

Ukraine is paying significant attention to problems of sustainable development.

President of Ukraine L.D. Kuchma, being a prime-Minister, was writing, that "Economic reform and structure reconstruction of national economy will correspond with people interests only when an effective ecological policy takes place.

I this case the economy ecologization can't be compressed to some measures of pollution restriction... Air, water, soil, other values of our Earth it is necessary to consider as national economic resources, which are used in production process and have some value, which should be reimburse in proper way.

Only under such approach the policy of economy structural reconstruction will be oriented towards complex criteria of production ecological-economic effectiveness, which will maintain sustain reduction of energetic and resource consumption per unit of gross national product or national revenue.

Thus, ecological imperatives should be included into all levels of new economic mechanism and system of management decisions adoption". (See "Robitnycha gazeta", 1993, February, 12).

During speech on special session of UNO General Assembly in 1997 (Earth Summit "Rio+5") Kuchma L.D. stressed: "ecological element of national security becomes one of dominating features of internal and external policy of Ukrainian State.

According to this we direct our endeavors toward real integration of nature protection policy into social-economic development strategy (See "Urjadovyy Kur'yer", 1997, June 26). In this speech President of Ukraine declared the necessity to "... begin the elaboration of Global International Legal Act, which aim to guarantee ecological safety of all countries of the world. It has to be such Act, which will determine allowable norms of environmental behavior of all states for nation survival and prosperity in XXI century". President of Ukraine has returned to this idea again in "Appeal on the occasion of Chernobyl Nuclear Power Station closure, December 15, 2000".

Among problems which were considered at International Scientific Conference "Ecological-Economic Doctrine: Origins, Problems, Perspective" in Lviv, September 20-22, 2001 this aspect was considered and was announce a support of President' idea concerning creation of Earth Ecological Constitution and control bodies.

Only under strong support from international community this issue could be included into Agenda of Earth Summit "Rio+10" in 2002.

On the basis of mentioned above we can make an conclusion, that economy ecologization is one of the important factors for Ukraine transition towards sustainable development.

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FUNDAMENTALS OF THE ECOLOGICAL-ECONOMIC DOCTRINE

Ecological-Economic Doctrine (EED) is a relatively new educational discipline, which studies the cause-consequence relations and interdependence between economic and ecological systems. By applying the methods of natural, engineering and social sciences EED attempts to find the interconnection between these sciences and the human intellectual ability to ensure sustainable development.

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Основи еколого-економічного вчення

Еколого-економічне вчення (ЕЕВ) є відносно новою навчальною дисципліною, що вивчає причинно-наслідкові взаємозв'язки і залежності між економічною і екологічною системами. Шляхом застосування методів природничих, технічних і соціальних наук ЕЕВ досліджує взаємозв'язок між цими дисциплінами і людською інтелектуальною спроможністю забезпечити сталий розвиток.

Introduction

The global economic – ecological situation requires serious changes to be made in all spheres of human activity. If these changes are to be accelerated in proper direction, the changes in economic theory and education must occur in advance, for only science and education can influence public opinion and practice.

It is well known that economic theory became an independent branch of research only in the 17th century. Theretofore all economic discussions were ad hoc and non-systematic. Economic activity was not seen as an independent sphere of activity (Mark Blaug, 1985) [1]. Final formation of economic science took place only at the end of the 19th and beginning of the 20th centuries.

The similar things are happening with the new science of the end of the 20th century – **Ecological-Economic Doctrine (EED)**. This science is at the beginning stage of its development.

On the one hand, it will not be fair to complain on the lack of research and publications in the sphere of **EED**. A large number of publications concerning this subject appeared both in the West and in transitional countries. Among others, in 1998 the First World Congress of Ecologists Economists took place in Venice and the Society of Ecologists Economists was organized in San Francisco. On the other hand, **EED** still has not turned into an integral part of economic theory, that has a negative influence on the solution of practical tasks in the preservation of the environment and *sustainable development*. In all economic theory textbooks environmental expenses and losses are treated as external factors in respect to economy and industrial activity, that contradicts the reality of our time.

The new economic theory of the 21st century must internalize the ecological imperative. The ecological requirements and unavoidable ecological limitations must transfix almost all aspects of the new economic theory.

Scientific-technological progress gives rise to both problems and opportunities. The problems are connected with the application of new methods of production, its influence both the environment and the quality and quantity of natural resources. The central problem in this context is the problem of preservation and improvement of the quality of environment, as well as the rational use, protection and regeneration of natural resources, as a basis for material production with the aim of *sustainable development*.

Considerable worsening of the ecological situation at global, regional, and local levels has provoked a new way of ecological-economic thinking. It is quite clear that nowadays it is unacceptable to act in accordance with traditional views of man's influence on the environment, and traditional methods for evaluating production-economic activity. It is necessary to develop new methods for the evaluation of production-economic activity, which are sensitive to the growing influence of the economy on its environment.

The decisions of the UN Conference on the Environment and Development (Rio-92) also imposes certain obligations upon us. The Rio-92 Conference documents are the result of scientific research work done by a great number of specialists from all the countries of the world. The first UN Conference on the problems of environmental protection, which took place in Stockholm in 1972, can be considered as the beginning of the work on these fundamental issues. Between the "Stockholm-72" and the "Rio-92" conferences there took place a number of other international forums on the different aspects of these problems. Much has been published that brings us closer to the understanding of current ecological-economic problems.

The report of the World Commission on the Environment and Development (1987), prepared by a team of authors headed by Gro Harlem Brundtland, became an outstanding publication on these problems. This report was prepared for the UN General Assembly and was conditionally entitled "The Global Program of Changes". It envisaged the development of long-term strategies in the sphere of environmental protection and proposed changes to ensure sustainable development on the planet up to 2000 and beyond.

The report of the Brundtland Commission was passed at the UN General Assembly Session in 1987 and was recommended for application by all member countries of the UN [2]. In fact, this report became a conceptual basis for the documents, which were passed later at the Rio-92 Conference. This report presented the concept of sustainable development, which was declared at the Rio-92 Conference.

Ecological-Economic Doctrine in Modern Economic Theory

The limited framework of this paper does not allow to discuss this important argument in details. Thus I would like to turn the reader's attention only to the key statements of the classic, neoclassic and modern economic theory, which I propose to supplement with ecological imperatives.

Firstly, it concerns the statement of economic theory about three factors of production: labor, capital and natural resources. Each economic system has to deal with a dilemma of making choices, deciding which kind of goods to produce, how they should be produced, who should perform the tasks, which tasks should be performed and who will be the customer of the results. The scarcity of the resources dictates the necessity of each choice. The first choice is the kind of goods to be produced. In the modern economic system the quantity of the produced goods and services is immense. But it is still impossible to produce as many goods as people would like to be produced because of the scarcity of the resources.

For the convenience, the productive resources are usually divided into three major categories, which are called the production factors. Labor includes all production costs which people originate in the course of their muscular and intellectual activity.

According to traditional definition, capital includes all productive resources created by people: instruments, machines, infrastructure as well as non-material things such

as computer software, etc. But I will argue that the meaning of "capital" needs to be broadened to include not only what was created by people, but also environmental conditions in which the production of goods and services took place (e.g., many-sided useful functions of the forest as a natural phenomenon: production of oxygen, regulation of water and climate, protection of soil from erosion, etc). The term "natural resources" means everything that can be used in its natural state (without processing) for the production purposes, e.g. fertile lands, land parcels for construction purposes, forests, minerals.

The meaning of this third factor of production was changing continuously since the times of William Petti [1]. If William Petti was saying that "labor" is the father of "wealth" and "land" is its mother, then the modern economists have broadened the meaning of land and call it "natural resources".

In my view, the time has come to deepen the meaning even further. In the new conditions of aggravating ecological situation both at regional and at global levels, it would be expedient for the economists to reconsider their views of the third factor in production. Apparently it will be necessary to distinguish in the existing economic theory the fourth factor of production – the Living Environment. This fourth factor will include both natural resources and the environment, that is the components of the biosphere not having direct involvement in the production process but without which the production, life itself and proper quality of air, soil, water, sea water, sun radiation are not possible.

If we look at the factors of production from this new point of view, another important definition of economic theory – "opportunity cost" will acquire even deeper meaning.

"Opportunity cost" is the cost of the production of goods or services, which is measured from the point of view of the lost opportunity of performing the best out of the possible alternative types of activity requiring the same amount of time or the same resources. As the resources used in production could have been used somewhere else, the production of any type of goods would result in the lost opportunity to produce other types of goods.

It is important to use the meaning of "opportunity cost" in choosing the best applications for the scarce resources in one or another region (country), taking into consideration not only economic but also ecological requirements. In its own turn, this could help to turn the so-called externalities into the internal effects of the economic system. According to the accepted economic definition the term "externalities" means the effects, not reflected in the cost, of the production or consumption of a good, which influence on its customers or sellers.

Environmental pollution is a classic example of an externality. In figure 1 externalities are shown as the negative ecological effect caused by human activity. According to the approach used by traditional economics all ecological effects given in figure 1 need to be treated as externalities in respect of the economic system. According to the EED, part of these effects are internal effects of the economic human activity. Why are they internal? They are internal because without their appearance the production is not possible.

For example, there is a certain indispensable commodity, of which production is vital because of the existing demand for it and its irreplaceable nature. The technology of its production may not be the best possible one but the only available. In this situation, the environmental pollution occurring in the process of the production will be not

the external but internal effect of the given technological process. This effect has to be treated not as external, but as an internal one because at present, the cause of its occurrence could not be eliminated. In this case, the negative ecological effect' compensation costs have to be included in the self-cost of the production as well as in the price of the goods. This can be explained by the fact that the negative ecological effect accompanying the production is being caused by the objective cause-consequence relationships between the production of goods and environmental pollution.

The above mentioned represents the major difference between the approaches for the evaluation of environmental protection used in ecological economics and in traditional economic theory.

However, I have to specify, that the given effect of pollution has to be treated as the "internal" one only if it could not have been avoided at the expense of the sum, not exceeding the size of the alternative cost [4]. If the pollution could have been avoided or lessened, e.g. by using different technology for the production of the same product, then the smaller or zero ecological effect caused by the production will turn into an external one and thus should not be included in the self-cost. The means for the compensation of the results of such external negative ecological effect should come not from the consumer of the product, but from the benefits of the producer-polluter.

The problem of "externalities" is a complex one and should be considered not only from the point of view of **EED** but also from the point of view of general Economic Theory, as externalities and public goods are increasingly seen as some of the reasons for market failure.

The problems of **EED** in modern Economic theory have to include the corresponding changes in the sections of economic theory which are dealing with: structure of the fiscal (tax) politics; offer and demand; consumer choice; costs and losses; pricing at the resource markets; capital and natural resource markets; theory of the public choice; externalities and economic problems of the environmental protection; International economic activity, international trade and trade politics.

Unity and Contradictions of the Ecological and Economic systems

Economy and ecology possess the same linguistic root. Interconnections also exist between these two systems. In the second half of the 20th century these interconnections have become so obvious that nowadays it is widely accepted that it is reasonable to consider economic and ecological systems as a integral ecological economic system. Such a postulate is easiest to understand at a macroeconomic level. In the long term any society has to pay for the negative ecological consequences, caused by the production-economic activity of enterprises and firms of different branches of the economy. The costs of environmental protection, the treatment of air and water, as well as soils and other components of the biosphere are currently covered mainly from the state budgets in Ukraine and in other transitional countries. At present, firms and enterprises do not bear direct responsibility for the environmental degradation and other negative ecological consequences of their activity. This results in environmental protection being the concern of the state, society and taxpayers, not for the environmental polluter.

The unity of the ecological-economic system is more difficult to understand at a microeconomic level. Microeconomics, which studies the activity of small economic structures does not accept such a unity. Ecological costs and losses are treated as external to the activity of households and firms. Moreover, households, firms are not willing

to include these expenditures in the cost of their production, as this therefore increases the price of products and decreases competitiveness and income.

EED assumes the organic unity of the ecological economic system both at macroeconomic and microeconomic levels. It reveals the main tensions between economic requirements and ecological imperatives and finds the ways of overcoming these tensions both at the sector and territorial levels. Also, it could be argued that the economic system is more dependent on the ecological one than vice versa.

The problem has been stated in the following terms: "Any system is developing at the expense of the environment. In any environment, as in a super-system, the compensatory reactions, able to sustain its homeostaz, are generated. Until the intensity of the destruction is less or equals the environment's capacity to withstand them, the development continues "conflict-free". However, when the destruction exceeds constructive processes, the crisis of the relations between the system and its environment occurs. And, as in the "system-environment" the first component always depends on the second, the destruction of the environment inevitably turns into a catastrophe for the system. Hence, the nature – the living environment – is of highest value. The loss of the living environment would mean the death for all the people, and it would happen "before the nature would die" (Reymers, 1980: 5) [3].

The cause-consequence relations interconnect economic and ecological subsystems of the general system. Development, stabilization and degradation of each one of these subsystems, influences the other. Moreover, degradation of the ecological subsystem always implies degradation of the economic subsystem. The degradation of both subsystems may happen either simultaneously or the economic subsystem may survive the ecological one for some time. Those, who don't realize the importance of the cause-consequence relations between economic and ecological subsystems, will, however, eventually suffer the consequences. Continuing production despite the degradation of ecological subsystem will inevitably lead to the collapse of the economic subsystem.

Environment and Natural Resources in the Integral Ecological Economic System

The environment includes the next main components of the biosphere: land, water, fossils, vegetation and the animal world, and air space. The environment includes man himself, who is a part of living nature.

The environment can be divided into life support services and natural resources, which represent the potential raw material base for material production. Life support services and natural resources form the integral natural material basis for both the economic and ecological systems. However, the traditional economic system is interested only in natural resources, which represents the present or potential raw material base for the different branches of economy. As for the non-resource components of environment (such as solar radiation, air, water, and other components of the biosphere, that are not used directly in the production process), they are considered as external to the economic system. However, the environment including life support services, natural resources and mankind constitutes an integral ecological system at all scales – global, regional, and local.

Life support services suffer considerable damage due to the productive activities of man, both through pollution and through extraction of raw materials. Disregarding the life support services component results in a non-rational use and depletion of the natural resources component and causes a decrease in the long-run ecological potential

of the whole ecological system. Thus, the economic system should include not only the resource part of the biosphere but the life support services as well. Sometimes it is practically impossible to distinguish between life support services and natural resources since the same components of the biosphere (e.g. land in agriculture and in forestry) act simultaneously in both. But the division into two components is important from a methodological point of view. Therefore life support system, as ecological system, should become a priority from the point of view of ensuring sustainable development.

Natural resources and life support services should be considered within the framework of the integral ecological-economic system. These components are integral parts of the economic process of material goods production as well as important factors in forming GNP and the national wealth.

The use of the environment should be understood as a threefold process of rational use, protection, and regeneration of twofold components of material production – life support services and natural resources (figure 1).

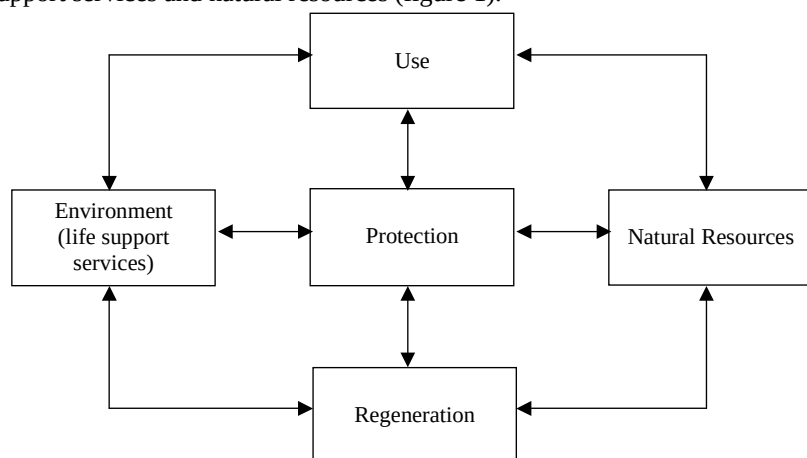


Figure 1. Ecosystem Management Model

The interaction of two life-ensuring systems – economic and ecological – in the production of goods and services is accompanied not only by a desirable *economic* result but also by an attendant *ecological* one.

Ecological effects mean any changes in quality of the living environment as well as in the quantity and quality of natural resources in space and time. Such changes may be either positive or negative in character – improvement or worsening of the natural conditions of life, increase or decrease of the natural resources quantity and quality. Ecological effects influence or can have future influence on the economic results of material production and on the non-production sphere.

Ecological effects are characterized, at least, by ten indicators (table 1).

The classification, given in table 1 has practical significance. It allows us to define the character of ecological effects and to undertake necessary measures to prevent undesirable ones. The most dangerous effects are concealed as non-forecasted ones, which can arise unexpectedly, inflicting great losses to an economic system and even causing victims.

Table 1. Classification of Ecological Effects

Definition of effects	Type of effects (negative or positive)	
1. Origin	natural (happening for natural reasons)	artificial (caused by human activity)
2. Forms of manifestation	obvious (visible or outwardly perceptible)	hidden (concealed, not perceptible or seen outwardly)
3. Possibility of quantitative evaluation	measurable (the one which could be measured quantitatively)	non-measurable (cannot be measured quantitatively)
4. Character of interdependence with economic effect	spontaneously turning into economic effect (directly transformed)	indirectly connected with achieving economic effect, mediate (indirectly transformed)
5. Time lag	coinciding in time with the achievement of economic effect	not coinciding in time with the achievement of economic effect
6. Possibility to reverse	reversible	non-reversible*
7. Durability	short-term	long-term
8. Possibility to foresee	can be forecasted	can not be forecasted
9. Scale	local and regional	global
10. Motivation	deliberate	unintentional

* – only negative

There are ten pairs of effects in table 1. Taking into consideration the fact that they can be either negative or positive total number is thirty nine. All of them are dynamic and can transform into each other. Effects of natural origin could be produced by human labor (artificially). For example, fish can be bred naturally as well as artificially. Hidden ecological effects become evident with time and visa versa – the evident one can become hidden. An ecological effect, which is at present only indirectly connected with the achievement of economic results in production, tomorrow can have direct influence on the economic results of this production.

Ecological Costs

Ecological costs are the total combination of expenses and losses in the sphere of natural resource use, protection and regeneration, as well as in environment protection. This is one of the fundamental notions of **EED**.

Ecological costs of material production and non-production sphere include:

- direct costs of environmental protection, treatment of air and water, lands, and other components of the living environment;
- costs of timely quality regeneration of the degraded living environment;
- losses connected with irreversible negative effects on the environment, quantity and quality of natural resources;
- losses connected with the necessity of reserving for environmental protective purposes objects of nature, which could be exploited and yield real economic effects;
- additional costs in connection with the development of natural resources under worsening conditions and resources remote from the centers of direct consumption;
- relatively high costs of processing secondary and low grade raw materials into commodity products in order to save the good quality raw materials;
- costs of extended regeneration of renewable natural resources, as well as for research and the creation of substitutes for non-renewable resources;

- general costs of fundamental and applied scientific-research and design works in the sphere of the living environment and natural resources, formal and non-formal ecological education of the population.

Due to the worsening of global and regional ecological situations, ecological costs have tended to increase both on the national and global scale. One may assert that there exists an economic law of the increase of ecological costs to society. The law states that there is an inevitable increase in space and time of the costs of material production, the non-production sphere on the protection, use, and regeneration of natural resources and quality of the living environment.

The economic law on the increase of the ecological costs to the society reflects objective cause-consequence relations existing between the level of intensity of natural resource use, the level of environmental pollution and other forms of ecological system degradation on the one hand, and the necessity of adequate compensatory expenditures for the regeneration of life support services and natural resources, on the other hand.

The effect of this law is preconditioned by the fact that no activity can function without utilizing the natural resources of the planet and without having some environmental impact. Therefore, in the process of mankind's development, there arises the necessity for an increasing expenditure of money for ecological purposes.

Ignoring the influence of this law on the economic system results in the degradation of the quality of life support services, in the depletion of the natural resources and finally in the need for new ecological expenditures to combat the increased probability of ecological losses. Thus, socioeconomic impoverishment follows. Application of this law in social practice at the global, national, regional, and local levels is a prerequisite for balance between ecological and economic systems, and for sustainable development.

The law would appear to be confirmed by empirical evidence, which demonstrates the relationship between intensity of the use of natural resources, the quality of life support services, and quality of human life itself. This law will be in effect until the reasons for its existence, such as noncompensable use of natural resources and noncompensable destructive changes in the living environment, take place. It is possible to decrease its effect by optimizing the interaction between the society and nature. This requires agreed actions at regional and global scales. In order for such actions to become a reality, it is necessary to replace the traditional economic criterion of the evaluation of efficiency in production by a unified ecological-economic one.

In accordance with this law "ecological costs" should be included into the list of production expenditures. "Ecological costs" in the structure of the cost of production and services can perform a double function. First of all, it can forestall anti-ecological economic activity and stimulate rational use, protection, and regeneration of natural resources. Secondly, it can become a source of the replenishment of the funds, directed at the financing of the environmental protection and development of new ecologically safe technologies.

Principles for the Ecological Economic Evaluation of Environment and Natural Resources

The depletion of natural resources implies loss of ecological potential, which it will be necessary to renew in the future. It also implies the degradation of the life support services, which would have to be improved at the expense of future investments.

The goals of preventing the loss of ecological potential and achieving sustainable development may be reached by two ways. The first is to bring the production technology into correspondence with ecological imperatives, to provide it with ecological orientation, and to structurally entwine ecological factors in the fabric of the corresponding technologies. The second is goal-oriented environmental protection activity. These often overlap. In particular this overlap takes place in extractive branches of industry, in agriculture, forestry, water management, as well as other spheres of production activity connected with the use and regeneration of natural resources. Complete unification of these two ways will, in the future, become a new stage in the development of human civilization. In order to achieve this, we should be guided by principles for the eco-economic evaluation of life support services and natural resources:

- The principle of complexity: the registration and evaluation of all interdependencies between life support services and natural resources in different territories and in their relationship.
- The principle of scarcity: weighting the relative scarcity of individual components and conditions of life support services and natural resources. In accordance with the requirements of this principle a comparatively higher weight is given to the irreplaceable, non-transportable life support services and resources, as well as conditions and resources, which are in shorter supply in comparison with others.
- The principle of the regional differentiation: this which envisages the different levels of evaluation of the qualitatively identical conditions of the living environment and natural resources (space evaluation).
- The principle of evolution: evaluations and forecasts, should take into account possible changes in ecological and economic conditions in future. This can affect the relative scarcity of individual ecological services and natural resources.
- The principle of feedbacks: taking into account boomerang effects (negative ecological effects).

This implies consideration in economic calculations of the mutual influence of economic activities on life support services and natural resources and vice versa.

Criterion of the Ecological Economic Effectiveness of the Human Activity

Production of goods and services toward to satisfying individual and social needs on the one hand, and the desire to maintain ecological conditions on the other hand, implies a new economic category – ecological economic effectiveness. Illustratively, the relationship between economic effects and ecological effects is shown on figure 2.

X axe – scale for the ecological effect (Ex);

Y axe – scale for the economic effect (Ey);

NM – discriminate of the positive and negative ecological economic (E-E) effect;

OR – vector of the optimal E-E effect;

XI, X2, X3, X4, X5 / Y1, Y2, Y3, Y4, Y5 – types of the hypothetical money value of the ecological economic effect in production activity.

On the ordinate axis – economic effects, on the abscissa axis – ecological effects. This illustrates the notion of ecological economic effectiveness.

Integral ecological-economic effect of the living environment and natural resources as well as of other production-economic activity is an algebraic sum of two different in nature effects – traditional economic and ecological ones. These effects are achieved, as a rule, with a different lag and, only in some cases, simultaneously. Usually

traditional economic effect is positive while ecological one could be both positive and negative. The negative effect is the most urgent one.

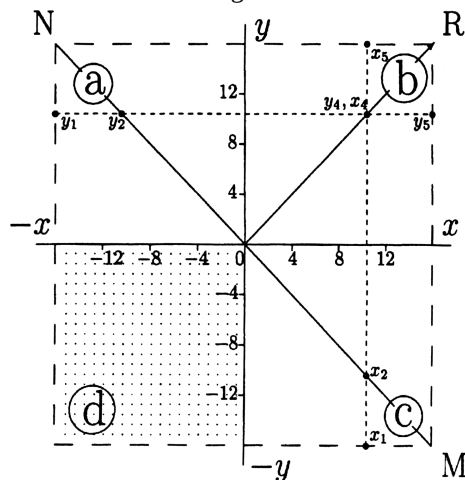


Figure 2. Graphic Interpretation of Ecological Economic Effectiveness of the Human Activity

The ecological effect reflects changes, in space and time, of life support services and natural resources under the influence of different factors. These changes may have both positive and negative character – improvement or worsening of man's life conditions, increase or decrease of the quantity and quality of natural resources.

The ecological-economic effect is based on the net economic effect of the production-economic activity minus ecological costs and losses. The notion of ecological economic effectiveness equally corresponds to the development laws of society and nature and therefore satisfies the principle of sustainable development.

A rough measure of ecological economic effectiveness is the ratio of the grade of the integral ecological economic effect of the production-economic activity to the sum of traditional economic and ecological expenditures. The Integral ecological-economic effect, achieved at minimum social costing, is an important factor in sustainable development. The criterion for the efficiency of an economic system is the maximization of the integral ecological-economic effect.

A sample numerical example follows. Hypothetical evaluation of the eco-economic efficiency is carried out by means of the five-point scale in table 2.

Table 2. Ecological-economic evaluation of possible variants of choice of conditions

No. of variant	Variant chosen	Analytical evaluation of conditions	
		Natural resources use	Environment protection
1	INEXPEDIENT	$Ey - Ex < 0$	$-Ey > Ex$
2	EXTREMELY PERMISSIBLE	$Ey - Ex = 0$	$-Ey = Ex$
3	SATISFACTORY	$Ey - Ex > 0$	$-Ey = 0$
4	OPTIMAL	$Ex = Ey$	$Ey = Ex$
5	ATYPICAL	$Ex > Ey$	$Ey > Ex$

The mathematical formulas for the evaluation of different types of production activity, given in the table 2 are presented in the hypothetical money value form in the table 3.

Table 3. Money value of the annual ecological economic effect in production activity, hypothetical units

No. of variant	Hypothetical value of the ecological economic effect	
	Natural resources use	Environment protection
1	$Ex1 = -14$ $Ey1 = 10$ $\Sigma Exy = -4$	$Ex1 = 10$ $Ey1 = -14$ $\Sigma Exy = -4$
2	$Ex2 = -10$ $Ey2 = 10$ $\Sigma Exy = 0$	$Ex2 = 10$ $Ey2 = -10$ $\Sigma Exy = 0$
3	$Ex3 = 0$ $Ey3 = 10$ $\Sigma Exy = 10$	$Ex3 = 10$ $Ey3 = 0$ $\Sigma Exy = 10$
4	$Ex4 = 10$ $Ey4 = 10$ $\Sigma Exy = 20$	$Ex4 = 10$ $Ey4 = 10$ $\Sigma Exy = 20$
5	$Ex5 = 14$ $Ey5 = 10$ $\Sigma Exy = 24$	$Ex5 = 10$ $Ey5 = 14$ $\Sigma Exy = 24$

Supposedly, there are five hypothetical variants of technologies for the production of some product. In the real life the number of these types could be numerous. If we calculate the results of production activity of the firm according to the traditional criterion of economic efficiency, then the economic effect of in all five types of activity, given in table 2, will be equal in value – 10 hypothetical units.

In the traditional input-output formula of calculating profits (benefits) does not matter for the firm which variant of technology to use:

- the technology polluting environment, worsening the quality of ecosystems or even damaging it (variant 1);
- the technology having less negative influence on the environment and producing benefits equal to ecological losses (variant 2);
- the technology having no visible negative influence on the environment and producing net benefits without ecological losses (variant 3);
- the technology doubling the integral ecological economic effect due to improving the quality of environment in the course of production (variant 4);
- the ecological technology causing larger positive ecological effect than the traditional economic one (variant 5).

As I have mentioned before, in the traditional criterion, it makes no difference for the firm which variant of technology will produce 10 hypothetical units. But, if we use the new ecological economic criterion, which is the key concept of the **EED**, then it will turn out that public efficiency (net efficiency) of these 5 variants of technologies will be far from equal.

In the first variant of production 10 hypothetical units of benefits for the firm will turn out into 4 hypothetical units losses for the society (table 2). This happens because to compensate for ecological losses, caused by this variant of technology, the society will have to spend 14 hypothetical units. The benefits of the firm are 10 hypotheti-

cal units, but the losses to the society are 14 hypothetical units. The difference according to ecological economic criterion is $10 - 14 = -4$.

In the second technological variant 10 hypothetical units of benefits will turn out into zero benefits for the society. All the benefits should have been spent to compensate for ecological losses, caused by the production activity of the firm. So the future ecological costs to the society will be equal to the benefits of the firm. The difference according to ecological economic criterion is $10 - 10 = 0$.

In the third technological variant the benefits of the firm will be real, as its activity have not caused ecological losses. The benefits of the firm will not cause any losses to the society, as there will be no ecological losses. The difference according to ecological economic criterion is $10 - 0 = 10$.

The fourth variant is even better, it could be called the "optimal" one, as it satisfies both ecological and economic requirements. However, it is extremely difficult to achieve this variant of technology in the real life. In this variant the benefits cause the equal positive ecological effect. The difference according to ecological economic criterion is $10 + 10 = 20$. This fourth variant satisfies the sustainable development principle announced by Rio-92. This variant of technologies should be a final goal for the individual subjects of national economics (firms), international firms as well as for the countries as it provides for long term sustainable social economic development.

And, finally, the fifth variant – atypical – is theoretically possible. In this case the positive ecological effect exceeds the traditional economic one. The difference according to ecological economic criterion is $10 + 14 = 24$.

Conclusions

The major task of **EED** is to understand organic unity of economic and ecological systems, to explain their interconnection and interdependence, as well as their contradictions and conflicts.

EED is a relatively new educational discipline, which studies the cause-consequence relations and interdependence between economic and ecological systems. It attempts to scientifically explain these relations and the driving forces behind local, regional and global ecological crises. By applying the methods of natural, engineering and social sciences **EED** attempts to find the interconnection between these sciences and the human intellectual ability to ensure sustainable development. Sustainable development could be achieved by stimulating preventive protection of the environment, by "ecologization" of all the spheres of material production as well as meeting ecological imperatives in all spheres of human activity. In order to achieve sustainable development ecological effects should be included in the assessment economic choices. **EED** points out the ways in which an economic incentives system may prevent environmental damage. It also suggests the possibility of compensation for the inevitable ecological damages without the violation of environmental legislation. These damages should be compensated by the responsible industrial and commercial structures. Thus, **EED** provides ways for achieving the goals of sustainable development.

If we truly seek the Sustainable Development called for in the Agenda for the Twenty first Century – we must turn away from the traditional economic thinking of the twentieth century and begin to train the economists of the new era, economist-ecologists enabled to communicate with each other throughout the world.

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NATURAL RESOURCE MANAGEMENT IN AN AGE OF LIMITS: AN ECOLOGICAL ECONOMICS PERSPECTIVE

"A great change in our stewardship of the earth and the life on it is required"

Union of Concerned Scientists, World Scientists' Warning to Humanity, 1993

Adapting to change

Adapting to change has long been the greatest challenge of natural resource management. The history of conservation is a history of responding to changing social, economic, political, technological and environmental conditions. Some examples from conservation history in the United States illustrate this point. The early conservation movement in the U.S. – at the turn of the last century – was in part a response to unregulated, destructive and unsustainable exploitation of forest resources and opposition to that exploitation by a small group of conservation leaders (Hays 1959). One of the results of this movement was the establishment of the U.S. Forest Service and creation of the U.S. National Forest System. Another example is the major U.S. environmental legislation of the 1960s and 70s, including the Wilderness Act of 1964, the National Environmental Policy Act of 1969, the Endangered Species Act of 1973, and the National Forest Management Act of 1976. These environmental laws and regulations were responses to growing perceptions of environmental decline and changing environmental attitudes and values.

The rise of ecosystem management as an alternative model of forest management is the most recent example of adaptation to the changing social and environmental context. Ecosystem management has been widely advocated as a "new" approach to natural resource management (Bengston 1994, Bengston and Fan 2001), although many of its core elements can be traced back to the 1920s and 1930s to Aldo Leopold and a few other visionary ecologists (Grumbine 1994, Flader 1994).

But what is ecosystem management? Definitions of ecosystem management have often been so broad and inclusive that they promise to be all things to all people. Ecosystem management is often characterized as emphasizing the following goals and means of implementation: Maintaining social, economic and ecosystem health and sustainability; incorporating social values and human uses; and using adaptive management and a collaborative approach to planning and management (More 1996, Corter and Moote 1999). These characteristics in many ways reflect responsiveness to changing so-

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