INNOVATIONS IN THE SPHERE OF GREEN LOGISTICS

Osintsev, Nikita A., *Nosov Magnitogorsk State Technical University, Magnitogorsk, Russia.*
Rakhmangulov, Alexander N., *Nosov Magnitogorsk State Technical University, Magnitogorsk, Russia.*
Baginova, Vera V., *Russian University of Transport, Moscow, Russia.*

ABSTRACT

In the last decade, the scientific researches focused on improvement of environmental friendliness and based on the principles of sustainable development, has been developed in transport sector, and this is «green» logistics. 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.

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

Background. *In the context of growing consumption and economic growth in the world, supply chains are increasingly recognized as key sources of competitiveness. Companies are trying to create powerful supply chains that will bring products to the market faster and more economically than their competitors [1].*

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.

Transport and environment

The driving force, one of the main elements of logistics, the link of supply chains is transportation. On the one hand, transport systems provide basic functions in the flow processes of logistics systems and are an important tool for solving social, economic and technological problems, on the other hand, their functioning is accompanied by a powerful negative impact on nature and the environment. This is expressed primarily through [2]:

1. Consumption of natural resources (energy, water, atmospheric and lithosphere resources).

2. Pollution of the environment by harmful substances (gaseous, liquid and solid).

3. Energy and visual pollution of the environment (noise, vibration, electromagnetic fields, heat emissions).

4. Alienation and land degradation.

5. Traumatism and death of people, animals, causing harm to health.

6. Damage caused by transport accidents, accidents and road accidents.

The generalization of scientific research, reports of state bodies, statistical data on the impact of transport systems on the environment in Russia allowed us to formulate the following brief conclusions:

• Russia ranks fourth in the world for current carbon dioxide emissions after China, the United States and India [3].

• The largest volume of pollutant emissions into the atmosphere is accounted for by road transport: in 2015 it amounted to 13818,6 thousand tons out of the total volume of 31114,3 thousand tons. The share of railway transport falls by less than 0,5 % of total emissions (154,3 thousand tons) [4].

• Russia has the fourth place in the world in terms of domestic consumption of petroleum products. From 2010 to 2015, it increased from 127 to 143 million tons [5]. At the same time, transportation is the main consumer of oil refining products (about 60 %) [6].

• Transport takes the fifth place in Russia among the energy consumption sectors after generation of heat and electricity, manufacturing and residential buildings [7]. It accounts for up to 30 % of total energy consumption [8]. The leader in this regard among all modes of transport is the road transport – 48 % [7, 8].

• Consumption of water resources for transport needs is low – 1,7–2,0 % of the total volume of water consumption in the Russian Federation [8, 9]. In 2015, the volume of water abstraction from natural sources amounted to 2914,18 million m^3, and the volume of discharge of sewage into surface natural water bodies – 171,02 million m^3 (including 30,76 million m^3 of contaminated water) [9].

• Seizure of land for transport infrastructure in Russia averages 7989,45 thousand hectares per year (from 2010 to 2015, an increase of 1,87 %) [4].

• The amount of generated waste from 2006 to 2015 increased by 44 % and reached 5060,2 million tons, of which 2,9 million tons are in the sector «Transport and Communications» [10]. In addition, in Russia an average of 70 million tons of solid municipal waste is generated per year, of which less than 2 % is burned and about 4 % is recycled [9, 11].

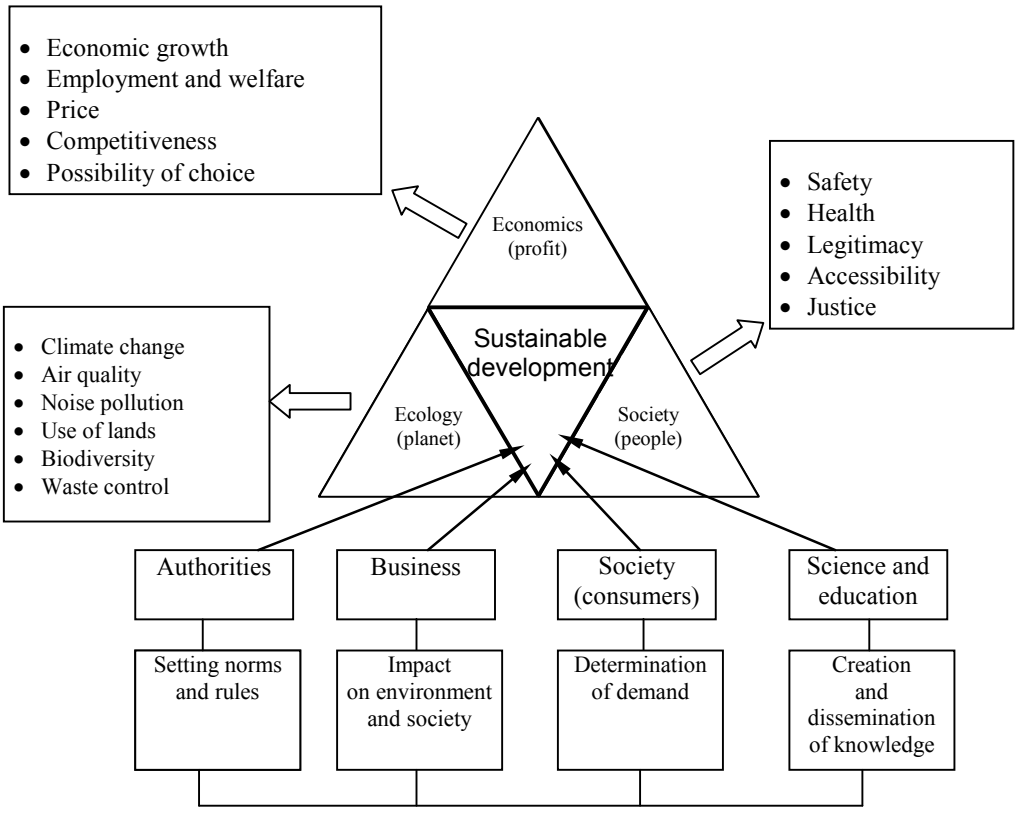
• The number of accidents in transport and those affected in them decreased from 2010 to 2015 by an average of 7 % and 11 %, respectively. The most dangerous mode of transport is the automobile (23114 dead and 231197 wounded in 2015) [12].

• More than 40 million people in Russia experience a constant impact of noise, 60–80 % of which in cities occurs as a result of movement of vehicles [13].

Thus, in modern conditions, the importance is high of setting priorities for ensuring safety and environmental friendliness of transport, which is a sphere of increased risks, is becoming one of the main polluters of the environment and consumers of irreplaceable natural resources. This set of problems is solved with support of the principles of sustainable development [14], which have become the basis of the transport policy of many countries [15].

Sustainable development concept

The concept of «eco-development» was first formulated in the framework of the first World Conference on the Environment (Stockholm, 1972) by Maurice Strong as an environmentally oriented socio-economic development, in which human well-being growth is not accompanied by a deterioration



Pic. 1. Scheme of the concept of sustainable development [28] (in the author's edition).

in the habitat and degradation of natural systems [16, 17]. The implementation of the principles of eco-development required the creation of special structures – the United Nations Environment Program (UNEP) and the World Commission on Environment and Development (WCED), which are called to solve environmental problems at the state level.

In the late 1980s, the term «sustainable development», which is close to the notion of eco-development, was included in international terminology. In the WCED report «Our Common Future» [18], it got the the following definition: «development that would satisfy the needs of the present without compromising the ability of future generations to meet their needs». In other words, the growth of opportunities to meet the needs in the present and the future is subject to conservation, and the exploitation of resources, technological improvement and quality of management are subject to change [19, 22].

Russian researchers pointed to the inaccuracy (incorrectness) of translating «sustainable development» into Russian [17, 20–22]. For example, V. I. Danilov-Danilyan emphasizes: «… it's not a matter of translation, but how we agree to understand the term. Translations of sustainable to other languages are also not very good: if you literally translate into Russian, you get non-movable, hard, etc. The Russian version is one of the most successful» [21]. In other countries, the concept is also ambiguous. For example, in Australia the concept of «environmentally sustainable development» is implemented, and in the Netherlands the concept of «sustainable economic and social growth» is legally fixed [20].

In modern literature [14, 23–25], sustainable development implies achieving a reasonable balance between economic, social (cultural), ecological development and needs. However, there are various interpretations of what is essential for sustainability of development. Some authors emphasize the importance of preserving the functionality of nature and the environment, others emphasize social aspects and political institutions, and stable economic growth in society [23, 24, 26]. As noted by T. V. Uskova [22, 27], modern science has not yet developed a generally accepted definition of «sustainability», «sustainable development», «sustainable growth» in relation to socio-economic systems. This testifies both to complexity of the concepts themselves and complexity of the object of research, which can be represented by the national economy (macroeconomics), and subsystems of the economy of a particular level, for example, industrial enterprises, logistics systems, transport organizations, etc.

At the company level, the concept of sustainable development is considered as «Triple Bottom Line», according to which not only financial indicators, but also social and environmental performance, are taken into account in the corporate decision-making process. Companies need to focus not on immediate profit, but on business success and environmental survival in the long term, which requires a change in financial performance and costs in the short term (Pic. 1) [28].

With regard to transport, sustainable development means that meeting transportation needs does not contradict the priorities of environmental protection and health, does not lead to irreversible natural

Table 1

Paradoxes of «green» logistics *

Scope of logistics	Result of traditional logistics	Contradiction with «green» logistics
Logistics infrastructure	Concentration of cargo flows in transport corridors and nodes	Increase of the environmental load in the locations of transport corridors and nodes
Material flows	Optimizing the size of freight and cargo consignments leads to a reduction in inventory, a decrease in the demand for the use of private inefficient warehouses	Increase in intensity of traffic flows, lack of capacity of elements of the logistics infrastructure, as a consequence – increase in the number and duration of congestion, the amount of emissions into the environment
Quality of delivery	Creation of integrated supply chains, the use of the «just-in-time» and «door-to-door» principles provide a flexible and efficient distribution system	The growth in production and sales, expansion of the distribution system requires increasing the occupied space, increasing energy consumption and increasing CO_2 emissions
Logistical costs	Reduction of logistics costs as a result of improved packaging and waste minimization	Environmental costs often exceed the effect of using packaging
Information flows	Improving the quality (timeliness) of delivery of goods on the basis of electronic commerce, including, as a result of reducing the size of freight and cargo consignments	Increase in energy consumption as a result of intensification of traffic flows, emissions

* Compiled by the authors according to the results [38–40].

changes and depletion of irreplaceable resources [15].

The Canadian scientist T. Litman [29] also notes a growing interest in the concepts of sustainability, livability, sustainable development and sustainable transport. He summarized the results of many studies, and, in his opinion, despite differences in approaches and definitions, most experts speak of a balance of economic, environmental and social aspects of sustainability [29, 30].

A similar opinion is held by domestic researchers. Thus, scientists of the Institute of Economics of the Ural Branch of the Russian Academy of Sciences understand under sustainable development «guaranteed achievement of targets at reasonable intensities of disturbing influences on the environment, economic complex and socio-demographic sphere» [22, 31]. In work [32], the concept of interaction between industry and the environment is considered, covering three components of sustainable development: responsibility for the state of the environment, economic reproduction (creation of material values) and social development. Corresponding member of the Russian Academy of Sciences, V. I. Danilov-Danilyan, defines sustainable development as social development, in which its natural basis is not destroyed, the created living conditions do not entail human degradation and social and destructive processes do not develop to the scales threatening the security of society. At the same time, he notes that the development of modern global civilization does not correspond to any of three aspects noted in the above definition, and this threatens the survival of mankind [21].

Definitions of «green» logistics

The beginning of the practice of using logistics to solve environmental problems and implement the principles of sustainable development was laid in the mid-1980s with the emergence of the concept of «universal responsibility», which, unlike the general theory of organization, considered the social component of logistic activity as well [33]. According to Paul Murphy and Richard Poist [34], the use of logistics to solve social and environmental problems, ensure safety and comfort of work, increase consumption is an effective tool.

Logistics has a significant potential for environmental control of transport systems, processes for recycling of products, minimization of environmental pollution, energy and resource conservation. In addition, the management of material and related flows, based on the principles of logistics, initially involves a reduction in the environmental burden on the environment [24, 26, 35–37].

At the same time, a number of researchers [38–40] point to the existence of contradictions between traditional logistics, the purpose of which is to minimize costs, and its «green» component aimed at reducing the harmful impact on the environment (Table 1). And scientists from the Netherlands and Germany, based on an analysis of political, economic, social and business motives, [41] critically approached the existing approaches of «green» logistics, they proposed two ways: public control and high taxation of carbon-containing raw materials (coal, oil); public investment in development of the biofuel industry and transport infrastructure with low emissions.

Integration of functions and tasks of environmental logistics and environmental management can be traced in [42, 43]. Thus, N. V. Pakhomova proposes to consider environmental logistics as an integral management tool aimed at identifying eco-destructive factors of logistic activity that must be identified and eliminated. In the studies of T. N. Skorobogatova, environmental logistics is a functional subsystem of the logistics system with the task of efficiently locating and utilizing waste [44]. Dutch scientists H. Visser and A. van Goor note that environmental logistics is aimed at optimizing business management, taking into account the constraints, wishes and requirements of the government and the market. This is reduced to simultaneous reduction of environmental pollution and improvement of business conditions [45].

In order to manage the flows of secondary resources (wastes) to the logistic terminology, it is proposed in [35] to introduce a special concept of «resource-saving logistics» with its subdivision (splitting) into a whole series of clarifying categories – «waste logistics», «waste producing logistics» and «waste consumption logistics».

It should be noted that the use of logistics principles for solving environmental problems

Table 2

Definitions of «green» supply chains *

Definition	Focus	Authors
A set of rules, actions and relationships formed on problems with the environment regarding design, acquisition, production, distribution, reuse and recycling of the company's products and services.	Goals, tasks: design, acquisition, production, distribution, reuse, disposal of goods and services. Tools, areas: rules, actions, relationships.	Zsidisin and Siferd, 2001
The part of supply chain management and internal organizational philosophy to achieve common economic indicators, as well as to improve the environmental and social performance of the organization and its partners.	Goals, tasks: improving economic, environmental and social indicators. Tools, areas: Supply Chain Management, Internal Philosophy.	Van Hoek, 2002
A new area of research on climate change, unsustainable consumption of natural resources and high energy consumption indicators	Goals and tasks: research. Tools, areas: climate change, resource consumption.	Sarkis, 2003
Expansion of supply chain management, including reuse and recycling of all products and service life cycle	Goals, tasks: improving management. Tools, areas: recycling, waste, product life cycle.	Kainuma and Tawara, 2006
Integrating environmental thinking into supply chain management, including product design, material selection, production processes, final product delivery to consumers and product management for the rest of its life cycle.	Goals, tasks: integrating environmental thinking and supply chain management. Tools, areas: life cycle of a product or a service.	Srivastava, 2007
The area from «green» purchases to integrated product lifecycle management in supply chains, following from the supplier, through the producer to the consumer and ending with reverse logistics.	Goals, tasks: expansion of the area of «green» logistics. Tools, areas: product or service life cycle, suppliers, producers, consumers, reverse logistics.	Zhu, 2008
Environmentally friendly solutions in supply chain activities, including supply, design and development, manufacture, transportation, packaging, storage, recovery, utilization and after-sales service of the goods.	Goals, tasks: development of environmental initiatives. Tools, areas: life cycle of a product or a service.	Min and Kim, 2012

* Compiled by the authors on the basis of [55].

occurred in stages. In [47] four stages of priority scientific research are distinguished:

• until 1990 – economic rationalization of environmental factors in production;

• from 1990 until по 2000 – development of Reverse Logistics;

• from 2000 until 2010 – Green Logistics on Enterprise Level;

• from 2010 to the present – Green Supply Chain Management.

In [46], green logistics means organization of movement of goods, passengers, other transport and logistics services, which are provided to economic agents and agents of the social sector using environmentally safe technologies that do not increase and simultaneously reduce the anthropogenic and technogenic load on the global ecosystem. The authors distinguish two conceptual methodological provisions of «green» logistics:

• gradual and systematic refusal of environmentally harmful and aggressive transport using petrol and other similar fuels with a high level of carbon dioxide emissions into the atmosphere;

• intensification of the use of transport capacities, not only to reduce pressure on the ecosystem, but also to reduce the burden on the transport and logistics infrastructure, the restoration of which is always characterized by high capital capacity.

L. M. Kapustina offers a classification of «green» technologies according to two criteria [48]:

• stages of the technological cycle of the product (concept, design, extraction of raw materials, transportation, production of the product, delivery to the consumer, consumption and disposal);

• objects of environmental impact: fuel economy, water saving, non-renewable natural resources (specific for production of a certain product), reduction or elimination of air, water and soil pollution (solid and liquid waste).

Another definition of green logistics is contained in [49] – a system of measures that involves the use of energy and resource-saving technologies, modern technical equipment and equipment in all parts of the supply chain in order to minimize the negative impact on the environment, leads to improved welfare and social comfort of citizens, reduces economic risks and a shortage of natural resources.

The author of one of the Ukrainian studies [33] carried out a classification of existing definitions of logistic management taking into account the environmental factor and proposed the term «eco-oriented logistics». This means scientific and practical activities that involve formation of an effective system (integration) of environmental aspects at all stages of planning, organizing, managing, controlling and regulating the movement of material, information and financial flows in space and time, from the source of their origin to the final consumer.

D. Lambert and J. Stock were among the first to put into circulation the definition of reverse logistics as a system for organizing the flow of materials that is reverse of the main flow [50], and J. Stock interpreted it also as a function of logistics regarding return of products, resource saving, recycling, replacement materials, waste management, recovery and reuse [51]. In [52], reverse logistics is represented as a stock control element. In the author's interpretation, it is the process of planning, implementing and monitoring logistic flows of goods returning from the sphere of circulation and consumption as a result of the reverse distribution of finished products, dangerous, damaged, expired and used goods and containers and related information in order to restore their value or proper disposal.

Scientific research over the past 15–20 years increasingly focuses on Green Supply Chain Management, as the impact of an individual company on the environment extends far beyond its limits. The opinion of foreign and domestic scientists boils down to the fact that environmental aspects should be taken into account at all stages of the supply chain operation from extraction and processing of raw materials through production and distribution of finished products to its final use or disposal.

According to Alan McKinnon [25], although the management of «green» supply chains is a relatively new area of research, it has already reached a rather high degree of methodological maturity. The paper [54] presents an overview of the chronology of development of the theory and practice of managing «green» supply chains from 1990 to 2009. In the scientific papers, the key themes of Green Supply Chain Management (GSCM) in recent years are the concepts of green design, green operations, reverse logistics, waste recycling and green production [53, 55–57].

R. Klassen and P. Johnson understand under the management of «green» supply chains «alignment and integration of environmental management» [58]. S. Shrivastava considers GSCM as an integration of environmental thinking in supply chain management, including product design, material selection, production processes, final product delivery to consumers and product management up to the end of its life cycle [59]. According to J. Sarkis [60], the management of «green» supply chains is addition of «green» to the existing practice, that is, a combination of «green» purchases, «green» production, green distribution and reverse logistics.

According to the researchers [57], GSCM originates in the following activities:

1. Green Supply Logistics, associated with ecologization of the main logistics processes.

2. Green Production Logistics, aimed at the use of environmentally friendly production technologies, more efficient use of resources and reduction of energy consumption and waste emissions.

3. Green Sales Logistics, which involves optimizing transport routes and creating a «green» sales network.

4. Reverse Logistics, associated with efficient and economical planning and management of reverse material flows, as well as information flows from the point of consumption to the point of origin for return of value or proper disposal.

In a number of cases, they operate the concept of «Sustainable Supply Chain Management», dividing it into three categories: Supply Chain Management (SCM), Green Supply Chain Management (GSCM) and Social/Societal Supply Chain Management (2SoSCM), each of which performs a function of managing economic, environmental and social aspects of sustainable development. Separation into a separate category of 2SoSCM pursues a goal of strategic management of the quality of life of people and raising the level of development of human resources [61].

A. V. Tsvetkov suggests using the term «eco-oriented supply chain management», which means integrated thinking in the field of supply chain management, covering planning, organization and control of movement of direct and reverse material and associated flows during the entire life cycle of goods for the purposes of minimization of negative environmental impact and efficient use of natural resources [62].

The analysis of the studies presented in [63] shows a surge of interest in this subject in 2014–2016 in China, as well as in countries with a high population density. At the same time, there is a low social susceptibility to «green» logistics and supply chains, the need to draw attention to the problem at the state level. The possible increase in social susceptibility [39] is seen in the change in the production paradigm, where sustainability is no longer considered in terms of additional inefficient costs, but represents a potential source of competitive advantage for companies.

Conclusion. *Thus, from the presented definitions of «green» logistics it can be concluded that they cover all the functional areas of interest to science. At the same time, an analysis of the results of integrating the environmental factor into the practice of logistic management shows that the studies conducted so far are fragmentary, in most cases they only affect certain areas of application of logistics.*

(To be continued)

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Information about the authors:
Osintsev, Nikita A. – Ph.D. (Eng), associate professor of Nosov Magnitogorsk State Technical University, Magnitogorsk, Russia, osintsev@magtu.ru.
Rakhmangulov, Alexander N. – D.Sc. (Eng), professor of Nosov Magnitogorsk State Technical University, Magnitogorsk, Russia, ran@magtu.ru.
Baginova, Vera V. – D.Sc. (Eng), professor, head of the department of Russian University of Transport, Moscow, Russia, baginova@rambler.ru.

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