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SCENARIOS MODDELING FOR THE SOCIO-ECOLOGICAL-ECONOMIC SYSTEM DEVELOPMENT (BASED ON THE PENZA REGION EXAMPLE)

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Abstract: The article describes the scenario modeling mechanism of social, ecological and economic system, allowing the decision maker in the region of the control system, to develop a comprehensive strategy for the development of the territory with the use of fuzzy cognitive maps. The main attention is paid to issues of environmental management, taking into account the mutual influences problematic factors (economic, environmental, social), internal and external environment, significant for the Penza region. The method of pulse processes, predicted alternative scenarios of socio-economic and ecological systems at various regional strategies.

Key words: social, ecological and economic system, internal environmental factors, environmental factors, cognitive modeling, system development scenario, the administrative decision.

Introduction

Based on the growing value of environmental factors in the sustainable development in the regional socio-ecological-economic system, it is important to estimate scenario modeling task in the regional systems development and different strategies impact for the implementation for territorial-industrial complex.

Management decision-making in environmental management model competitive territorial industrial complex has not determinated perfectly in practice yet; economic decisions are made in the absence of predictability result influence. Methodology cognitive modeling is one of the most effective methods for the complex study at the conceptual and mathematical (pulsed) levels poorly structured social, ecological and economic systems and internal processes in it. We consider the main characteristics of socio-ecological-economic system the study to construct a cognitive map (conceptual level), in the Penza region.

The main characteristics of the socio-ecological-economic system of the Penza region are presented in Table 1.

Table 1.

The main characteristics of the Penza region [1]

Наименование показателя	Характеристика
The land air	43,4 th. sq. км^2
Численность населения на 1 января 2015 г.	1355,6 th. people
Average annual number of employed in the economy	660,6 th. people
Average annual number of employed in the economy (per month)	19601,2 rubl..
Consumer spending in the average per capita (per month)	14447,1 rubl.
Среднемесячная номинальная начисленная заработная плата The average monthly nominal wage	22392 rubl.
Gross Regional Product in 2013	270854,1 million rubl..
Fixed assets in the economy (the full book value, end of year)	853113 million . rubl.
Sales of manufactured and works and services by type of activity	
mining	596 million . rubl.
manufacturing	139216. million . rubl.
production and distribution of electricity, gas and water	19667 million . rubl.
Investments in fixed assets	83690 million . rubl.

There are more than 1500 industrial natural resources enterprises in the Penza region, This region is characterized by the concentration - electricity, - metallurgy, - construction, - fuel, chemical and petrochemical, - pulp and paper, glass, porcelain and faience, light, food and flour-and-cereals and feed mill capacity as a territorial- industrial complex. This negative (destructive) system impact on the environment.

Indicators and their dynamics are presented in the Penza region in Table 2.

Table 2.

Emissions and discharges of pollutants in the Penza region

Year	Emissions of pollutants into the atmosphere from stationary sources (thousand tons)	Discharge of polluted wastewater into surface water bodies (millions of cubic meters)
2005	24	139
2010	22	111
2011	37	108
2012	22	105
2013	28	100
2014	33	95

1 Regions of Russia. Social-economical estimations. 2015: P32 Стат. сб. / Росстат. М., 2015. 1266 p. http://www.gks.ru/free_doc/doc_2015/region/reg-pok15.pdf

The government conservation and protection programs of natural resources in the Penza region, namely by "Provision of energy conservation and energy efficiency of the Penza region in 2016-2020 years", "protection, reproduction and use of natural resources in the Penza region in 2016-2020 years" "in the years 2016-2020 Development of forestry of the Penza region." It is not approved in the field of environmental safety programs. At the same time the federal legislation of the Russian Federation provides for a radical restructuring of the valuation of pollution sources of the principle of protection, considering the environmental safety as a part of national security. We can expect, that in the near future will be adopted by the project "Russian environmental safety strategy for the period up to 2025", which will be an incentive for the leadership of the Penza region to the adoption of a regional in the area of the environmental security program.

The processes interdependence of the ecological, technological and social complex development dynamics in the of the Penza area considered by us with the help of a software product - decision support system "Igla", developed by a team of scientists Korostyleva[2] D.A. Podvesovskii[3] A.G., D.G. Lagereva, The Bryansk State Technical University. It should be noted that, international and Russian scientific journals are widely presented the experience of the scientists involved in the use of cognitive maps in the Russian practice of corporate governance theory in recent years. The research was conducted by scientists: Prichina O.S[4]. Karanashevym A.H., Tselykh L.A [5]., Perfilev A.D.[6], E.A. Panfilova, Karasheva A.G ., Thibeault I.V[7]., G.V. Gorelova, Ismihanov Z.N.[8] This allows to take into account identified strong ties constructed cognitive maps for a large volume of processed empirical basis of the regional socio-ecological-economic and socio-technical systems. DSS in the "Igla" cognitive modeling algorithm territorial socio-ecological-economic system includes the following steps: Identify the factors (social, economic, environmental) that affect the performance of the enterprise, the region and the country. We have identified by 39 factors.

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2 Коростелев, Д.А. Система поддержки принятия решений на основе нечетких когнитивных моделей «ИГЛА» / Д.А. Коростелев, Д.Г. Лагерев, А.Г. Подвесовский // Одиннадцатая национальная конференция по искусственному интеллекту с международным участием КИИ-2008 (28 сентября – 3 октября 2008 г., г. Дубна, Россия): Труды конференции. В 3-х т. Т. 3. – М.: ЛЕНАНД, 2008. – С. 329-336.

3 Подвесовский А.Г. Применение нечетких когнитивных моделей для формирования множества альтернатив в задачах принятия решений / А.Г. Подвесовский, Д.Г. Лагерев, Д.А. Коростелев // Вестник Брянского государственного технического университета. - 2009. - № 4 (24). – С. 77-84)

4 Причина О.С., Опыт использования методов когнитивного моделирования в практике корпоративного управления // Научные труды Московского университета имени С.Ю. Витте сборник научных статей. Москва, 2015. С. 159-169.

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8 Исмиханов З.Н. Моделирование социально-экономического развития региона на основе когнитивного подхода (на примере республики Дагестан) // Бизнес-информатика. 2015. № 2 (32). С. 59-68.

Firstly, it must be the key target factors identification. In this case, the target factors of social, ecological and economic systems include:

1. The deterioration of public health reduce in the working or living area.

2. Reducing the environmental stress level

3. The level of financial and budgetary performance increasing in the enterprise, increasing GRP GDP.

The current level of the above factors is set based on the analysis of statistical information for Penza, and is reflected in Table 3.

Table 3.

Factors affecting on the social, ecological and economic system in the Penza region on the initial level

№ п/п	Фактор	Текущий уровень
1.	The physical and moral deterioration level of the main basic equipment	High
2.	The physical and moral deterioration level of environmental protection equipment	High
3.	The technological discipline level	Medium
4.	The labor discipline level	Medium
5.	The debt in a nature of the charges for negative impact level	Medium
6.	Application of ecological safety and environmental management in the stages of development of technical documentation	Low
7.	Annual gross emission of pollutants into the air	Medium
8.	Annual total emissions of substances 1 and 2 classes of danger	Medium
9.	Annual gross emission of pollutants from wastewater	Medium
10.	Annual total emissions of substances 1 and 2 classes of danger with sewage	Medium
11.	The annual volume of waste to be disposed of	High
12.	The annual volume of waste entering recycling	Low
13.	The level of water consumption	High
14.	Products after lifetime biodegradable	Low
15.	Products after the end of life is recycled	Low
16.	Products designed for disassembly	Low
17.	Products with reduced power consumption	Low
18.	Reusable products	Low
19.	The amount of payment "fee for a negative impact on the environment	Medium
20.	The presence of the company environmental program	Low
21.	Voluntary use of environmental performance of the external audit	Very low
22.	Investments in environmental activities	Very low
23.	Current costs of environmental activities	Medium
24.	The level of labor discipline	Medium

25.	The experience of operation of the enterprise market	Below the average
26.	The deficit of working capital units of the technological chain	High
27.	The level of private consumption.	Low
28.	The level of waste minimization through the introduction of low-waste and resource-saving technologies	Low
29.	The level of productivity of the region's ecosystem.	Medium
30.	The level of deterioration of health	Medium
31.	экспорта Exports of environmental capacity	Below the average
32.	The level of protected areas	Low
33.	The level of energy intensity of GRP	Medium
34.	The level of noise pollution	Medium
35.	The level of electromagnetic pollution	Medium
36.	Conflict of corporate interests	Low
37.	Ecological insurance	Low
38.	The level of environmental stress	Medium
39.	The level of financial and budgetary efficiency	Low

Mutual positive impact factors is presented in Figure 1

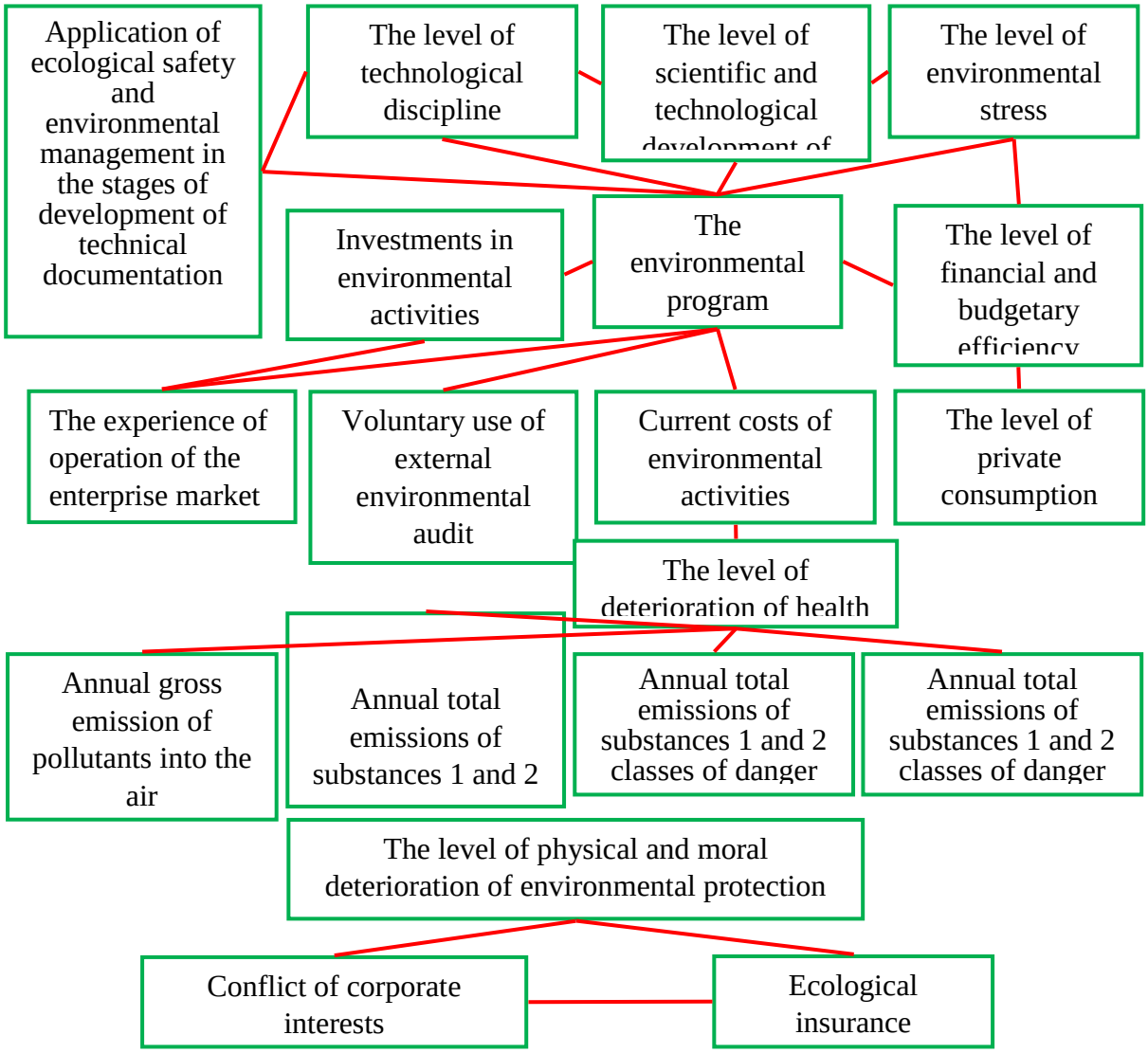

Figure 1. Relative positive impact factors (level 1 slice)

Consider the impact of communication on the target factor "level of environmental stress" the following factors:• The availability of environmental program of the enterprise (factor №20);• The level of scientific and technological development of production (factor №24);•The level of financial and budgetary efficiency (factor №39)Communication factors №20, №24, №39 to the target - "the level of environmental stress" (№38 factor) are direct, decisive in terms of (means - purpose), which is confirmed by the results of calculations presented in Table 4. In this case, the system analysis data interference factors considered (. Figure 1) shows that only the direct expenditure of funds for the factors: "the level of physical and moral deterioration of environmental protection equipment" (№2 factor), "conflict of vested interests' (factor №36)," ecological insurance "(factor №37) is ineffective because of their autonomy and the lack of direct links with the target factor.

Table 4.

Table 4 A fragment of the matrix of mutual positive influence

	30	31	32	33	34	35	36	37	38	39
20	0.3072	0	0	0	0.384	0.384	0	0.8	**1**	1
21	0.378	0.384	0.70	0.384	0.2268	0.288	0.384	0.2592	0.54	0.54
22	0.8	0.384	0.384	0.384	0.48	0.48	0.64	0.6	0.48	0.48
23	1	0.2458	0.4096	0.2458	0.6	0.6	0.8	0.64	0.3072	0.3072
24	0.360	0.1382	0.1382	0.1382	0.288	0.288	0.288	0.48	**1**	1
25	0.8	0.384	0.384	0.384	0.48	0.48	0.64	0.6	0.48	0.48
26	0.54	0.1843	0.3072	0.1843	0.36	0.36	0.48	0.54	0.48	0.48
27	0.1843	0	0	0	0.2304	0.2304	0	0.384	0.8	1
28	0.512	0	0	0	0.384	0.384	0.64	0.64	0.512	0.512
29	0.2765	0	0	0	0.3456	0.3456	0	0.72	0.648	0.648
30	0.8	0.1475	0.2458	0.1475	0.6	0.6	0.8	0.9	0.54	0.54
31	0.1475	0	0	0	0.1843	0.1843	0	0.3072	0.8	0.8
32	0.2458	0	0.64	0	0.3072	0.3072	0	0.512	0.8	0.8
33	0.1475	0	0	0	0.1843	0.1843	0	0.3072	0.64	0.8
34	0.6	0.1843	0.3072	0.1843	0.3240	0.3240	0.6	0.54	0.324	0.324
35	0.6	0.1843	0.3072	0.1843	0.324	0.324	0.6	0.54	0.6	0.6
36	0.8	0	0	0	0.6	0.6	0.64	1	0.8	0.8
37	0.9	0.3072	0.512	0.3072	0.54	0.54	1	0.8	0.48	0.48
38	0.54	0.8	0.8	0.64	0.324	0.6	0.8	0.48	0.8	1
39	0.54	0.8	0.8	0.8	0.324	0.6	0.8	0.48	1	0.8

Held at the state level monitoring only for the following indicators: "annual gross emissions of pollutants into the air" (factor №7), «annual total emissions of substances 1 and 2 classes of danger" (factor №8), «annual gross discharge of pollutants from wastewater "(factor №9) and" gross annual discharge of substances 1 and 2 classes of danger with sewage "(№10 factor) will not bring the proper result because identified the factors considered relationships are a logical consequence of the relationship with the parent (in system performance) controlling factor "presence of the company environmental program." The mutual negative influence of factors is presented in Figure 2.

Figure 2.The mutual negative influence of factors (level 1 slice)

To check the reliability of connections and their impact construct graphs mutual consonance (Figure 3) and mutual dissonance (Figure 4).

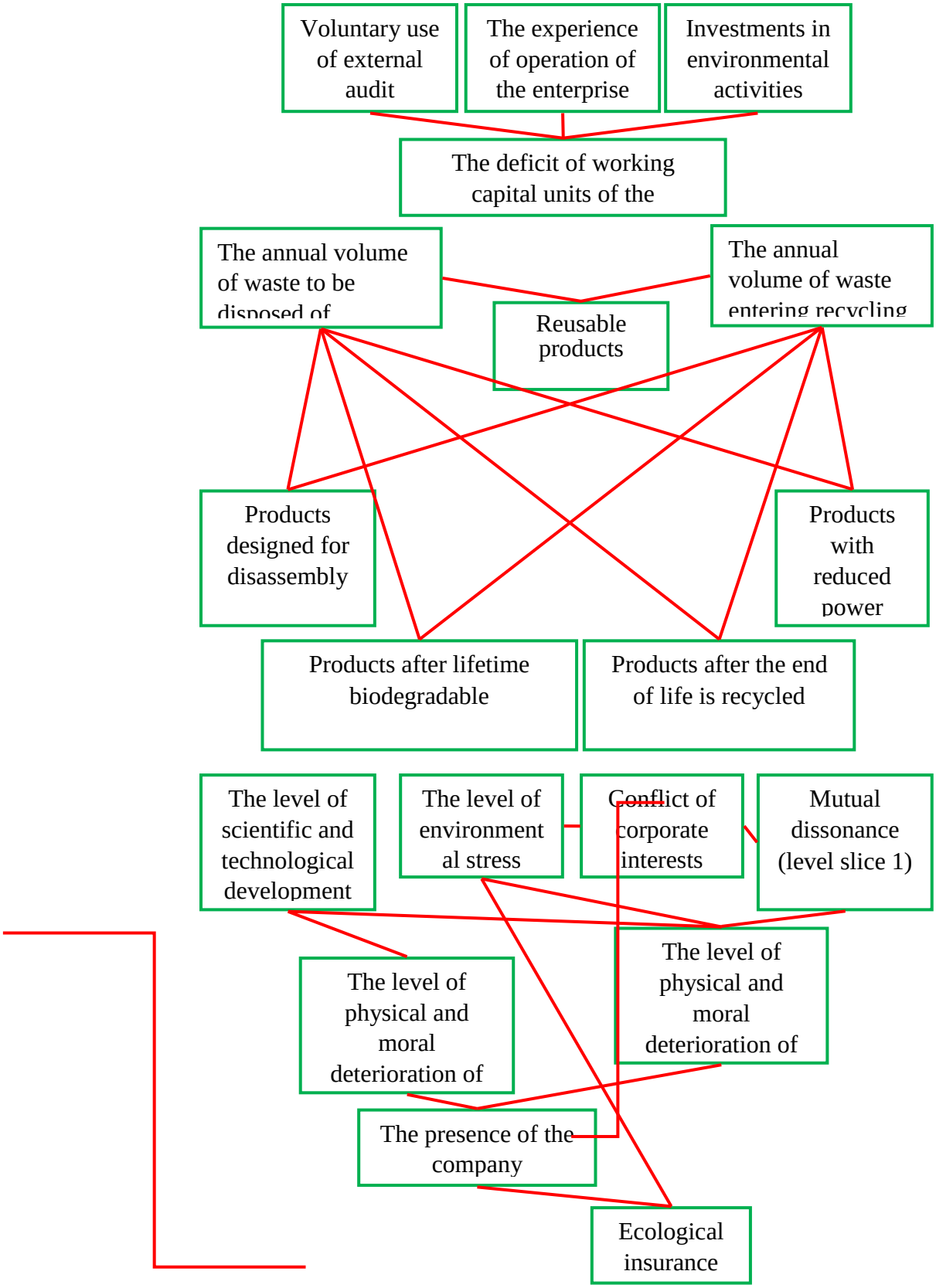
Voluntary use of external audit
The experience of operation of the enterprise
Investments in environmental activities
The deficit of working capital units of the
The annual volume of waste to be disposed of
The annual volume of waste entering recycling
Reusable products
Products designed for disassembly
Products with reduced power
Products after lifetime biodegradable
Products after the end of life is recycled
The level of scientific and technological development
The level of environment al stress
Conflict of corporate interests
Mutual dissonance (level slice 1)
The level of physical and moral deterioration of
The level of physical and moral deterioration of
The presence of the company
Ecological insurance

Figure 2.The mutual negative influence of factors (level 1 slice)

To check the reliability of connections and their impact construct graphs mutual consonance (Figure 3) and mutual dissonance (Figure 4).

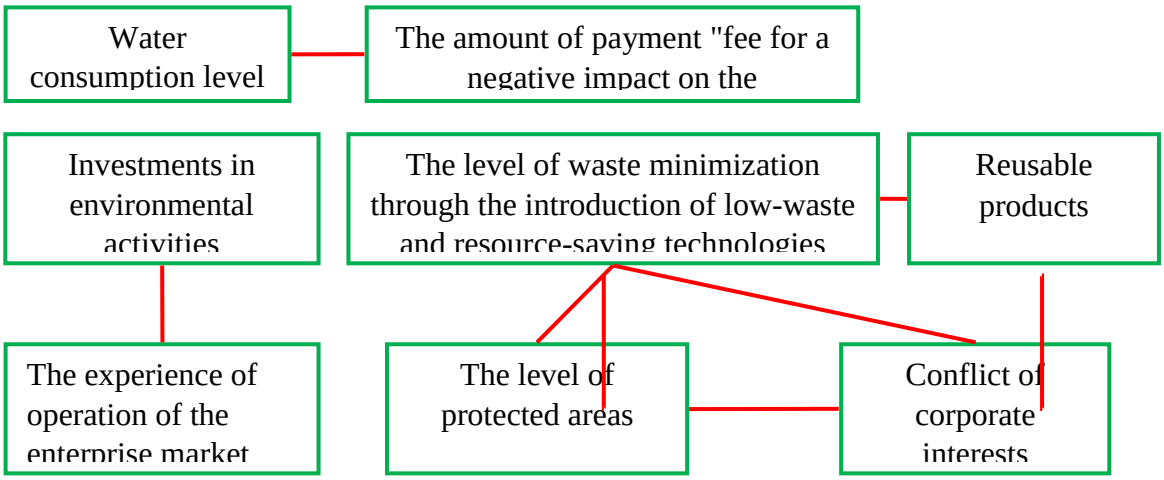

Figure 3.Mutual consonance (level 1 slice)

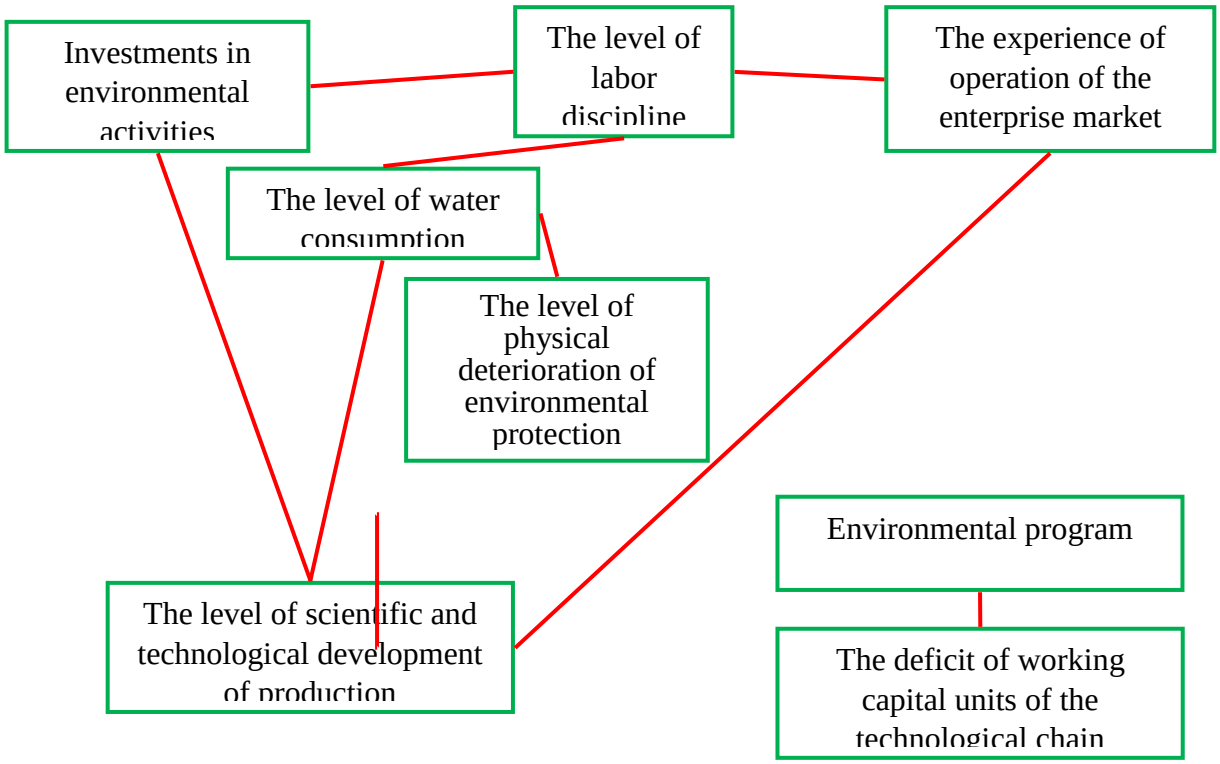

Figure 4. Mutual dissonance (level slice 1)

Analysis of consonance and dissonance (Fig.3 and Fig.4) indicates that the indicators available in other factors absent communication between the slice, so they have a high degree of reliability. Modeling the behavior of social, ecological and economic systems in decision support system allows the official decision-maker (the official, the founder, director, chief engineer, etc.) reasonably predict, select and fund projects (programs, grants), whose contribution to the complex territory development and industrial complex enterprises on it on target factors is maximal. Dynamic modeling of 39 factors affecting the socio-ecological-economic system has allowed to consider alternatives to 10704 of the situation and choose from the 13 most responsible for the targeting criteria 3 best case scenario. Changes in the target states of the factors in the impact of the scenarios on the three selected alternatives is represented in Figures 5.6.The y-axis reflects the change in value of the selected concept. The x-axis simulation cycles, which are very weakly correlated with the real time in a simulated system, but reflect the dynamics of the flow pulse process fuzzy cognitive map. Figures 5.6 show the results of all 3 alternatives to reach the target state by the factor of "the level of deterioration of the health of the population", while as on the factor "level of environmental stress" as close as possible to the desired result is the only alternative to №10704, presented in table 5.

Table 5.

Parameters controllable factors alternative №10704

Stepr	Concept	Level
1	The level of technological discipline	Very high
1	Application of ecological safety and environmental management in the stages of development of technical documentation	Very high
1	The presence of the company environmental program	Very high
1	The level of scientific and technological development of production	Very high
1	The deficit of working capital units of the technological chain	Very high
1	Ecological insurance	Very high

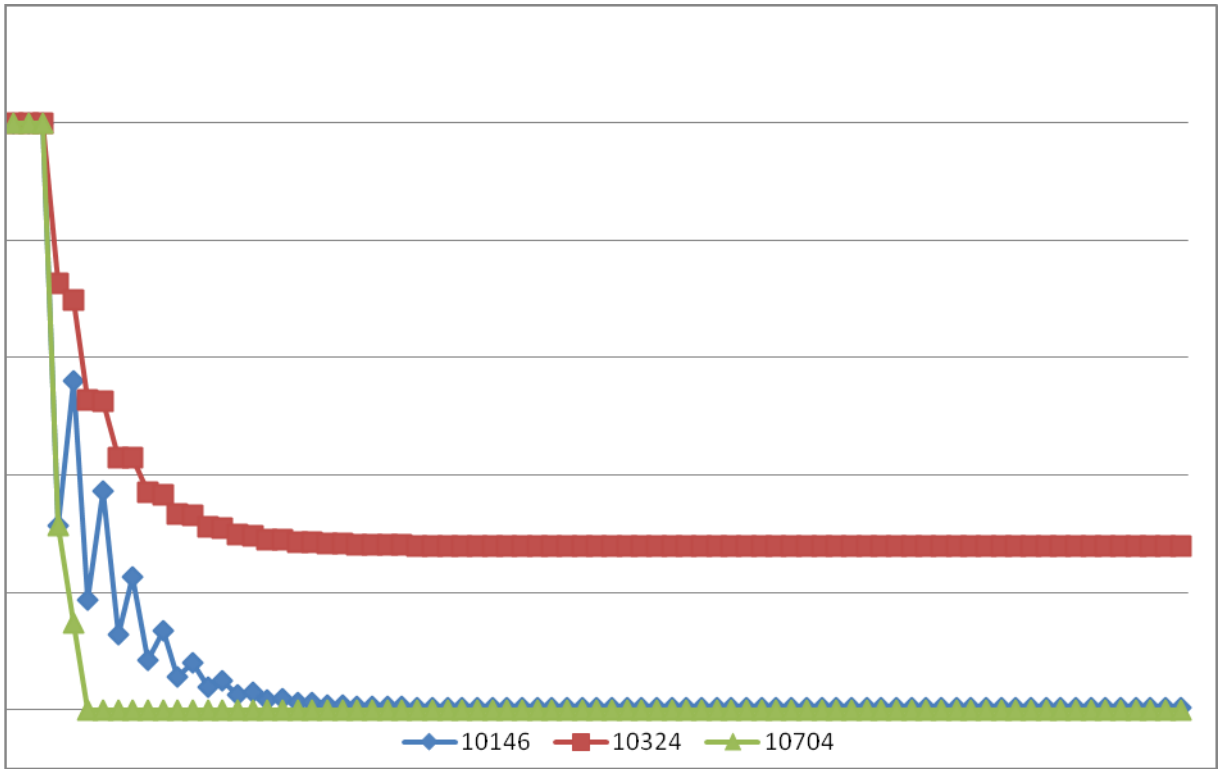

Figure 5.

Projected dynamics of changes in the state factor "level of deterioration of the health of the population"

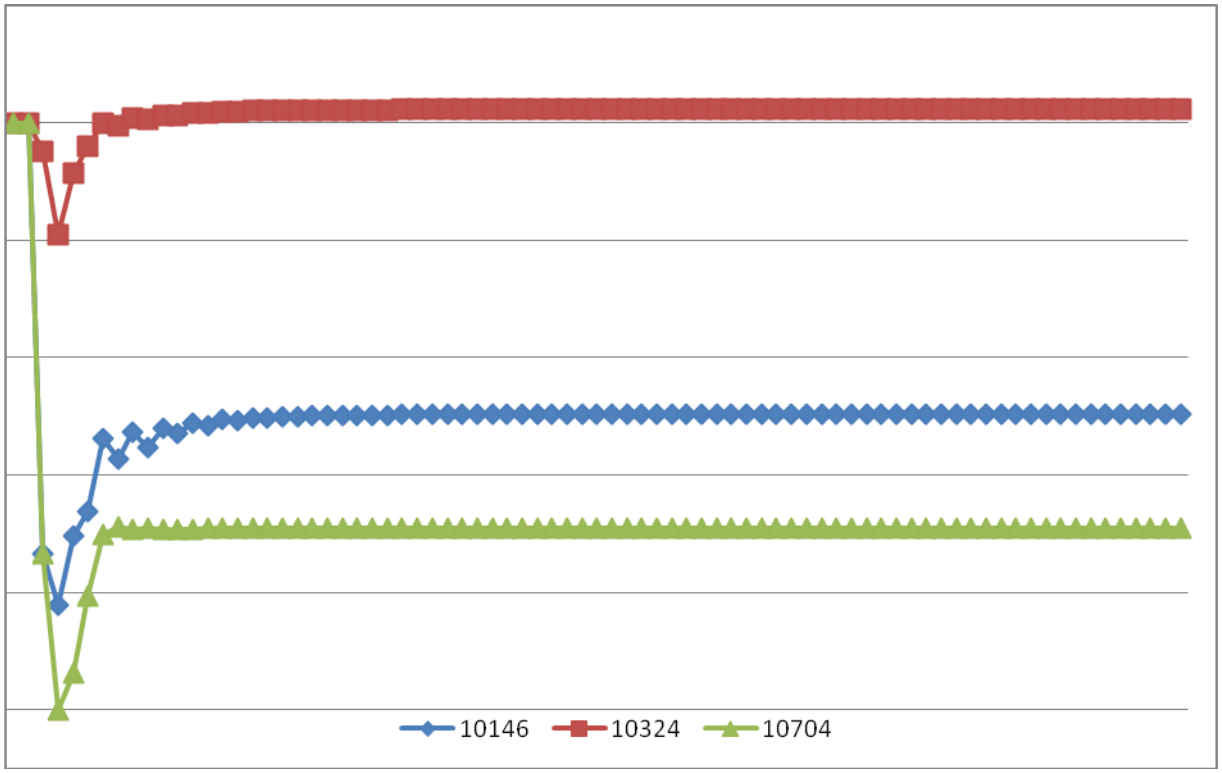

Figure 6. Projected dynamics of change factor state "level of environmental stress"

Conclusion:

The article on the example of the Penza region discussed scenario forecasting algorithm for the task difficult, semi structured territorial socio-ecological-economic system. This study allows to set:1. Within the framework of static modeling to identify nodal sections negative interactions influence and territorial factors caused the economic development component of the target environmental performance - the level of environmental stress. In particular, it is determined that conducted at state level monitoring of emissions performance in the air and waste water will not bring proper integral effect for the whole socio-ecological-economic system, as identified as a result of the factors considered relationships modeling is a logical consequence of correlation factor of a higher order of importance (in system performance) - "Presence of the company environmental program," and in this case, as practice shows - its absence.2. As part of the dynamic simulation scenarios get 10704 changes the behavior of socio-ecological-economic system of the Penza region as a result of specific management actions, including the concept of "the presence of the company environmental program" as the dominant factor in reducing the environmental stress level of socio-ecological-economic system of the Penza region.3. Select from the 13 most responsible for the targeting criteria - 3 scenarios of the likely socio-ecological-economic system (at the level of consonance), select and compare the effects of these scenarios (for effective system component) for management decision making in the selection of projects, programs, grants, aimed at the development of environmental management of the enterprise (site).

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