# Green Investments as Tools for Stimulating the Sustainable Financing of Logistics Systems Development

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**Abstract.** Changes in the modern paradigm of ecological thinking require a significant reorganization of logistics processes and the need to transform logistics systems in the context of the concepts of green economy. In view of this, the purpose of this paper is the further development of theoretical and methodological provisions and justification of the feasibility of applying a comprehensive approach to green investment in logistics systems development, taking into account modern global environmental challenges and threats. To achieve the aim of the research, the following scientific methods were used: analysis, synthesis, induction, deduction, observation, comparison, formalization, classification, expert evaluations, statistical analysis, and structural and logical generalization. The article clarifies the meaning of the concepts "sustainable financing", "green investments", and "green bonds" from the standpoint of logistics systems development. A systematic approach to evaluating the effectiveness of the logistics systems development in the countries of the world is proposed. The key shortcomings of the existing methods of evaluating the logistics systems development have been revealed. A comparative analysis of indicators characterizing the current state of operation of the logistics system using the example of the United Kingdom, Poland and Ukraine was performed. The expediency of applying a comprehensive approach to sustainable financing of the logistics systems development is substantiated, the essence of which is the integration of the main components of the organizational and economic mechanism (principles, functions, management methods, information systems and green technologies), green investment and insurance tools for the implementation of priority areas of green transformation of logistics systems.

## 1 Introduction

Climate change has become a defining political and economic issue and is likely to remain so for years to come. All over the world, governments, investors and corporations are beginning to take action in response to the climate crisis, with a particular focus on the green

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economy and decarbonization strategies. The transition to a low-carbon development model of national economies will require a significant amount of nontraditional sources of investment, especially in the form of green finance, to support activities to reduce greenhouse gas emissions and help corporations adapt to the effects of climate change. In turn, the change in the modern paradigm of ecological thinking leads to the reorganization of logistics processes and the need to transform logistics systems in the context of the concepts of green economy and balanced sustainable development.

In the course of a survey conducted in 2019 by the consulting company PwC [1], it was found that 41% of managers of transport and logistics enterprises in 85 countries of the world are concerned about climate change and environmental damage, which is associated with the growth prospects of their business.

In 2009, the World Economic Forum [2] established that greenhouse gas emissions during logistics activities accounted for 5.5% of global greenhouse gas emissions. In 2015, the share of greenhouse gas emissions from passenger and cargo transportation was 18% of the global volume of such emissions [3]. According to A. McKinnon [4], 13% of greenhouse gas emissions fall on logistics infrastructure. At the same time, warehouse infrastructure facilities generate approximately 20% of the total volume of transport emissions of greenhouse gases in the USA [5] and 11% in the United Kingdom [6]. In Germany, the share of greenhouse gas emissions from the operation of the logistics system (warehouses, logistics centres, terminals, ports) is 15% [7].

It is worth noting that in 2022, the recovery of passenger and cargo transport activity after the COVID-19 pandemic led to a 3% increase in greenhouse gas emissions in the transport sector compared to 2021. During 1990-2022, emissions from the transport sector grew by an average of 1.7% faster than in any other final consumption sector (except industry). To achieve the scenario of net zero emissions (NZE) by 2050, greenhouse gas emissions from the transport sector must be reduced by more than 3% per year by 2030 [8].

Therefore, countries worldwide are actively applying mechanisms of strict state regulation and fiscal incentives, and large-scale investment programs are being implemented with the aim of modernizing transport and logistics infrastructure by “greening” them to minimize the negative impact on the environment. Such programs, as a rule, are based on the technologies of the fourth industrial revolution. For example, the Transport Strategy of the EU [9] envisages reducing greenhouse gas emissions by 80-95% below the 1990 level by 2050. This strategy lays the foundation for the green and digital transformation of the European Union's transport system and helps it become more resilient and adaptable to crisis situations.

According to the G20 estimate [10], to achieve global sustainable development and goals related to the fight against climate change, a global investment of 90 trillion dollars is needed over the next 15 years. According to the International Energy Agency [11], by 2035, total investments in the amount of 48 trillion dollars are needed in the energy sector. It is predicted that annual investments in energy supply in the amount of 1.6 trillion dollars will steadily grow over the next decades to 2 trillion dollars. Annual costs for energy efficiency will increase 4.2 times over the years 2012-2035, or from 130 to 550 billion dollars.

The European Bank for Reconstruction and Development undertook to allocate more than 50% of funding for climate and other environmental goals by 2025 [12]. Another obligation is related to the alignment of all future operations with the goals and principles of the Paris Agreement, which means that any investment will be evaluated according to its content. This approach will affect the reorientation of finances and the way of interacting with customers and operations. Thanks to the Green Economy Transition Approach 2021-2025 [13], the EBRD aims to achieve an annual net reduction of greenhouse gas emissions by 25 million tons. The new GET approach is based on the EBRD's many years of experience in financing environmental investments. Thus, since 2006, the EBRD has invested more than 49 billion

euros in environmental investments and financed 2600 environmental projects, the implementation of which will reduce carbon emissions by 124 million tons per year. In the future, the EBRD plans to become more involved in the development of climate strategies and policies at the national and sectoral levels.

It should be noted that European countries implement measures within the framework of the implementation of the Action Plan on Sustainable Financing [14]. This program document includes the EU Taxonomy of Sustainable Financing, i.e., a strategy that allows investors to scientifically define the classification of economic activities for decarbonization. The essence of the taxonomy is that the introduction of low-carbon technologies and solutions requires sustainable financing, including for the purpose of transforming logistics systems. The EU taxonomy is expected to promote security and reduce risks for private investors from "greenwashing" or "green camouflage". In addition, the taxonomy may become the basis for issuing "green" bonds in the coming years.

In 2021, the European Commission planned to issue green bonds in the amount of 250 billion euros. For this purpose, the mechanism of functioning of green bonds has been approved, which should guarantee that the funds raised will be directed to the implementation of green projects. In July 2021, the European Commission presented the Strategy for Sustainable Financing to Combat Climate Change and the European Standard for Green Bonds [15]. The strategic document stipulates requirements for issuers of green bonds and reporting to investors, mandatory external verification of the terms of the issue by an independent verifier, etc. Environmentally sustainable bonds are one of the main instruments of investment financing in the EU related to green technologies, energy and resource efficiency, as well as sustainable infrastructure.

According to the Climate Bonds Initiative [16], the volume of the global green financing market amounted to 1 trillion dollars in 2020. The global annual issuance of green bonds has increased every year since 2007, and in 2019, it amounted to 266.1 billion dollars. In 2020, the market volume of green bond issuance amounted to 222.8 billion dollars. The reduction is due to the negative consequences and impact of the COVID-19 pandemic.

In addition, in recent years, it has become obvious that to ensure the transition to a low-carbon economic development model, a combination of capital from the public and private sectors is appropriate because public funds alone cannot cover these costs. Therefore, there is an urgent need to strengthen the ability of the financial system to mobilize private capital for green investments in the sustainable development of transport and logistics infrastructure and networks. In turn, this requires the development of a new financial toolkit for selecting potential investors for the needs of green investment and facilitating the mobilization of capital in the necessary volumes.

In view of this, it is expedient to search for innovative tools and scientifically based "green" solutions, as well as the introduction of fundamentally new organizational and management approaches and "green" technologies to increase the efficiency of logistics systems.

## 2 Literature Review

The transition from a traditional model of economic growth to a green one is a worldwide global trend, in the framework of which the green economy is recognized as a tool for achieving sustainable development.

The theory of external effects by A. Pigou [17] immediately precedes the concept of sustainable development, as it considers the emergence of externalities as a result of the interaction of two business entities with respect to the environment. Here, it is appropriate to mention the "market of emission rights" and the need for government intervention to eliminate "market failures" through the mechanism of corrective taxes, subsidies and

production activity quotas. The alternative theory of R. Coase [18] is also logical from the standpoint of the theoretical justification of sustainable development and the social responsibility of business through the practice of voluntary agreements. This allows for the prioritization of the environmental growth trajectory through a balanced approach between public costs and public benefits.

Among the representatives of modern currents of economic science are leading scientists such as F. Bierman et al. [19], G. Brennan [20], J. Buchanan [20, 21], J. Rinne et al. [22], G. Tullock [21], and many others [23-44]

The school of ecological economics, which was formed in the mid-1970s, today rightfully occupies the most significant place in the concept of sustainable development. This is because its representatives were the first to identify environmental costs as a consequence of economic growth.

Speaking of the founders of the theory of sustainable development, it is necessary to mention the 2018 Nobel Prize laureate W. Nordhaus [45], who is rightfully called the "father" of climate change economics. He was one of the first to outline the problem of climate change as an economic one and proposed mechanisms of state regulation through price policy on the carbon market (emission rights market).

The foundations of the formation of the green economy were laid within the framework of the concept of sustainable development in the late 1980s. This term was first mentioned in 1989 in the work of the English economist "Blueprint for a Green Economy" (D. Pearce et al. [46]), where the need for economic support for environmental policy is substantiated.

Many scientific works of scientists are devoted to the problems of sustainable finance (A. Eshet [47]; Ch.-Ch. Lee et al. [48]; M. Linnenluecke et al. [49]; N. Magalhães [50]; S. Quatrini [51]; R. Ronaldo, T. Suryanto [52]; I. Siedschlag, W. Yan [53]; A. Sudmant et al. [54]; C. Wang et al. [55]; Q. Yang et al. [56], and many others [57-62]. Sustainable financing involves a comprehensive approach that combines various strategies to improve the social, economic and environmental performance of the financial system. In this regard, green finance can be considered part of the strategic agenda of sustainable finance, a necessary condition for overcoming environmental crises, and a paradigm of sustainable development.

Researchers (I. Ari, M. Koc [63]; P. Demirel et al. [64]; L. Huang, Z. Lei [65]; G. I. Iacobuță et al. [66]; M. Ikram et al. [67]; Zh.-Zh. Li et al. [68]; M. Madaleno et al. [69]; C. Nwani [70]; A. Rokhmawati [71]; K.-H. Wang et al. [72]; J. Wen et al. [73]; C.-H. Yu et al. [74]; S. Zhang et al. [75]; M. Zhou, X. Li [76]; R. Zimmerman et al. [77], and many others [78-126]) pay attention to the definition and evaluation of cause-and-effect relationships between green investments in the development of various spheres of economic activity, environmental responsibility, green technologies and innovations, financial intermediation, resource distribution, environmental sustainability, environmental regulation, and sustainable development.

It is believed that the field of green financing was first identified in 1992 by the American economist R. Sandor [127]. This area mainly involved financing related to climate change (climate change investment). Later, this term began to be used in a narrow sense, assuming the implementation of projects and programs aimed at ensuring the mitigation of consequences and adaptation to climate change and reducing the level of risks of climate disasters (B. R. Marshall et al. [128]).

Currently, among foreign scientists and practitioners, a single approach to the classification of green financing tools has not been defined. They include the following:

- public support mechanisms; public financing instruments (loans, equity capital, investment instruments that exclude risks) (S. Venugopal et al. [129]);

- instruments through which direct financing is carried out (shares, credit lines, loans and grants); instruments that do not involve direct financing but can transfer knowledge or reduce risks (guarantees and technical assistance); instruments used to attract additional private

resources transferred to "green" projects through one of the abovementioned instruments (green bonds and structured funds) (N. Lindenberg [130]);

- green shares, green bonds (M. Voica et al. [131]);
- green bonds, green stocks, green loans, and budget financing instruments (V. Kazlauskiene et al. [132]).

According to scientist H. J. Noh [133], all "green" financial products should be divided into four basic groups:

- retail finance (green mortgage, green loans for the purchase of housing, green loans for the construction of commercial real estate, green credit cards, green car loans);
- corporate/investment finance (financing of green projects, green venture capital and private capital, technological leasing and carbon finance);
- asset management (fiscal or treasury fund, environmental fund and low-carbon fund, green bonds, disaster fund);
- insurance (car insurance, carbon insurance, green insurance).

In modern practice, different approaches to defining the concept of "green finance" are distinguished. In the broadest sense, these are investments in the development and implementation of programmes in the field of rational (balanced) nature management (for example, water resources management, soil protection, biodiversity conservation); projects of environmental orientation (in particular, reduction of greenhouse gas emissions and adaptation to changes in climatic conditions and production, focused on measures to increase the efficiency of processing and secondary use of resources, support of renewable energy [134]; J. Makower [135]).

According to X. Wang & Q. Wang [136], green financing is a mechanism that provides financial support for environmental projects, promoting technological progress and sustainable economic development. Hence, it is an important driver of green economic growth and structural transformation. The development of the field of green financing is recognized as a strategic step for promoting the modernization of the industrial structure, achieving ecological development and accelerating ecological civilization.

Currently, there are dozens of interpretations of the term "green investment" as an economic category, which are referred to in various international documents. However, despite the lack of a single, agreed upon and internationally approved definition of "green investment", it is advisable to use its interpretation formulated by experts of international economic and financial organizations. Thus, the International Monetary Fund (IMF) considers "green" investments, the end result of which is the reduction of emissions of greenhouse gases and pollutants into the air, without a significant reduction in the level of production and consumption of nonenergy goods. The Organization for Economic Co-operation and Development (OECD) interprets "green investments" (in a broader sense, "low-carbon", "climate-sustainable") as investments in enterprises, projects and financial instruments, mainly in the renewable energy sector, which contribute to reducing the level of carbon emissions, mitigating climate change and spreading environmental technologies.

It should be emphasized that the most important instrument of green financing is green bonds. For the first time, green bonds were issued by the European Investment Bank in 2007 and were called Climate Awareness Bonds.

Within the framework of the described terminology, the broadest definition of green bonds – climate-aligned bonds – is proposed by the relevant Climate Bonds Initiative (CBI) to designate financial instruments, the proceeds of which are fully or partially used to finance projects to create low-carbon and climate change-resistant infrastructure. Green bonds are similarly defined by the World Bank, which implements a green bond program to finance environmentally sustainable growth in developing countries.

In the specialized financial literature, the term "greenwashing" ("green camouflage") is found – an additional nonfinancial risk of green bonds. This term refers to the intentional

misleading of investors and state authorities regarding the directions of use and the validity of the amount of financial funds received as a result of the emission of "green" bonds, compliance with the principles of environmental additionally and effectiveness.

Certain aspects of the development of the green bond market as an effective mechanism for combating climate change and achieving sustainable development are highlighted in the works of many scientists (J. Banga [137]; J. P. Braga et al. [138]; X. Cao et al. [139]; Y. Chen, Zh. J. Zhao [140]; R. Ferrer et al. [141]; C. Flammer [142]; D. Guo, P. Zhou [143]; B. Kocaarslan [144]; L. Pham, C. P. Nguyen [145]; J. Piñeiro-Chousa et al. [146]; I. Sangiorgi, L. Schopohl [147,148]; A. Sinha et al. [149]; A. Torvanger et al. [150]; R. Zhang et al. [151], and many others [152-183183]).

Despite the wide range of scientific research on the chosen topic, the multifacetedness and debatable nature of certain issues require further development. In particular, the solution to this problem is actualized at the current stage of transformation of models of economic development in the conditions of a green economy.

Thus, this problem determined the purpose of this paper, which consists of the scientific and methodological substantiation of the feasibility of applying a comprehensive approach to green investment in logistics systems development, taking into account modern global environmental challenges and threats.

## 3 Methods

The theoretical and methodological basis of the research is the provisions of economic theory, institutional theory, green economy, systems theory; concepts of financial, strategic, logistics management; financial analysis; and modelling of economic processes.

The following general scientific methods were used in the research process: analysis and synthesis; induction and deduction; observation, comparison, formalization, classification; expert evaluations; statistical analysis; and structural and logical generalization.

The information base of the research is statistical and analytical materials Armstrong & Associates, Inc., Climate Bonds Initiative (CBI), The Group of Twenty (G20), The International Energy Agency (IEA), International Transport Forum (ITF), European Bank for Reconstruction and Development (EBRD), European Commission (EC), PwC, United Nations Environment Programme (UNEP), World Bank (WB), and World Economic Forum (WEF).

To determine the modern problems of the logistics systems development in the countries of the world in the conditions of the green economy, the Logistic Performance Index (LPI), Climate Change Performance Index (CCPI), Environmental Performance Index (EPI), and Sustainable Development Goals Index (SDG Index) were used.

The World Bank has developed the Logistics Performance Index (LPI) for comparative analysis and rating evaluation of the effectiveness of the development of logistics systems in the countries of the world. This integrated indicator is based on a global survey of logistics operators, which measures the performance of the entire logistics supply chain in a country.

The Logistics Performance Index (LPI) is a weighted average of the country based on six key indicators (parameters) (*Table 1, 2, 3*): 1) efficiency of the customs clearance process (that is, speed, simplicity and predictability of formalities) by border control authorities, including customs; 2) infrastructure quality (logistics, transport, warehouse, information); 3) ease of organization of international delivery at a competitive price; 4) competence and quality of logistics services (for example, transport operators, customs brokers); 5) possibility of cargo tracking; and 6) timeliness of delivery of shipments to the destination within the planned or expected time.

**Table 1.** Top 10 countries in the world in the LPI Rating in 2007

| Country | LPI | Indicators | | | | | |
|---|---|---|---|---|---|---|---|
| | | Customs | Infrastructure | Ease of shipment | Logistics services | Ease of tracking | Timeliness |
| Singapore | 1 | 3 | 2 | 2 | 2 | 1 | 1 |
| Netherlands | 2 | 1 | 1 | 1 | 1 | 4 | 5 |
| Germany | 3 | 4 | 3 | 4 | 3 | 5 | 8 |
| Sweden | 4 | 6 | 5 | 5 | 6 | 3 | 4 |
| Austria | 5 | 8 | 8 | 3 | 4 | 13 | 3 |
| Japan | 6 | 11 | 6 | 10 | 5 | 7 | 6 |
| Switzerland | 7 | 5 | 4 | 14 | 8 | 9 | 2 |
| Hong Kong, China | 8 | 7 | 9 | 7 | 9 | 8 | 7 |
| United Kingdom | 9 | 13 | 10 | 6 | 7 | 6 | 11 |
| Canada | 10 | 9 | 12 | 8 | 12 | 11 | 13 |

*Source:* [162].

**Table 2.** Top 10 countries in the world in the LPI Rating in 2018

| Country | LPI | Indicators | | | | | |
|---|---|---|---|---|---|---|---|
| | | Customs | Infrastructure | International shipments | Logistics quality and competence | Tracking | Timeliness |
| Germany | 1 | 1 | 1 | 4 | 1 | 2 | 3 |
| Sweden | 2 | 2 | 3 | 2 | 10 | 17 | 7 |
| Belgium | 3 | 14 | 14 | 1 | 2 | 9 | 1 |
| Austria | 4 | 12 | 5 | 3 | 6 | 7 | 12 |
| Japan | 5 | 3 | 2 | 14 | 4 | 10 | 10 |
| Netherlands | 6 | 5 | 4 | 11 | 5 | 11 | 11 |
| Singapore | 7 | 6 | 6 | 15 | 3 | 8 | 6 |
| Denmark | 8 | 4 | 17 | 19 | 9 | 3 | 2 |
| United Kingdom | 9 | 11 | 8 | 13 | 7 | 4 | 5 |
| Finland | 10 | 8 | 11 | 16 | 15 | 1 | 8 |

*Source:* [162].

**Table 3.** Top 10 countries in the world in the LPI Rating in 2023

| Country | LPI | Indicators | | | | | |
|---|---|---|---|---|---|---|---|
| | | Customs | Infrastructure | International shipments | Logistics quality and competence | Tracking | Timeliness |
| Singapore | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| Finland | 2 | 4 | 5 | 1 | 3 | 3 | 1 |
| Denmark | 3 | 2 | 9 | 14 | 9 | 2 | 10 |
| Germany | 3 | 7 | 3 | 8 | 3 | 3 | 10 |
| Netherlands | 3 | 7 | 5 | 8 | 3 | 3 | 17 |
| Switzerland | 3 | 2 | 2 | 14 | 2 | 3 | 4 |
| Austria | 7 | 14 | 16 | 4 | 11 | 3 | 1 |
| Belgium | 7 | 7 | 9 | 4 | 3 | 16 | 4 |
| Canada | 7 | 4 | 3 | 14 | 3 | 11 | 10 |
| China | 7 | 12 | 14 | 2 | 11 | 3 | 10 |

*Source:* [162].

Let us consider changes in the Logistics Performance Index for 2007-2023 using the example of the United Kingdom, Poland and Ukraine (Table 4).

**Table 4.** The place of the United Kingdom, Poland and Ukraine in the LPI Rating

| Indicators | UK | | Poland | | Ukraine | |
|---|---|---|---|---|---|---|
| | 2007 | 2023 | 2007 | 2023 | 2007 | 2023 |
| Customs | 13 | 22 | 38 | 24 | 97 | 90 |
| Infrastructure | 10 | 25 | 51 | 39 | 74 | 89 |
| International shipments | 6 | 22 | 52 | 38 | 83 | 75 |
| Logistics quality and competence | 7 | 28 | 38 | 33 | 90 | 92 |
| Tracking | 6 | 16 | 40 | 23 | 80 | 94 |
| Timeliness | 11 | 30 | 40 | 21 | 55 | 76 |
| Overall LPI | 9 | 19 | 40 | 26 | 73 | 79 |

*Source:* [162].

The analysis shows that the overall rating of the United Kingdom has deteriorated by 10 points. This is due to a decrease in the country's position according to the indicators "logistics quality and competence" by 21 points; "timeliness" by 19; "organization of international shipments" by 16; "infrastructure quality" by 15; "tracking" by 10; and "efficiency of customs" by 9 points.

The overall rating of Ukraine also deteriorated by 6 points. In Ukraine, as a result of Russian aggression, the position of the "Timeliness" indicators has significantly worsened by 21 points; "Infrastructure quality" by 15; "Tracking" by 14; and "Logistics quality and competence" by 2. However, the country's position improved according to the indicators "Organization of international shipments" – by 8 points; "Efficiency of customs" – by 7.

During the researched period, a positive trend of Poland's positions in the ranking of the main indicators characterizing the efficiency of logistics activity was revealed. Thus, according to the Logistics Performance Index, Poland rose by 14 points. This happened due to an increase in the rank of all indicators: "Timeliness" – by 19 points; "Tracking" – by 17; "Organization of international shipments" and "Efficiency of customs" – by 14; "Infrastructure quality" – by 12; "Logistics quality and competence" – by 5 points.

For an analytical assessment of the state of development of the global market of 3PL operators by the consulting company Armstrong & Associates, Inc., [185] calculated logistics costs and revenues of the 3PL sector by region (Table 5) and countries of the world (*Table 6*). The analysis shows that the highest share of logistics costs falls on the CIS countries – 16%, and the smallest – on the countries of North America (8.4%) and Europe (8.6%).

**Table 5.** The main indicators of the development of the logistics services market in 2020 (by region of the world)

| Region | Indicators | | | | |
|---|---|---|---|---|---|
| | GDP, *billions dollars USA* | Logistics Costs | | 3PL Revenue | |
| | | *billions dollars USA* | share in GDP, *%* | *billions dollars USA* | share in logistics costs, *%* |
| Asia Pacific | 30,301.6 | 3,896.9 | 12.9 | 389.9 | 10.0 |
| North America | 24,152.1 | 2,025.5 | 8.4 | 267.4 | 13.2 |
| Europe | 19,123.8 | 1,653.7 | 8.6 | 173.8 | 10.5 |
| Middle East | 3,701.6 | 498.9 | 13.5 | 44.6 | 8.9 |
| South America | 2,833.4 | 343.8 | 12.1 | 31.4 | 9.1 |
| Africa | 2,409.5 | 344.2 | 14.3 | 27.9 | 8.1 |
| CIS | 2,052.8 | 329.1 | 16.0 | 26.7 | 8.1 |
| Grand Total | 84,574.8 | 9,092.1 | 10.8 | 961.8 | 10.6 |

*Source:* [185].

**Table 6.** The main indicators of the development of the logistics services market in 2020 (by countries of the world)

| Country | Indicators | | | | |
|---|---|---|---|---|---|
| | GDP, *billions dollars USA* | Logistics Costs | | 3PL Revenue | |
| | | *billions dollars USA* | share in GDP, *%* | *billions dollars USA* | share in logistics costs, *%* |
| United States | 20,932.8 | 1,674.6 | 8.0 | 231.5 | 13.8 |
| China | 14,722.8 | 2,134.8 | 14.5 | 227.4 | 10.6 |
| Japan | 5,048.7 | 429.1 | 8.5 | 46.8 | 10.9 |
| Germany | 3,803.0 | 308.5 | 8.1 | 32.4 | 10.5 |
| United Kingdom | 2,711.0 | 230.2 | 8.5 | 22.6 | 9.8 |
| India | 2,708.8 | 351.8 | 13.0 | 26.0 | 7.4 |
| France | 2,598.9 | 228.2 | 8.8 | 23.8 | 10.5 |
| Italy | 1,884.9 | 169.4 | 9.0 | 17.4 | 10.3 |
| Canada | 1,643.4 | 147.9 | 9.0 | 15.7 | 10.6 |
| South Korea | 1,630.9 | 146.7 | 9.0 | 16.9 | 11.5 |
| Mexico | 1,076.2 | 129.1 | 12.0 | 13.9 | 10.8 |
| Poland | 594.2 | 60.3 | 10.1 | 6.1 | 10.2 |
| Ukraine | 151.5 | 24.1 | 15.9 | 2.0 | 8.2 |
| Grand Total | 84,574.8 | 9,092.1 | 10.8 | 961.8 | 10.6 |

*Source:* [185].

According to Armstrong & Associates, Inc. [185], in 2020, the share of expenses for the organization of logistics activities in the GDP of the United Kingdom was 8.5%, that of Poland was 10.1%, and that of Ukraine was 15.9% (world average – 10.8%). During this period, the share of revenues of the 3PL sector was 9.8% of the volume of logistics costs in the United Kingdom, 10.2% in Poland, and 8.2% in Ukraine (world average – 10.6%). In 2020, the share of the United Kingdom's GDP was 3.2% of the global GDP, costs for logistics activities – 2.5% of their total volume in the world, and revenues of the 3PL sector – 2.3% of the global volume. The share of Poland's GDP was 0.7% of the global GDP, expenses for logistics activities – 0.66% of their total volume in the world, and revenues of the 3PL sector – 0.63% of the global volume. The values of these indicators in Ukraine were 0.18, 0.27, and 0.21, respectively.

It is worth noting that the Logistics Performance Index developed by the World Bank does not contain an environmental component and does not take into account the modern challenges of the green transformation of logistics systems. Therefore, this article considers the Climate Change Performance Index (CCPI), Environmental Performance Index (EPI), and Global Sustainable Development Goals Index (SDG Index).

The Climate Change Performance Index (CCPI) is an independent tool for monitoring and evaluating the effectiveness of climate protection in 59 countries and the EU. It is an important tool to facilitate investment redistribution by providing important environmental, social and corporate governance (ESG) information on climate change. On the basis of the CCPI, the rating of the world's countries is analysed by groups of indicators such as the amount of greenhouse gas emissions, renewable energy, energy use, and implementation of climate policy.

In 2023, Denmark will lead the CCPI index, followed by Sweden and Chile (*Table 7*). The last three were Iran, Saudi Arabia and Kazakhstan. The United Kingdom took 11th place, and Poland took 54th place. There are no data for Ukraine, as it was not assessed due to the Russian invasion. In 2022, the United Kingdom took 7th place in the CCPI rating (in 2019 – 8th), Ukraine – 20th place (in 2019 – 18th), and Poland – 52nd place (in 2019 – 41st).

**Table 7.** Top 10 countries of the world in the CCPI for 2023

| Country | Rank | Score |
|---|---|---|
| Denmark | 4 | 79.61 |
| Sweden | 5 | 73.28 |
| Chile | 6 | 69.54 |
| Morocco | 7 | 67.44 |
| India | 8 | 67.35 |
| Estonia | 9 | 65.14 |
| Norway | 10 | 64.47 |
| United Kingdom | 11 | 63.07 |
| Philippines | 12 | 62.75 |
| Netherlands | 13 | 62.24 |

*Source:* [186].

The Environmental Performance Index is an integral indicator for quantitative assessment and comparative analysis of indicators of the success of the implementation of the environmental policy of the countries of the world. Based on the EPI, countries are ranked according to their performance in several categories, which are grouped into two groups: ecosystem viability and ecological health. The index of ecological efficiency as a composite indicator includes 40 indicators of sustainable development, which are combined into 11 categories: mitigation of the consequences of climate change; air quality; drinking water and sanitary standards; heavy metals; waste management; biodiversity and habitat; ecosystem services; fishing; acid rains; agriculture; and aquatic resources. In addition, in 2022, climate change was included in the EPI for the first time as an equal political goal alongside the environmental goal.

In 2022, Denmark, the United Kingdom and Finland were among the leading countries with effective environmental policies (Table 8). Poland took 46th place among 180 countries of the world, and Ukraine took 52nd place.

**Table 8.** Top 10 countries of the world in the EPI 2022

| Country | Rank | Score |
|---|---|---|
| Denmark | 1 | 77.90 |
| United Kingdom | 2 | 77.70 |
| Finland | 3 | 76.50 |
| Malta | 4 | 75.20 |
| Sweden | 5 | 72.70 |
| Luxembourg | 6 | 72.30 |
| Slovenia | 7 | 67.30 |
| Austria | 8 | 66.50 |
| Switzerland | 9 | 65.90 |
| Iceland | 10 | 62.80 |

*Source:* [187].

To comprehensively assess the achievement of sustainable development goals, the SDG Index is used, which includes 94 global indicators and 26 additional indicators specifically for OECD countries.

In 2022, Finland, Denmark and Sweden were leaders in sustainable development (Table 9). The United Kingdom took 11th place among 163 countries of the world, Poland – 12th, and Ukraine – 37th.

According to estimates by the Climate Bonds Initiative [16], the volume of the green bond market was 1 trillion dollars in 2020 (64.7% of the global volume of the sustainable financing market). Green bonds are used by more than 70 countries of the world. The number of issuers is 1,428, and the number of instruments is 7,716.

**Table 9.** Top 10 countries of the world in the SDG Index

| Country | Rank | Score |
|---|---|---|
| Finland | 1 | 86.5 |
| Denmark | 2 | 85.6 |
| Sweden | 3 | 85.2 |
| Norway | 4 | 82.3 |
| Austria | 5 | 82.3 |
| Germany | 6 | 82.2 |
| France | 7 | 81.2 |
| Switzerland | 8 | 80.8 |
| Ireland | 9 | 80.7 |
| Estonia | 10 | 80.6 |

*Source:* [188].

Europe ranks first in the ranking of green bond issuance with 432.5 billion dollars. This is due to the mature green bond market, which includes many large issuers in both the private and public sectors. However, the regional profile differs significantly by bond type. Thus, in August 2020, the Luxembourg Ministry of Finance put into effect a system of sustainable development bonds that complied with the principles of the International Capital Market Association (ICMA) and the recommendations of the European Taxonomy Regulation. In April 2020, the European Parliament adopted the Resolution "On creating a framework for promoting sustainable investments and amending Regulation (EU) 2019/2088".

Issues of government green bonds have become widespread. For example, in October 2021, the European Union issued green bonds as part of the Next Generation EU Compensation Plan. Proceeds from the issue were used to finance green and sustainable costs within the Recovery and Resilience Facility.

An effective tool for reducing risks for investors in green finance is guarantees from third parties, including governments. Different countries provide financial benefits in the field of green financing, including preferential lending conditions and mechanisms for reducing the burden on regulatory capital. For example, from January 1, 2020, to December 31, 2023, according to the Green Preferential Capital Requirement Program of the Central Bank of Hungary, credit institutions can use deductions from capital requirements for loans that serve energy-efficient residential needs, and borrowers can receive interest rate subsidies.

North America ranks second in green bond issuance, with 237.6 billion dollars. In the Asia-Pacific region, 219.3 billion dollars were issued, i.e., it ranks third. In Latin America and the Caribbean, 20.0 billion dollars were issued, and 3.5 billion dollars of green bond issuance was issued in Africa (Figure 1).

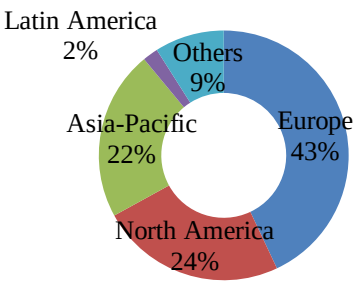


**Fig. 1.** Regional Breakdown of the green bonds

*Source:* [16].

The USA is the largest player in the "green" bond market, having issued this type of securities in the amount of 211.7 billion dollars. China is in second place (127.3 billion dollars), France is in third place (115.6 billion dollars), and Germany is in fourth place (78.3 billion dollars). Sweden (40.2 billion), Spain (34.0 billion), Canada (25.9 billion), Japan (24.2 billion), and Italy (17.8 billion dollars) occupy sixth to tenth place (*Figure 2*).

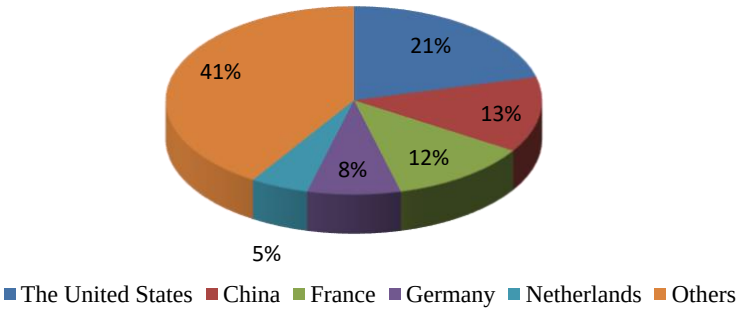


**Fig. 2.** Breakdown of green bonds by countries
*Source:* [16].

As the analysis shows, a significant part of green investments is aimed at the development of the energy sector (354.7 billion dollars), low-carbon construction (263.5 billion dollars), and the modernization of transport infrastructure (190.7 billion dollars). Together, these three segments make up approximately 80% of the green bond market (*Figure 3*). The development of water infrastructure ranks 4th with 98.7 billion dollars. In 5th place is the field of waste management, with 36.9 billion dollars. Industry, the field of information and communication technologies and land use together amount to 40.8 billion dollars.

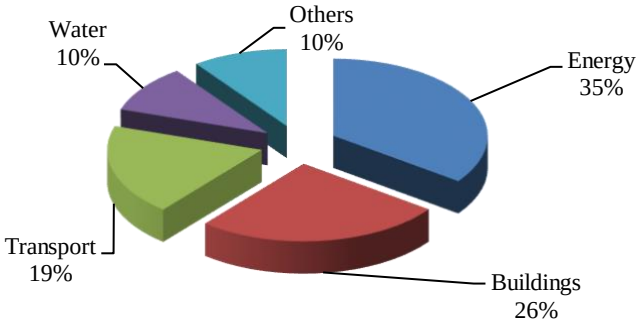


**Fig. 3.** Use of proceeds from green bonds by types of economic activity
*Source:* [16].

The largest source of green bond issuance is financial corporations (205.6 billion dollars). This is followed by nonfinancial companies (205 billion dollars), followed by development banks (158.8 billion dollars). The issue accounts of organizations supported by the state amounted to 153.1 billion dollars, and those of local authorities amounted to 63.9 billion dollars. Asset-backed securities (ABS) amount to 116.2 billion dollars (*Figure 4*).

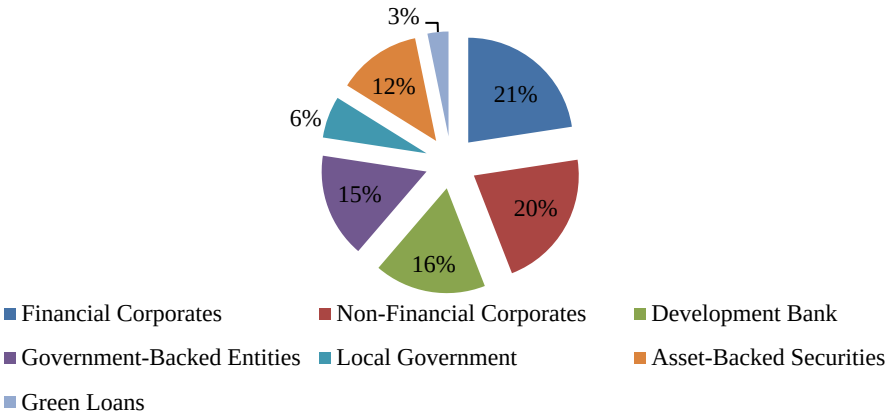


**Fig. 4.** Green Bond Issues

*Source:* [16].

## 4 Results

As a result of the conducted research, it was established that in recent years, most countries of the world have taken a course towards sustainable development, successfully implementing the concept of a green economy. At the same time, some countries experience significant difficulties in the transition to a "green" economy and the development of the green investment market. For example, Slovenia's "greening" budget reforms have been unsuccessful, even though the country has many "green" taxes that go directly to the state budget. The green state policy was adopted in 2011, but its practical implementation has slowed down and today requires political will, additional decisions and the implementation of a set of measures.

In this regard, for a more effective implementation of models and mechanisms for the development of the green investment market in the medium term, it is advisable to:

1) form national strategies for sustainable financing of priority areas of economic activity to achieve green goals and objectives;

2) justify and create a system of indicators of the green transformation of logistics systems for monitoring and evaluation and identify shortcomings and corrective measures;

3) adapt the implementation mechanisms, which are based on the goals and objectives defined in the "green growth" strategies ("green" taxes, pollution duties, subsidizing "green" transport and eco-technologies, cancelling fossil fuel subsidies, "green" purchases, "green" bonds, etc.);

4) support the implementation of eco-innovations and "green" technologies, as well as the creation of ecosystem start-ups;

5) determine the mechanisms of financial support for logistics system development based on the principles of the green economy;

6) develop concepts of green financing for the sustainable development of logistics systems;

7) develop and adopt Roadmaps for attracting green investments as a tool for stimulating sustainable financing of the logistics systems development.

At the same time, international obligations and opportunities can push the economic growth of countries worldwide. For example, participation in the Paris Climate Agreement requires a low-carbon strategy and provides access to international climate finance through sustainable development mechanisms and climate adaptation funds. Coordination and

implementation mechanisms should be in line with national conditions, legal systems, and institutional frameworks but should also reflect national best practices to ensure consistency with modern approaches to sustainable financing of logistics system development.

For the sustainable functioning of the logistics system based on the principles of the green economy, it is advisable to apply a coordinated comprehensive approach. Its essence consists of the integration of the main components of the organizational and economic mechanism (principles, functions, management methods, information systems and green technologies) (*Figure 5*) and green investment tools for the implementation of priority areas of green transformation of logistics systems of various levels.

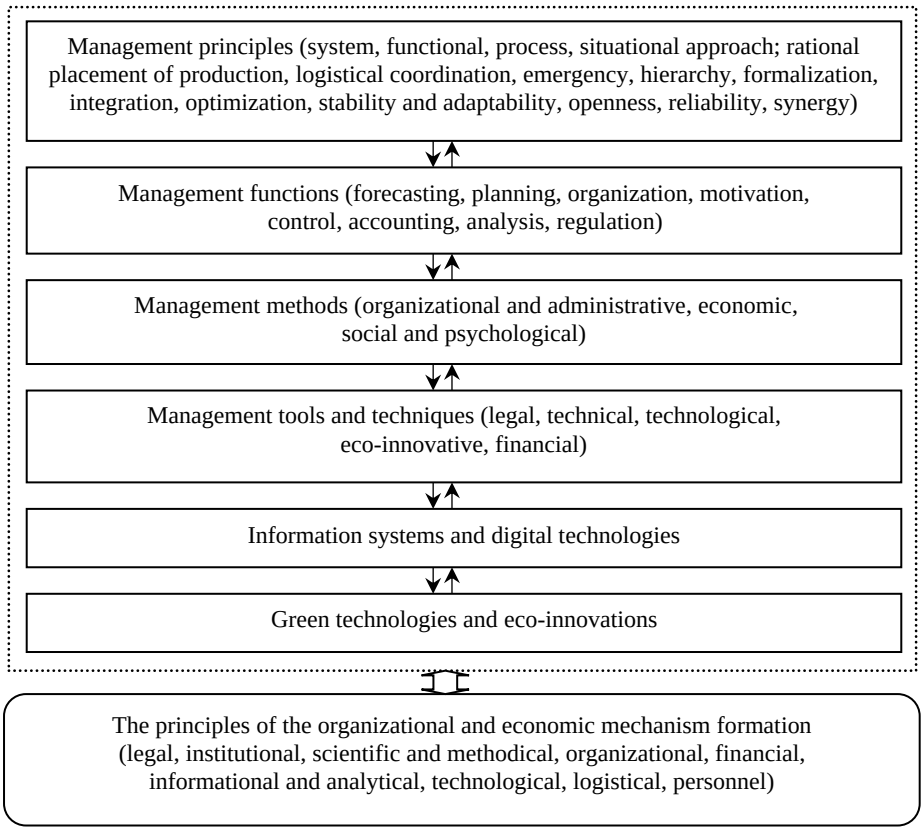


**Fig. 5.** The structure of the green financing mechanism in the context of sustainable development of logistics systems

*Source:* Author's development.

The implementation of the proposed integrated approach (*Figure 6*) will contribute to the adoption of sound innovative and green decisions on the environmental management of logistics activities, the reduction of the level of greenhouse gas emissions, the minimization of risks (climatic, environmental, logistical, “greenwashing”, financial), and the increase of the level of environmental safety.

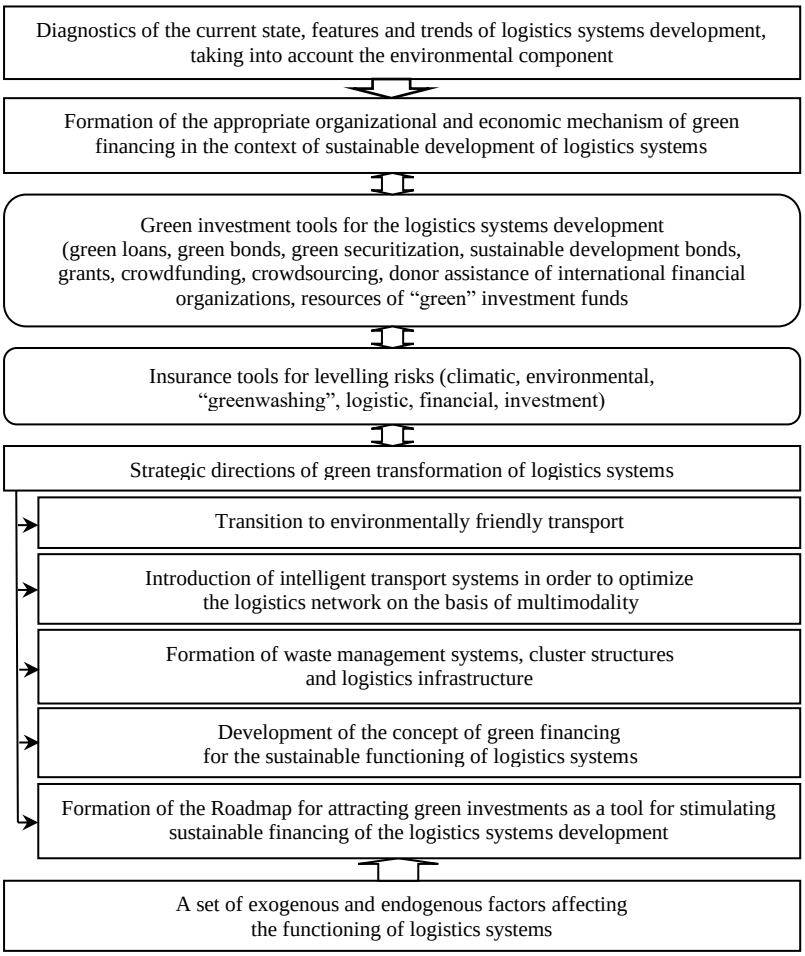


**Fig. 6.** Structural and logical scheme of the green transformation of the logistics system on the basis of sustainable financing

*Source:* Author's development.

## 5 Conclusions

Green investments are an effective tool for ensuring the functioning of logistics systems in various countries of the world, which is determined by the goals of sustainable development. This financial mechanism is recognized as effective in the system of managing financial relationships in the world, as it contributes to the stimulation of sustainable financing of the logistics systems development at various levels (global, international, national, regional, local). Based on the generalization of existing conceptual provisions and the results of our own research [80-90], the author's approach to defining the essence and content of the terms is proposed:

- "Sustainable financing" as a financial support mechanism that integrates environmental, social and governance criteria into financial services to achieve sustainable development of logistics systems, including mitigation and adaptation to the adverse effects of climate change and crisis phenomena;

- "Green investments" as entrepreneurial capital (material, intellectual, raw resources, digital technologies, information systems), which is directed to the modernization of

infrastructure facilities, the ultimate goal of which is to reduce the volume of greenhouse gas emissions and the level of environmental pollution;

- "Green investments" as a tool for stimulating sustainable financing of the logistics systems development;

- "Green bonds" as a financial instrument, the funds from the issue of which are used to finance projects aimed at the green transformation of logistics systems and the formation of low-carbon and climate change-resistant infrastructure.

To rate the effectiveness of the development of logistics systems in the countries of the world, the Logistics Performance Index was used. However, as the analysis shows, this integral indicator allows monitoring the effectiveness of customs operations, the organization of international delivery, the infrastructure quality and logistics service, and the ability to track cargo and their timeless delivery. However, the Logistics Performance Index does not contain indicators that would reflect the state and trends of the greening of logistics activities and financial support for the logistics systems development using green investments. Therefore, in the future, it would be advisable to pay special attention to the development of a methodical approach to evaluating the logistics systems development, taking into account the environmental and financial components. It has been established that the most important principles of "green" investment in logistics systems development include the following:

- the principle of strategic policy orientation, according to which the actions of all subjects (the state, private financial institutions, financial regulators and supervisory bodies, various business associations and unions, international financial organizations) should be aimed at achieving the long-term goals of the logistics systems development;

- the interaction of the state and business in solving the key goals of sustainable financing of the development of logistics systems;

- the principle of social responsibility of business, without the implementation of which effective and socially beneficial interaction between business and the state is impossible;

- the principle of international cooperation in the implementation of the green investment policy and in close coordination and consistency with the development of relevant financial support mechanisms in the world and Europe;

- the principle of taking into account the national specifics of the logistics system development, which is determined by the historical path of the country, the achieved level of socioeconomic development, and the profile of its competitive advantages compared to other countries of the world (there is no single model of investment policy that could be used by all countries of the world; each country has a specific policy);

- the principle of a systemic approach to the implementation of the "green" investment policy means that thanks to a wide range of interrelated measures and policy instruments, a positive result can be achieved.

Based on this, the policy of "green" investment of the logistics systems development should simultaneously be formed on the following principles:

- establishment of strategic goals and coordination of policies;

- formation of an attractive investment policy that would stimulate investment in green and infrastructure projects;

- support for long-term investments, introduction of innovative financial mechanisms for risk distribution, such as "green" bonds or direct support for investments in "green" projects;

- use of resources and capacity building for the "green" transformation of logistics systems;

- promoting the development of "green" business and the further formation of environmentally responsible behaviour of consumers.

Prospects for further research consist of substantiating the conceptual provisions of green investment for the sustainable development of logistics systems, forming a roadmap for

attracting green investments as a tool for stimulating sustainable financing of the development of logistics systems and determining the mechanisms for its implementation.

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