Integration of environmental indicators into the management decision-making system

Integración de indicadores ambientales en el sistema de toma de decisiones de gestión

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Abstract

Climate change demands integrating environmental indicators into management decision-making systems, highlighting shifts towards environmental safety and stricter emissions regulations. This research develops a scheme for such integration, filling the gap in literature on the relationship between environmental factors and management decisions. Literature analysis and data examination through scientific and mathematical methods, including linear and multicriteria analysis, have led to a model emphasizing the importance of embedding environmental considerations into decision-making. The

Resumen

El cambio climático exige integrar los indicadores ambientales en los sistemas de toma de decisiones de gestión, destacando los cambios hacia la seguridad ambiental y las normativas más estrictas sobre emisiones. Esta investigación desarrolla un esquema para dicha integración, llenando el vacío existente en la literatura sobre la relación entre los factores medioambientales y las decisiones de gestión. El análisis de la bibliografía y el examen de los datos mediante métodos científicos y matemáticos, incluido el análisis lineal y multicriterio, han dado lugar a un modelo que subraya la importancia de integrar las consideraciones medioambientales en la toma de

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findings highlight the role of multi-criteria decisions in various conditions and establish a comprehensive model for the interplay between economic and environmental indicators, enhancing eco-efficiency in management practices. This approach introduces a novel method for incorporating environmental sustainability into management strategies, underscoring its significance for ongoing research and application in eco-efficient management decision-making.

Keywords: management decision, environmental performance, eco-efficiency, climate change.

decisiones. Los resultados ponen de relieve el papel de las decisiones multicriterio en diversas condiciones y establecen un modelo integral para la interacción entre indicadores económicos y ambientales, mejorando la ecoeficiencia en las prácticas de gestión. Este planteamiento introduce un método novedoso para incorporar la sostenibilidad ambiental a las estrategias de gestión, subrayando su importancia para la investigación en curso y su aplicación en la toma de decisiones de gestión ecoeficientes.

Palabras clave: decisión de gestión, rendimiento medioambiental, ecoeficiencia, cambio climático.

Introduction

In order to reveal the topic of our work, it is first of all necessary to answer the following questions: what a management decision is and how is it related to ecology.

The first question can be answered by saying that a management decision is the result of an alternative formalisation of economic, technological, socio-psychological, and administrative management methods, on the basis of which the organisation's management system directly affects the managed system, but there are many more interpretations of this concept.

The answer to the second question is that the environment is the physical, biological, cultural, social and economic environment in which people, plants, animals and all other living things are connected throughout life. There are several historical examples of such decisions that have led to such consequences that it has become a well-known fact. Here are some of the most famous examples:

− It is the situation with rabbits and cats in Australia;
− The problem with the environment and human health due to the use of certain herbicides in America, Germany;

− The distribution of lead compounds throughout the world as result of their use as additives in petrol.

It should be noted that these solutions were initially quite successful, and their harmfulness was discovered later. But today, in addition to the usual problems, the climate issue has already gone beyond environmental protection and has also become an economic topic. The social sphere, including production, infrastructure, etc., now depends on the environmental situation. An example of how climate change leads to economic and production problems hydropower plants is, which have become significantly less productive due to drought and produce between 40 and 6% of their rated capacity. As Bloomberg put it "the world's biggest source of green energy is rapidly evaporating". Therefore, the countries most affected by this are facing the need to obtain energy from other sources, which in turn are affected by other environmental and climatic factors, for example, smoke from forest fires reduces solar energy production. In other words, the quality of human life is now overwhelmingly dependent on climate, ecology, economics, and politics, as shown schematically in Figure 1.
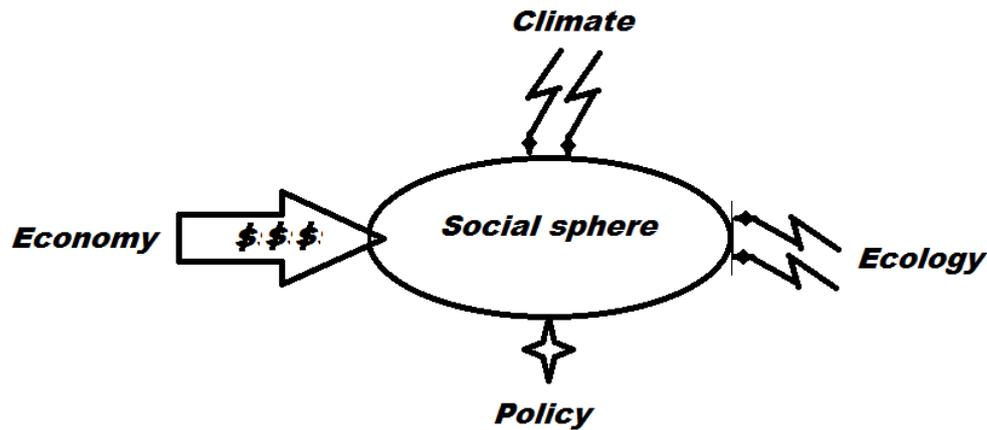
Fig. 1. Factors affecting human life.
Created by the authors

Climate change is forcing more attention to be paid to the environment. This is reflected in policy changes towards "greening", the creation of stricter environmental safety conditions, increased emissions control, downward changes in regulations, especially for CO2, methane, exhaust gases, water, etc., and increased fines for violating environmental safety rules, which accordingly affects the economy, which is also rapidly "greening" (Sembiyeva et al., 2023). Therefore, the integration of environmental indicators into the management decision-making system becomes extremely necessary. However, the question arises: how and at what stage of making a management decision should this be done? How does the environmental policy of states influence management decisions taking into account environmental indicators?

This work is based on the study and analysis of research by various authors concerning both management issues taking into account environmental indicators and issues related to the influence of environmental policies of some countries on management decision making. The work makes an attempt to build a model that allows us to imagine the interaction of the management decision-making system with economic and environmental indicators. The main feature of this model should be the possible versatility.

Literature review

Among the works devoted to this topic are those related to reporting forms that take into account environmental indicators Bezuidenhout, de Villiers, & Dimes (2023), Abdullaeyeva & Ataeva (2022), practical studies of the use of environmental indicators in performance management, works Shi et al., (2019),

Zharfpeykan, & Akroyd (2022), Shakun (2022), Briushkova, Nikoliuk, & Udovytsia, (2020).

The concept of managerial decision has been carefully studied by the authors Karpenko & Kobzar (2021), Anishchenko (2019), Bezuidenhout et al (2023).

The authors of the study Schaumberger & Dasayanaka (2023) noted that in recent years, much more attention has been paid to how companies affect the environment and governance. The authors interviewed six large Swedish companies and collected data that allowed them to draw conclusions about the impact of changes towards sustainable development. It was found that, firstly, a huge number of rules and guidelines were passed everywhere; secondly, it had a negative impact on the harmonisation of reporting within companies; thirdly, companies use their reports as marketing tools. Almost all of the companies surveyed use the GRI (Global Reporting Initiative) index as their sustainability disclosure framework. However, the findings indicate that companies desire a unified reporting framework, such as future integration with CSRD (sustainability reporting) and see potential benefits and some specific current challenges related to sustainability reporting.

In Shi et al., (2019), based on the study of regional sustainable development as a complex system that is difficult to assess objectively and scientifically using a single method. The authors presented a new integrated indicator system and evaluation model that most accurately reflects the regional level of sustainable development The indicator system and evaluation model were built using the results of a study of 17 cities in China The indicator system includes 4 subsystems, i.e. economy, society, resources, and

the environment These indicators were selected through correlation analysis and discriminant analysis A neural network was used to estimate the respective scores of the 4 subsystems The composite indicator for regional sustainable development was assessed using an entropy-corrected analytical hierarchy process.

In Fernandes et al., (2023), a conceptual model is developed to describe the internal relationship environment (IRE). Critical factors affecting the environment, characteristics of the parties involved, and the relationship. The work is mainly concerned with the formation of a management system - successful implementation or external and market, taking into account environmental factors The conceptual model and its tools describe the relationship between the support team and operational groups, described by the ER model of company management.

LearningForSustainability.net offers the development of indicators for performance-based sustainable management. There is a global trend towards the wider use of indicators to monitor development and track progress. This is evident at all levels and is reflected in the proliferation of indicator reports in recent years. Indicators quantify and simplify a phenomenon and help us to understand and make sense of current realities. In the context of natural resource management, their greatest strength lies in the way they can help us assess the status of a resource and monitor the efficiency of its use. To be more meaningful, a monitoring programme should provide insight into the relationships between environmental or socio-economic causes and stressors, as well as the expected responses of the ecosystem and subsequent economic outcomes.

The issue of understanding and assessment is raised - what should be assessed. Within resource management, these are typically either programme-based or driver-based. Regardless of which structure is chosen, the report notes that it will be important to provide three sets of supporting information to prepare the utility and transparency of subsequent models, reflecting:

- plans and planning;
- well-documented core proposals;
- internal and external factors affecting outcomes. Attention is paid to the indicator Characteristics and system capacities required to support interoperable adaptive management.

The authors of Lin et al., (2020) studied a control system based on the fuzzy Delphi method. Using this method, they evaluated expert opinion on each indicator that affects decision-making Zharfpeykan & Akroyd (2022) investigated how different factors influence whether companies integrate economic, social, and environmental performance into their performance management system. Managers from 239 Australian and New Zealand companies across a wide range of industries were surveyed. The researchers used hierarchical multiple regression analysis for the analysis. The study found that industry, company size, and managers' perceptions of the importance of sustainability influenced the integration of environmental performance into a company's performance management system. In particular, larger companies and companies in industries with low environmental impacts tend to integrate more indicators into their performance management systems, especially if sustainability is perceived by managers as important for performance. Large companies and companies in industries with significant environmental impacts integrate social indicators, but generally not environmental indicators, into their performance management systems. The inclusion of environmental indicators in corporate sustainability reports does not affect their integration into the company's performance management. The framework thus emphasises the lack of synergy between external sustainability reports and performance management. At the same time, the authors believe that organisations need to address the issue of integrating environmental indicators in order to become more environmentally sustainable. Similar results were obtained (Sayed, 2023).

According to the website Ministry of Environmental Protection and Natural Resources of Ukraine, (s.f), "environmental indicators are the main tool for assessing the state of the environment in the countries of Eastern Europe, the Caucasus, and Central Asia. Appropriately selected indicators based on sufficient time series of data (time trends) can not only reflect the main trends but also contribute to the analysis of the causes and consequences of the current environmental situation. They also allow us to monitor the implementation and effectiveness of environmental policy in countries".

We should also note the development of artificial intelligence and neural networks (machine learning) and the prospects for their use, including in management decisions. These issues are addressed by the authors Entezari, Aslani,

Zahedi, & Noorollahi (2023), Khalid (2023), Rakhimov (2023), Waas et al., (2014).

Using search theory and dynamical systems theory, the authors of Ye et al., (2022) studied ecological dynamism in the model of the relationship between green entrepreneurial orientation and the search for boundary intervals related to the environment, economy, and social sphere.

Numerous publications on the interaction between ecology and management decisions reflect a deep interest in this topic. However, the different approaches demonstrated by the authors require further research and there is still a wide scope for further work.

The purpose of our work was to develop a scheme for integrating environmental indicators into management decision-making systems.

Let us highlight the main problems raised by the authors of publications reviewed:

Problems with the reporting format lead to differences between external and internal reporting companies. Reporting does not keep pace with changes in the environmental policy, which leads to the emergence of many instructions, orders, rules that negatively affect harmonization reporting within companies, and also makes it difficult to take the necessary management decision. Also, although most companies in developed countries use the GRI (Global Reporting Initiative), there is still no unified form of reporting and connection to the CSRD (reporting about sustainable development).

There is a problem of integrating environmental indicators into the performance management systems companies. For large companies in different countries, the inclusion of environmental indicators in corporate sustainability reports do it not affect the integration of these indicators into management efficiency of companies. Large companies and companies in industries that have a significant environmental impact, integrate social rather than environmental indicators into decision-making systems. There are no unified models that allow assessing the impact of integrating various indicators into systems for making management decisions of companies. Thus, taking into account the identified problems, the goal of our work was to develop a scheme integration of environmental indicators into the management decision-making system. Also with taking into account the difference in approaches to solving this issue in different industries and companies, the diagram should be visual and practically universal.

Methodology

Literature analysis was used as a research tool, and information from open sources, including news publications and news agencies, was studied and processed BloombergNEF (2023), Learning for Sustainability (2016). Methods of scientific analysis, comparison; generalisation; data visualisation etc. were used, Microsoft Office 10 was used to work with the data.

Results and discussion

The rule of choice is the basic principle of making a management decision based on the results of monitoring activities, namely diagnostics and forecasting. Decision-making theory distinguishes between single-criteria and multi-criteria choices under conditions of certainty, risk, and fuzzy conditions. Management decision-making should be viewed as a constantly solved task in the management process Young (2023), Hryshyn (2014), Kuzmin & Melnyk (2003), Anishchenko (2019), Rahi, Johansson, Blomkvist, & Hartwig (2023), Rahi et al. (2022).

The task of making a managerial decision is aimed at determining the most effective way of action to achieve the set goals.

The process of managerial decision-making is accompanied by the formation of alternative solutions and the assessment of their benefits.

The stages of managerial decision-making are shown in Table 1.

Table 1.

Stages of managerial decision-making according to different authors

Stages of managerial decision-making		
According to (Young, 2023) 1. Defining the goals of the organisation; 2. identifying problems in the process of achieving the defined goals; 3. researching problems and linking their features 4. Search for solutions to the problem; 5. Evaluating all alternatives and choosing the best one; 6. Coordination of decisions in the organisation; 7. Approval of the decision; 8. Preparing the decision for implementation; 9. Managing the implementation of the solution; 10. Checking the effectiveness of the solution.	According to (Hryshyn, 2014) 1. The emergence of a situation that requires decision-making; 2. Collection and processing of information on the developed management methods; 3. Identification and evaluation of alternatives inherent in the developed management methods; 4. Preparation and optimisation of a management decision that is taken as a set of alternatives; 5. Making a management decision (legitimising the alternative); 6. Implementation of the management decision and evaluation of the result.	According to Kuzmin & Melnyk (2003) 1. The existence of a situation that needs to be addressed, collection and analysis of information on the general problem; 2. Identification and evaluation of alternatives inherent in the developed management methods; 3. Making a management decision (legitimisation of alternatives); 4. Implementation of the management decision and evaluation of results; 5. Control over the implementation of the decision, which allows to detect deviations and establish feedback between the controlling and managed subsystems.

Created by the authors based on works by Young (2023), Hryshyn (2014), Kuzmin & Melnyk (2003).

It is possible to formulate the tasks of managerial decision-making, which can be both individual and group, the data are presented in Table 2.

Table 2.

Approaches to managerial decision-making

Centralised approach	Decentralised approach
Most decisions are made by top management	Transfer of decision-making responsibility to a lower management level
Individual approach	Group approach
Decision-making by the manager alone	Several employees work together on the same problem
The task of making an individual managerial decision: in a problem situation, with the available time and resources to make a managerial decision, it is necessary to define the situation by a set of alternative situations, formulate a set of goals, constraints, alternative solutions, evaluate the benefits of solutions and find the optimal solution from the set, guided by the selection criterion	The task of making a group management decision: in a problem situation, with available time and resources, it is necessary to define the situation by a set of alternative situations, formulate a set of goals, constraints, alternative solutions, evaluate the benefits of solutions, build a group preference function based on the principle of consent and find the optimal solution that would meet the group preference

Compiled by the authors based on data from Anishchenko (2019), Young (2023)

Environmental and economic indicators are a criterion for the development of environmental management, which requires a comprehensive and systematic approach to the formation of such indicators.

The degree of environmental impact of production is determined by a cluster of quantitative and qualitative indicators, including:

– the amount of raw materials and energy used;
– amount of gaseous pollution emitted;
– amount of waste per unit of output;
– efficiency of raw material use;
– energy efficiency;
– number of accidents resulting in negative impact on the environment;
– the degree of utilisation of production and consumption waste;
– potential of packaging for further recycling;
– transport mileage per unit of finished product;
– investments made in environmental protection;
– the number of lawsuits resulting from environmental violations, etc. (this also applies to administrative fines for minor violations).

Thus, eco-efficiency can be presented as a system of interaction of economic and environmental indicators with the management system or as a system of making management decisions based on the interaction with environmental and economic indicators, as shown in Fig. 2.
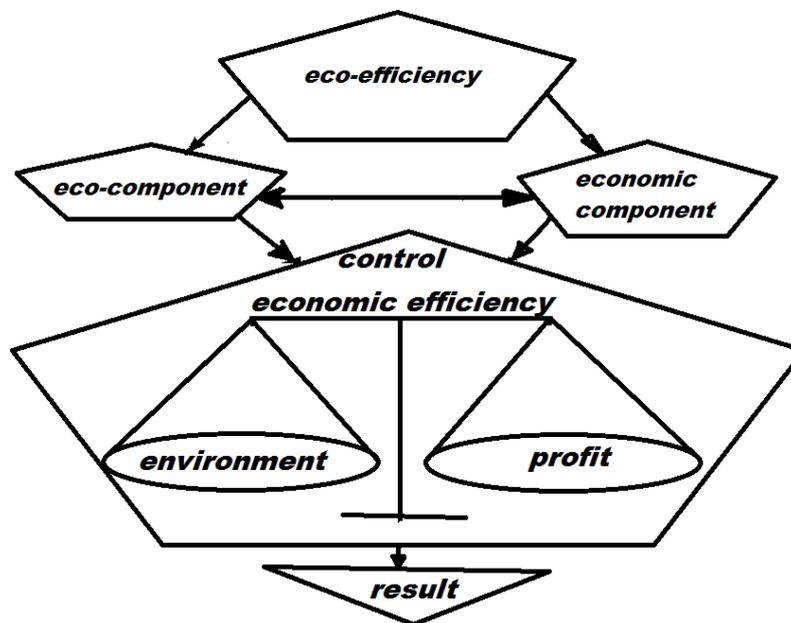
Fig. 2. General scheme of interaction between the management decision-making system and environmental and economic indicators.

Built by the authors based on studying the works of Young (2023), Bosi, Lajuni, & Lim (2022), Clement, Robinot, & Trespeuch (2023), Correia (2019), Kerr & Rouse (2015), Weston, & Ninadi (2021), Park, Konge, & Artino (2019), Traxler, Schrack, & Greiling (2020).

The scheme reflects the interaction of environmental and economic indicators on management decision-making to achieve environmental efficiency.

Let's look at specific example of such interaction.

Examples of decisions focused only on profit.

Increasing requirements for the quality of disposal of electronic waste has led to the fact that according to Adesina (2012).

1) Outdated electronics (computers, mobile phone, televisions, refrigerators, etc.) are imported into developing countries as "second-hand goods" and are sold though out ventures in order to obtain arrived. And .the problems of further disposal fall on the buyer.
2) In addition, according to the some agencies and organizations through donations send them to schools, hospitals, etc., thus getting rid of unnecessary equipment,
3) Particularly unscrupulous donors may send under type of donations mainly faulty equipment. The considered examples show the results of making management decisions profit-oriented, with virtually no environmental performance are taken into account.

Note that even such decisions can be transferred to a neutral level by introducing as counterbalance the achievement of environmental indicators for the first of two examples. For example in the first of case , it is possible to organize the acceptance of failed equipment in order to further disposal either, or by selling company itself or by selling this waste to companies that are engaged in the purchase of such waste as raw materials for further processing. In the second case, it is possible for the donor company to receive tax preferences for philanthropy and reputation enhancement, in addition to reducing costs for recycling. An increase in environmental efficiency can be proposed similar to the first occasion. The third example suggests a solution that is likely to result in financial lass to the donor company, but will save its business reputation – this is the replacement of faulty equipment and its further disposal. Let us note the emerging trend for large

companies, which are in favor of increasing environmental efficiency may make decisions that lead to lower profit. For example, according to the website DSnews.ua (2021), Apple announced its transition to consumption of only renewable energy for your needs from April 9, 2018.

Conclusions

The study results suggest that:

The introduction of environmental indicators into the management decision-making system makes it possible to reduce damage to the environment. In the examples discussed, this makes it possible to reduce environmental pollution by electronic waste containing hazardous compounds, such as compounds of mercury, heavy metals, lithium, cadmium, plastics, etc.

In the course of the study, many studies related to management decision-making through the prism of eco-efficiency were reviewed and analysed. The necessity of integrating environmental indicators into the management decision-making system is determined. The existing strategies for making managerial decisions are considered in detail. The main environmental factors that influence environmental efficiency are identified. As a result of the process, a general model of the interaction of economic and environmental indicators on management decision-making is proposed.

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