INNOVATIONS IN THE SPHERE OF GREEN LOGISTICS[1]

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ABSTRACT

In the last decade, many researchers focused on improvement of environmental friendliness and on the principles of sustainable development, green logistics became a new field of transport research. The article presents an overview of the research in this area using as an example foreign and Russian projects. It is shown that the existing approaches, methods and instruments of «green» logistics are scattered, their use leads to making contradictory decisions that do not contribute to a systematic reduction of the harmful impact of transport on the environment. The authors proposed their approach to systematization of principles and methods of «green» logistics, which will allow creating more balanced programs to improve the environmental friendliness and efficiency of transport systems. The second part of the article (the first part was published in previous issue of World of Transport and Transportation) is dedicated to the features of object environment.

Keywords: transport, sustainable development, green logistics, logistics, ecology, environment.

Background. *Consideration of «green» logistics as an element of the concept of sustainable development presupposes the observance of 27 principles of sustainable development [1], adopted at the UN conference in Rio de Janeiro in 1992. Initially the green logistics existed in direct accordance with the provisions of paragraphs 20–22 of Agenda 21 of the UN conference and the actions of its supporters concerned mainly the solution of environmental problems, disposal of various wastes, including their transportation. The implementation of «green» principles in other functional areas of logistics was complicated by the fact that there is a contradiction between the logistic principles aimed at maximizing profits and ensuring economic growth and activities related to reducing the harmful impact on the environment.*

An analysis of works of domestic and foreign scientists showed that in the modern scientific literature there are no clearly formulated principles of «green» logistics [3]. Very different authors use very similar concepts «principle», «method», «way», «rule», «practice», «decision», «tools» in relation to the field of activity of interest to us. Therefore, the actual task is to determine the general and specific sense, invested in these concepts. Study of features attributed to be belonging to green logistics, and the entire polyphonic picture of the research field are also within the field of the paper.

Features of the Object Environment

Researchers from Australia [4] note the uneven distribution of publications on the management of «green» supply chains among scientific organizations from different countries. They analyzed 1586 works submitted to international scientometric systems, and the following results were obtained: publications from Europe make 39,41 %, the United States – 28,99 %, Asia – 22,57 %, Canada and Oceania – 4,36 %, South America – 1,21 %. At the same time, Russia, Kazakhstan and most countries of the African continent are not represented in the Scopus and Web of Science systems by scientific publications on this issue.

Scientists distinguish seven main advantages [5] of «green» logistics and «green» supply chains:

• Positive impact on financial performance. As a rule, their effectiveness in the long term is considered.

• Resource sustainability, that is, effective use of the organization's production resources.

• Reduction of costs and increase of efficiency. Skilful management of resources (including reduction of waste, their utilization and reuse) helps to reduce operating costs, reduce fines, and to use of tax incentives and other economic instruments.

• Product differentiation and competitive advantage. The positioning of services and products as environmentally friendly allows to attract profitable customers (partners), strengthens the image of the company and its reputation in the market.

• Regulation and risk reduction. The introduction of «green» technologies reduces the risk of being held accountable for violations in the field of environmental protection and the use of unethical business practices.

• Quality of services and products. Organizations that produce technologically advanced and environmentally friendly products increase brand image and reputation among customers.

• Involvement of the society, partners in the supply chain, employees, suppliers and customers in the development and implementation of long-term «green» solutions. This helps to strengthen relations with clients, forms and develops corporate citizenship and social corporate responsibility.

In [6], the authors identified six main subject areas for the study of management of «green» supply chains:

• policy – issues of business ethics and corporate social responsibility, environmental audits, environmental protection, compliance with environmental legislation;

• synthesis – literature reviews, studies and training manuals on the management of «green» supply chains at all stages of the delivery of goods;

• purchasing – environmental problems related to the relationship between suppliers and customers, certification and compliance with environmental quality standards;

• manufacturing – problems of ecology in development and processing of products in order to reduce harmful emissions and waste;

• green logistics – environmental issues aimed at reducing CO_2 emissions and associated with sustainable transportation, handling and storage of hazardous materials, stock management, warehousing, packaging and location of facilities;

• reverse logistics – increase of logistics efficiency in processing of return flows and management of waste disposal at the end of the product life cycle.

From the point of view of the research methodology, five main areas are mentioned:

• conceptual – concerning the strategic importance of initiatives to manage green supply chains, new concepts and concepts based on a qualitative analysis of the environment;

• case study – focused on the problem-situational analysis of one or more real situations;

[1] Final part. See the frist part in: World of Transport and Transportation, 2018, Vol. 16, Iss. 2.

Table 1

Directions for development of «green» logistics and ways*

No.	Direction	Brief characteristics	Main ways of problem solution
1	Reducing freight transport externalities	Study of the impact of road freight transport on the environment and the study of ways to reduce this impact	– ways to rationally transport goods by road; – improving the use of load capacity and capacity of cars.
2	City logistics	Study of urban freight transportation, congestion of vehicles and the street-road network taking into account economic and environmental costs	– ways to consolidate cargo in order to reduce traffic, energy consumption, emissions and costs; – creation of transshipment or consolidation centers around urban areas in order to unbundle and aggregate cargo flows; – development of intermodal technologies.
3	Reverse logistics	Study of flows reverse to the main flow of material flow, as well as waste management, their restoration and reuse	– rationalization of movement of household waste in urban areas; – ways of recycling waste and packaging in the system of cargo flows; – managing and optimizing the return flow of waste and products throughout the supply chain.
4	Logistics in corporate environmental strategies	Study of the environmental policy of logistics and transport companies and its impact on reducing the impact on the environment at all stages of the value chain	– development of international standards and environmental programs; – optimization of logistics operations taking into account environmental requirements in economic conditions; – centralization of the distribution system, consolidation of freight flows.
5	Green supply chain management	Study of material flows in the supply chain taking into account the impact on the environment from sources of raw materials to the after-sales service phase	– evaluation of suppliers for environmental requirements (criteria); – ecological audit of the supply chain; – use of mathematical and statistical methods in the analysis of «green» supply chains; – development of methods for analyzing the life cycle of goods in supply chains, taking into account their impact on the environment; – use of software («carbon calculators») for the analysis of emission levels.

* compiled by the authors on the basis of [13].

• *exploratory – analysis of data on the basis of questionnaire and other types of surveys to determine the most common methods for studying environmental protection and gaining expert opinion on environmental decisions;*

• *empirical – based on methods of social experiment and social modeling, aimed at obtaining and processing empirical data, their systematization, as well as testing hypotheses and theories;*

• *analytic – use of practical tools for mathematical and simulation modeling.*

Objective. *The objective of the authors is to consider innovations in the sphere of green logistics.*

Methods. *The authors use general scientific methods, economic evaluation methods, comparative analysis, scientific description.*

Results.

State and market

*In modern conditions, **the principles** of «green» logistics are implemented on the basis of two parallel approaches – state and market [2]. The state approach to the implementation of principles is based on a combination of mandatory requirements and constraints with incentives that leave market actors with the right to choose, but give them certain advantages when choosing «green» solutions. The market approach is based on gaining economic benefits, competitive advantages, increasing the image and public popularity of companies using «green» technologies.*

In work [7], environmental principles that are applicable to supply chains are classified into six categories: product design, packaging, collection and transportation, waste recycling and disposal, creation of an eco-business environment, storage.

Other authors [8] consider the guidelines for environmental design for the sustainability of supply chains in relation to the product life cycle strategy.

*The review of existing and promising **tools** that fully implement the state and market approaches to reducing the impact of transport on the environment for the period until 2050 allowed them to be grouped into four groups [8, 9]:*

• *economic instruments are aimed at increasing the cost of transportation, which forces companies to use cheaper and more environmentally friendly modes of transport, optimize the level of loading of rolling stock and others, but these instruments have a limited front, since transportation costs constitute a relatively small share in the cost of goods;*

• *legal tools are pre-established and approved regulatory restrictions in the established manner; can be used to accelerate the technological development of transport systems by gradually tightening standards and requirements for vehicles, the level of harmful emissions into the environment;*

• *information and analytical tools – for example, research, training, dissemination of best practices, benchmarking, consulting, use of carbon calculators and eco-labeling;*

• *social policy tools include the creation of transport infrastructure that meets environmental requirements, the introduction of urban intelligent transport systems, the rational organization of passenger transportation.*

*Some researchers [10] assess **the methods** of «green» logistics from the point of view of business and include: management of the transportation system (combined transport, 3PL-logistics), packaging management (to reduce the impact of packaging materials on the environment), the organization of «green» communications and production, management of warehousing and waste.*

In [11] a matrix of methods of «green» logistics, systematized by the levels of management of the processes of transportation, storage and provision of additional services, is presented.

*Existing **modes** of sustainable logistics in [12] are classified as «The Four A's» (Awareness, Avoidance, Acting and Shifting, Anticipation). In the Russian language version of this approach, we are invited to consider this as a rule of «four P» [the further quoted terms in Russian start with P – ed.note]: **understanding** the importance of sustainable logistics and public awareness of the effectiveness of its use; **prevention** of extra resources consumption; **transition** to more eco-efficient ways of*

transportation and trade; ***forecasting*** *the emergence of new resource-saving and environmentally friendly technologies.*

Professor of the Kühne Logistics University (Hamburg, Germany) Alan McKinnon [13] identifies five main directions for development of «green» logistics and the corresponding ways to reduce the negative impact on the environment (Table 1).

In work [14] the methods of reducing emissions of harmful substances in logistics activities are systematized in three directions: technical, operational (operational) and logistics. Technical measures include a complex of measures to improve the design of vehicle engines, the use of alternative fuels (energy), reduce the resistance to movement and the loading of vehicles. Operational measures include driver training and the use of information and communication technologies. Logistical measures include optimization of the distribution network, procurement and production activities taking into account CO_2 emissions, use of intermodal technologies, green design of warehouses, management of packaging activities, reverse logistics and waste management.

Study of 172 transport enterprises in Sweden [9] revealed 12 main ways to reduce the impact on the environment. More than 77 % of companies consider the most effective reduction of CO_2 emissions, optimization of routes for motor vehicles and organization of combined shipments. In most companies, it is believed that also the methods of operational management, such as the regulation of the transportation process, the increase in the carrying capacity of vehicles, eco-driving, etc., are more effective than those at the strategic level, for example, to change the structure of the transport system.

Sustainability priorities

In [15], ten options classified according to complexity and efficiency were proposed as priority measures for sustainability of logistics systems. The most complex and productive are: technologies for carbon capture and storage; transition to the preferential use of more environmentally friendly modes of transport (for example, marine); reduction of volumes of transport work by means of regional systems of purchase. The least effective and simpler in implementation: installation of energy-saving lamps; eco-driving; use of multi-turnaround containers.

In [16, 17], an analysis of logistics operations related to the «green» supply chains was carried out from the positions of strategic, tactical and operational control. The following features are revealed:

• in the field of strategic management, the largest amount of research (up to 46 %) is devoted to «green» products, the transportation process and the logistics infrastructure are respectively 34 % and 20 %; the problems of designing «green» buildings, methodological issues related to creation of generalized models, methods and calculation methods are not sufficiently studied;

• in the field of tactical management, little attention is paid to the problems of «green» planning of the objects of the logistics infrastructure, the proposed solutions are mainly related to optimization of technological processes and equipment capacities;

• in the field of operational management, there is a shortage of studies aimed at ensuring the healthy condition of vehicles and equipment to reduce the negative impact on the environment.

A review of the use of «green» technologies in transport corridors is contained in [18]. The authors analyzed 263 technologies, which are divided into eight categories: engine mechanisms and system; fuel and energy resources; handling and transportation of cargo; heating and cooling; loading and cleaning of rolling stock; means of transport; navigation technologies; technology for diffusion of innovation. About a third of the analyzed examples are classified as promising from the ecological transport corridor perspective.

The paper [19] presents a brief description of ten key sustainable transport development measures developed in the USA with the support of the presidential administration within the framework of sustainable development of society and taking into account climate change. The proposed initiatives are grouped into economic ones (taxes, credits, price formation, programs); technological (vehicles, fuel, transport and cargo flows, intermodal technologies); infrastructure (transport communications, land use); information (environmental programs and projects, environmental education and education); research.

Thus, the analysis of scientific works in the field of sustainable development and «green» logistics allowed us to systematize existing principles and methods.

The idea of balancing the economic, ecological and socio-cultural stability of the logistics system is the basis for systematization of the principles of «green» logistics.

1. Economic sustainability:

• the polluter pays principle – the transport service provider must fully reimburse the environmental damage associated with its provision at all stages of the production and transport process – from resource consumption to utilization of vehicles and transport waste [2, 15, 20];

• the principle of fairness – in the supply chain, the aggregate benefit from the acquisition of goods by the consumer must be proportionally distributed among producers, sellers and carriers [21];

• the principle of efficiency and safety – decisions in the field of transport development, as well as the implementation of transport and storage processes should be evaluated both in terms of economic efficiency, and in terms of safety and environmental impact of transport, and all these criteria are equivalent [2, 22, 23];

• the principle of optimality – development of optimal solutions in the logistics system is carried out on the basis of an assessment of the company's environmental costs as part of the overall logistics costs [21–24];

• the principle of wastelessness and resource-saving – maximum use of waste products, packaging and packaging as secondary raw materials or their environmentally safe disposal, as well as the minimum use of raw materials and packaging that are not recyclable or safe disposal [22, 23, 25].

2. Environmental sustainability:

• the principle of minimal impact – reducing the negative impact on nature during the whole cycle of production, transportation, direct use and processing [21, 24, 25];

• the principle of innovation – introduction of innovative technologies to reduce the environmental burden on the environment [22, 23, 25];

• the principle of rationality – the rational use of natural resources and the potential of enterprises [22, 23].

3. Socio-cultural sustainability:

• the principle of responsibility – increasing the environmental responsibility of personnel, formation of a corporate environmental culture [22, 23, 26, 27];

• the principle of transparency – building relationships with customers and stakeholders on the basis of interactivity, information and financial transparency [24, 28];

• the principle of reasonable consumption – the desire to reduce the transport needs of society and the state, not violating the rights and freedom of movement and trade [2].

Table 2

Systematization of the methods of «green» logistics

Element of LS	Function of an element	Existing methods «green» logistics
Input element	Supply market research	• analysis and selection of suppliers in terms of environmental friendliness of supplied raw materials and materials [16, 31, 32, 33]; • analysis and selection of nearby suppliers [9, 15, 16, 34].
	Determination of needs in the flows	• reduction of consumption as much as possible [34, 35]; • reduction and utilization of waste in the elements of LS [8, 9, 16, 34].
	Determination of supply methods	• consolidation of freight flows [11, 21, 33, 34, 36, 37];
	Analysis of the cost of supply	not identified.
	Analysis of quality of supply	• selection and purchase of raw materials, materials and services by the criterion of minimum impact on the environment [25, 33, 39]; • use of environmentally friendly fuels and lubricants and fuel [9, 11, 12, 16, 32, 34, 39]; • use of environmentally acceptable packaging materials [25, 32, 33, 34, 39].
	Planning of supply	• procurement planning taking into account recycling opportunities [8, 9, 12, 32, 34] and reuse [8, 9, 15, 34].
	Control of supply	not identified.
	Coordination (agreement) of work on promotion of flows	• cooperation with suppliers in the issues of environmental friendliness of supplies [9, 34].
Output element	Market research and identification of market needs in LS products	• awareness of consumers about the environmental orientation of the company's activities by marking the packaging with special signs [38, 39].
	Selection and organization of distribution channels	• analysis of distribution channels by the criterion of environmental impact and their rational organization [12, 32]; • formation of a system of movement of the «reverse» resource flow [8, 32]; • organization of the process of return of packaging material and old products [16, 32].
	Pricing	not identified.
	Formation of the flow of services	• provision of services for utilization of LS, formation of utilization processes in the form of reverse supply chains (collection and sorting of waste, their delivery to distribution warehouses, delivery of finished products derived from waste, to the trading network, etc.) [8, 12, 31]; • use of multi-turn packaging [11, 15, 21, 31, 34, 36, 39].
	Planning of supply and service flow	• consolidation of cargo flows [11, 21, 33, 34, 36, 39].
	Control of supply and services	not identified
	Adjustment of flow parameters taking into account the market requirements	• building interaction with clients on the principles of interactivity, information and financial transparency in the field of ecology [28]; • partnership with other companies [9, 34].
Processing element	Planning of production	not identified.
	Coordination of the work of structural units	• ensuring and monitoring the conformity of the production program of the installed capacity [32].
	Quality management of production and products	• reduction of material damage [9]; • organization of a waste management system [11, 28, 32, 39].
	Personnel management	• providing comfortable and environmentally safe working conditions [32]; • environmental training of employees [9, 27, 34]; • eco-driving [9, 12, 15, 34].
	Improvement of technical and technological support	• use of environmentally acceptable equipment and technology (ensuring resource and energy saving, maximum use of raw components, minimization of «unavoidable» production wastes) in the production process [32]; • application of maintenance of modern diagnostic methods and tools in the technological process [38]; • use of sewage treatment systems [9, 34].
	Cost management for the production of products	• trade in processing waste [39]; • analysis of resource, energy and waste capacity of production [32].
Accumulation element	Optimization of stock levels	• decrease in reserves to reduce the need for storage space [31, 33, 39].
	Control and regulation of the level of stocks	not identified.
	Management of material flows, their distribution	• consolidation of cargo flows [11, 21, 33, 34, 36, 39]; • ensuring environmentally sound spatial organization of storage elements (effective land use) [9, 32, 34]; • optimization of loading and unloading operations [11, 39].
	Improvement of technical equipment and warehousing technology	• ensuring that the conditions for placing and storing stocks, finished products and wastes are standardized [32, 33, 39]; • ecological design of buildings [9, 12, 16, 34]; • environmentally friendly loading and unloading facilities [9, 11, 16, 34, 39]; • thermal insulation of warehouses and use of energy-saving technologies [11, 15, 16, 21, 31, 36].
	Quality management of flow processing	• reduction of packaging waste [34]; • optimization of weight and volume of the packaging material [9, 16].

When systemizing the methods of «green» logistics, the authors used structural-functional and system approaches [29, 30], which assume the isolation of specific functions of structural elements of logistics systems (LS) for handling and processing of logistical flows. Systematized methods with LS elements and their functions are presented in Table 2.

Conclusion.

Review and analysis of authoritative publications, as well as the results of modern scientific research in the field of sustainable development of transport systems, of «green» logistics and integration of the environmental factor into the practice of logistics management show:

Transport element	Choice of optimal transportation schemes	• use of multimodal technologies [9, 11, 12, 16, 21, 28, 33, 34]; • optimization of transport routes according to the criterion of minimum adverse impact on the environment and population [9, 12, 15, 31, 32, 34, 36]; • selection and use of environmentally friendly vehicles and modes of transport (rail, water) [9, 11, 16, 31, 32, 34, 36, 39]; • exclusion of intermediate storage and transshipment points from the logistics chain [31]; • reduction of iterations and links in supply chains [28].
	Choice of the system for organizing the advancement of material flows	• reduction of supply frequency [15, 33]; • consolidation of cargo flows [11, 21, 33, 34, 36, 39].
	Operational management of material flow parameters	• motion control technologies [9, 12, 34]; • optimization of the technical speed of vehicles to reduce emissions [16, 28, 34].
	Improving the technical support of the transportation process	• analysis of the qualitative characteristics of the fleet for compliance with established legal standards [32]; • standardization of truck sizes [11, 39]; • increasing the carrying capacity of vehicles [9, 11, 16, 31, 34]; • reduction of the resistance to movement (improvement of aerodynamic properties of vehicles, body structure, monitoring of tire pressure) [12].
Control element	Development of logistics strategy	• incorporation of environmental aspects into the company's strategy [9, 8, 34]; • implementation of a policy of information openness and transparency (transparency policy) [34].
	Organization of interaction and coordination of operation of LS elements	• implementation of integrated environmental protection systems [11, 32]; • harmonization of production strategy and operations with transport operations [9, 34]; • organization of an audit and examination system for workplaces and working conditions [9, 34]; • adjustment of the structure of the logistics system (transfer of production and warehouses) [9].
	Coordination and regulation of work of LS elements	• use of electronic document circulation [21]; • introduction of the latest information technologies (RFID, GPS, GIS and EDI systems) [9, 21, 34]; • use of information and communication technologies (Information Management Systems, Cold Chain Logistics, Freight Operation Information System (FOIS), Electronic Data Interchange (EDI)) [12, 39].
	Formation of a favorable socio-economic environment for LS	• dissemination of information on achievements in the field of ecology [9, 34]; • stimulating the use of «green» methods [9, 34]; • membership in environmental programs [9, 34]; • formation of corporate social responsibility in the field of sustainable development [7].
	Monitoring the sustainable functioning of LS	• audit of compliance with environmental requirements [9, 34]; • assessment and control of environmental efficiency [9, 11, 34].

• on the whole, the conceptual and terminological apparatus of «green» logistics, approaches and principles of sustainable development have been formed, the regulatory and legal framework for their implementation has been created;

• various environmental programs and projects involving public and state institutions, business structures, research organizations and international associations are implemented in support of the ideas of «green» logistics.

However, until now, the generally accepted principles of «green» logistics have not been formulated, there is no single system of methods and tools for their implementation. There is a situation where there is a large number of theoretical studies in the field of sustainable development of transport systems, but the overall results of these developments are poorly used to systematize a variety of private technical and technological solutions to reduce the harmful impact of transport on the environment.

Insufficient systematization in implementation of methods and tools of «green» logistics in practice often leads to a decrease in the efficiency of each of them separately, does not contribute to the emergence of a «green» synergistic effect in supply chains.

In the article the approach to systematization of existing methods of «green» logistics, based on the structural-functional analysis is offered. The use of the demonstrated approach will allow, in the opinion of the authors, to formulate more balanced programs for increasing the ecological compatibility of transport systems.

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