

APPROACHES TO THE ASSESSMENT OF ECOLOGICAL AND ECONOMIC EFFICIENCY OF INVESTMENT PROJECTS: BRIEF REVIEW AND RECOMMENDATIONS FOR IMPROVEMENTS

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ABSTRACT

The implementation of investment projects has an important role to play in the development of the economy and also to be in concordance with the Circular Economy concepts, as it causes not only the flows of financial and labor resources into the regional economy, but also stimulates the development of scientific and technological progress and the emergence of innovations. A comprehensive assessment is essential approach of any investment project to achieve sustainable development and to close the loop as requested by the Circular Economy through balancing between social and economic development, as well as preservation of environment. The assessment of ecological and economic efficiency of investment projects is one of the most significant stages of project implementation as it allows to uncover the potential negative effects and possible failure of the project. So far, there are no unified approaches to assessing the effectiveness of investment projects, especially its environmental component. That fact leads to a biased assessment of the impact of an investment project on the environment. The problem is caused not only by the lack of a common, internationally accepted methodology, but also by the complexity of accounting for externalities and negative financial impact. The purpose of the study is to examine and systemize existing approaches to the assessment of ecological and economic efficiency and provide recommendations for its enhancement. The article highlights two conceptual approaches to the efficiency assessment of the project and their benefits and drawbacks.

Keywords: investment project, eco-efficiency, efficiency assessment, circular economy.

1 INTRODUCTION

Rapid economic and scientific development encourages enterprises and governments in both developed and developing countries to invest in the implementation of various investment projects. The introduction of Circular Economy (CE) in order to close the loop is also one of the most studied and developed concepts [1]–[5]. Successful project implementation implies a return on investment, obtaining commercial profit, meeting social needs, improving living standards and gaining a competitive advantage, all considering not only the economic aspects but also the environmental and possible the human health ones [6]–[9]. Investments stimulate further economic development and accelerate developments in science and technology. In spite of its socio-economic benefits, implementation of any investment project involves a great deal of risk that might have a negative impact on the final project performance.

The assessment of economic efficiency of the investment project is carried out on the initial stages of project development. The purpose of that process is to uncover potential risks in a timely manner in order to offset them. It includes not only the assessment of economic risks but also the assessment of social, financial and technical risks that may arise within project implementation. Nowadays it is also mandatory to provide the assessment of



eco-efficiency of investment projects owing to the stable annual increase of human pressures on the environment. Therefore, the successful implementation of investment project should also consider mitigation of the negative influence of any human activities on the environment (in case of eco-modernization of the already existing facility) or achieving the minimum anthropogenic pressures on the environment as a result of the project implementation (in case of establishing a new enterprise) [10].

The approaches to economic efficiency assessment of the investment project, that are given in the scientific and methodical literature units, can be divided into two groups: discounting assessment methods and statistical assessment methods. Discounted methods are based on using a discount rate that allows to assess the project's effectiveness considering the influence of the time factor and the probability of emerging risk situations [11]–[14]. Statistical methods do not consider the time factor that makes them less in demand in the assessment process. However, statistical methods are more understandable for project stakeholders and they are often used at the initial stage of investment projects selection.

The assessment of eco-efficiency is based on evaluation of ecological dimensions of project implementation. The difficulty in assessing effectiveness is that the part of ecological dimensions cannot be measured by quantitative methods as it relates to external effects or externalities [15]. The most common approaches to the assessment of eco-efficiency of investment projects include the environmental component (e.g. environmental costs or benefits) in the calculation of economic indicators such as NPV (Net Profit Value) or PI (Profitability Index). The results of evaluation in case of using these approaches might incorrectly display the real impact of the investment project on the environment and usage of natural capital [16]. The aim of this research is to present a brief review of the existing conceptual approaches to the assessment of ecological and economic efficiency of performance, highlight their benefits and drawbacks and to propose recommendations for their improvements.

2 COMPARATIVE ANALYSIS OF THE ASSESSMENT APPROACHES OF ECOLOGICAL AND ECONOMIC EFFICIENCY IN INVESTMENT PROJECTS

The assessment of ecological and economic efficiency of investment projects involves the evaluation of ecological dimensions in monetary units. The analysis is carried out by comparing the potential economic benefits of the projects and the associated costs of potential negative impacts of the project implementation on the environment.

Ecological dimensions of the investment project include environmental benefits and environmental costs. The list of environmental costs contains [17]–[19]:

- cost of quantitative or qualitative losses of natural resources;
- abatement costs and expenditure on the environmental regeneration;
- cost of natural resource restoration;
- loss of profit and other losses.

Environmental benefits of the project implementation include potential public benefits, increase in the efficiency of natural resource use, mitigation of negative impact on the environment, all in concordance with the CE concepts. According to the World Bank Operational Policy regarding Environmental Impact Assessment, environmental costs and environmental benefits must be quantified [20].

Approaches to the assessment of economic and environmental efficiency of investment projects might vary depending on the author of the methodology or the organization that



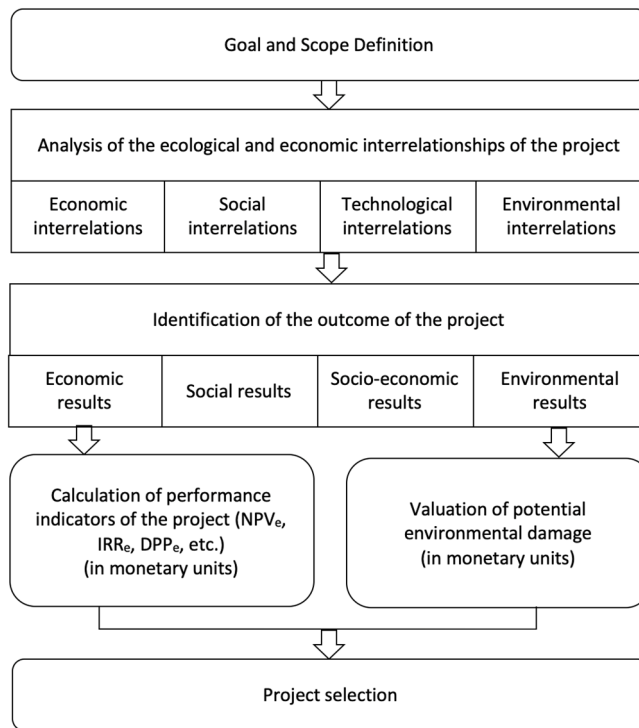


Figure 1: Framework of the assessment of ecological and economic assessment of investment projects. (Source: Based on [6], [10], [11], [19], [22].)

work on the same task. The common framework of the assessment of ecological and economic efficiency of investment project is provided in Fig. 1.

Social and technological aspects also have an important role to play in the process of the efficiency assessment of investment projects. The fundamental goal of any investment project is to have a return on the investment and to make a profit. However, the social responsibility of business and the increasing public focus on environmental and social challenges force investors and stakeholders to demonstrate the social significance of the project and its safety for the environment [21]. For instance, investment project implementation should improve the standard of living in the region, create new jobs, reduce environmental pollution or provide low level of negative impact on the environment, etc.

There are two main conceptual approaches that are presently used to assess the economic and ecological efficiency of the investment project, namely, cost-efficiency approach and cost-benefit approach [23]. The basic principle of both approaches is to involve all possible ecological benefits and costs in the cashflows of the investment project (Table 1).

The reviewed approaches to the assessment of economic and ecological efficiency evaluate ecological aspects in monetary units that determines the success rate of the investment project only in terms of profit considering potential ecological costs and benefits (eqn (1)) [23]–[25]:

$$(B + Be) - (C + Ce) > 0. \quad (1)$$

Table 1: Comparison of approaches to the assessment of ecological and economic efficiency of investment projects. (Source: Based on [12], [23]–[28].)

Approach to the efficiency assessment	Cost-efficiency approach	Cost-benefit approach
Characteristics of the approach	The method is based on a comparison of options with different cost ratios and the result obtained. The best option is considered to be the one with the lowest costs, ensuring the achievement of the necessary economic and environmental results.	The method is based on the comparison of economic and ecological benefits to the economic and ecological costs incurred.
Indicators	<p>Indicators (eqns (2)–4):</p> <ul style="list-style-type: none"> $NPV_e = \sum_{t=0}^T \frac{(B_t + Be_t) - (C_e + Ce_t)}{(1+r)^t}, \quad (2)$ <p>where NPV is net profit value, in value units; B and Be_t are economic benefits and ecological benefits respectively, in monetary units; C and Ce_t are economic costs and ecological costs respectively, in money units; r is the discount rate; T is the reporting period, years; t is the number of the year.</p> $IRR_e: \sum_{t=0}^T \frac{(B_t + Be_t) - (C_e + Ce_t)}{(1+r)^t} = 0, \quad (3)$ <p>where IRR is the internal rate of return.</p> $PI_e = \frac{NPV_e}{Investments}, \quad (4)$ <p>where PI_e is profitability index.</p> <p>The following indicators are also used within the assessment process: DPP_e, ROI, etc.</p> 	<p>Benefit-cost ratio (eqn (5)):</p> $Project\ efficiency = \frac{(B + Be)}{(C + Ce)}. \quad (5)$
Advantages of the approach	<ul style="list-style-type: none"> the approach considers the influence of the time factor; the approach is used when it is necessary to obtain a certain ecological result; allows to compare the effectiveness of environmental measures within a single project. 	<ul style="list-style-type: none"> universality of the indicator; ability to compare the results of alternative projects; easy interpretation.
Disadvantages of the approach	<ul style="list-style-type: none"> the difficulty of integrating all ecological benefits and costs in monetary units; not considering the efficiency of the natural capital use, reduction of resource consumption, etc. NPV does not allow to compare alternative investment projects, as it is an absolute indicator; the complexity of calculations, the subjective nature of the choice of the discount rate and the impossibility of changing it due to changing environmental conditions 	<ul style="list-style-type: none"> low informativeness; complexity of accounting for all environmental benefits and costs in monetary units; not considering the efficiency of the use of natural capital, reduction of resource consumption, etc.



The benefits of the project should exceed the costs of its development and implementation: the investment project shows its effectiveness only if it has a positive closing balance.

The main drawback of the reviewed approaches is that they do not allow to provide comprehensive description of the impact of investment projects on the environment, the efficiency of natural capital use at all stages of the project life cycle and long-term consequences for the environment [29]. Both approaches do not evaluate energy efficiency of the project in physical units. Potential environmental damage within the framework of the considered approaches is estimated as the amount of emissions or costs for eliminating negative impacts on the environment, which can vary significantly depending on the country's legislation and the availability of environmental technologies, which makes the assessment of environmental impact biased and makes it difficult to compare alternative investment projects [30].

The potential benefits of the investment project may be several times higher than the expected costs of its implementation (including such ecological costs as the cost of eliminating negative impacts), which negatively affects the motivation of investors and stakeholders to continue to reduce the impact of the implementing project on the environment and invest in the development of resource-saving and environmental technologies.

Moreover, it is almost impossible to consider all the external effects of the project implementation or externalities at the development stage in the assessment process [31]. In the majority of cases, externalities and other long-term external effects are not considered due to the high degree of uncertainty of long-term consequences and the lack of official need for their assessment [32], [33]. This can lead to shortsightedness of entities and to considerable economic losses in the long term.

According to the given results, the following shortcomings of the considered conceptual approaches to assessing the ecological and economic efficiency of investment projects can be identified:

- the complexity or inability of comparing the alternative investment projects in terms of their ecological efficiency (efficiency of natural capital use, energy efficiency of the project, etc.);
- the low level of results informativeness of the ecological assessment for project investors and stakeholders;
- the assessment of ecological benefits and costs is made only in monetary units, that makes it biased when comparing alternative investment projects of different scales;
- difficulties in performing calculations and the inability to change the specified valuation parameters (for instance, the discount rate) due to changing environmental conditions.

3 RESULTS AND DISCUSSION

Strengthen the objectivity of assessing the ecological effectiveness of investment projects is a key driver for improving the existing approaches to ecological and economic assessment.

International Association for Impact Assessment (IAIA) defines and environmental impact assessment (EIA) as the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made [34]. EIA can be made in relation to any activity of any business entity, including investment projects. The ISO 14045 and ISO

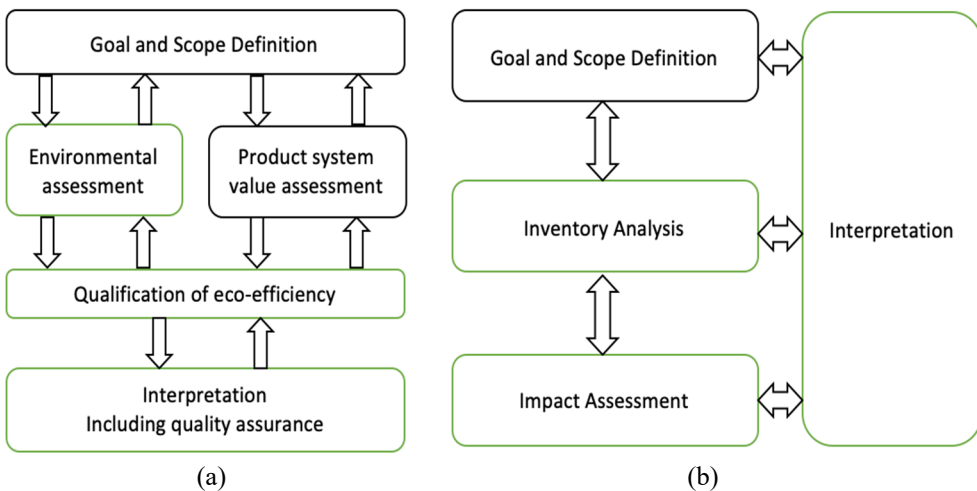


Figure 2: Frameworks of the environmental assessment. (a) Eco-efficiency assessment (ISO 14045:2012); and (b) Life-cycle impact assessment (LSIA) (ISO 14040:2006). (Source: Based on [35], [36].)

14040 standards contain two conceptual approaches to the methodology for assessing environmental performance (Fig. 2).

Both approaches involve a comprehensive assessment of the ecological impact of the business entity. The results of the environmental performance assessment according to ISO 14045 can be used in the development of measures to improve the efficiency of production and sales of products, strategic planning and investment analysis. Life cycle impact assessment is a more flexible and comprehensive approach to assessing environmental performance at all stages of the product life cycle, but its adaptation to the life cycle of an investment project can cause difficulties in calculating, generating cash flows, considering externalities and other environmental impacts at each stage of the project life cycle and interpreting the results obtained [37]–[39].

To improve the methods of assessing the ecological and economic efficiency of investment projects, it is proposed to:

- include ecological indicators in the assessment process in three dimensions: indicators of environmental pollution, indicators of use of natural capital, indicators of energy efficiency indicators;
- calculate ecological indicators in physical units, give preference to relative environmental indicators;
- keep the calculation of ecological and economic efficiency indicators of the project (NPVe, IRR_e, DPPe, IPe), but compare them with proposed ecological indicators.

Table 2 presents a basic system of ecological indicators that can be used to assess the environmental performance of an investment project. The indicators of energy efficiency include indirectly the role of renewable energy use. The indicators of use of natural capital include indirectly the checking of the adoption of the CE principles.

Table 2: The proposed system of ecological indicators for the assessment of ecological and economic efficiency of investment project.

Group of ecological indicators	Indicators
Indicators of environmental pollution	<ul style="list-style-type: none"> • total greenhouse gas emissions, in physical units; • greenhouse gas emissions per unit of production; • total emissions of harmful substances, in physical units; • emissions of harmful substances per unit of production; • total water pollutants, in physical units; • water pollutants per unit of production; • total waste generation, in physical units; • waste generation per unit of production.
Indicators of use of natural capital	<p>Resources capacity of production – a ratio of the natural resources used by the facility, to the corresponding amount of annual production (in physical units):</p> <ul style="list-style-type: none"> • water capacity of production; • fuel capacity of production; • natural resources capacity of production etc.
Indicators of energy efficiency	<ul style="list-style-type: none"> • total energy consumption, in physical units; • energy capacity per unit of production; • total use of hydrocarbon fuel, in physical units; • use of hydrocarbon fuel per unit of production.

Comparability of alternative investment projects is achieved through the use of ratios, which allow to compare investment projects on the environmental component. All indicators should be calculated over time in order to highlight potential changes in the dynamics. The project provides effectiveness when most ecological indicators demonstrate a downward trend.

Another advantage of the proposed system is the informativeness of indicators and the simplicity of their interpretation that allows to compare alternative projects with each other. Also, the proposed system allows to compare scenarios “with the project” and “without the project”, which may provide added information on the benefits of the project in terms of environmental components. In some cases, the scenario “without the project” that means the complete rejection of the project implementation, might bring more economic and ecological benefits in comparison to the scenario when the project is implemented. Moreover, in case of eco-modernization the proposed indicators should be calculated at least twice: before eco-modernization project and after eco-modernization project.

The proposed system of ecological indicators can be also adapted to the type of investment project and the branch of the economy to which this investment project belongs. An example of adaptation is given in the paper “Improving the approach to efficiency assessment of investment projects in the energy sector” [40], where indicators of the natural capital use were adapted to the energy facility.

Fig. 3 shows the system of assessment of ecological and economic efficiency of investment projects proposed by the authors.

Several ecological indicators can be determined in terms of monetary units. These determinations are appropriate if investment projects are characterized by the same scale, level of investment and production.

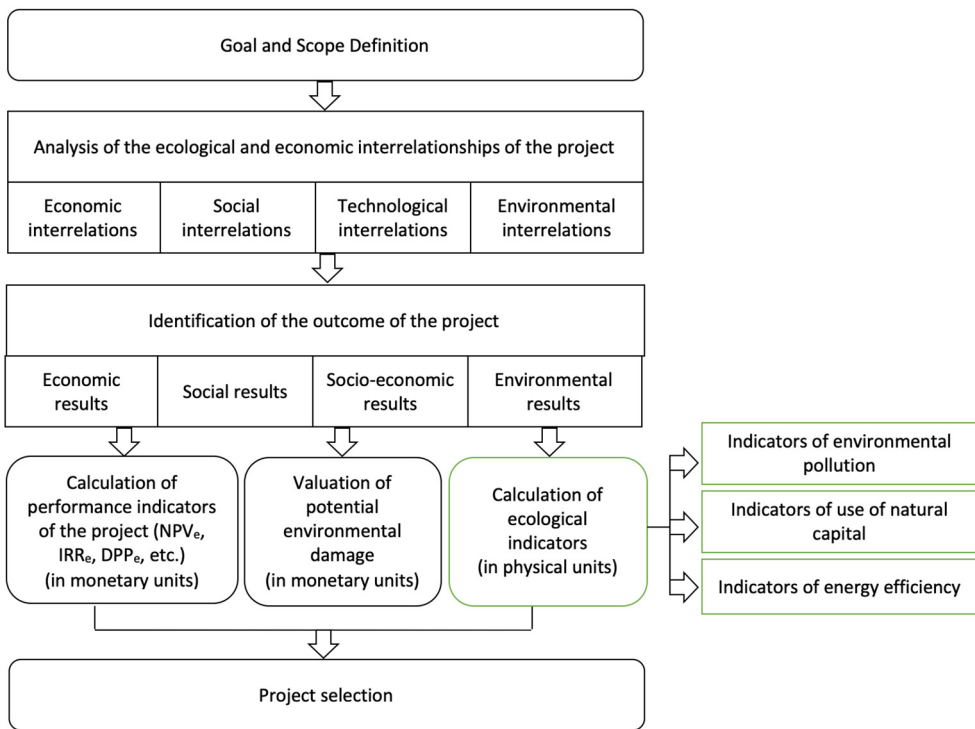


Figure 3: The proposed framework of the assessment of ecological and economic assessment of investment projects.

4 CONCLUSION

Authors proposed extended system of ecological indicators as contribution to improve the methodology for the ecological and economic efficiency assessment of investment projects. The proposed system of indicators allows for a comprehensive assessment of the impact of an investment project on the environment, energy efficiency of the project and the efficiency of natural capital use within its implementation. Advantages of the system of ecological indicators are the following:

- the possibility of comparing alternative investment projects by ecological aspects;
- simplicity of calculations and interpretation of the results obtained;
- informativeness of the results obtained and their comprehensibility for investors and stakeholders of the investment project;
- the objectivity of the system of ecological indicators in the framework of assessing the eco-efficiency of the investment project.

As a further improvement in the assessment of economic and ecological efficiency of investment projects, further development of a broader system of ecological indicators and their adaptation to various sectors of the economy. In addition, it is possible to develop an integrated indicator for assessing the ecological and economic efficiency that allows a comparison with alternative investment projects only by one criterion.

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