TECHNOLOGY, CREATIVITY, IMPLEMENTATION

ANALYSIS OF THE ASSESSMENT OF LOGISTICS SUSTAINABILITY IN THE CONTEXT OF IMPLEMENTING SUSTAINABLE DEVELOPMENT PRINCIPLES

Ivan Hets
Higher Education Student of the First (Bachelor) Level, National Transport University, Ukraine
e-mail: ivanhets4000@gmail.com, orcid.org/0009-0002-0863-0157

Iryna Halak
Associate Professor at the Department of Logistics and Project Management, National Transport University, Ukraine
e-mail: 1017imiia@gmail.com, orcid.org/0000-0002-5038-7771

Ilona Khalatska
Assistant Lecturer at the Department of Logistics and Project Management, National Transport University, Ukraine
e-mail: ilona_h@ukr.net, orcid.org/0000-0002-0896-3421

Summary

The implementation of sustainable development goals and principles is increasingly addressed in various spheres of economic activity, including logistics. Despite extensive scholarly research, a universal indicator for assessing sustainable development in logistics has not yet been established, which complicates research and the identification of existing shortcomings in this sector. Logistics is a key value-creating activity and a core component of the service-based economy in developed countries, significantly influencing economic conditions at both national and global levels. The objective of this study is to calculate an integral sustainability indicator for the logistics sector and apply it to several European countries in order to assess the level of sustainable development, identify strengths and weaknesses, and outline possible solutions for advancing sustainable logistics. The object of the research is the logistics systems of selected European countries, while the subject is the level of sustainable development in logistics. Scientific novelty consists in the development of an integral logistics sustainability indicator enabling interstate comparative analysis. The practical significance lies in the applicability of the results for public policy-making, corporate strategic planning, and further research.

Key words: sustainable development, sustainable logistics, integral sustainability indicator, logistics sector, European countries, comparative analysis.

DOI https://doi.org/10.23856/7433

1. Introduction

The theoretical foundations of sustainable development in logistics have been addressed in a number of scholarly studies. In particular, the issue has been examined by Saiensus M. A. in the study "Logistics as a component of strategies for sustainable development" (Saiensus M. A.,2018) as well as by Filip Z. Bugarcic and Vladimir Micic in "Analysis of the Sustainable Development Concepts in the Logistics Industry" *(Filip Ž. Bugarčić, Vladimir Mićić, 2023)*. The implementation of sustainable practices in the field of freight transport is also examined in the study by Oksana Bilonoh, Serhii Yanishevskyi, Oleksandra Kostiuchenko, Volodymyr Fartuchnyi, Igor Chernenko and Yevgen Yanishevskyi entitled "Implementation of sustainable development approaches in the management of transport service processes of economic entities" *(O.Bilonoh, 2025)*. Additionally, the study entitled "Specifics of project's decisions-making process and its formation in reverse supply chains management" examines specific measures and their implementation aimed at increasing the sustainability of the logistics system *(Halak I. I., Khrutba Y. S., 2022)*. It is also worth noting the study by Kyrych N. B., "Indicators of Regional Sustainable Development," in which a system of indicators is proposed to determine the sustainability of a region, based on the principles of the "pressure-state-response" (PSR) model developed by experts from the Organisation for Economic Co-operation and Development (OECD) *(Kyrych N., 2018)*.

It is logical to begin with the concept of "sustainable development" in general. The most appropriate approach is to refer to the internationally recognized definition. It is presented in the Report of the World Commission on Environment and Development titled "Our Common Future". The definition is as follows: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". According to this report, sustainable development consists of two main components:

– the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given;

– the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

In domestic scientific thought, the concept of sustainable development is considered as a multidimensional category that combines economic, social and environmental aspects of the development of society and economic systems. Thus, O. Kotykova focuses on the substantive content of the concept of sustainable development, emphasizing its integrative nature and the need to reconcile economic growth with long-term preservation of resource potential *(Kotykova O., 2007)*. In the works of I. Tarasenko, sustainable development of enterprises is interpreted from the standpoint of management methodology, where institutional, organizational and strategic mechanisms for ensuring balanced development of production systems are of key importance *(Tarasenko I., 2011)*. At the macro level, the concept of sustainable development is deepened in the national report edited by E. Libanova and M. Khvesyk, where the sustainable development of Ukraine and its regions is considered as the result of effective use of socio-economic potential, taking into account interregional disparities and demographic challenges *(Libanova E., Khvesyk M., 2014)*. At the same time, Bagrov M., Kostrikov S., Chervanyov I. focus on the formalization of the environmental dimension of sustainable socio-economic development, emphasizing the need for quantitative measurement of environmental parameters in the system of management decisions *(Bagrov M., Kostrikov S., Chervanyov I., 2008)*. The current stage of evolution of the concept of sustainable development is reflected in the works of M. Nahara, where sustainable development is interpreted as a transformation of

the paradigm of economic development in the context of the greening of the economy and the strengthening of the role of "green" innovations *(Nahara M., 2011)*. Special attention is deserved by the studies of O. Khanova and S. Skibina, who analyze approaches to assessing sustainable development in EU countries, emphasizing the importance of a system of indicators as a tool for monitoring and comparative analysis of achieving sustainable development goals *(Khanov O., Skibina S., 2017)*. Taken together, these approaches indicate the evolution of scientific views on sustainable development - from the conceptual understanding of its essence to the development of methodological and applied assessment and management tools. Considering this works and in the context of the development of the concept of sustainable development and its implementation at the international level and, in most countries, at the national level within legislative frameworks, the following definition is proposed: "Sustainable development is a system of measures that ensures a balanced development process, taking into account the equilibrium between the economic, social, and environmental components, thereby meeting the needs of society without causing negative consequences for future generations". According to the Resolution adopted by the United Nations General Assembly on September 25, 2015, 17 Sustainable Development Goals and 169 corresponding targets were established.

It is worth noting that the logistics approach serves as a means of achieving the majority of the Sustainable Development Strategy goals and their corresponding targets. For example, Goal 2: “End hunger, achieve food security and improved nutrition and promote sustainable agriculture”, and Target 2.1: "By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round". The role of logistics in achieving this goal lies in the fact that year-round access to safe food requires the development of appropriate supply chains, the organization of distribution centers, storage methods, and the formation of procurement systems based on the established consumer basket. In other words, the development of logistics directly influences the advancement of the sustainable development concept. At the same time, the sustainable development strategy also directly affects the development of logistics and its methodologies. For example, Goal 13: “Take urgent action to combat climate change and its impacts”. This goal necessitates the adaptation of transport infrastructure to climate change in order to prevent and mitigate further negative impacts.

Thus, it is important to emphasize that the concepts of logistics and sustainable development are closely interconnected and mutually complementary.

As a result of this strong interrelation, a unified concept has emerged – the concept of sustainable logistics (fig. 1). It involves the implementation of logistics functions and tasks in accordance with the requirements of the Sustainable Development Strategy.

Fig. 1. Interconnection between logistics concepts and sustainable development

Therefore, the study of the level of sustainability in logistics is highly relevant, since, as we have established, logistics and sustainable development directly influence one another. Accordingly, the definition of an indicator that would reflect the sustainability of logistics will make it possible to determine the prospects for further implementation and scaling of sustainable development in national economies through the influence of logistics as one of the key shaping factors.

2. Challenges in Assessing Logistics Sustainability in an International Context

All the reviewed studies provide a general overview of sustainable development, its relevance, and various measures to improve the efficiency and sustainability of logistics, as well as its compliance with the requirements of sustainable development. However, none of these works reflect the sustainability of logistics either in general or in individual countries, since there is no indicator that would represent it. Therefore, despite the recognition of the importance of logistics in achieving the Sustainable Development Goals, the main issue lies in the fact that a unified approach to evaluating the sustainability of logistics systems has not yet been established. This limits the ability to conduct monitoring, international and regional comparisons, and complicates the adoption of effective managerial decisions that would ensure and coordinate the implementation of the sustainable development strategy across various sectors of the economy, including logistics as the "circulatory system of the economy." In today's context, where issues of decarbonization, energy efficiency, accessibility, and inclusiveness are gaining global importance, the existence of a transparent and comparable tool for assessing the sustainability of logistics is not only desirable but also a necessary condition for the effective management of logistics processes in accordance with the Sustainable Development Goals.

This paper proposes the creation of an indicator that would reflect the sustainability of logistics in the following countries: Ukraine, Germany, Romania, Poland, Spain, and Turkey. The list of countries is formed based on their diversity in terms of economic development levels, geographical location, and the degree of integration into the European logistics system. Germany demonstrates advanced approaches to sustainable logistics, while Ukraine and Romania are examples of countries with a transitional economy. Poland serves as an example of effective logistics adaptation to the requirements of sustainable development in the context of rapid integration into the EU. Spain adds a southern European context to the study, with a focus on innovative urban logistics, while Turkey represents a country with an Asian-European context and high transit potential. This selection allows for a comparative analysis of different models of implementing sustainable solutions in logistics. The sustainability indicator in logistics will be based on the principle of the harmonious combination of economic, environmental, and social vectors, as Kuspljak H. I. and Kuspljak I. S. note that sustainable development requires interdependence between these three vectors (economic, environmental, social) (Kuspliak G., Kuspliak I.,2020).

Therefore, in the context of this study, the existing UNTAD SFT index (UNCTAD) will be examined. Although it characterizes the level of development in the logistics industry, it does not provide a complete assessment of the sustainability of the logistics sector, as it only integrates the quantitative indicators of the three vectors. However, the SFT index does not show the deviation in the development levels of these three vectors relative to each other. That is, due to the scale effect, the gap between them will only increase, which violates the core principle of sustainable development – the harmonious combination of economic, social, and

environmental vectors. Therefore, within the scope of this research, an indicator of the deviation of the sustainability indicators of the three interfaces in logistics relative to each other will be calculated to assess the sustainability of the logistics sector in the proposed countries.

Thus, the objectives of the research are defined as follows:

– Development of an approach for calculating the logistics sustainability indicator;
– Carrying out calculations for a number of European countries;
– Identification of the strengths and weaknesses of the examined logistics systems in ensuring the sustainability of their development.

3. Methodology of Logistics Sustainability Assessment

As previously mentioned, the SFT index was chosen as the basis for calculations. The UNCTAD SFT index measures and visualizes countries' performance in sustainable freight transport (SFT) in an internationally comparable manner, covering around 160 economies. Aligned with the UNCTAD SFT framework, the index comprises the overall score, scores for the three pillars of SFT (i.e., economic score, social score, and environmental score), and scores for the SFT categories (e.g., infrastructure score, safety score, etc.). These scores offer insights into an economy's relative standing in SFT performance worldwide. A score of 0 indicates that the economy has the worst performance in the world for all underlying SFT indicators, while a score of 100 indicates the best performance in the world for all indicators (UNCTAD). To reflect the overall level of sustainable development in logistics of the selected countries, it is appropriate to present the SFT index score and the scores for the SFT categories (table 1, fig. 2).

Table 1

SFT index score and scores for the SFT categories for selected countries

Country	SFT index score	Economic score	Social score	Environmental score
Germany	87,44	82,2	81,92	98,21
Spain	79,26	77	72,5	88,28
Turkey	73,44	70,62	60,87	88,82
Poland	70,78	65,87	64,15	82,33
Romania	67,47	52,31	56,87	93,23
Ukraine	52,02	37,21	54,83	64,02

We can see that among the countries considered, Germany is the leader both in the SFT index score and in all the scores for the SFT categories. However, in the case of other countries, discrepancies are observed. For example, Romania ranks second in the environmental indicator in the reviewed list, but fifth in all other categories, indicating a significant discrepancy in the sustainability vectors of the country's logistics, thus violating the balance between them. This highlights the need for measures to balance these indicators to enable economic scaling in the country, as failing to take necessary actions will only increase the discrepancy as scaling progresses. The situation is different in Spain, where the country ranks fourth in the environmental indicator but second in all others. Poland is ranked third for the social indicator, but fourth in all others. Turkey, on the other hand, ranks third in all indicators, with the social indicator being ranked fourth. Germany and Ukraine, although they occupy the same positions

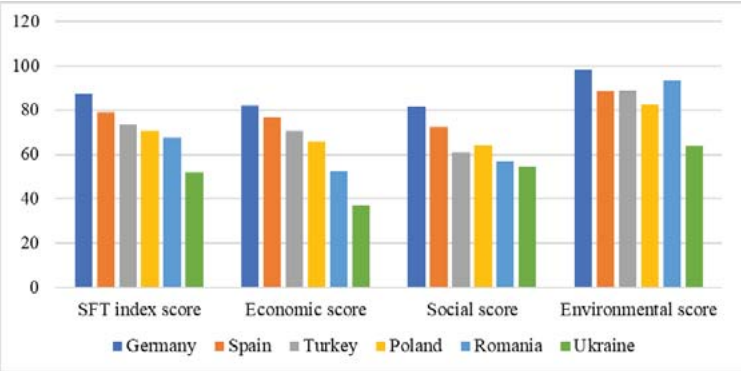

Fig. 2. SFT index score and scores for the SFT categories for selected countries

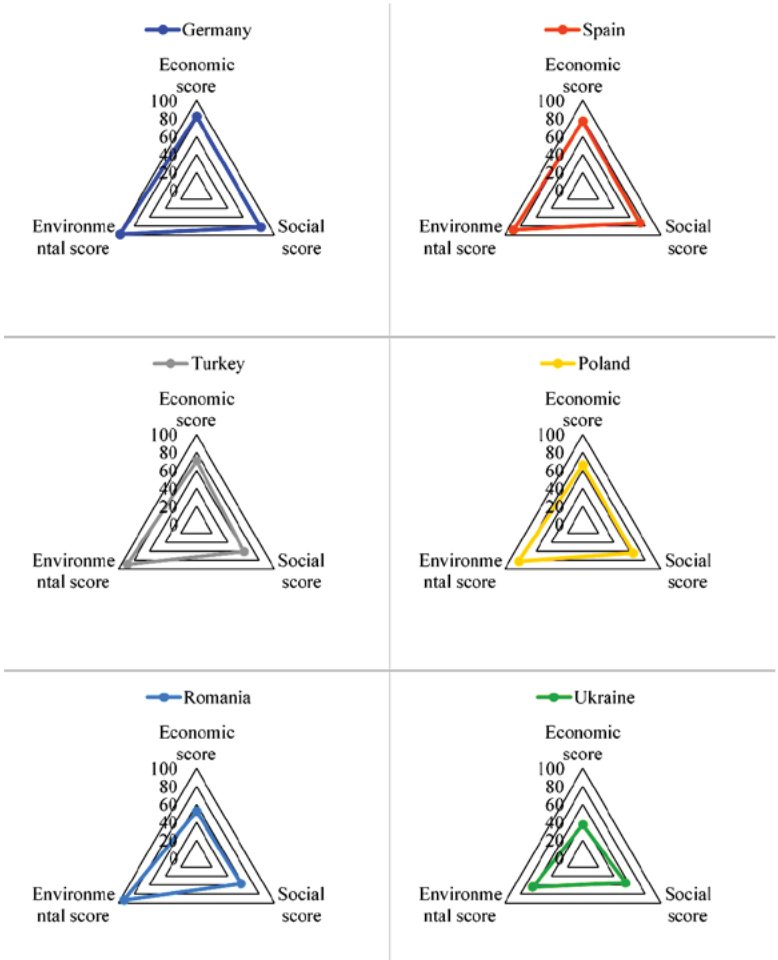

Fig. 3. Structure of sustainable development in logistics of selected countries

in the ranking – first and sixth respectively – also show significant discrepancies when examining the sustainability vectors in logistics in quantitative terms. Such discrepancies point to the imperfection of the UNTAD SFT index due to the failure to account for these differences, which means that this indicator requires improvement. Based on the provided data, the structure of sustainable development in logistics for the selected countries should be depicted (fig. 3).

Based on the graphical representation, it can be observed that in each country there is a more or less significant unevenness in the structural components of the SFT index. In other words, despite a certain level of sustainable development, it cannot be considered truly sustainable due to the failure to adhere to the fundamental principle – the harmonious integration of the economic, social, and environmental vectors.

Based on this, to reflect the sustainability of logistics in the listed countries, it is advisable to calculate the measure of unevenness between these vectors. The best approach for this is a calculation based on the Gini index, which measures the degree of disparity between values. This coefficient varies from 0 to 1, where 0 means all values are equal, and 1 represents maximum inequality of values. The Gini index is determined as follows:

$$G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|n_i - n_j|}{2n^2\bar{x}} \quad (1)$$

where n_i and n_j – the value of the score for a specific SFT category;

n – the number of attributes, in our case – 3;

$\bar{x}$ – значення SFT index.

Based on this, we can form an indicator reflecting the sustainability of logistics development in each country, i.e., the uniformity of each vector relative to one another. We will denote this indicator as Slogistic, and calculate it as follows:

$$S_{\text{logistic}} = (1 - G) \quad (2)$$

Considering this indicator, we can calculate the SFT index by adjusting it for its sustainability, and we will represent it as SFT* and calculate it as follows:

$$\text{SFT}^* = \text{SFT index} * S_{\text{logistic}} \quad (3)$$

Based on the formulas, we can calculate the corresponding indicators for each country (table 2).

Table 2

Calculation of the SFT index score adjusted for the level of logistics sustainability

Country	SFT index score	Economic score	Social score	Environmental score	G	Slogistic	SFT*
Germany	87,44	82,2	81,92	98,21	0,0414	0,9586	83,82
Spain	79,26	77	72,5	88,28	0,0442	0,9558	75,75
Turkey	73,44	70,62	60,87	88,82	0,0846	0,9154	67,23
Poland	70,78	65,87	64,15	82,33	0,0571	0,9429	66,74
Romania	67,47	52,31	56,87	93,23	0,1348	0,8652	58,38
Ukraine	52,02	37,21	54,83	64,02	0,1145	0,8855	46,06

Next, we can visualize the values of the logistics sustainability indicator (Slogistic) in the selected countries (fig. 4). We can also display a comparison of the adjusted SFT index score (SFT*) (fig. 5).

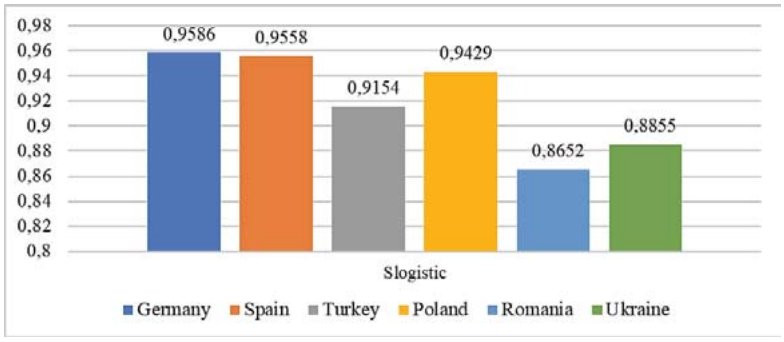

Fig. 4. The value of the logistics sustainability indicator (Slogistic) in the selected countries

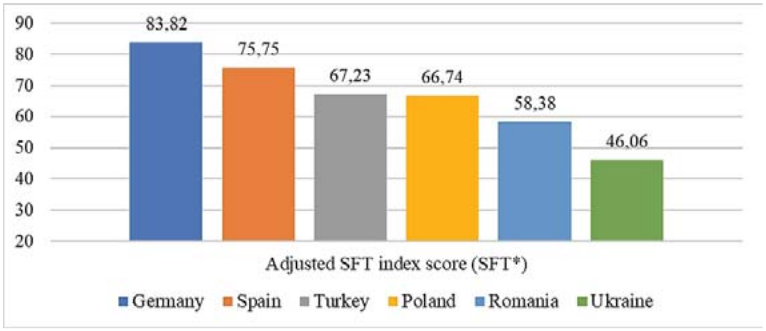

Fig. 5. Comparison of the adjusted SFT index score (SFT*) in the selected countries

Based on the calculations, it can be noted that the logistics sustainability indicator (Slogistic) in the selected countries shows that despite the gap between Germany and Spain in the SFT index score, Spain's logistics activity is just as sustainable as Germany's. In other words, when the scale of logistics activities in Spain increases to Germany's level, the unevenness in indicators will not increase, and the logistics activity will remain equally sustainable. A different trend can be observed in the indicators for Poland and Turkey. Poland's logistics activity is more sustainable and is approaching the level of highly developed countries like Germany, while Turkey's indicator is lower. Therefore, with further development and expansion of logistics activity in Poland, it will remain sustainable. In contrast, in Turkey, the discrepancy between the sustainability vectors in logistics will increase, making logistics activity in the country less sustainable. As for Romania and Ukraine, they have the lowest values in this indicator, which indicates the need for a review of national policies and the promotion of underdeveloped vectors, according to fig. 3, these are the economic and social indicators.

At the same time, the adjusted SFT index score shows a slightly different difference between the countries, similar to the basic SFT index score. However, the difference in the indicators for Poland and Turkey has become less significant, while for countries like Romania and Ukraine, the need to stimulate and develop both the lagging vectors and logistics activity

in general is clearly visible. Based on the examined indicators, we can identify the problems and propose certain solutions to enhance the level of sustainable development in logistics in the countries considered.

In Germany, the current situation indicates high performance across all categories of the SFT index. Therefore, the country should continue its comprehensive approach to logistics development with a focus on balance. We can also suggest that Germany serves as a model for other countries by offering expertise and partnerships in the transfer of sustainable transport technologies.

In Spain, despite lagging behind in the overall index, the sustainability of logistics is very close to that of Germany. Therefore, the country could focus its policy on the environmental sector, which is the most lagging, to drive further improvement. It would also be beneficial to attract investments in "green" transport and infrastructure without compromising the balance between social and economic aspects.

In Turkey, we can identify the issue of imbalance due to the relatively weak social component. Therefore, it would be advisable to improve working conditions in the logistics sector, including safety, labor protection, and training. Additionally, it is important to implement a policy of corporate social responsibility for logistics companies.

Poland has a relatively high level of sustainability. Therefore, it is recommended to maintain the existing balance of sustainable development through targeted support for all three vectors, as well as to develop infrastructure for sustainable transportation with a focus on innovation, considering that the country is ready for logistics scaling.

In Romania, the main issue is that it has very weak economic and social components, despite having a high environmental component that nearly reaches Germany's level. Therefore, it is recommended to create programs to stimulate economic activity in the logistics sector, such as government investments or subsidies. It is also important to enhance workforce qualifications, improve working conditions, and implement safety standards.

Ukraine faces significant challenges in implementing sustainable development, as it shows the worst economic and social indicators among the countries considered. Therefore, it is recommended to undertake a reform of transport and logistics policies, focusing on economic support for the sector. It is also crucial to invest in social aspects, such as salaries, working conditions, and workforce training. Particularly important is the integration into European logistics networks, thus attracting foreign investments to enhance the sustainability of the country's logistics sector.

4. Conclusions

Thus, the study determined that sustainable development and logistics are interrelated concepts, which led to the emergence of a new concept – sustainable logistics, which involves adapting logistics processes to the requirements of sustainable development. It was found that there is currently no universal indicator for sustainable development in logistics, making comparative analysis between countries and regions and the adoption of effective management decisions in the field of logistics more difficult. During the research, a new integrated sustainability indicator for logistics was proposed, taking into account three main vectors: economic, ecological, and social. Its application allows for the evaluation of the level of sustainable development of the logistics system of any country. Through a comparative analysis of the sustainability of logistics in countries such as Ukraine, Germany, Romania, Poland, Spain, and Turkey, problems

were identified, and certain solutions were proposed to improve the sustainability of logistics in the countries under consideration.

The practical significance of the study lies in the potential use of the obtained indicator for strategic planning at the national level, as well as for scientific research in the field of sustainable logistics and the development of recommendations for improving logistics systems. The chosen approach to evaluation could serve as the basis for creating a unified methodology for monitoring the sustainable development of logistics at both national and international levels.

References

1. Saiensus M. (2018) Lohistyka yak skladnyk stratehii staloho rozvytku [Logistics as a Component of Strategies for Sustainable Development]. Ekonomika i Suspilstvo. 17.46-52. URL: https://economyandsociety.in.ua/journals/17_ukr/7.pdf [in Ukrainian].

2. Filip Ž. Bugarčić, Vladimir Mićić. (2023). Analysis of the Sustainable Development Concepts in the Logistics Industry. Advances in Human Services and Public Health (AHSPH) Book Series, 341–366. https://doi.org/10.4018/978-1-6684-7730-4.ch013

3. O. Bilonoh, S. Yanishevskyi, O. Kostiuchenko, V. Fartuchnyi, I. Chernenko, Ye. Yanishevskyi. (2025) Vprovadzhennia Pidkhodiv Staloho Rozvytku Pid Chas Upravlinnia Protsesamy Transportnoho Obsluhovuvannia Subiektiv Hospodarskoi Diialnosti [Implementation of sustainable development approaches in the management of transport service processes of economic entities]. Dorogi i mosti. Kyiv. 31. 331–344. https://doi.org/10.36100/dorogimosti2025.31.331 [in Ukrainian].

4. Halak I., Khrutba Y. (2022) Osoblyvosti formuvannia ta pryiniattia proiektnykh rishen v protsesi upravlinnia reversyvnymy potokamy v lantsiuhakh postachan [Specifics of project's decisions-making process and its formation in reverse supply chains management]. Visnyk Natsionalnoho transportnoho universytetu. Tekhnichni nauky. 1(51). 84-95 http://publications.ntu.edu.ua/visnyk/51/095_102.pdf [in Ukrainian].

5. Kyrych N., Libus T., Spivak S. (2018). Indicators of sustainable development in the region [Conference paper]. Materials of the International Scientific and Technical Conference Fundamental and Applied Problems of Modern Technologies, 304–305. Ternopil National Technical University named after Ivan Puluj.https://elartu.tntu.edu.ua/bitstream/lib/25449/2/MNTK_2018_2018_Kyrych_N-Indicators_of_sustainable_304-305.pdf [in Ukrainian]

6. Report of the World Commission on Environment and Development: Our Common Future. URL: http://www.un-documents.net/wced-ocf.htm

7. Kotykova O. (2007). Zmist poniattia stiikoho rozvytku [The content of the concept of sustainable development]. Scientific Bulletin of Lesya Ukrainka Volyn State University. 12. 170–174. [in Ukrainian]

8. Tarasenko I. (2011). Metodolohichni osnovy staloho rozvytku pidpryiemstv lehkoi promyslovosti [Methodological foundations of sustainable development of light industry enterprises] (Doctoral dissertation abstract). Kyiv, Ukraine. [in Ukrainian]

9. Libanova E., Khvesyk M. (2014). Sotsialno-ekonomichnyi potentsial staloho rozvytku Ukrainy ta yii rehioniv [Socio-economic potential of sustainable development of Ukraine and its regions] (National report). Institute for Demography and Social Studies of the National Academy of Sciences of Ukraine. [in Ukrainian]

10. Bagrov M., Kostrikov S., Chervanyov I. (2008). Do pytannia formalizatsii invaironmentalnoho vymiru staloho sotsialno-ekonomichnoho rozvytku suspilstva [On the issue of formalization of the environmental dimension of sustainable socio-economic development of society]. Geopolitics and Ecogeodynamics of Regions, 1–2, 5–15. [in Ukrainian]

11. Nahara M. (2021). Stalyi rozvytok: transformatsiia paradyhmy v umovakh ekolohizatsii ekonomiky [Sustainable development: Transformation of the paradigm in the context of economic greening]. Innovative Economy, 5–6, 36–42. [in Ukrainian]
12. Khanov O., Skibina S. (2017). Stalyi rozvytok krain YeS: metodyka y indykatory otsiniuvannia [Sustainable development of EU countries: Methodology and indicators of assessment]. Problems of the Economy, 3, 20–32. [in Ukrainian]
13. Resolution adopted by the General Assembly on 25 September 2015. Transforming our world: the 2030 Agenda for Sustainable Development. URL: https://digitallibrary.un.org/record/3923923?v=pdf
14. Kuspliak G., Kuspliak I. (2020). Stalyi rozvytok: etapy stanovlennia, sutnist poniattia, osnovni vektory ta interfeisy [Sustainable development: stages of formation, essence of the concept, main vectors and interfaces] State Formation. DOI: https://doi.org/10.34213/db.20.01.08. [in Ukrainian]
15. The UNCTAD Sustainable Freight Transport Framework. URL: https://sft-framework.unctad.org/about-sft-index