Development of Economical Environmental of Protection Mechanism

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Economic and ecological systems are physically connected through the materials and energy metabolism: raw materials, energy resources from the ecosystem get into the economic system and then from this system go back to the ecosystem as produced goods, heat, waste and pollutant emissions. This is due to the physical law of matter conservation: the same amount of materials being used as raw materials come back in the form of production and waste. However the economic system depends not only on the natural resources, considering as raw materials for production and consumption, but on the services provided by ecosystems. too. So, it is necessary to determine and evaluate not only the role of the ecological system as the main source of inputs into the production of goods, but also to treat it as the source of never-ending services enabling protection the in area of human beings and to ensure development of the ecosystem itself. No efficient use of resources may have catastrophical consequences for the future of countries in transition to market economy, including Lithuania.

The main purpose of this study is to project fiscal flows (of course these flows have a contrary direction of movement) adequate to the materials flow between ecological and economic systems and to create mechanism able to ensure creation of appropriate fiscal flows and they purposeful movement. This is the basic feature of equivalent interaction between the economic and ecological systems and the main precondition of ecologically and economically sustainable development.

The category economical pollution damage is used like the main instrument for disclosure of interaction between economy and ecological *systems. The conception o economical environmental protection mechanism is based on the system of interests of ecological resources users to minimize their individual ecological cost and interests of ecological damage recipients – to receive an adequate compensation. The practical calculations of economical pollution damage carried out on the Lithuanian data re presented in the paper.*

1. Economic Aspects of Environmental protection

Economic solution of environmental problems is based on the utilization of fiscal information (utility, efficiency) adequate to the material flows between ecological and economic systems. In the economic system there are available such conditions of perfect competition [1]:

- producers and consumers seek and are able to reach the greatest benefit;
- production inputs and prices of realization are the functions of goods turnover;
- relation between inputs and prices do not depend on the will of consumers and producers;
- all resources and goods are in private ownership.

These conditions guarantee, that the economic system will be orientated to the achievement of Pareto optimality, i.e. efficient utilization of the resources in the production process, their rational disposal to consumers and the most appropriate structure of production at the same time.

In the ecological system motives and rules of free competition available in economic system do not act. This is due to:

- ecological resources are not in the private ownership, enabling the seeking the of greatest benefit;
- the use of ecological resources is not individual, but common, so there are no motives which are able to guarantee the setting in of market prices.

Another obstacle for taking root of market conditions in the ecological system is, that it is required to take in account not only material ecological resources, such as air, water, forests, soil and etc., but also

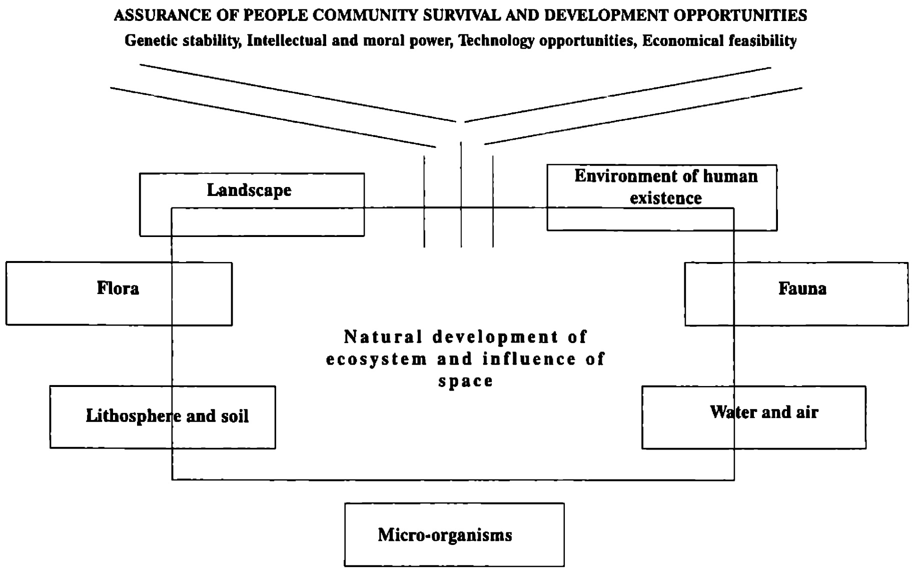

Figure 1. **General sight on environment improvement**

such components of surrounding environment, which do not have material dimensions, i. e. bio-magnetic fields, radiation, acoustic, thermal, electromagnetic milieu. There are no methods and techniques for the evaluation of „non-material" ecological resources. In this case we must rely on the well-founded evaluation of losses related to the decrease of quality of these subsystems – the change of the state set in during the environment evolution process, i. e. evaluation of they negative utility or economic damage caused by they changes.

When speaking about the possibility to estimate pollution damage it is necessary to turn attention to the fact, that even in the scientific literature the conception of harm is treated as the direct harm to the recipients. Direct harm named external costs is rather informative index, describing the influence between the ecological and economic systems and indicating efficient and purposeful measures of environmental protection. But the direct harm estimate is not such universal and objective measure of negative environmental changes, as for example the price is the measure of goods value. The direct harm is more the measure of recipient's losses incurred due to the changes of environment, though the objective evaluation of these changes.

The most appropriate equivalent of price in the environment of negative changes is above proposed the economic damage D_E conception:

$$D_E = \min\left\{I_1, I_2, I_3, I_4, \dots, I_{1,2,3,4}\right\}, \tag{1}$$

where I_1 – direct evaluation of the damage; I_2 – evaluation of a direct cost needed to abolish a negative impact; I_3 – cost incurred by reconstruction functions of the previous state; I_4 – real expenses (taxes, fines, licenses and fees) if they developed in the conditions close to an open and competitive market;

$I_{1,2,3,4}$ – situation where one seeks to recover the previous functions of the environment and evaluates the damage of the factors left.

D_E is objective, not always coinciding with the damage of recipients or with the will of resource consumers, estimate, which depends mostly on the situation formed in the field of technological progress and production, environmental protection level and the culture of human's activity. So the economic damage is objective fiscal estimate of environmental changes in the region.

Practically in all ecological and economic literature the harm is identified as direct harm [2]. This do not allow the harm conception to carry out not only the function of equivalent compensation measure, but to stimulate the efficiency of environmental protection. If the harm is considering as economic damage, then the statement, that it must be compensated will stimulate efficiency of environmental protection.

2. Social-Economic evaluation of the Consequences of Antropogenic Impact on the Environment

2.1. Identification of activities and environmental changes causing the negative impact to the recipients. In order to create the system of economic damage evaluation, which enables to evaluate not only the harm for the main its recipients, but to address it to the primary sources of damage creation, it is necessary:

- to identify factors, causing the negative changes of environment; to determine the recipients of negative impact and the ways of harm manifestation;
  to create adequate instruments of damage evaluation and to carry out specific economic damage evaluations;
  to select the efficient mechanism able to address different parts of harm experienced by recipients to its agents.

2.2. Determination of negative impact recipients and ways of harm manifestation. There are some methodological difficulties related to the determination of negative impact recipients and ways of harm manifestation [3]. The same ecological subsystems being in the role of ecological resources at the same time can act as damage recipients. It is clear, that circumspection is needed in order to avoid repeated harm calculations. For example, air pollution (utilization of resource) and decrease of human health (the harm to recipient) caused by the air pollution. Another example – disappearance of forests (utilization of resource, which has even utility value) and loss of forest's functional abilities (the harm to others subsystems).

Determining final damage recipients in order to avoid repeated damage calculations, we follow the rule described above. The main harm recipient is the human being: peoples health, the changes of the organism functions. The second goes material property, created by man and having a direct value. Then we have the property created by the nature: flora, fauna, processes influencing creation of property – soil, water and forests productivity. The last – non material property: landscape, comfort of environment, the prestige of the placement.

2.3 Selection of adequate instruments for the economic damage evaluation. In the first part of this paper was introduced the economic damage estimate, which requires evaluation of the direct harm and evaluation of the costs of possibilities to avoid it. The damage evaluation techniques vary from the subjective expert evaluation systems to the strict analytic relationships, relating damage value to the factors causing it. The expert systems vary on their own from the market simulation in damage and price evaluation to the systems able to assess the expert evaluations or other available information on the harm and prices. Below we analyze preconditions necessary in order to select analytical functions for damage evaluation.

As a typical, broadly used, sufficiently founded and reasonably interpreted physically example of an analytic function is the Weibull's function. Among the set of applications it issued also to evaluate dependency of the yield of wheat grain from O_3:

$$y = a\exp\left\{-(x/s)^c\right\}, \tag{2}$$

where y – obtained (observed) yield; a –hypothetical maximum yield at zero ozone; x – seasonal average of observed concentration at a certain time of the day; s – ozone concentration when yiel d = 0.37 a; c – nondimensial parameter of loss function.

As one may notice, the formula (2) allows for the evaluation derivations of obtained yield from the expected (theoretically and practically grounded) yield.

One should notice, that the rather simple form of the function (2) is maintained in the case of the only one yield derivation causing factor x, and the resulting factor, here it is yield and has a direct dimension. In other cases the form of the function (2) becomes more sophisticated. Issue of the form of the function is important for practical application also. Formula (2) is the value of yield on the average O_3 concentration. In order to have more adequate to the reality relationship, one should assume that both factors and results are random variables or processes, i. e. determined by certain probability distributions. The factor distribution may be determined from the observations data, but about the damage distribution function we may only have assumptions. But in the case of the sophisticated form of (2) and complicated inter relations between the factors it is hard to make correct assumptions on the damage distribution function even if the factor distribution functions are known. In order to solve this problem a special computer model was developed. It allows to evaluate the damage distribution function and its numerical characteristics in a case of the complicated form of (2) and with the presence of various interrelation between the damage causing factors.

When evaluating the value of damage, caused in various regions of Lithuania due to water and air pollution to the population was calculated using the following function:

$$x_i^j = C\exp\left\{\left(\frac{q_i^j}{q_i^l}\right) - \left(\frac{p_i^j}{\bar{p}_i}\right)^{\alpha_2}\right\}, \tag{3}$$

where x_i^j – annual value of damage caused by the atmospheric pollution to the population in the j-th region due to the i-th pollutant concentration, Lt; C – constant value, showing the scale of the damage, then $q_i^j = q_i^1$ and $p_i^j = \bar{p}_i$, (Lt); q_i^j – average annual concentration of the I-th pollutant the j-th region, (mg/m³); q_i^1 – the allowable level of concentration of the i-th pollutant. As a rule, with this level of pollution there is a real possibility to calculate directly or at least evaluate by an expert the scale of damage, (mg/m^3); p_i^j – indicator characterizing chances of the j-th region population to avoid the dangerous impact of pollution; $\overline{p}_i$ – average indicator for all regions; α – parameters.

One should notice, that the relationship (3) is a corestone of the harm evaluation system. It is caused by the following reasons:

- as practically all variables and parameters of the equation (3) have a transparent material and value interpretation, they were the basis for the expert evaluations and revisions as also compatibility of the damage evaluation obtained by different methods;
- the developed computer modeling system allows the making of assumptions on the harm distribution function, and dependence of the form of this function and its numerical characteristics on the form of the function, factors distribution function and variation of the (3) parameters as also on the interrelations of the factor distributions;
- relationship has become one of the basis for the real harm evaluation, i. e. unavailable damage minimum evaluation;
- the obtained evaluations of the harm is based on the aggregate data indicators, e. g. total reduced air pollution or total harm to a set of recipients by the expert approach were addressed to the separate pollutants and recipients.

We should mention here that in many other than (3) analytical relationship were applied, including also functions, relating the level of the damage directly with the volume of emissions. They will be discussed broadelly in the section describing evaluation of damage caused by transport pollution.

2.4. The models for the evaluation of ecological resources. The methods of ecological resource evaluation are broadly used in the direct harm evaluation techniques [4]. They also can be applied for the economic damage calculations. All these methods of ecological resource evaluation and together the methods of economic damage (the function of decreased value of ecological resources) evaluation can be grouped according the market they rely on into objective and subjective techniques (Table 1). The first are based on the information obtained from conventional markets. Others are based on the use of implicit and constructed markets. A variety of valuation techniques may be used in accordance of concepts of value. Methods based on conventional markets are used for evaluation of the use value of ecological resources, Methods based on implicit and constructed markets are being used for evaluation of non-use value of ecological resources.

Table 1. ***Classification of valuation techniques of ecological resources***

Conventional market	*Implicit market*	*Constructed market*
Change of productivity	Travel cost	Artificial market
Human capital technique	Wage differences	Contingent valuation
Defensive or preventative cost	Property values	
Replacement cost	Proxy marketed goods	

From the Table 1 representing methods of ecological resource evaluation we must understand, that they give a real opportunity to obtain damage estimates. But at the same time we must notice, that many of these methods and methodological incorrectness create difficulties for the evaluation of damage. Even in the prestige ecological literature one may find statements, that concept of damage has not one meaning, because different evaluation techniques provides with different results. The principal mistake of these studies is that ecological resource evaluation techniques are identified with economic harm estimates. Obtained specific estimates can vary from the objective economic damage estimates. In addition the most of ecological resource evaluation techniques are based on observations of subject's behavior and rely on subjective decisions, they on the other hand are based on the individual damage estimates. Individual damage estimates are higher comparing with the objectively reached minimum. According to our concept of economic damage we can claim, that dimensions of economic damage D may fulfill requirements of this relationship:

$$D \leq min\ (V_1, V_2, ..., V_i) \tag{4}$$

where V_i – estimate of lost resource, obtained using I-method.

So estimates of ecological resources together with others means of damage evaluation can be successfully applied as alternatives of economic damage evaluations.

3. Practical Evaluations Pollution Harm According to Main Pollutants and Damage Recipients

The main air pollutants and they impact on the recipients. Mostly CO, SO_2, NO_x and dust are emitted. Volumes of NO_x usually are reported converting them into NO_2. Even 90–98% of all emission is made out of 5 ingredients: SO_2, CO, NO_x, hydrocarbon and dust, and only 2% – other pollutants. CO_2 is not considered as harmful substance although huge volumes are emitted, approximately 15 times more than the other taken together. Nevertheless their evaluation and limitation in energy sector development is necessary because of the possibility of its contribution to a change of climate ("greenhouse effect").

The negative impact of atmosphere pollution causes increased morbidity and mortality of people, decrease of they working ability, the growth of physical wear out extent for the long term assets, decreased yield of agriculture production and etc. Due to these changes the economy is experiencing additional losses related to medical services for inhabitants, production losses due to decreased working ability and productivity, increased reparation, supervision and operation needs for long term assets and increased cleaning work extent. According to these three main recipients of harm caused by atmosphere pollution are selected: inhabitants, agriculture and long term assets.

Evaluation of economic damage, using analytical method. After the first stage determining specific relationships between physical changes of recipients and the changes of pollutants concentrations in the atmosphere, causing these changes of recipients, we go to the second stage of the evaluation process. Using the data about specific pollutants concentrations in the atmosphere of different regions and taking into account specific conditions of each region economic losses related with air pollution were being calculated for each recipient, in each region due to each pollutant.

The main relationship, used estimating harm by analytical method, was:

$$H_{ij}^{k} = h_{ij}^{k}\left(C_{j}^{k}, P_{j}^{k}, S_{ij}^{k}\right), \tag{5}$$

where H_{ij}^{k} – amount of harm to i recipient in j region caused by k resource irrestorable consumption (in a given case air pollution is considered); C_{j}^{k} – concentration of k pollution in j region; P_{j}^{k} – annual amount of k waste out-thrown in j region (in an environment of i recipient); S_{ij}^{k} – possibility of i recipient of j region to avoid k pollution influence; h_{ij}^{k} – function giving harm estimations (non-agriculture, agriculture, people).

Really (3) and (5) formulas can be treated as Weibul's function describing impact of increased pollutants concentrations to the recipients.

$$Z_{ij}^{k} = \alpha \exp(f(x, y)), \tag{6}$$

were $f(x, y) = \left\{ \left(\frac{x_{ij}^{k}}{q_{i}^{k}} \right)^{\beta_1} - \left(\frac{y_{ij}^{k}}{p_{i}^{k}} \right)^{\beta_2} \right\}.$

Here Z_{ij}^{k} – annual value of damage caused by the atmospheric pollution to the population in the j-th region due to the i-th pollutant concentration, Lt; α – constant value, showing the scale of the damage, when $\exp(f(x, y)) = 1$ or $x_{ij}^k = q_i^k$ and $y_{ij}^k = \bar{p}_i^k$; x_{ij} – average annual concentration of the i-th pollutant in the j-th region, (mg/m^3); q_i^k – the maximum allowable level of concentration of the i-th pollutant. As a rule, with this level of pollution there is a real possibility to calculate directly or at least evaluate by an expert the scale of damage, (mg/m^3); y_{ij}^k – indicator characterizing chances of the j-th region population to avoid the dangerous impact of pollution; $\bar{p}_i^k$, – average indicator of y_{ij}^k for all regions; β_i – parameters.

As one can notice from the formula (6) during the damage evaluation process in each region the scale of pollution and conditions reducing negative impact were taken into account. Administrative regions were grouped according they possibilities to avoid negative impact of pollution.

According to performed damage evaluation during the year 1994 (the lowest level of pollution) only because of air pollution, total value of economic damage done to the main recipients (agriculture, long term assets, people) reached 0.985 bill Litas (1 USD = 4 Lt). It is approximately 6% of GDP. Damage distribution over the territory of Lithuania is uneven. The greatest amount of harm fell on inhabitants – 52%, agriculture – 28%, long term assets – 20%. The most polluted regions according the emissions into atmosphere in tones per square km are: Mazeikiai (45.8 t/km^2), Akmene (18.6 t/km^2), Trakai (9 t/km^2) and Jonava (6.8 t/km^2) regions. The average amount of emissions in tones per square km in the territory of Republic is 3.1 t t/km^2 .The greatest economic harm in Lt per square km is calculated in Mazeikiai (3077 Lt/km^2), Vilnius (2620 Lt/km^2), Kaunas (2264 Lt/km^2) and Klaipeda (1304 Lt/km^2) regions. The greatest economic harm per capita is indicated in Mazeikiai, Akmene, Kelme and Jonava regions. In the territory of Lithuania average harm per capita fluctuates from 25 to 480 Lt. The dynamics of economic harm caused by air pollution is shown in Table 2.

Table 2. ***The dynamics of economic harm caused by air pollution***

Pollutants	*Economic harm, thou. Lt*				
	1992	*1993*	*1994*	*1995*	*1996*
CO	450 745	375 775	367 643	385 383	402 681
NO_x	204 000	162 000	159 000	159 000	168 000
Dust	46 500	43 500	39 000	36 000	40 500
SO_2	262 000	236 000	232 000	176 000	204 000
CH	173 600	165 200	160 440	148 680	154 000
Total	1 136 845.2	982 475	958 083.2	905 063.2	969 181.2

Economic damage caused by water pollution. The total amount of polluted water emitted into rivers basins in 1996 was 5000.2 mln m^3 (1994 – 3778.5 mln m^3;1995 – 4492.6 mln m^3). The dynamics of economic damage caused by water pollution is presented in Table 3. The greatest amount of damage fell on the basins of rivers Neris, Nemunas, Akmena–Dange and Musa. The least amount of damage fell on the basins of rivers Bartuva, Minija, Dubysa.

Table 3. ***The dynamics of economic damage caused by water pollution, thou. Lt***

Pollutants	*1993*	*1994*	*1995*	*1996*
Detergents	137 750	116 000	94 250	87 000
BOD_5	168 916	320 650	127 050	120 274
Suspended particulate	65 728.8	83 160	56 160	52 920
Oil products	19 575	21 025	15 950	16 675
Phosphorus	18 898.8	18 480	14 537.6	14 414.4
Nitrogen	37 058.6	40 931.88	27 951	27 225
Iron	1 450	2 421.5	1 029.5	870
Cooper	6 277.3	3 138.6	2 441.1	1 394.9
Zinc	7 651.6	7 362.9	4 764.2	3 031.7
Nickel	1 569.3	1 743.7	1 046.2	871.8
Chrome	2 266.8	2 092.4	1 569.3	1 569,3
Manganese	3 983.4	11 950.2	5 311.2	5 311.2
Lead	1 062.2	398.3	265.5	265.5
Total	472 188.1	513 354.7	258 075.9	244 823.1

The greatest amount of damage is related to emissions of organic compounds (about 92%). The share of suspended particulate in the total damage amount is 5%. The share of damage related with chrome, zinc and cooper emissions is 1.2%, with oil – about 0.2%. Because emissions into the water are decreasing from 1990, economic damage caused by water pollution is decreasing too. This is mainly due the decreased emissions of organic compounds.

Economic damage caused by soil erosion. Economic damage caused by soil erosion was evaluated as economic losses related to decreased yield of agriculture production. According to the structure of land-tenure set in Lithuania and average yield of wheat and other agriculture products we can determine , that 1 ha of soil lost due to erosion gives 4.1 thou. Lt of economic damage in 1994 prices. The dynamics of economic damage caused by soil erosion is shown in figure 3. We can draw the conclusion that decreasing area of lend-tenure not leads only to the damage increase, but also creates many problems related to the agriculture sector development.

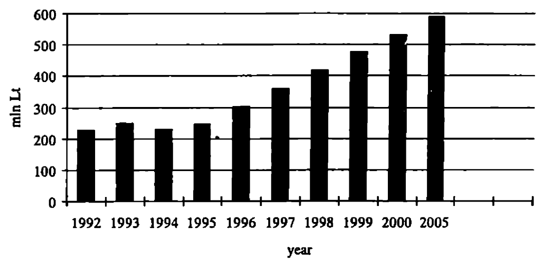

Figure 2. ***The dynamics of economic damage caused by soil erosion***

Economic harm to forests caused by antropogenic pollution. Economic damage to forests due to antropogenic pollution is evaluated as economic losses related to decreased increment of timber according to the defoliation of trees. The dynamics of economic damage to forests is shown in figure 3. As one can notice from the figure economic losses are decreasing from 1994 due to amelioration of the state of trees in the forests.

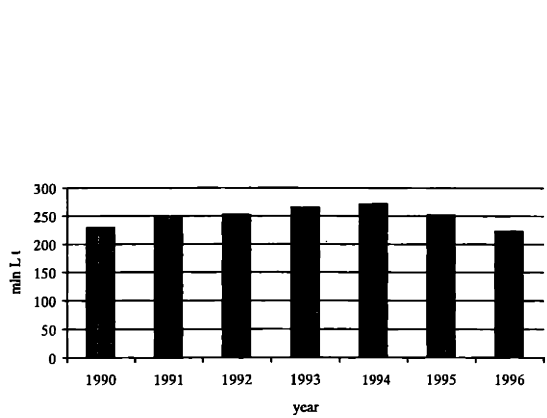

Figure 3. ***The dynamics of economic damage to forests***

Economic damage caused by premature deaths related with cancer disaster. Evaluation of economic damage caused by morbidity of cancer is based on the indicator of years of potential life lost. This indicator underlines the social economic impact of premature deaths. The concept of years of potential life lost entails estimating the average time a person would have lived had he not died prematurely. Economic damage is evaluated by multiplying the indicator of years of potential life lost marginal GDP per capita. Figure 12.5 shows the dynamics of economic damages caused by morbidity of cancer disaster. One can notice the stable increase of damage from 1965 because of increasing morbidity of cancer.

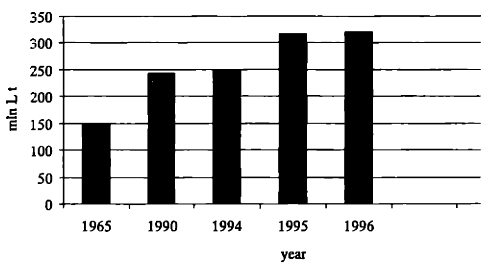

Figure 4. ***The dynamics of economic damages caused by morbidity of cancer disaster***

Economic evaluation of losses related with transport pollution. According to the data obtained from the social questioning in 1992, 75% of inhabitants settled in Vilnius think that the surrounding environment is polluted. The main source of pollution indicated by the social questioning is transport. According to the answers of respondents the main sources of air pollution are cars (62%), trucks (32%0, busses (23%), railway (17%), factories (17%).

Economic damage to selected recipients (human health, communal sector, industry, agriculture, forests, green plantation of the town) due to transport pollution is estimated using formula:

$$N = \gamma \cdot \sigma \cdot f \cdot M \tag{7}$$

where N – damage in Lt per year; γ – multiplier evaluating losses due to 1 tone of conventional pollutant emitted into atmosphere (CO). Multiplier γ evaluates complex losses for all indicated recipients; σ – coefficient evaluating the type of territory; f – coefficient evaluating distribution and settlement of pollutants in the territory; M – annual amount of conventional pollutants emitted into atmosphere in the territory (t/year).

Evaluation of economic damage caused by transport pollution in Vilnius. Evaluating economic damage related to transport pollution in Vilnius in 1994 (8) relationship was used. Economic damage obtained:

$$Y_{sum} = Y_{co} + Y_{ch} = \\ = Y_{no2} + Y_{so2} + Y_{kd} + Y_{pb} + Y_{bzp} = 229\ mln.\ Lt. \tag{8}$$

where Y_{sum} – total economic damage; Y_i – economic damage related to different pollutants.

Evaluation of economic damage caused by transport pollution for the transport corridors. The methodology applied for the damage evaluation in the transport corridors of Lithuania is the same as described above. Economic damage due to transport pollution for 1 km of the road in transport corridors is indicated:

In 1994 – 17 053.0 Lt.; 1995 – 22 573.4 Lt.; 1996 – 28 233.9 Lt. (in current prices).

4. Economic Mechanism of Environmental Protection and Integration of External Costs

4.1 Economic mechanism of environmental protection is a system of social and economical motives, legal regulations and economic-ecological norms, that, forming a complex of the aimed economical, technological and ecological factors in the behavior of social and economic subjects, guarantee wanted changes of ecological state. Efficiency of the economic mechanism during the process of ecological resources reproduction greatly depends on a full utilization of the market power [5]. For this, existence of efficient system of economical interests is required. Primary interests of the ecological resources consumers and ecological harm recipients should become a basis of the system:

- recipients should be equivalently compensated for the harm done; it is a possibility for the consumers of ecological resources to minimize individual ecological costs.

It should guarantee the capacity of economic interest system and private ownership rights. Ecological problems are often treated as disagreements related to ownership rights and solution of these problems bring to the elimination of these disagreements. The scheme describing motives and purposes of economic mechanism of environmental protection is presented in Figure 5.

Satisfaction of interests of primary damage recipients and ecological resource consumers is in the realization of equivalence principle in the relation to the environment and between the subjects of society. The main idea is, that the compensation to recipients must be equal to the economic damage. The compensation must come from the side of damage agents. It should be acknowledged, that even countries, where well developed systems of environment protection are functioning do not have unanimous regulations, making presumptions for an immediate work of market power and ownership interests in a process of environment protection [6]. Practically this can be done by establishing special services, whose functions would coincide with control over conditions of separate ecological subsystems using economical levers or legislature, that would require consumers to obey definite regimes of ecological resources consumption.

The motives to implement mechanism				
The system of ecological-economic interests		*Necessity to create market conditions in the nature resource utilization*		
Interest of ecological resource consumers to minimize their ecological expenses	Interest of damage recipients to receive economically equivalent compensation for the harm suffered	The necessity of resource prices	The necessity of ecological normative	The necessity of environmental taxes

The direct purposes of economic mechanism			
Efficiency of environmental protection technologies	The rational share of society resources to the environment protection	The optimal distribution of financial resources between environmental protection directions	Ecological costs minimization

Strategic purposes of environmental protection	
Economically and ecologically sustainable development of the country (region)	
Saving possibilities of future generations to satisfy they needs	Creation of technological and material basis for the satisfaction of future generations needs

Figure 5. ***The motives and purposes of the economic mechanism of environmental protection***

4.2 Integration of external costs. It is important not only to evaluate external costs of production and to calculate economic damage, but also to integrate these costs into external production costs. This will create possibilities to regulate environmental aspects of production in the most efficient way, using not administrative, but economic methods. Another important aspect is selection of economic development scenarios taking into account not only economic efficiency, but environmental restrictions too. For these purposes externalities are used.

In other words "extended" economic analysis, supplemented with ecological criterion, is applied for the development scenarios selection. In this case the best solution is based on the least social costs. Besides that integration of economic damage in calculations of pay-back of expensive ecological projects would stimulate implementation of these projects. For example, in energy sector in order to stimulate the use of renewable energy resources integrated resources planning, based on the integration of avoided damage burning different fuels is applied.

Nowadays, in most developed Western countries the projects for the implementation of environmental accounting, enabling to evaluate the state of environment and economic damage caused by pollution are widespread. So called "green" accounting used for the computation of macroeconomics indices becomes very popular. Such an indicator, supplementing economic information provided by GDP is the index of social welfare. The calculation of these indices enables determination of the quality of environment in the countries and they possibilities to achieve sustainable economic and ecological development and also to compare countries between each other.

4.3. The index of social welfare and economic damage. Very important field of social costs integration is supplementation of national accounts with environmental indicators and computation of indices of sustainable social welfare. Economic damage is being calculated due to antropogenic impact on the main components of environment: atmosphere, water and soil.

Indices of social welfare are formed as modifications of GDP [7]. All these modifications are based on the procedure of supplementation of conventional income and product account so that they can capture certain features of the environment. The system of national accounts entirely characterizes basic phenomena of economic life: production, income, consumption, accumulation and assets. One of the balancing items of the national account is Gross Value Added or Gross Domestic Product (GDP). The three methods are used to assess it: production (the total value of the goods and services produced within a country), expenditure (a total amount of final expenditure) and income (the estimation involves adding up the cost components of value added).

We propose such national account modification (Table 4). This modification is based on the integration of environmental indicators in the GDP calculation. Thus, modified GDP can be defined as conventional GDP less damage due air, water and soil pollution or conventional GDP plus environmental services. Environmental services in business are defined as waste disposal into the water, atmosphere and soil services. The value of environmental service is determined as pollution abatement approximately to the zero costs. In our proposed Lithuanian national account figures in the right and lefts side are equal, supposing that marginal pollution abatement costs are equal to the marginal damage caused by pollution.

Table 4. ***Gross Domestic Product by expenditure and income approach in 1994 Lt (in current prices)***

Expenditure		*Income*	
Consumption expenditure	15 127.7	Compensations of employees	7 095.7
Households	12 020.5	Wages and salaries	5 707.4
Government	3 107.2	Social contribution	1 388.3
Gross domestic investment	2 107.5	Consumption of fixed capital	977.6
Gross fixed capital formation	3-283.5		
Changes in inventories	–1 176.0		
Export	9 360.8	Taxes on production	1924
Import (–)	10 378.4	Subsidies (–)	269.8
		Operating surplus and mixed income	6 490.1
GDP	16 217.6	GDP	16 217.6
Environmental services (–)	1 726.3	Economic damage (–)	1 726.3
a. Atmosphere	900	a. Air pollution	900
b. Water	578.6	b. Water pollution	578.6
c. Soil	247.7	c. Soil pollution	247.7
Modified GDP	14 461.3	Modified GDP	14 461.3

Conclusions

1. Taking into account, that environment and its different subsystems are not able to become goods, having price determined in the market, the concept of strategy based on the efforts to achieve Pareto optimality conditions in the environment is proposed. The concept of economic mechanism of environmental protection is grounded and the system of economic interests guaranteeing capacity of this mechanism is proposed.

2. The concept of economically and ecologically sustainable development of the country, which require adequate to ecological changes economic information was well-founded. Economic damage of pollution as the main element of interaction between ecological and economic system was defined. Constructive concept of economic damage was developed, consider economic damage as the element of ecological costs and the distinctive feature of environmental costs and benefits.

3. Theoretically grounded evaluation of ecological costs and management are the necessary conditions for the achievement of economically and ecologically sustainable development of the country. The methodology for the evaluation of economic damage caused by antropogenic pollution and for the evaluation of ecological resource restoration is proposed. The principles for the minimization of these costs (environmental protection costs plus economic damage) are developed.

4. The system of economic damage evaluation is created. The system is based on the compatible application of analytical methods and expert systems all together. The developed computer modeling system allows to make assumptions on the damage distribution function and its numerical characteristics, factors distribution function and variation of the parameters as also on the interrelations of the factor distribution. Based on analysis of different interacting components of regional ecosystem "Lithuania" presented in Program Ecological Sustainability of Lithuania, the initial assessment of economic damage to air, soil, water, forests and human healthiness caused by antropogenic pollution was carried out.

5. The methods of economic damage evaluation were applied in these fields: cost-benefit analysis, economic regulation of environmental protection, calculations of indices of sustainable social welfare. The scheme for social costs integration in order to promote ecologically attractive projects is proposed. Avoided damage due to reduced pollution during cost-benefit analysis is being integrated as a benefit. Another important field of external costs evaluation – modification of national accounts by supplementing them with environmental indices – was analyzed and modified GDP for Lithuania was calculated.

6. As far as damage caused by antropogenic activity form a considerable part of GDP, its economic evaluation and minimization becomes the main target for the creation of economic mechanism of environmental protection.

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Aplinkosaugos ekonominio mechanizmo raidos problemos

Santrauka

Straipsnyje aptariamos ekonominės aplinkosaugos problemos. Ekonomikos ir ekologinės sistemos sąveikos atskleidimo ir ekonominio įvertinimo priemone pasirinkta ekonominės žalos kategorija. Atskleista ekonominės žalos samprata ir jos privalumai, palyginti su išorinių sąnaudų sąvoka, tiek atliekant ekonominę analizę, tiek rengiant ir įgyvendinant ekonominį aplinkosaugos mechanizmą.

Pateiktas ekonominio aplinkosaugos mechanizmo konkretizavimas ir siūlymas grįsti šį mechanizmą kertiniais ekonominiais ekologinių išteklių vartotojų ir žalos dėl neatkuriamojo tų išteklių vartojimo recipientų interesais. Šių interesų – ekologinių išteklių vartotojams turėti galimybę minimizuoti individualias ekonomines sąnaudas, o žalos recipientams gauti ekvivalenčią kompensaciją – įgyvendinimas suteikia ekonominės žalos kategorijai požymių, būdingų gaminių ar paslaugų kainai. Straipsnyje pateikti konkretūs ekonominės žalos įvertinimai Lietuvos sąlygomis, taip pat išvados ir siūlymai.

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