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THE IMPACT OF THE "GREEN LOGISTICS" CONCEPT ON ENTERPRISE COSTS AND ENVIRONMENTAL SUSTAINABILITY

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Abstract. This article analyzes the essence of the "green logistics" concept and its economic and environmental significance for enterprise activity. Drawing on international statistical data and academic sources, the study examines the impact of green logistics on the efficient use of resources, the reduction of waste and the optimization of enterprise costs across transport, storage and distribution processes. Four strategic directions of green logistics — transport optimization, energy efficiency, resource circulation and investment attractiveness — are substantiated with quantitative indicators. The article also considers the priority directions for "greening" the logistics system under Uzbekistan's conditions. The findings show that environmental and economic efficiency can be achieved simultaneously.

Keywords: green logistics, environmental sustainability, transport costs, carbon footprint, waste reduction, energy efficiency, reverse logistics, circular economy, sustainable development.

Introduction.

As the world economy develops rapidly today, the processes of industrialization and globalization are in turn deepening the global environmental crisis. Climate change, the sharp rise in carbon dioxide emitted into the atmosphere and the limited nature of natural resources place before the modern economy the task of radically reforming production and service systems. The logistics sector in particular, which forms the basis of the global supply chain, is identified as one of the sectors that exert the greatest pressure on the environment.

Traditional logistics systems are oriented mainly toward economic profit and speed and often fail to take environmental costs into account. Harmful emissions from vehicles, high energy consumption in logistics centers, non-recyclable packaging materials and inefficient routes cause serious damage to nature. According to the Intergovernmental Panel on Climate Change (IPCC), the transport sector accounts for roughly 14–15 percent of global greenhouse gas emissions and 23–24 percent of energy-related CO_2 emissions[1].

According to estimates by the International Energy Agency (IEA), in 2022 the transport sector emitted around 8 gigatonnes of CO_2 into the atmosphere, and these emissions grew by an average of 1.7 percent per year over the period 1990–2022[2]. Approximately three-quarters of these emissions are

[1] IPCC. Climate Change 2022: Mitigation of Climate Change. WG III, Chapter 10: Transport. Cambridge University Press, 2022. (Transport ≈ 14–15% of global GHG and 23–24% of energy-related CO_2.)

[2] IEA. Transport – Energy System. Paris, 2023. URL: https://www.iea.org/energy-system/transport (≈ 8 Gt CO_2 in 2022; average growth 1.7%/yr, 1990–2022.)

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attributable to road transport[3]. These figures, summarized in Figure 1, confirm that the ecological reorganization of the logistics sector is relevant not only for protecting nature but also from the standpoint of global economic stability.

Figure 1. Transport sector contribution to emissions

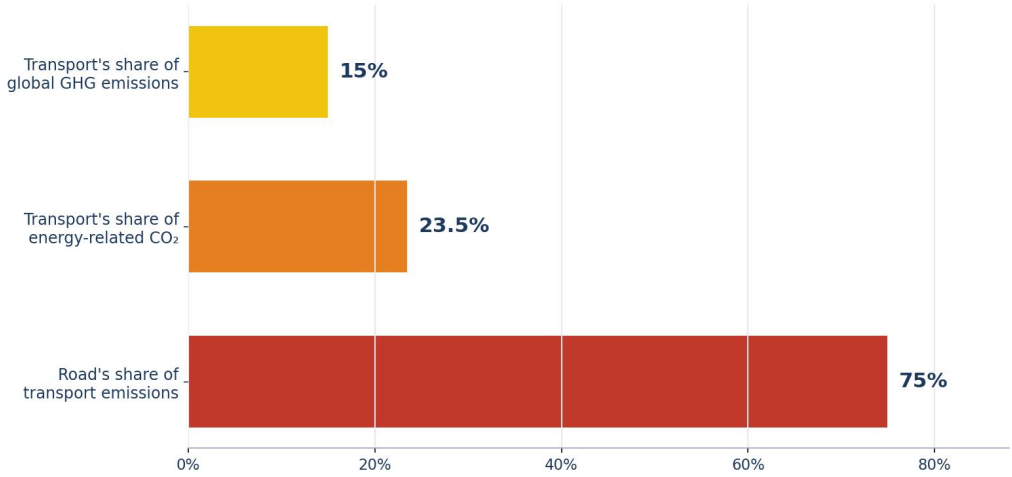


Figure 1. Transport sector contribution to emissions

As a solution to these problems, in recent years the "Green Logistics" concept has internationally become an integral part of the economy. Green logistics is an environmentally sustainable approach aimed at minimizing the negative impact on the environment across all stages of delivering goods — from sourcing raw materials to handing over the finished product to the consumer and disposing of waste[4]. Green logistics does not mean merely "environmentally clean transport"; it encompasses a complex of measures: using intelligent routing systems to reduce fuel consumption and switching to electric or hydrogen-powered transport; installing solar panels in warehouse complexes and introducing natural lighting and energy-saving technologies; using recyclable or biodegradable materials instead of plastic; and establishing systems for recycling products and effectively managing returned goods.

Importantly, green logistics is beneficial not only for protecting nature but also economically for business. Conserving resources, reducing fuel consumption and applying waste-free technologies significantly lower an enterprise's operating costs. At the same time, achieving "green" brand status increases an enterprise's competitiveness and investment attractiveness in the international market. Under Uzbekistan's conditions, too, "greening" the logistics system should become an important link in economic reform, for it is a strategic path not only to increasing export potential but also to preserving a clean environment for future generations.

Review of the relevant literature.

The issues of green logistics and sustainable development are today considered one of the most pressing strategic directions of the global economy and are being studied systematically by many international organizations and scholars. In particular, the concepts developed within the UN Sustainable Development Goals (SDGs) and by the World Bank identify the development of

[3]Ritchie H., Roser M. Cars, planes, trains: where do CO_2 emissions from transport come from? Our World in Data (based on IEA data), 2020. (Road transport ≈ three-quarters of transport emissions.)

[4]McKinnon A., Cullinane S., Browne M., Whiteing A. Green Logistics: Improving the Environmental Sustainability of Logistics. London: Kogan Page, 2010 (3rd ed., 2015).

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environmentally safe transport systems and the reduction of the "carbon footprint" in logistics processes as a fundamental condition of economic growth.

Whereas R.H. Ballou, a classical theorist of logistics management, analyzed the supply chain from the standpoint of cost minimization[5], J. Sarkis developed the "green supply chain" concept and proposed a model for integrating environmental criteria into strategic decision-making[6]. In their "Green Logistics" monograph, A. McKinnon and colleagues substantiate with empirical data that green logistics significantly reduces operating costs over the long term and enhances a brand's standing in the international market[7]. J.-P. Rodrigue, a leading specialist in transport geography, in analyzing the environmental impact of transport systems, emphasizes the strategic importance of "modal shift" — transferring freight from environmentally harmful road transport to rail and water transport[8].

In modern literature, the concept of "Logistics 4.0" is analyzed in close connection with green strategies. Researchers note that Big Data, the Internet of Things (IoT) and artificial-intelligence technologies ensure transparency in the freight chain and thereby help eliminate empty runs and minimize fuel consumption. At the same time, the reuse of product packaging and the conservation of resources on the basis of circular-economy principles are being accepted as a new standard of logistics management. Many scholars are also advancing the concept of the "green warehouse," which envisions a sharp reduction of energy consumption through the use of solar panels, natural lighting and automated sorting systems in warehouse complexes.

International experience shows that, within the framework of the European Union's "European Green Deal" initiative, alongside placing environmental responsibility on logistics companies, a system of tax incentives and "green subsidies" has been established for them[9]. According to the "environmental hypothesis" advanced by M. Porter and C. van der Linde, strict environmental norms encourage enterprises to innovate, which in turn lowers the cost of products through the efficient use of resources and strengthens competitive advantage[10]. Today green logistics is manifested not merely as social responsibility but as an important condition of economic survival under conditions of scarce natural resources and climate change, ensuring stability in the global supply chain.

Research methodology.

This study made extensive use of a systems approach, comparative analysis and logical generalization. In assessing the economic efficiency of green logistics, the methods of analysis and synthesis were applied, and the impact of environmental innovations on enterprise costs was scientifically substantiated. In studying international experience, the comparative-analysis method was

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[5]Ballou R.H. Business Logistics / Supply Chain Management. 5th ed. Upper Saddle River: Pearson/Prentice Hall, 2004.

[6]Sarkis J. A strategic decision framework for green supply chain management // Journal of Cleaner Production. 2003. Vol. 11, No. 4. P. 397–409.

[7]McKinnon A. et al. Green Logistics. London: Kogan Page, 2010 – empirical evidence on long-term operating-cost reduction and brand value.

[8]Rodrigue J.-P. The Geography of Transport Systems. 5th ed. London; New York: Routledge, 2020.

[9]European Commission. The European Green Deal. COM(2019) 640 final. Brussels, 2019.

[10]Porter M.E., van der Linde C. Toward a New Conception of the Environment–Competitiveness Relationship // Journal of Economic Perspectives. 1995. Vol. 9, No. 4. P. 97–118.

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used to examine the sustainable-development models of developed countries as well as the statistical data of such authoritative organizations as the IPCC, the IEA and the World Bank. As the methodological basis of the study, approaches of mutually reconciling quantitative and qualitative indicators and of statistically analyzing empirical data were selected.

Analysis and results.

Analysis of the impact of the green logistics concept on enterprise activity shows that this approach is not merely environmental responsibility but a key driver of efficiency at both the micro- and macroeconomic levels. As a result of the analysis conducted, the impact of green logistics on the strategic development of an enterprise was systematized along the following four main directions.

First, optimizing costs in the transport-communication system. In traditional logistics, transport costs account for roughly 40–50 percent of total logistics costs. The analysis shows that introducing AI-based routing systems (Routing Optimization) can reduce the distance travelled by up to 15 percent and fuel consumption by 12–18 percent. In addition, using aerodynamic trucks and smart tire-pressure control systems reduces carbon dioxide emissions while also lowering maintenance costs. Applying the "modal shift" strategy in freight transport — transferring cargo from air and road transport to rail — was found to increase energy efficiency by an average of four-fold[11].

Second, growth of energy efficiency in infrastructure and warehouse operations. Analysis of modern "green warehouses" (Green Warehousing) shows that energy-saving lighting systems (LED) and natural ventilation methods save up to 30 percent of electricity consumption. Solar panels installed on warehouse roofs can cover 40–60 percent of an enterprise's internal needs and create an additional source of income by selling surplus energy to the general grid. At the same time, automated sorting systems (AS/RS) reduce errors caused by the human factor and raise the warehouse-space utilization coefficient by 25 percent.

Third, resource circulation and waste management. One of the most important results of green logistics is the effective organization of the "reverse logistics" (Reverse Logistics) flow. The analysis shows that replacing plastic and paper packaging materials with biodegradable or reusable materials reduces material costs by 20 percent in the medium term. The waste-recycling chain enables an enterprise to implement a "Zero Waste" strategy; this not only protects the environment but also creates new economic value in the secondary raw-materials market[12].

Fourth, long-term economic profitability and investment attractiveness. Although introducing green technologies requires large capital investments (CAPEX) at the initial stage, the payback period of investments (ROI) averages three to five years thanks to the reduction in operating costs (OPEX). The results show that enterprises with environmental certificates — for example, the ISO 14001 standard — enjoy advantages in obtaining "green bonds" and low-rate loans in international financial markets[13]. Moreover, as consumers' environmental awareness rises, demand for brands committed to green logistics principles and customer loyalty are growing roughly 1.5 times faster than for traditional enterprises.

The quantitative indicators presented above are systematized as a whole in the following table (Table 1).

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[11] Estimate based on Rodrigue J.-P. (2020) and IEA data: rail freight is, on average, about four times more energy-efficient per tonne-kilometre than road freight.

[12] McKinnon A. et al. (2010); circular-economy literature on reverse logistics and secondary raw-material markets.

[13] ISO 14001:2015. Environmental management systems – Requirements with guidance for use. Geneva: ISO, 2015.

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Table 1.
Economic and ecological efficiency of green logistics measures

Direction	Green logistics measure	Economic and ecological effect
Transport and routing	AI-based route optimization (Routing Optimization)	Distance −15%; fuel consumption −12–18%
Modal shift	Shifting freight from road to rail / water transport	Energy efficiency rises ~4-fold
Warehouse operations	LED lighting, natural ventilation, AS/RS automation	Electricity −30%; space utilization +25%
Solar energy	Installing solar panels on warehouse roofs	Covers 40–60% of internal energy needs
Packaging and resources	Biodegradable and recyclable materials; reverse logistics	Material costs −20% (medium term)
Investment	ISO 14001 certification, "green bonds"	ROI of 3–5 years on average; access to low-cost credit

Source: compiled on the basis of IPCC (2022), IEA (2022–2023), McKinnon et al. (2010) and the author's analysis.

The quantified effects of these measures are visualized in Figure 2 below.

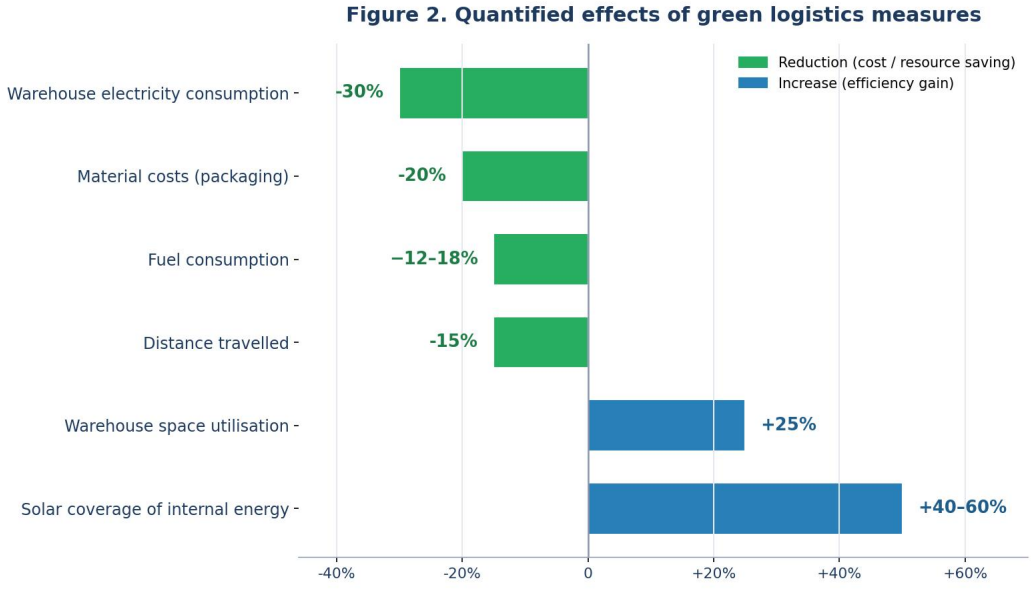


Figure 2. Quantified effects of green logistics measures (based on Table 1)

Strategic prospects for introducing green logistics in Uzbekistan's economy.

Today, amid the modernization of Uzbekistan's economy and the drive to increase export potential, "greening" the logistics system is becoming not merely an environmental trend but a strategic necessity. Our country's geographical position — the need to cross at least two state borders to reach the world ocean (double-landlocked) — raises the share of transport costs in product cost. According to the World Bank's Logistics Performance Index (LPI), in 2023 Uzbekistan ranked 88th

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among 139 countries; although this indicator has been improving in recent years, it underscores the continued need to optimize logistics costs[14].

In 2019 Uzbekistan adopted the "Strategy for the Transition of the Republic of Uzbekistan to a Green Economy for 2019–2030"[15], and on 2 December 2022 Resolution No. PQ-436, aimed at accelerating this process, was signed[16]. Within the framework of COP26 (2021), our country undertook a commitment to reduce greenhouse gas emissions per unit of GDP by 35 percent by 2030[17]. According to the latest data, the goal has been set to raise the share of renewable energy sources in electricity generation to 40 percent by 2030[18]. These strategic documents create a solid legal and institutional basis for "greening" logistics. The consolidated strategic targets are summarized in Table 2.

Table 2.
Uzbekistan's strategic green economy targets

Strategic indicator / target	Value	Source / framework
Reduction of GHG emissions per unit of GDP by 2030	−35%	COP26 commitment (2021)
Share of renewable energy in electricity by 2030	40%	OECD (2025); national targets
Logistics Performance Index (LPI) rank, 2023	88 / 139	World Bank (2023)
Energy-efficiency gain from modal shift	~4-fold	IEA; Rodrigue (2020)
Strategy for transition to a green economy	2019–2030	Presidential Decree (2019); Resolution PQ-436 (2022)

Source: compiled by the author on the basis of national strategic documents, World Bank (2023), IEA (2022) and OECD (2025).

[14]World Bank. Connecting to Compete 2023: Trade Logistics in the Global Economy. Logistics Performance Index. Washington D.C., 2023. (Uzbekistan ranked 88th of 139; overall LPI ≈ 2.6.)

[15]Decree of the President of the Republic of Uzbekistan "On the Strategy for the Transition of the Republic of Uzbekistan to a Green Economy for 2019–2030." Tashkent, 2019.

[16]Resolution of the President of the Republic of Uzbekistan No. PQ-436 "On measures to accelerate the transition to a green economy by 2030." Tashkent, 2 December 2022.

[17]IEA. Solar Energy Policy in Uzbekistan: A Roadmap. Paris, 2022. (COP26, 2021: commitment to reduce emissions per unit of GDP by 35% by 2030.)

[18]OECD. Roadmap for Sustainable Investment Policy Reforms in Uzbekistan. Paris, 2025. (Renewable-energy share planned to rise to 40% by 2030.)

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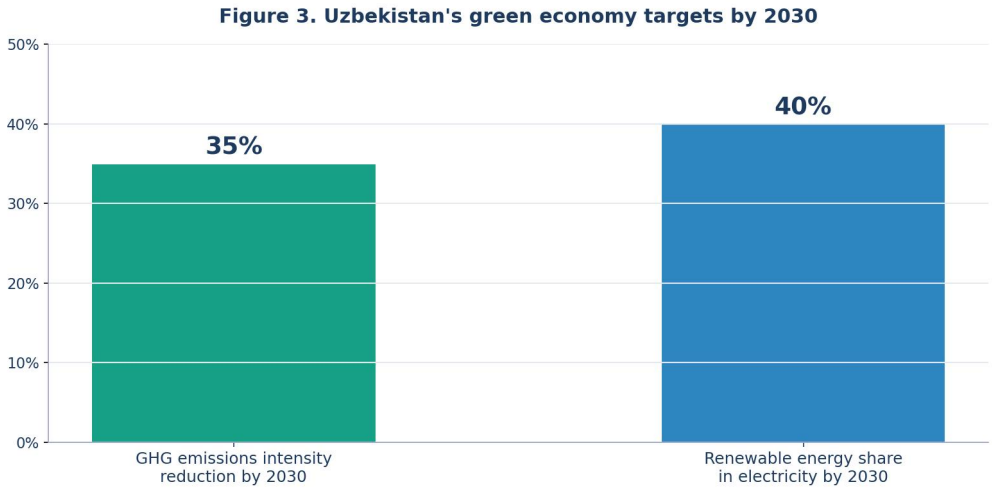


Figure 3. Uzbekistan's green economy targets by 2030

Accordingly, it is advisable to implement green logistics principles in the national economy through the following priority directions.

A "modal shift" strategy in the transport system. To make effective use of Uzbekistan's transit potential, freight should be gradually transferred from environmentally harmful road transport to rail and intermodal carriage. This not only reduces harmful gases emitted into the atmosphere but also optimizes carriage cost by increasing energy efficiency by an average of four-fold.

"Green packaging" and resource economy in agro-industry. In the supply chain for export-oriented fruit-and-vegetable and textile products, it is necessary to abandon plastic materials and switch to a biodegradable or recyclable packaging system. Together with "reverse logistics" mechanisms, this approach makes it possible to cut material costs by 20 percent in the medium term.

Alternative energy sources in infrastructure. Given Uzbekistan's high solar insolation, installing solar panels on the roofs of major logistics hubs and "Class A" warehouse complexes is highly profitable economically. According to IEA estimates, the bulk of the country's renewable-energy potential lies precisely in solar energy[19]. The experience of modern "green warehouses" shows that this makes it possible to cover 40–60 percent of an enterprise's electricity needs and significantly reduce operating costs.

International competitiveness and the "green brand." In the global market — in particular, within the requirements of the EU's "European Green Deal" — opportunities to obtain customs and tax incentives and "green subsidies" expand for local exporters holding environmental certificates (ISO 14001). This in turn raises the international investment attractiveness of Uzbek brands and consumer loyalty by roughly 1.5 times. In sum, introducing green logistics principles under Uzbekistan's conditions not only ensures environmental sustainability but also serves as a foundation for national enterprises to take a worthy place in the global supply chain.

Conclusions and recommendations.

As a result of the analysis conducted and the scholarly generalizations made, it may be concluded that, under modern economic conditions, the green logistics concept is not merely an environmental obligation for enterprises but the most important strategic direction ensuring long-term sustainability. The study showed that the ecologization of logistics processes is a mechanism that, alongside reducing

[19]IEA. Solar Energy Policy in Uzbekistan: A Roadmap. Paris, 2022.

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the negative impact on the environment, brings direct economic benefit by optimizing an enterprise's operating costs and increasing resource efficiency.

By introducing a green logistics system, enterprises not only reduce fuel and energy consumption but also gain the ability to turn production waste into value with the help of "reverse logistics" and circular-economy principles. This process, in turn, increases an enterprise's competitiveness in international markets, strengthens its brand image and attracts the attention of environmentally responsible investors and consumers. Under conditions of global climate change and resource scarcity, failure to use green technologies may in the future lead to enterprises losing their market position and to economic losses due to high environmental taxes.

On the basis of the above, the following recommendations are advanced: first, introducing digital technologies and intelligent management systems into transport and warehouse operations at enterprises; second, redistributing freight flows to rail and intermodal routes through the "modal shift" strategy; third, switching to biodegradable materials in packaging and establishing a reverse-logistics system; and fourth, creating a preferential tax and credit environment at the state level for entities investing in environmental innovations. As a final outcome, the development of green logistics will not only increase the profitability of individual enterprises but also serve to ensure sustainable economic growth nationwide, preserve natural resources for future generations and build a healthy ecological environment.

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