Sustainable development – state and prospects
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Analytical and information support of the structural development of eco-entrepreneurship in the system of sustainable development

Introduction

Over the past few decades, the relevance of implementing the sustainable development concept provisions has been constantly increasing. The goals declared by the concept oblige industrial enterprises to be responsible to a society and future generations for the impact on the environment, the rational use of natural resources, as well as the safety of goods offered on the market. Since environmental problems are global in nature, despite the fact that not all industrial enterprises are large business structures and operate in limited, local areas, all of them are obliged to develop environmental management systems. Because of the instability of the external environment and the increasing challenges, environmental management system environmental activities require a regular improvement. To accomplish this task, the managers of these enterprises must have a high level of personal and corporate responsibility for approved decisions. An important aspect of the effectiveness of management and engineering decisions in the field of environmental protection is also the awareness of management entities, their creativity and willingness to innovate. These factors recognize the environmental potential of the enterprise and its role in meeting public environmental needs.

The purpose and objectives of the study

The purpose of the study is to reveal the essence of analytical and information support of the structural development of eco-entrepreneurship in the system of sustainable development. The objectives of the study are: definition of criteria for development of eco-entrepreneurship; consideration of the model of optimization of ecological projects management.

Literature review

Among the modern researches devoted to problems of developing management systems of the enterprise environmental protection activity, it is ad visible to allocate some vectors. The first is the research, in which the enterprise is considered as an element of the sustainable development system, which requires permanent adaptation to the environment [1], as well as the construction of the management system that would ensure only those changes that do not harm future generations [2]. The second is the research, which focuses on the enterprise social responsibility [3], in particular, the corporate, environmental one [4]. In this direction it is necessary to allocate the scientific works devoted to such problems as: search of balance between the managing subjects' satisfaction of economic interests [5] and the society ecological needs [6]; ecological risks [7], ecological safety [8–9] and administrative and legal mechanisms of its providing [10]. The third is the research, in which the society environmental needs are considered in the context of a separate consumer niche [11]. It is about environmental challenges for economic entities [12], as an objective circumstance that requires technological innovation [13] and environmental management systems improvement [14], in particular, the systems' development through the use of universally recognized, transparent mechanisms [15]. This group of studies should include the works in which environmentally friendly products are considered as a competitive advantage [16]. Among these and other scientific works, the structure of environmental management systems of enterprises is considered only in fragments, which is the reason for the imperfection of their development models in the context of the concept provisions of the sustainable development.

Results and discussion

Under the conditions of globalization of economy, fast growth of mechanisms of business corporatization, accompanied by constant increase of society informatization level, increase of level of formalization and adaptability of communication systems, strengthening of competition for resources and markets of sales it becomes obvious the necessity to strike a balance between pragmatic nature of economic entities and realities society in the face of natural resources depletion threat , ecological catastrophes and humanitarian collapses. Nevertheless, it should be acknowledged that, against the backdrop of the multipolarity of a society, achieving such a balance is unrealistic, since responsibility for global problems is constantly relegated to the background because of the urgency of solving local problems, as well as the lack of mechanisms to use "coercive power" to counteract the sacrifice of one's needs for the benefit of others. The problem is that in the XX and XXI centuries the phenomenon of globalization is accompanied by the emergence of contradictions: on the one hand, emerged and dynamically developing mega systems that are aimed at meeting the diverse needs of society, and, on the other hand, the development of mega systems occurs so that the society is unrestrained solving its global problems through its greatest values is decentralization, and, strangely enough, democracy, which should guarantee security and comfort to everyone together and to everyone in particular.

Given that the ecosystem is common to eco-economic, eco-information and tourism systems, there is no doubt that a key function of society as a basis for the concept of sustainable development is the permanent search for ways to optimize development on the basis of objective natural laws and strengthening social collective and individual responsibility for the results of decisions made to future generations, for vectors and characters of development. In this case, the development of mega systems is advisable to understand the achievement of qualitative changes in the society in order to obtain opportunities to satisfy all without exception. Development is often characterized by the alignment of selfish positions of certain groups of society with the values of society in general. Competition as a driver of progress leads to the search for compromises, the integration of the potentials of antagonistic groups of society, the rationalization of ways of achieving the primary goals. Mega systems are open systems whose development is the result of the fight against antagonisms. Integration of mega-systems is the vector of their development, which will allow to translate the opposition from the channel of the struggle for resources into the channel of the struggle for the benefit of investing in the conservation and reproduction of natural resources, which, judging by the modern concepts of development, will be characterized by chance of development options, irreversibility of development processes, uniqueness mechanisms of development.

Forming mechanisms to balance the pragmatism of economic entities and the realism of protecting the interests of society requires the search for a common basis in such mega-systems as eco-economic, tourism and eco-information systems. Studies have shown that such a basis is a society that, despite its multipolarity, is inclined to achieve its goals on the basis of a systematic approach. Different groups of society, by building systems to achieve the set goals and meet the needs, one way or another encourage the mega systems to integrate them. Insofar as selfish, corporate, and collective goals do not contradict common social needs, their attainment is influenced by objective natural laws and rules of reflection. Consequently, the development and implementation of mechanisms for solving global problems is inevitable, but the speed of exacerbation of problems requires immediate revision of the vectors of development potential use by society, in particular the transformation of provisions of many leaders of different groups of society into real-acting mechanisms of solving problems.

Problems of reproduction and rational use of natural resources as components of ecological-economic, tourist and eco-information systems have always been important for humanity, but today they have grown into one of the most important global problems of our time, because the more fully used natural resources, the greater the risk of their depletion, especially when it comes to non-renewable natural resources. This is explained by the significant increase in population on the Earth, the overuse of natural resources and the consequences of scientific and technological progress. In this regard, the rational use and reproduction of natural resources is becoming one of the most pressing problems of humanity.

Ecological and economic problems of reproduction and rational use of natural resources include the application of a set of environmental measures, eco-projects that depend on the type of economic activity and aimed at reducing and eliminating negative anthropogenic impact on the environment, preserving, improving and rational use of the country's natural resource potential , namely: construction and operation of treatment, disposal facilities and equipment; development of small and waste-free technological processes and productions; location of enterprises and systems of traffic flows, taking into account environmental requirements; land reclamation; soil erosion control measures; measures for the protection and reproduction of flora and fauna; mineral protection and rational use of mineral resources. Their main purpose is not only to eliminate eco-destructive phenomena, but also to prevent them.

In the context of the development of the concept of sustainable development in the business and scientific circles the problem of ways to activate eco-entrepreneurship is considered quite lively. Thus, during the independence period in Ukraine 347 theses were defended in the name of which is the phrase "sustainable development" [18], the number of journals in the SCOPUS scientific-metric database, in the name of which the term "sustainable development" appears, as of February 13, 2020 — 20 of them belong to the subject area:

- Geography, planning and development — 6 (31.57%);
- Development — 2 (10.52%);
- Urban Studies — 2 (10.52%);
- Business and International Management — 2 (10.52%);
- Multidisciplinary — 2 (10.52%);
- Agronomy and crop production — 1 (5.26%);
- Energy and energy technologies — 1 (5.26%);
- Save — 1 (5.26%);
- Renewable energy, sustainability and environment — 1 (5.26%);
- Sociology and political science — 1 (5.26%).

Areas of interest in SCOPUS, the most common metric for sustainable development issues:

- Economics, econometrics and finance;
- General Economics, Econometrics and Finance;
- Business, management and accounting;
- Technology and innovation management;
- Energy;
- Energy, engineering and technological capacity;
- Renewable energy, sustainable development and the environment;
- Environmental science;
- Management, monitoring, policy and law;
- Earth and Planetary Sciences;
- Economic geology.

The most common areas of research on economic issues of sustainable development are:

- economic assessment of the impact of sustainable development policy on added value;
- economic modeling of systems to ensure the growth of human well-being, poverty and inequality;
- analyzing the legal problems of applying economic mechanisms to implement the concept of sustainable development;
- impact of education on economic decisions in the sustainable development system;
- developing principles and mechanisms for rationalizing the use of natural resources, as well as achieving the safety of processing and consumption of renewable resources;
- study the relationship between economic growth, sustainable development and ecosystem status;
- analyzing the experience of implementing reforms aimed at ensuring sustainable development;
- improvement of mechanisms of application of economic levers of influence on the state of the Earth's water resources;
- the impact of transport infrastructure on sustainable development.

In their turn, the subjects of economic research within the framework of sustainable development are:

- economic evaluation and analysis;
- modeling of economic systems;
- development of new and improvement of existing mechanisms of application of economic levers of influence on economic entities.

The analysis we conducted showed that, beyond the attention of researchers, there remained analytical and information support for eco-entrepreneurship as an integral part of sustainable development, as well as approaches to optimization of eco-project activities.

Studies have shown that the main sectors of eco-entrepreneurship (X) are:

1) entrepreneurship that ensures the effectiveness of environmental measures (X_1);
2) targeted environmental production (remedies, eco-friendly products, etc.) (X_2);
3) production and conservation of energy (energy saving, energy efficiency and development of renewable energy sources) with the introduction of innovative technologies. Here the findings of previous studies (X_3) are noteworthy;
4) consulting technology, expert systems technology, and some decision support systems (X_4), in particular, in the works.

In a formalized form, the relationship between the eco-business sectors and their constituent components is written as:

$$X \supset \{X_1 \wedge ... \wedge X_4\} \mid X = f(\mathrm{a,b,c,d,e,g,h,i}), \quad (1)$$

where a is entrepreneurship in the field of dissemination of environmental technologies under leasing, franchising and licensing conditions; b — Entrepreneurship in the field of communication and energy optimization services; c — creation and implementation of environmental protection technologies; d — production of environmentally friendly goods; *e* — energy production; *g* — energy conservation; *h* — consulting technologies; *i* — expert systems technologies, as well as some decision support systems.

Sectors $X_1 \ldots X_2$ is correlated with $a \ldots$ and both productive and factor traits. The value of factor traits can have only one-to-one interpretation, which is formally equated with 0 or 1. That is, if we consider X through the prism of metric space, then:

$$\left.\begin{array}{l} d(\mathrm{a}_0^1;\mathrm{a}_1^1) = \begin{cases} 0, & \mathrm{a}_0^1 = \mathrm{a}_1^1 \\ 1, & \mathrm{a}_0^1 \neq \mathrm{a}_1^1 \end{cases}; \\ \ldots. \\ d(i_0^1;i_1^1) = \begin{cases} 0, & i_0^1 = i_1^1 \\ 1, & i_0^1 \neq i_1^1 \end{cases}. \end{array}\right\} . \quad (2)$$

In the expression (1) several metric spaces have formed, namely:

$$\left.\begin{array}{l} a_1^1 \Leftrightarrow r; a_1^1 \in a \mid d(a_0^1;a_1^1) \prec a_1^1; a_0^1 \sim a \setminus d; \\ \ldots\ldots \\ i_1^1 \Leftrightarrow r; i_1^1 \in i \mid d(i_0^1;i_1^1) \prec i_1^1; i_0^1 \sim i \setminus d. \end{array}\right\} . \quad (3)$$

In this case, $X \wedge X_1$, as well $X \wedge X_2$, $X \wedge X_3$, $X \wedge X_4$ are ordered pairs, where X is a set and $X_1 \ldots X_4$ systems of subsets. The relation between plurals and subsets satisfies the following conditions:

$$\left.\begin{array}{l} \because X \supset X_1 \sim \Lambda_1 \therefore \Lambda_1 \sim X \mid X \cap (a \wedge b) \in X; \\ \ldots\ldots\ldots \\ \because X \supset X_4 \sim \Lambda_4 \therefore \Lambda_1 \sim X \mid X \cap (h \wedge i) \in X, \end{array}\right\} , \quad (4)$$

where $\Lambda_1 \ldots \Lambda_4$ — are the topologies for $X_1 \ldots X_4$.

From the standpoint of information and analytical support for the development of eco-entrepreneurship, structural relationships between the constituent components of X indicate that the eco-enterprise has features of the system, so it should be developed on the basis of a system-structural approach. At the same time, it is important to monitor permanently the causal connections between the structural components of the system within the topological spaces and to monitor the nature of changes in the factors that affect its state and dynamics of development. These include factors such as climate change, changes in the share of harmful substances in the environment, changes in sources of environmental pollution, the emergence of innovative technologies in the field of energy conservation, replacement of natural resources with artificial resources, protection of the environment from harmful emissions and more.

Within the framework of a single entrepreneurial organization, the development of eco-entrepreneurship on the basis of a structural approach implies the launch of eco-projects within all components (X). As a consequence, the enterprise should form a portfolio of eco-projects, which requires multicriteria optimization, which, due to the variability of the environment, requires permanent reformulation. The characteristic features of these portfolios are that they are mostly shaped and reformed, taking into account the level of systematic and non-systematic risks. O. Balatsky, O. Telizhenko, M. Sokolov reveal the essence of optimizing the ratio between risk and risk-free instruments in the investment portfolio based on the following assumptions [19]:

1. Calculation of the expected profitability of the eco-projects portfolio:

$$M(E_n) = X_0 A_0 + (1 - X_0) M(A_p) = M(A_p) + X_0 (A_0 - M(A_p)), \quad (5)$$

where:
A_0 — the profitability of risk-free investment in eco-projects;
$M(A_p)$ — expected return on risky investments $M(A_p) > A_0$;
X_0 — the share of funds invested in risk-free eco-projects;
$1 - X_0$ — the share of funds invested in risky eco-projects.

2. Determination of the variance of the ecoproject portfolio in the part of theirisk ecoprojects that are its component [20]:

$$C_{kon} = (1 - X_0)^2 C_{kop}{}^2 \text{, from here:}$$

$$X_0 = \frac{1 - C_{kon}}{C_{kop}}, \quad (6)$$

$$\frac{M(E_n) - A_0}{M(A_p) - A_0} = \frac{C_{kon}}{C_{Ckop}}, \quad (7)$$

where C_{kop} — is the varience of the package of risky ecoprojects.

3. Identification of variation of eco-projects portfolio:

$$B_{ni} = \frac{C_{kop}}{M(A_p) - A_n} - \frac{A_n C_{kop}}{M(E_n) M(A_p) - A_n}. \quad (8)$$

Exceeding the yield of risky financial instruments over the risk-free yield is called the risk premium, which is measured by a factor. This ratio is usually determined by the formula:

$$M(A_p) = A_0 + \beta (M(E_n) - A_0), \quad (9)$$

$$\text{where } \beta = \frac{C_{kop}}{(C_{kon} - 1)/(1 - X_0)}.$$

Decisions on forming and reformulating portfolios of eco-projects, in particular those containing different types of eco-projects, make the decision by optimizing two-criteria economic-mathematical problem, in which one criterion is to minimize the level of risk associated with the initiation and implementation of eco-projects, and the other — maximizing the profitability of eco-projects.

To build this economic and mathematical model, the following are introduced [21]:
1) known quantities:
   - n — number of types of eco-projects;
   - j — number of separate kind of eco-projects ($j = \overline{1, n}$);
   - a_j — the number of *j*-type eco-projects that are included in the enterprise eco-projects portfolio at the current period;
   - p_j — the cost of the *j*-th eco-project, provided its implementation by the enterprise in the current period;
   - q_j — the cost of starting an additional eco-project of the *j*-type in the current period;
   - r — interest rate for a loan if the company attracts additional funds at the current time;
   - s — interest rate on bank deposit;
   - I — the amount of cash available to enterprises in the current period that can be used to reform the portfolio of eco-projects;
2) unknown quantities:
   - v — the amount of credit that an enterprise needs to attract to reform the eco-projects portfolio;
   - w — the amount of cash available to the enterprise after the transformation of the eco-projects portfolio, which can be put on a bank deposit;
   - x_j — the number of *j*-type eco-projects that is expedient for an enterprise to implement due to their practical non-use or to reform the eco-projects portfolio;
   - y_j — the number of *j*-type eco-projects that the company is expedient to purchase in the current period to reform the eco-project portfolio;
   - z — the amount of profit of the enterprise received from operations with securities during the current period;
3) unmanaged parameters:
   - d_j — a profit that will provide one *j*-type security in the current period.

In the first stage of optimization of the eco-projects portfolio the relations between the known, unknown and unmanaged parameters are specified. The essence of these relationships is that:

– the amount of cash available to the enterprise that can be used to form or reform the portfolio of eco-projects, the funds received from outsourcing of individual eco-projects to other enterprises, as well as the amount of loan attracted, should be equal to the cost of starting new eco-projects and the amount of free cash remaining enterprise funds;
– total profit from an enterprise eco-project portfolio is defined as the difference between the amount of profit from the use of eco-projects after the transformation of the eco-project portfolio and the amount of interest in the form of interest payable on the use of a bank loan, taking into account the profits derived from free cash deposited by the enterprise.

The introduced conditions also reflect the restrictions on the number of eco-projects to be implemented at the current time, among the existing ones, as well as to introduce the conditions of inalienability of other managed variables, in particular the number of eco-projects of the *j*-type that the enterprise is expedient to purchase in the current period to update the portfolio, the amount of credit that must be borrowed from the enterprise to improve (upgrade) the portfolio of eco-projects, and the amount of cash available to the enterprise after improving (upgrading) the portfolio that can be put on bank deposit.

In the second stage of the process of optimizing the portfolio of eco-projects build an optimization model, taking into account the above conditions. The current composition of the eco-projects portfolio will be optimal, that is, it will not require updating (improvement) if inequalities are fulfilled [22]:

$$(1+s)p_j \leq d_j \leq (1+s)q_j \ , j=\overline{1,n}\,. \tag{10}$$

This inequality reflects the decision-making criteria for the need to update the eco-project portfolio. They reveal the decision to start a new eco-project which is only advisable if the profitability is higher than the profitability of the other eco-projects used. The inequality also indicates that the profit from the use of eco-projects should be equal to the profit from the placement of free cash on deposits or exceed it [23].

The composition of eco-projects portfolio formed from corporate, debt and derivative eco-projects is optimal if the number of *j*-type eco-projects that are expedient for the enterprise due to their practical non-use or for reformulation of the portfolio, and the number of *j*-type eco-projects that the enterprise is expedient to purchase the current period for reforming the portfolio of eco-projects, as well as the amount of credit that must be attracted to the enterprise for reformulation of the eco-projects portfolio will be zero. That is, in the third stage of the process of optimizing the portfolio of eco-projects, taking into account the above, it is necessary to remove the variable w from the objective function of the model.

The resulting economic-mathematical model and inequality, which reflects the optimality of the portfolio structure of eco-projects, as well as other similar optimization problems [24], implies a number of constraints, which are correlations between the known values of the problem of optimal portfolio management of eco-projects. Thus, an enterprise with an eco-projects portfolio has certain investment resources that can be used to reform it in the current period, and it has no financial obligations. In addition, the current market value of the eco-projects used is not zero, but their sale will occur at a price lower than the market value of the new eco-projects needed by the enterprise to reform the eco-projects portfolio. Interest rates on loans received are higher than interest rates on deposits, and interest rates on deposits are higher or equal to zero.

It is well known that the period of ensuring the optimization of the portfolio of eco-projects is short. Most likely, you constantly need to look for solutions to optimize it. A sign of the need to develop and implement such solutions is to detect the fact that the profitability of eco-projects included in the portfolio is reduced compared to the probable level of profitability of similar eco-projects that have appeared on the market or the level of profitability of the funds temporarily placed on deposits.

Identification of one or both of the selected features indicates the need to replace certain eco-projects with new ones. This requires removal from the target function:

$$\sum_{j=1}^{n} d_j a_j ,$$

which is shown in the fifth step of the eco-project portfolio optimization process. The objective function meets the requirement of choosing such a composition of the eco-projects portfolio, so that its use will provide the enterprise with maximum profit.

In a market environment, decisions on the formation and disposal of securities are always associated with financial, managerial and other risks, that is, in the practice of asset management, unmanaged parameters should be considered as random variables, which are characterized only by certain statistical parameters. Kigel notes that the choice of economic and mathematical tools is determined by the type of risk attitude of specific investors. If the investor, in this case the head of the enterprise, is risk-neutral, then in the given economic and mathematical model the determined values of the profit indicators will be replaced by the mathematical expectations of the corresponding random variables [25]. In turn, in conditions where the head of the enterprise is not inclined or, conversely, is exposed to risk, it is necessary to determine the optimal management of the composition of the eco-projects portfolio by solving a two-criterion problem in which the variance of the total profit from the implementation of the eco-projects portfolio management (σ^2) is optimizing focus on maximum for risk-averse executives, minimum — for risk-averse executives. The minimization task of optimizing the portfolio of eco-projects is presented in the fifth stage and highlighted with a dotted line.

In its turn, in the sixth stage, the sequence of determining the optimality of managing the portfolio of eco-projects under uncertainty is indicated:

1) specification of tasks for optimizing the portfolio of eco-projects [26]:

$$\begin{aligned} &[\min_{d \in D} z(d,x,y,v,w)] \underset{(x,y,v,w)\in\Omega}{\rightarrow} \max, \\ &\ddot{a}\mathring{a}\ \ d=(d_1,....,d_n),\ \ x=(x_1,....,x_n),\ \ y=(y_1,....,y_n), \\ &z(d,x,y,v,w)=\sum_{j=1}^{n} d_j(a_j - x_j + y_j)-(1+r)v+(1+s)w, \qquad (11) \\ &D=\{(d_1,....,d_n) \mid \ d_j^{\min} \le d_j \le d_j^{\max},\ j=\overline{1,n}\}, \end{aligned}$$

the Ω set is given by the constraint system [3, 4]:

$$\begin{aligned} &\sum_{j=1}^{n}(-p_j x_j + q_j y_j) - v + w = 1, \\ &0 \le x_j \le a_j,\ \ y_j \ge 0,\ \ j=\overline{1,n};\ \ v,w \ge 0. \end{aligned} \qquad (12)$$

2) formulation of the problem to find the minimum value of the uncontrolled parameter [3, 5]:

$$\left.\begin{aligned} & z(d)=\sum_{j=1}^{n} d_j(a_j-x_j+y_j)-(1+r)v+(1+s)w \rightarrow \min, \\ & d_j^{\min} \le d_j \le d_j^{\max}, \quad j=\overline{1,n}. \end{aligned}\right\} \quad (13)$$

$$z(d)_{\min}=\sum_{j=1}^{n} d_j^*(a_j-x_j+y_j)-(1+r)v+(1+s)w. \quad (14)$$

3) formulation of the problem of finding the best option for managing the portfolio of eco-projects [21–23]:

$$\begin{aligned} & z(x,y,v,w)=\sum_{j=1}^{n} d_j^*(a_j-x_j+y_j)-(1+r)v+(1+s)w \rightarrow \max, \\ & (x,y,v,w)\in\Omega. \end{aligned} \quad (15)$$

4) recording of the results of portfolio optimization based on conjunction theory [20, 23]:

$$\begin{aligned} & \lambda = I\alpha+\sum_{j=1}^{n} a_j\beta_j \rightarrow \min, \\ & -p_j\alpha+\beta_j \ge -d_j, \quad j=\overline{1,n}; \\ & q_j\alpha \ge d_j, \quad j=\overline{1,n}; \\ & (1+s)\le\alpha\le(1+r), \\ & \beta_j \ge 0, \quad j=\overline{1,n}, \end{aligned} \quad (16)$$

where α and β are unknown values (profitability levels).

5) the solution of the dual problem [26–28]:

$$\alpha^* = \min\left\{\max\left\{(1+s);\frac{d_j}{q_j}, j=\overline{1,n}\right\};(1+r)\right\}; \quad (17)$$

$$\beta_j^* = \max\left\{p_j\alpha^*-d_j;0\right\}, j=\overline{1,n}. \quad (18)$$

That is, the search α^* involves determining the eco-project with the maximum level of profitability, as well as choosing the eco-project with the minimum level of profitability from the maximum. In turn, the search β^* involves selecting the maximum value between the difference value $p_j\alpha^* - d_j$ and the zero value.

Considering this task from the point of view of optimizing the portfolio management of eco-projects, the optimal value α^* should be considered as an option when the profitability in one of the areas of investment (j'), i.e. investing in one of the groups of the eco-project portfolio exceeds the profitability from placing funds on deposit. If this profitability is higher than the level of borrowing costs, then it is necessary to attract a bank loan and channel the entire amount of free resources to start this eco-project. If the level of profitability of the eco-project is higher than the level of interest on the deposit, but lower than the level of the interest rate on the loan, that is

$$(1+s) \prec \alpha^* \prec (1+r)$$

it is financially unprofitable to attract a bank loan. For maximum benefit, all available funds should be channeled to start a highly profitable eco-project.

Having acquainted with the materials of enterprises that were engaged in eco-entrepreneurship during 2015–2019, we can notice that there was a high increase in the volume of portfolios of eco-projects, which testifies to the intensification of investment activity of enterprises.

Among the portfolios of eco-projects, the biggest increase was observed due to the increase in the number of projects implemented in the field of energy saving and production of environmentally friendly products. During the analyzed period, the average growth of these projects in portfolios was 3% and 2.882% respectively.

As for other eco-projects, the results of the expert study showed a relatively similar increase in the number of them during the analyzed period, but the largest increase was found in portfolios formed from investments in low risk of eco-projects. This fact is related to the current situation in the construction market of Ukraine.

One of the characteristic features of enterprise eco-project portfolios is that, among their total, the number of local eco-project portfolios has increased significantly. During the analyzed period, the average annual growth of these portfolios was 4.096%. As regards foreign and trans-boundary eco-projects, their growth was not so high (1.03% and 2.184% respectively). In general, the promotion of local investment sites and their combination with foreign ones demonstrates the improvement of the investment climate in Ukraine and the deepening of the level of diversification of the risks related to investment activities in the field of energy saving, production of environmentally friendly products and technology transfer. It is important to note that the diversity of eco-project portfolios has been reached by new market players. Experts argue that, on the one hand, diversification of types of eco-project portfolios is a reason for the need to reduce risks, and on the other hand, a local improvement of the investment attractiveness of the regions. The latter is also evidenced by the fact that during the analyzed period the number of long-term portfolios of eco projects increased significantly. Their average annual growth was 3.5%.

Managers who were interviewed during the expert review indicate that most businesses build eco-project portfolios based on the use of a situational approach. That is, the decision to form a new or reformulate an existing portfolio is not based on the development of a long-term strategy for all possible investment objects, but is made taking into account the priorities of eco-entrepreneurs, factors that affect the effectiveness of certain eco-projects, the ability of financial managers to obtain and use information about the change in the situation. In view of this, they consider the fact of almost identical average annual growth of single-purpose (3.228%) and poly-purpose (3.066%) portfolios of eco-projects to be a natural phenomenon that accompanies virtually all developing regions.

Despite the dynamic development and the need for permanent reformulation of eco-project portfolios, different levels of activity of enterprises in reforming eco-project portfolios have been revealed in different regions of Ukraine. The most active portfolios of eco-projects were transformed in the Central (44.71%) and Eastern regions of Ukraine (22.12%), which is related to the regional imbalance in the level of development and concentration of enterprises in the Central and Eastern regions of Ukraine.

In the table 1 it is shown the dynamics of the profitability of eco-project portfolios of enterprises during 2015–2019. As we can see, during the analyzed period the subjects of eco-entrepreneurship possessed rather profitable portfolios. The highest average annual portfolio yield gains were found in the range of 25.1% to 50%. They increased annually by an average of 2.624%.

Table 1. Profitability of eco-project portfolios during 2015–2019, % up to the previous year

Profitability limits	Years				
	2015	2016	2017	2018	2019
From 0 to 25%	1.01	0.03	0.77	0.26	1.65
From 25.1 to 50%	1.22	2.12	2.01	3.65	4.12
From 51 to 75%	1.22	2.36	0.70	0.32	1.89
From 75.1 to 100%	0.36	—	0.22	1.32	0.45
More than 100%	—	0.41	1.71	—	—

Conclusions

The proposed model of analytical and information support for the structural development of eco-entrepreneurship should be considered as part of the sustainable development system. Against this background, further research should be conducted to balance the entrepreneurial interests and environmental needs of society. Public-private partnership on forming mechanisms of structural development of eco-entrepreneurship on the basis of multicriteria optimization is becoming relevant in this direction. For such mechanisms, the proposed analytical and information support model could be the basis for creating algorithms for selecting and justifying management decisions, in particular for the implementation of start-up projects for the implementation of eco-innovation.

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