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## Conceptualization of sustainable boreal forests development in present-day economics.

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## **Conceptualization of sustainable boreal forests development in present-day economics**

A new synthetic approach to sustainable development of the regional timber cluster evaluation of the Komi Republic that considers the system structure integrity is worked out. Methodological and applied schemes of sustainable development evaluation of the regional timber sector are tested and possible mechanisms of the evaluation results use in sustainable boreal forests planning are described.

Key words: concept, sustainable development evaluation, boreal forests, synthetic model of the timber cluster duality.

In September 2013 the Russian Federation Government approved basics of the state policy in forest use, conservation, protection and regeneration on the territory of the Russian Federation by 2030, which in fact means implementation of a long-term planning concept of social and economical development in forest use. It was made in accordance with the RF President's mandate summarizing the results of the State Council presidium meeting that took place on April 11<sup>th</sup> 2013. One of the main aims in forest planning and sustainable development is evaluation of boreal forests resource and ecological potential, scientific rational of the balanced use and northern taiga forests regeneration.

### **Research methodology**

Forest sector of economics is divided into two unequal parts: forestry and forest use. That difference strengthens an impact of one uneven part onto the other and initiates its development.

Introduced by R. Descartes in analytical geometry in 1637 the notion of Cartesian product allows making some linear transformation as the product of two linear transformations [1]:

$$A = K R, \quad (1)$$

where  $A$  – is a linear transformation, which reflects a continuously emerging new dimension of future sustainable development, in our case timber sector, «a sum of dilemmas» of present; on the right there is the product of linear transformations  $K$  и  $R$  – matrixes, possessing a diverse composite structure, where  $K$  – is a transformation, in our case forest use, is responsible for strengthening-weakening processes, it is a transformation of coevolution;  $R$  – orthogonal transformation of forestry, that is responsible for the symmetry, harmony and optimality.



The physical meaning of the formula (1) is that, sustainable timber cluster development in reality contains as a minimum two qualitatively different characteristics or functions: forest use and forestry.

The aim of a mathematical description of interactions and connections in the system of sustainable development of timber sector is to get optimal solutions for sustainable timber sector management. The optimal structure of the projecting system of sustainable timber sector development can be reached when both transformations ( $K$  and  $R$ ) are proportional among themselves.

To get a general solution of the task, if correlations of matrixes  $K$  and  $R$  get the maximum of the linear transformation ( $A$ ), we put in the following designations of apparent variables:

$$K = \alpha X_1; \quad (2)$$

$$R = \beta X_2; \quad (3)$$

$$A = \alpha \beta X_1 X_2, \quad (4)$$

where  $X_1$  – is a transformation of the forest use matrix (coevolution);  $X_2$  – is a transformation of the forestry matrix;  $\alpha$  – is an indicator of forest use improvement;  $\beta$  – is an indicator of forestry symmetry.

General solution of the problem. Assuming that,

$$\alpha \in [0, 1]; \beta \in [0, 1]; \alpha + \beta = 1, \text{ или } \beta = 1 - \alpha.$$

then the expression (4) is:

$$A = \alpha (1 - \alpha) X_1 X_2.$$

We define, at what values  $\alpha$  and  $\beta$ , variable linear transformation  $A$ , which characterizes a sustainable level of timber sector development gets its maximum. The required condition for point of extremum is:

$$\frac{dA}{d\alpha} = X_1 X_2 (1 - 2\alpha) = 0.$$

As far as  $X_1$  и  $X_2 \neq 0$ , then  $(1 - 2\alpha) = 0$ , it follows that, if  $\alpha = \beta = 0,5$  we have the maximum indicator of a sustainable development level, wherein a closed cycle of contradiction conflict of a timber sector development «initiates» a cycle into a new dimension of innovative development, that can be achieved under conditions of the most efficient and accessible technologies use.

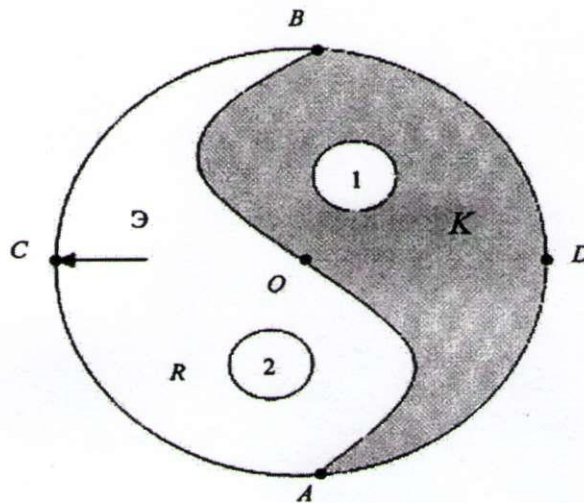
A mirror-group like symmetry of the transformation  $A$  explains a specific role of dualism. The group concept means existence of the opposite pair elements. In the mirror-group every element has a pair. The inner product of two vectors readily illustrates that in the form of the

Cartesian product:

$$(\bar{X} \cdot \bar{Y}) = X_1 Y_1 + X_2 Y_2 + X_3 Y_3. \quad (5)$$

Inside each summand there is a dualism of projections product. Example (5) shows that all interpretations (summands in a formula) in complicated (big) systems are complementary, that is form the whole. Then the description of the whole in terms of parts is introduced by the whole sum of linearly independent terms (parts), where each term is unremovable dual and is similar to the others.

An algebraic formula (1) can be made by means of a geometrical image, which contains two main reflecting inverse elements, making the whole circular disc, surrounded by a rim, representing result *A* (picture 1).



Picture. 1. The scheme of a geometrical image of sustainable development of timber sector:

*R* – transformation of forestry;

*K* – transformation of forest use;

*ACD* – part of stable equilibrium position;

*BCD* – part of unstable equilibrium position;

*COD* – optimus (ideal) level of sustainable equilibrium position;

*ACBD* – a cycle rim, which corresponds to the result in the cycle evaluation - level of sustainable development of timber sector in a certain period of time;

1 and 2 – symbols of input information;

Θ – outgoing vector, which contains energy of interaction between forest use and reforestation.



The geometrical meaning of the formula (1) assumes a turn to a new dimension according to the principle of a vector product, when two inplane vectors predetermine an axial vector ( $\Theta$ ), leading to a spatial cubage. The outgoing vector  $\Theta$  contains energy, that's why an "entry" should have an equivalent "exit", for different transformations, two entries in our case. Symbols of entries are marked by circles 1 and 2 in picture 1.

The outgoing vector  $\Theta$  reflects a continuously coming up new dimension of sustainable development in perspective (future), «a sum of dilemmas» in present. Formula (1) allows to determine the term «sustainable development of timber sector». Genuinely, sustainability means transformation of a forestry optimum ( $R$ ), whereas for development there the transformation of forest use should be found ( $K$ ). An illusory contradiction is solved by the formula (1), where  $A$  reflects a continuously coming up new dimension of future, «a sum of dilemmas» in present.

The ideal situation might be reached when the stable equilibrium position is on line  $COD$  – in case of rencontre of levels of forest use and forest management, but this opportunity in timber sector management in real life is impossible.

#### **Methods and results of an integrated evaluation of level of the regional timber sector sustainable development**

In order to estimate the level of sustainable development of forest sector there are developed methods of the integrated evaluation, they consider the level (criterion) of coversine of range of variables:

$$Y_{л.с} = f(\text{Экон., Экол., Биол., Соц., Ит., Инв., Инс.}),$$

where  $Y_{л.с}$  – is a level of sustainable timber sector development; Экон., Экол., Биол., Соц., Ит., Инв., Инс. – respectively economical, ecological, biological, social, innovative-technological and informational, investment, institutional factors that define the level of sustainable forestry development.

The level (index) of sustainable forest sector development can be defined by the formula:

$$Y_{л.с} = \sum_{i=1}^n \alpha_i X_i, \quad (6)$$

where  $\alpha_i$  – is a weightage coefficient, defining the contribution of  $i$  factor into the common value of the criterion  $\left(\sum_{i=1}^n \alpha_i = 1\right)$ ;  $X_i$  – is a rated value, describing  $i$  element of the criterion;  $n$  is a number of parameters of sustainable development of timber sector.

Methods of carrying out an expert survey was developed based on the cited literature analysis [2]; [3]. It is important to determine coefficients of importance of the studied factors. They are

defined by an expert way and show which factor is more important, which factor can be given up and on the contrary, which factor should be paid more attention to, demands more resources.

The initial data for sustainable development of timber sector characteristics was taken from the statistics data. In a suggested model the meaning of each factor was evaluated through the share of the corresponding indicator in the common value in the region. For each factor criterion of sustainable development of timber sector there are coefficients of weightage, that were selected based on the importance of the indicator by means of expert evaluation methods [4] (table 1).

Table 1. Functions of forest resources and forestry in the Komi Republic

Name of a function (variable)	Index	Weightage coefficient
Productive (economical) component	Forest regeneration coefficient	0,20
	Mature and over mature forest fund land area	0,10
Component of forest viability (ecological)	Area of drying or dying forests caused by unfavorable conditions (fires, pests, diseases)	0,15
Biological diversity component and contribution to the global carbon cycle	Nature protected areas	0,09
Social component	Employment in forestry	0,13
Innovative, technological and informative component	Costs for research and development and forest specialists training	0,08
Investment component	Investments in forestry including forests cultivation, conservation and protection	0,24
Institutional component	Available programs in sustainable development	0,01
Total		1,00



In this case the formula to calculate the level of sustainable development of forestry was:

$$Y_{л.с} = 0,20 \text{ Экон.} + 0,15 \text{ Экол.} + 0,09 \text{ Биол.} + 0,13 \text{ Соц.} + \\ + 0,09 \text{ Ит.} + 0,24 \text{ Инв.} + 0,01 \text{ Инс.} \quad (7)$$

The received integrated index characterizes a regional forestry level (table 2).

Table 2. Change of forest resources and forestry level in the Komi Republic, 2013

Index of forest resources and forestry	Value
Investments in forestry including forest plantations, forest conservation and protection by the total investments volume ( $X_1$ )	0,001
Regenerated forest areas by the total clear cut areas volume( $X_2$ )	0,1884
Drying or dying forest areas by the total volume ( $X_3$ )	0,0390
Employed in forestry by the total employment ( $X_4$ )	0,0008
Mature and over mature forest fund land area ( $X_5$ )	0,0720
Nature protected areas by the total area of the region ( $X_6$ )	0,0019
Costs for research and development and forest specialists training by the total volume costs in forestry ( $X_7$ )	0,011
Available programs in sustainable development	0,01
Forest regeneration development level	0,3241

The second index has to characterize the other component of sustainable development of a regional timber sector, dealing with its functioning, notably forest use. The pattern of index and weightage coefficients calculation is identical to the situation in forestry. Taking into account such an important Cartesian product property as a group symmetry, the same structure of factors to define the second index can be used. The received factors of forest use are presented in table 3.

Table 3. Functions of forest use in the Komi Republic

Function Name	Index	Weightage coefficient
Economical component	Annual allowable cut use in final cuttings	0,18
	Non-timber forest products use	0,06
	Cutting area that is accessible for commercial forests harvesting	0,18
Ecological component	Balance of an average increment and the	0,11

	total timber harvested volume	
Social component	Employment in timber harvesting, timber processing, pulp and paper industries; non-timber forest products processing, recreation and tourism	0,16
Innovative and technological, informative component	Costs for research and development and specialists training	0,09
Investment component	Investments in timber harvesting, timber processing and non-timber forest products processing, recreation and tourism	0,21
Institutional component	Available programs in sustainable development	0,01
Total		1,00

In this case the calculation formula of the forest use development level in the Komi Republic timber sector is:

$$Y_{н.л} = 0,18 ЭКОМ_1 + 0,06 ЭКОМ_2 + 0,18 ЭКОМ_3 + 0,11 ЭКОЛ. + 0,16 Соц. + 0,1 Ит. + 0,21 Инв. + 0,01 Инс. \quad (8)$$

The received index, characterizing the forest use level in the region is presented in table 4.

Table 4. Change of the forest use level in the Komi Republic in 2013

Index of forest use	Value
Investments in timber processing, non-timber forest products processing, recreation and tourism by the total amount of investments ( $X_1$ )	0,1900
Actual timber harvesting volume by allowable cut volume ( $X_2$ )	0,0489
Accessible volume of commercial forests harvesting in annual allowable cut ( $X_3$ )	0,1080
Employed in timber harvesting, timber processing, pulp and paper industries by the total employment number ( $X_4$ )	0,0133
Balance of the average increment and the total timber harvested volume ( $X_5$ )	0,0178
Costs for research and development and specialists training in the total amount of expenses for production ( $X_6$ )	0,005



Non-timber forest products use in the total forest use volume ( $X_7$ )	0,0001
Available programs in sustainable development	0,01
Level of forest use development	0,3886

In order to define the integrated index (criterion) of sustainable development of the regional forest sector we used the Cartesian product [5] that allows presenting the linear transformation of sustainable forest sector development as a product of two linear transformations: i.e. a level of forestry development and a level of forest use development.

The calculation of the actual level of sustainable development of timber sector in the Komi Republic is made by the formula (5) and is presented in table 5.

Table 5. Actual level of sustainable forest sector development in the Komi Republic in 2013

Indexes of forest resources and reforestation	Indexes of forests condition and forest use	Indexes of actual level of forest sector development
0,001	0,1900	0,00019
0,1884	0,0489	0,00921
0,0390	0,1080	0,00421
0,0008	0,0133	0,000011
0,0720	0,0178	0,001282
0,0019	0,0005	0,000001
0,011	0,0001	0,000001
Total		0,0149052

In that case the actual level of sustainable development of forest sector is:  $Y_{\phi}^{n,c} = 0,0149$ .

The optimal level of sustainable development of forest sector based on the general solution and its maximum is:

$$Y_{onm}^{n,c} = Y_{onm}^{n,g} \cdot Y_{onm}^{u,n} = 0,5 \cdot 0,5 = 0,25.$$

Interpretation of indicators in the frame of the general concept of sustainable forest management demands “to guarantee and meet the demands of the present day, leaving no threats for demands of future generations” and raises a question about the scale (levels) of evaluation (an area unit, a forest management unit, a municipality, a region, a country) and its timeframe (a year, a period of five years, a decade). Researches in forestry planning show that the smaller area or shorter the time period is, according to sustainability requirements, the



lower is the level of index because any development is a long-term process and it is possible to evaluate it within a minimum period of 20 years time.

Nonequilibrium of processes in forest use and forestry influenced by external market factors leads to chaotic development that is a driving force for forest sector development. A dualistic regional forest sector of economics has its limit, determined by the allowed relations between forest management and forest industry spheres.

On the assumption of nonequilibrium of processes in forest use and forest management in the system of regional forest sector influenced by external market factors that lead to chaotic development we suggest the following.

1. If the subsystem level of development – forest resources use – equals to level of development (line  $OD$ , picture 1) of the opposing subsystem – forestry – in module during the certain period ( $Y_{л.л} = Y_{л.в}$ ), then that is an objective condition (precondition) for an evolutionary, balanced development of the forest sector system or lack of its development during a certain period of time. In such case there is no disbalance in interaction. Development of forest sector reached its maximum sustainability in the cycle (convolution). Entropy\* in this case remains intact and characterizes lack of qualitative changes in the forest sector system (revolutionary effect). This condition is for the qualitative system development. Recognition of the global biospheric role of forests led to introduction of the concepts “ecosystem functions”, “ecological services” or “ecosystems functions” provided by the forests. Development of forest ecosystems services market results in the real costs of the national forests increase. In the nearest future sustainable forest management issues will become the matters of the public choice, not the industrial sectors issues. Forest countries should improve legislative and institutional basics of forest management in order to provide a stable volume of forest systems services and their increase and to provide forest management issues. Obviously, all the above can testify to a new round of sustainable forest sector development (service). Transition of the regional forest sector system to innovative technologies is an objective condition (precondition) of a new level of development.

2. If the subsystem level of development – use of forest resources – is higher than development level of the opposite subsystem – forestry – during the certain period of time ( $Y_{л.л} > Y_{л.в}$ ) (line  $OB$ , picture 1), then that is the objective condition (precondition) to get the negative synergetic effect in the regional forest sector system. That is, the forest use subsystem brings a destructive pressure to bear on the forestry subsystem, locates the regional

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\* Measure of stay of the system in a particular state, its growth brings the system to equilibrium.



forest sector activities. When forestry use influence is not compensated by natural and artificial forest resources regeneration, forest resources are exhausted, sometimes completely.

3. If the forest use subsystem development in the region during some time period is lower than the level of development of the opposing subsystem – forestry ( $Y_{л.п} < Y_{л.б}$ ) (line *AO*, picture 1), then that is an objective condition (precondition) for the positive synergetic effect in the regional forest sector activities. The forest use subsystem in order to achieve a positive synergetic effect should start production of high-tech products, new forest products modifications dealing with development of multifunctional forest use.

The integrated model of sustainable forest sector development and the required methods of boreal forests evaluation for practical implementation are suggested as a basic tool to solve a wide range of regional aims in strategic planning and sustainable boreal forests management.

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