table 1).

Table 1. Assessment of Lithuanian SFM indexes.

Indicators	Unit	Years	Value of indicators			Index, %
			Actual (x)	Maximal max(x)	Minimal min(x)	
Economic						
1.1 (6.2) ¹ Contribution of forest sector to GDP	%	2015	2.43	3.1	0.6	73.2
1.2 (6.3) Net entrepreneurial revenue	€/ha	2011	37.3	176	0	21.2
1.3 (3.3) Value of marketed non-wood forest goods	€/ha	2015	3.8	66	0	5.8
1.4 (3.4) Value of marketed services on forests	€/ha	2015	0.3	6.1	0	4.9
1.5 (3.2) Ratio: value of marketed roundwood / growing stock	€/1000 m ³	2015	510	931	254	37.8
1.6 (6.4) Investment in forests and forestry	€/ha	2015	19.7	117	2	15.4
1.7 (6.8) Net import as per cent of consumption	%	2015	-16.8	-71	66	60.4
1.8 (6.9) Share of energy from wood in energy production	%	2020	62.8	51	4	100
On average						39.8
Ecological						
2.1 (1.1) Annual change in forest area	%	2010-2020	0.1	0.21	-0.21	73.8
2.2 (1.2) Annual change in growing stock	m ³ /ha	2010-2020	1.3	3.1	-1.1	57.1
2.3 (1.3) Per cent of even-aged forest in regeneration phase	%	2015	18.4	20	0	92.0
2.4 (1.4) Annual change in total living carbon stock	%	2010-2020	1.4	2.1	-1.1	78.1
2.5 (2.1) Deposition and concentration of air pollution in forest	ND	ND	ND	ND	ND	ND
2.6 (2.2) C/N index	index	2015	13.5	20.7	10.9	26.5
2.7 (2.3) Per cent of sample trees in defoliation classes 2+3+4	%	2019	19.2	8	81	84.7
2.8 (2.4) Share of forests damaged (exc. Fire)	%	2015	0.1	1.0	13	100

2.9 Forest land degradation (2.5)	ND	ND	ND	ND	ND	ND
2.10 (3.1) Ratio: felling/net annual increment	%	2015	70.3	0	101	30.4
2.11 (4.1) Share of single species stands	%	2015	14.7	14	71	98.8
2.12 (4.2) Share of natural regeneration	%	2015	45.4	96	14	38.3
2.13 (4.3) Share of plantations	%	2020	0.0	0.9	76	100.0
2.14 (4.4) Share of introduced species	%	2020	0.1	0.19	46	100.0
2.15 (4.5) Value of deadwood	m ³ /ha	2015	22.8	16	6	100.0
2.16 (4.6) Number of population for genetic conservation	number/million ha	2020	60	620	0	9.7
2.17 (4.7) Forest patches separated by non-wood forest land	%	2018	13.1	41.5	1.2	29.5
2.18 (4.8) Number of threatened tree species	number/million ha	2015	17.4	0	96	81.9
2.19 (4.9) Area protected	%	2020	16.1	21	14	30.0
2.20 (4.10) Occurrence of common breeding bird species related to forest ecosystem	ND	ND	ND	ND	ND	ND
2.21 (5.1) Share of protective forests	%	2020	9.9	53.2	0	18.6
On average						63.9
Social						
3.1 (3.5) Percentage of forest under management plan or equivalent	%	2020	100	100	0	100.0
3.2 (6.1) Share of private forests	%	2015	38.4	0	84.8	54.7
3.3 (6.5) Forest sector labour force as per cent of population	%	2015	1.4	1.31	0.19	100
3.4 (6.6) Non-fatal accident per 1000 workers	number	2015	2.8	4.9	36	100
3.5 (6.10) Annual visits per hectare	visits/ha	2011	61.5	501	49	2.5
3.6 (6.7) Consumption of wood products (roundwood equivalent) per head	m ³	2015	2.0	3.0	0.44	60.9
On average						69.7
Total average						57.8

¹ Indicators numbering according [17]

ND – No data

Lowest assessment of economic function results in income from wood, non-wood products and forest services. Lithuanian forestry outputs are the lowest in the Baltic and Central-Eastern Europe countries (Table 2). The highest rated economic indicators: 1.1 Contribution of forest sector to GDP and 1.7 Net import as per cent of consumption.

Table 2. The outputs of forestry and connected secondary activities in Baltic and Central-East Europe countries at 2016-2018 (Eurostat data)

Countries	Output, €/ha			
	2016	2017	2018	An average
Estonia	278.7	289.6	367.3	311.9
Latvia	290.8	306.0	416.1	337.6
Lithuania	195.4	216.6	261.0	224.4
Romania	330.5	320.5	422.4	357.8
Czech Republic	933.0	1017.5	1061.9	1004.1
Hungary	244.0	257.0	274.7	258.6
Poland	538.3	590.0	592.5	573.6
Slovakia	649.4	680.0	616.7	648.7

The higher assessment of ecological functions results positive changes in growing stock and biomass carbon, absence of forest plantations, a large amounts of dead wood, lower share of single species stands, small proportion of introduced tree species. Lowest assessed ecological indicators: share of protected and protective forests, number of population for genetic conservation. The highest assessment of social forests functions leads indicators: forest share with forest management plans, the percentage of the forest sector labour force in the population and the low number of accidents. Lowest assessed the social indicator-annual visits per hectare for recreation.

Forests economic, ecological and social functions are unbalanced. In the SFM overall index (57.8%), economic functions accounts for 23.0%, ecological functions for 36.8%, and social functions for 40.2%. In order to achieve the balance of Lithuanian forest function groups all forest function groups (economic, ecological and social) should be encouraged especially economic.

4. Discussion

There are no possibilities to compare the results of this study with other analogous studies, because the studies on balancing of forest functions is not available in Lithuania and not only.

Lithuanian and other European countries SFM is assessed in the State of Europe's Forests reports. European SFM criteria and indicators are applied. Lithuanian forest authorities periodically provided initial data for these assessments. Five State of Europe's Forest reports have been published. In the year of 2003, the report presented the SFM indicator values of each European country, grouped according to SFM criteria [14]. In the year 2007, the indicators in the report were still grouped according to six European regions (Central Europe, East Europe, Nordic Baltic, North West Europe, South East Europe, South West Europe) and established trends since 1990 [15]. The most detailed assessment of European Forest SFM were carried out in 2011. In addition to describing the states and trends for the quantitative and qualitative indicators the State of Europe's Forest 2011 report assesses progress towards SFM in Europe. For this purpose a new experimental method has been used. For each indicator, the official data supplied by countries were assessed on a scale from one to five, using objective and transparent parameters and thresholds. These results were combined to provide assessments at the level of six countries groups. For most country groups and indicators, the assessment shows a balanced and generally satisfactory situation. Almost all the assessments at the level of criteria and country groups are satisfactory, at the level 3 and 4. The data and method are not yet suitable to assess individual countries or to provide a single overall assessment for sustainability [16]. However, the assessment experiment was not expanded, and in 2015 and 2020 State of Europe's Forests reports focused only on describing state and trends of indicators.

The application of the SFM criteria and indicators reveal gaps in the supply data. The following challenges have been identified in the Forest Europe process: the lack data, weak data, difficult to harmonize the definition, expensive data collection, lack of meaningful information [27]. Lithuania has a wealth of data on forest areas and wood resources.

However, there is a lack of statistical data on forests services, non-wood products, recreation in forests, forest economy. Some indicators on Lithuanian forest management were still missing from analysis of State of European forests in 2020 [17]. E. g., annual visits in the forest, investment in forests and forestry, income factor and net entrepreneurial revenue. European criteria and indicators not fully take into account of the specificities of individual countries. For example, the indicators "Export round-wood" and "The share of associated private forest owners" would be important for the assessment of Lithuanian SFM. High export of roundwood in Lithuania (20-30%) has a negative impact on the country's economy. There is in Lithuania the unresolved problem of association and cooperation of several hundred thousand private forest owners. These and some other important indicators for the assessment of SFM are not included in the European list.

Threshold is an important task in assessing SFM. Only in the SoEF 2011 Report were experimental thresholds used in the Forest Europe. They were not applied later in 2015 and 2020. SFM thresholds values for Lithuania forests have do not exist either.

Debatable is the weighting of criteria and indicators in the calculation of the indexes of SFM. This question was extensively analysed in the early stages of developing the SFM methodology [20-21]. The main approaches to designing weights include equal weights, mathematical weights, expert weights, and subjective weights [28]. Due to the difficulty and uncertainty in determining weighting factors based on experts' opinion, equal weighting was suggested [18]. Equal weighting was used in methodology of the Europe Sustainable Development Report 2020. Equal weights were therefore retained and countered as the most suitable option [19]. European SFM assessments also do not assess the significance of criteria and indicators [13-17].

The methodology of Forest Europe aims to provide policy and decision makers and stakeholders with updated information on the status and trends in forest and SFM in Europe. The current State of Europe forests assessment system cannot perform assessment of the SFM and forest functions balance of each country due to informational and methodological problems. Therefore, individual assessment of each country based on the common principles of European SFM assessment are required, taking into account the peculiarities of their forest management. This study develops methodology for assessing the SFM on the country level by supplementing it with assessment the balance of forest function groups.

The assessments of Lithuanian SFM in this study raise problems for further research into the development of Lithuanian national SFM monitoring system: adaptation of European SFM criteria and indicators on Lithuanian conditions, statistics of actual values of indicators, threshold values, assessment procedures, assessment of forest functions balance.

5. Conclusions

Lithuanian forests economic, ecological and social functions are unbalanced. The lowest assessed forests economic functions (index 39.8%), more was ecological (index 63.9%) and mostly was social (index 69.7%). In the SFM overall index, economic functions accounts for 23.0%, ecological functions for 36.8%, and social functions for 40.2%. Lowest assessment of economic function results in income from wood, non-wood products and forest services. Lithuanian forestry and connected secondary activities outputs (€/ha) is the lowest in the Baltic and Central-Eastern Europe countries. The higher assessment of ecological functions results positive changes in growing stock and biomass carbon, absence of forest plantations, a large amount of deadwood, lower share of single species stands, small proportion of introduced tree species. Lowest assessed ecological indicators: share of protected and protective forests, number of population for genetic conservation. The highest assessment of social forest functions leads to forest share with forest management plans, the percentage of the forest sector labour force in the population, and the low number of accidents. Lowest assessed the social indicator- annual visits per hectare.

When evaluating the conclusions of the study on the unbalance of the Lithuanian SFM, it is necessary to take into account the fact that the European list of indicators does not fully take into account the specifics of Lithuanian forests. There are no threshold values for indicators adapted to Lithuania, no statistics for some indicators actual values. The assessments of Lithuanian SFM in this study raise problems for further research into the development of Lithuanian national SFM monitoring system: adaptation of European SFM criteria and indicators on Lithuanian conditions, statistics of actual values of indicators, threshold values, assessment procedures, assessment of forest functions balance.

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