

## Economic Mechanisms of Management of Socio-Ecological Systems' Sustainability

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### Abstract

The purpose of the article is to develop perspective economic mechanisms of management of socio-ecological systems' sustainability. In order to achieve this goal, the authors use the method of correlation and regression analysis, scenario analysis, method of modeling and forecasting, as well as methods of systemic and problem analysis, synthesis, induction, deduction, and graphic and table representation of information. In the process of the research, the authors determine the essence of socio-ecological systems' sustainability, study the contradiction of interests of society's development and protection of the environment. For realization of the set tasks, the authors determine the current state of socio-ecological systems from the point of view of balance of these interests and analyze the connection between economic and ecological indicators of the countries' development. A tool for confirming the offered hypothesis is calculation of correlation of ecological effectiveness index and gross internal products. As a result of the research, the authors come to the conclusion that economic reasons are the main ones for emergence and aggravation of the problem of harmonic and sustainable development of socio-ecological systems; thus, economic tools are required for solving this problem. The authors offer perspective mechanisms of management of sustainability of modern socio-ecological systems and view scenarios of future development of events in the sphere of management of sustainability of socio-ecological systems.

**Keywords:** economic mechanisms, management, sustainability, socio-ecological system, corporate ecological responsibility.

### Introduction

With development of the global economic system, the needs of consumers grows, production capacities of enterprises increase, and contradiction of interests of society and environment rises. Dynamic development of economy leads to aggravation of the planet's ecological state.

It is obvious in the 21<sup>st</sup> century that further increase of the volumes of industrial production will inevitably lead to ecological crisis with catastrophic consequences in planetary scale. In order to preserve high living standards of the population in the countries of the world and favorable conditions of economy, it is necessary to ensure sustainability of modern socio-ecological systems.

Under the conditions of market economy, self-limitation of the scales of production activities by industrial enterprises does not take place due to market laws and economic system subjects' orientation at maximization of their own profit. That's why it is necessary to manage sustainability of socio-ecological systems and regulate ecological aspects of economic activities.

The applied measures for limitation of ecological damage from industrial activities do not lead to normalization of the situation and do not perform the required effect on economy. Thus, the topicality of development of new mechanisms that allow effectively performing management of sustainability of modern socio-ecological systems grows.

This work offers a scientific hypothesis that economic reasons are the main ones in emergence and aggravation of the problem of harmonic and sustainable development of socio-ecological systems – so, in order to solve this problem, there's a need for economic tools. The purpose of the article is to verify this hypothesis and to develop perspective economic mechanisms of management of sustainability of socio-ecological systems.

### **Methodology**

Socio-ecological systems offer co-existence of human society and nature (del Mar Delgado-Serrano et al., 2015). At present, these systems face such serious problems as depletion of resources (Hamann et al., 2015), air and water pollution with harmful industrial waste (Bennett and Gosnell, 2015), (Berardo, 2014), reduction of bio-diversity (Allison, 2015), (Epstein et al., 2014), etc.

System sustainability is its capability to reproduce and develop in perspective (Epstein et al., 2015). Unsustainable systems are subject to crises (Leslie et al., 2015). Management of sustainability of socio-ecological systems is performed within the state policy (Erickson, 2015) with limiting measures (Fischer et al., 2015).

A lot of scholars, among which are (Anderies and Janssen, 2013) and (Leslie and McCabe, 2013) note that despite the problem of sustainability of socio-ecological systems, modern global society hasn't yet realized it and is not ready for its complex solution.

Economic aspects of management of sustainability of socio-ecological systems are limited by consideration of institutional aspects and risk components of this issue (Rommel, 2015) и (Koontz et al., 2015). Possible directions of solving this problem are adaptive management (Garmestani and Allen, 2015), (Allen and Garmestani, 2015) and (Levin et al., 2013) and creation of ecological clusters (Popkova et al., 2014) and (Volosatova et al., 2014).

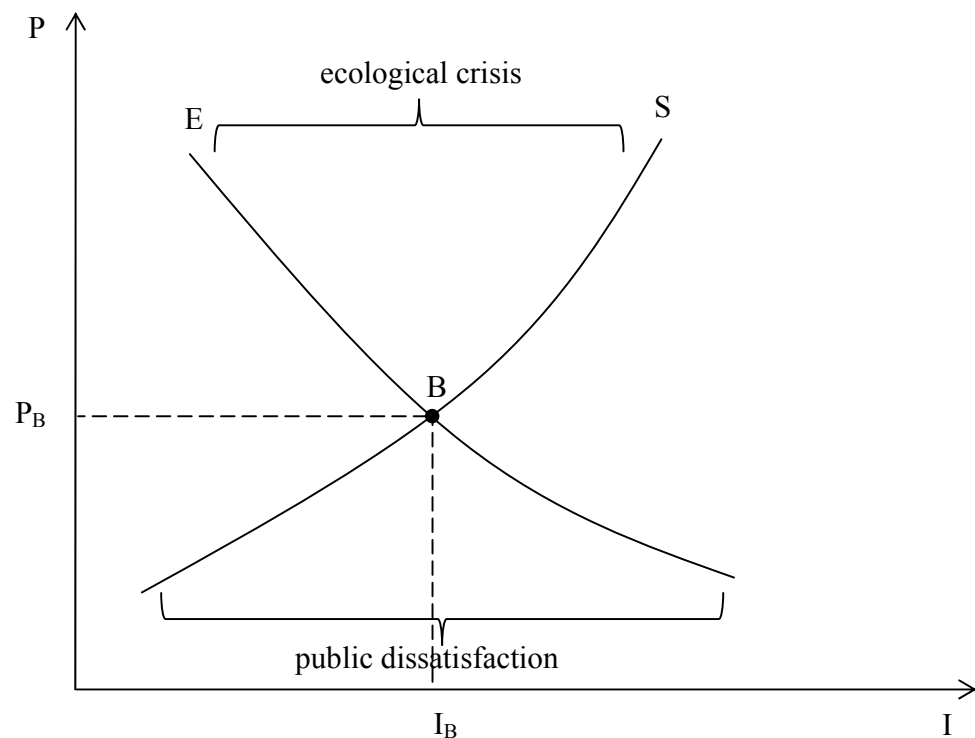
Literature overview on the topic of the research showed that despite the excess of materials in the sphere of study of the notion, essence, and specifics of development of socio-ecological systems, issues of management of their sustainability are viewed by most scholars only with focus on theoretical aspects of the problem. Economic instrumentarium of management of sustainability of socio-ecological systems is not developed enough, which leaves room for further research in this sphere.

Methodological foundations of this work include the method of correlation and regression analysis. The authors use this method to verify the offered hypothesis and find the dependence of economic reason – level of GDP and ecological consequence – value of index of ecological effectiveness (ESI) by the example of various countries.

For forecasting the sustainability of modern socio-ecological systems in future, this work uses the method of scenario analysis and method of modeling and forecasting. The authors also use such methods of scientific research as method of systemic and problem analysis, synthesis, induction, deduction, and graphic and table presentation of information.

### **Results**

Sustainability of socio-ecological systems is treated as preservation of balance of interests of society development and protection of environment and harmonic development of society and nature. Contradiction of these interests is presented in Figure 1.



**Fig. 1. Contradiction of interests of social development and environment protection**

where  $I$  – level of interests' satisfaction;

$P$  – volume of industrial production;

$E$  – interests of environment;

$S$  – interests of society;

$B$  – balance between interests of society and environment;

$P_b$  – equilibrium volume of industrial production;

$I_b$  – upper limit of allowable depletion of natural resource and lower limit of satisfaction of public needs.

As is seen from Fig. 1, graphic image of contradiction of interests of social development and environment protection is a curve of balance of demand and offer in the market. Production volume is volume of global GDP. The larger the volume of industrial production, the larger is the volume of consumption of natural resources and volume of polluting emissions.

Socio-ecological systems are sustainable in point  $B$ , which was reached in the middle of the 20<sup>th</sup> century. As of now, socio-ecological systems develop in the direction of maximization of satisfaction of social needs and are on the path to ecological crisis above point  $B$  on  $P$  axis.

In order to verify this hypothesis, let us analyze connection of the most important economic indicator – volume of GDP of countries – to the indicators of the state of environment – index of ecological effectiveness (ESI). For provision of representation of the research, let us view countries from various economic categories.

The category of economically developed countries is presented by Switzerland, Germany, and the USA; category of developing countries – Russia, India, and Saudi Arabia; category of underdeveloped countries – Bangladesh, Congo, and Kuwait. Initial data are given in Table 1.

**Table 1. Dynamics of GDP and index of ecological effectiveness of the countries of the world in 2006-2014.**

	2006		2008		2010		2012		2014	
	GDP	ESI	GDP	ESI	GDP	ESI	GDP	ESI	GDP	ESI
Developed countries										
Switzerland	360.5	96.3	401.8	95.5	412.7	89.1	441.8	76.7	473.3	87.7
Germany	3,003.0	79.4	3,275.9	86.3	3,279.7	73.2	3,557.5	66.9	3,748.1	80.5
USA	13,855.9	78.5	14,718.6	81.0	14,964.4	63.5	16,155.3	56.6	17,348.1	67.5
Developing countries										
Russia	2,579.6	77.5	3,084.5	73.1	3,031.0	61.2	3,397.8	45.4	3,576.8	53.5
India	3,687.0	49.7	4,402.5	45.9	5,370.6	41.4	6,255.5	36.2	7,411.1	31.2
Saudi Arabia	930.4	61.0	1,119.3	58.9	1,217.8	55.4	1,466.8	50.0	1,609.6	66.7
Underdeveloped countries										
Bangladesh	292.4	43.5	344.0	43.1	391.7	42.9	460.8	42.6	536.5	25.6
Congo	27.5	49.4	32.6	47.3	36.6	45.5	43.3	47.2	57.8	39.4
Kuwait	208.1	44.7	236.6	41.2	219.0	39.4	271.0	35.5	282.6	63.9

Source: (GDP of countries of the world, 2015), (Index of ecological effectiveness, 2015).

As is seen from Table 1, economically developed countries are peculiar for not only higher level of GDP but for higher level of ecological effectiveness. As a result of automatized calculations, the results of correlation analysis were obtained (Table 2).

**Table 2. Correlation of index of ecological effectiveness and GDP of the countries in 2006-2014**

Countries	Correlation
Switzerland	44.28945
Germany	5.487738
USA	34.45491
Developed countries	28.07737
Russia	71.07087
India	99.81092
Saudi Arabia	0.258875
Developing countries	57.04689
Bangladesh	62.64986
Congo	84.73879
Kuwait	20.70693
Underdeveloped countries	56.03186

As is seen from Table 2, correlation of index of ecological effectiveness and GDP of the countries of the world in 2006-2014 is rather high, connection between the viewed indicators is strong and direct, and models are significant – which proves the offered hypothesis on economic nature of the problem of sustainability of socio-ecological systems.

Deeper analysis in view of GDP structure allowed finding dependence of index of ecological effectiveness and GDP with countries with the largest share of industry in structure of GDP. It is possible to see that connection is seen in the group of developed countries, but it is not very strong.

Level of correlation of index of ecological effectiveness and GDP of Switzerland constitutes 44%, USA – 34%, and Germany – only 5%. This is predetermined by small share of industry in economy of developed countries. On average, correlation level in the group of developed countries constitutes 28%.

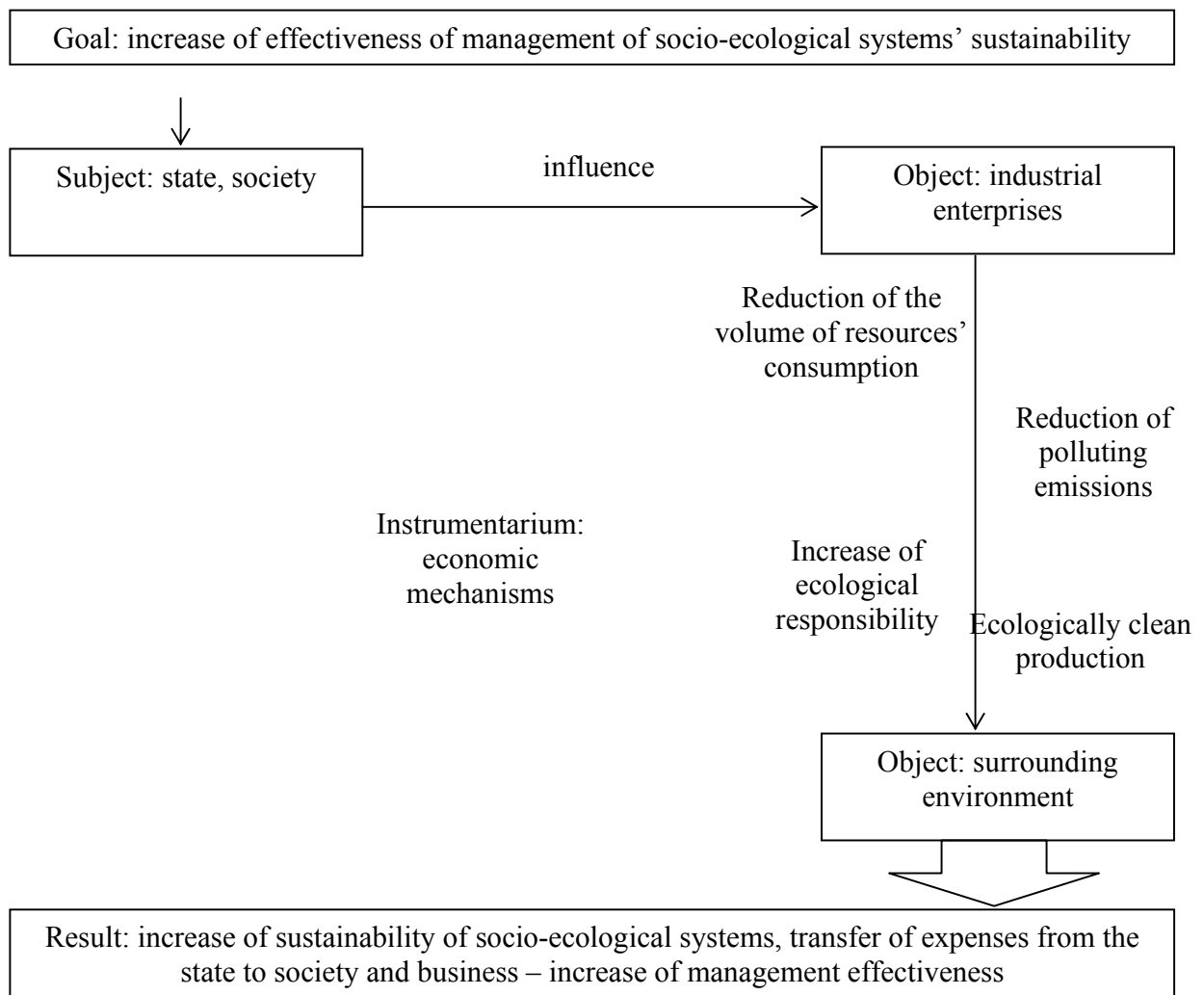
The group of developing countries has the closest connection of the viewed indicators. The level of correlation of index of ecological effectiveness and GDP in Russia constitutes 71%, in India – almost 100%, and in Saudi Arabia – less than 1%, which is caused by domination of raw materials production in economy of this country and low level of development of industrial production. On average, the correlation level constitutes 57% in the group of developing countries.

In the group of underdeveloped countries the connection is weaker which is caused by agrarian orientation of economy. Thus, in Bangladesh, the level of correlation of ecological effectiveness index and GDP constitutes 62%, in Congo – 84%, in Kuwait – 20%. On average, correlation level constitutes 56% in the group of underdeveloped countries.

This work offers the following perspective economic mechanisms of management of sustainability of modern socio-ecological systems:

- Self-limitation of production activities by industrial enterprises within expansion of corporate ecological responsibility. At that, the role of state and society, related to stimulation of corporate ecological responsibility, grows in solving the issue of sustainability of socio-ecological systems;
- Involvement of wide layers of society into the process of management of sustainability of socio-ecological systems and increase of accessibility of information on ecological consequences of industrial production. This supposes legal establishment of wide possibilities for control over activities of industrial enterprises by representatives of the public;
- Implementing the system of measures on tax stimulation of ecologically responsible business in industrial sphere. This will create financial stimuli for minimization of damage to environment and manufacture of ecologically clean products;
- State stimulation of creation of ecological clusters of industrial enterprises. Within such clusters, industrial enterprises exchange successful experience of development of technologies of ecologically clean production and cooperate with R&D organizations that develop innovational technologies for them;
- Provision of simplified and subsidized access to credit resources for modernization of purification equipment and production technologies to industrial enterprises. This will allow enterprises that suffer from lack of financial resources to receive access to financing of modernization projects in the sphere of production equipment.

Work of economic mechanisms of management of sustainability of socio-ecological systems is graphically shown in Fig. 2.



**Fig. 2. Economic mechanisms of management of socio-ecological systems sustainability**

As is seen from Fig. 2 the purpose was to increase of effectiveness of management of socio-ecological systems' sustainability. The subjects are state and society. The objects of management are industrial enterprises.

Under the influence of economic mechanisms with interaction with environment, they reduce the volume of resources consumption and the volume of polluting emissions, increase corporate ecological responsibility, and develop ecologically clean production. As a result, there is increase of sustainability of socio-ecological systems and transfer of expenses from state to society and business, which leads to increase of management effectiveness.

### Discussion

Thus, in the process of the research, the offered hypothesis was proved, and it was shown that economic reasons are the main ones in emergence and aggravation of the problem of harmonic and sustainable development of socio-ecological systems – so solving this problem requires economic tools. The variants of future development of events in the sphere of management of sustainability of socio-ecological systems could be shown in the form of three possible scenarios.

The optimistic scenario supposes practical realization of the developed recommendations (offered economic mechanisms), increase of effectiveness of the process of management, and substantial increase of sustainability of development of socio-ecological systems. This is accompanied by increase of consumers' awareness throughout the whole world as to industrial products and their choosing ecologically clean products.

As a result, corporate ecological responsibility in the sphere of industrial production and strict public control over observation of the set norms in this sphere grow. Probability of realization of this scenario in the whole world could be evaluated as 0.2 due to state, business, and society of underdeveloped and developing countries not being ready for these measures. In the developed countries, this scenario is highly probable.

The pessimistic scenario supposes the countries' unreadiness for joint efforts for environment protection and refusal from realization of the offered recommendations. As a result, current situation in the sphere of socio-ecological systems is preserved, and growth of volume of industrial production, aggravation of state of ecology, and ecological crisis continues.

The probability of realization of this scenario in the global scale is assessed as 0.3 due to society's being not ready for changes in economic activities and self-limitation of satisfaction of unlimited needs. In the developed countries, realization of this scenario is minimal.

According to realistic scenario, most of consumers and states realized seriousness of ecological problems and will toughen requirements to business, which, in its turn, will reduce the volume of polluting emissions, reduce the volume of industrial production, and develop manufacture of ecologically clean products. Probability of realization of this scenario in the global scale constitutes 0.5, in developed countries it is higher.

### **Conclusion**

The results of the research showed that despite high complexity of solving the contradiction of interests of satisfying the society's needs, which suppose maximization of production, and interests of environment protection, which suppose reduction of the rates of industrial production, it is possible, and solution to this problem lies within the sphere of economic mechanisms.

Theoretical significance of the conducted research consists in development of the concept of corporate ecological responsibility, concept of sustainability of socio-ecological systems, and concept of effective management of systems. Practical significance of the work consists in the possibility and necessity for use of the developed proprietary recommendations (economic mechanisms) in the process of management of sustainability of development socio-ecological systems in the countries of the world.

A certain limitation of the performed research is narrow nature of selection of the countries for verification of the hypothesis and determination of the level of correlation of growth rates of GDP of a country and aggravation of its socio-ecological system's state, as well as theoretical character of the offered recommendations. That's why their practical realization and conduct of full research on the basis of certain countries of the world offer the perspectives for further research in this sphere.

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