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Green Logistics: A System of Methods and Instruments - Part 2

Zelena logistika: sustav metoda i instrumenata – 2. dio

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Summary

The first part of this paper presents the review on most authoritative studies in the field of sustainable development and green logistics, as well as a new approach to achieve the goals of sustainable development in the operation of logistics and transport systems. The second part reflects the results of systematisation of methods and instruments of green logistics, used to achieve the goals of sustainable development. The application of the presented approach to achieving the goals of sustainable development could form the balanced programs to raise environmental performance and effectiveness of supply chains' operation, and systemic implementation of methods and instruments of green logistics will provide achieving the goals of sustainable development.

KEY WORDS
sustainable development
green logistic
methods
instruments

Sažetak

Prvi dio ovoga članka predstavlja pregled najautoritativnijih studija u području održivoga razvoja i zelene logistike, kao i novi pristup postizanja ciljeva održivoga razvoja u djelovanju logistike i sustavu transporta. Drugi dio odražava rezultate sistematizacije metoda i instrumenata zelene logistike koji se koriste da se postignu ciljevi održivoga razvoja. Primjena predočenoga pristupa postizanja ciljeva održivoga razvoja može oblikovati izbalansirane programe da bi se podigla ekološka izvedba i djelotvornost opskrbnih lanacâ, a sstavna implementacija metoda i instrumenata zelene logistike osigurat će ciljeve održivoga razvoja.

KLJUČNE RIJEČI
održivi razvoj
zelena logistika
metode
instrumenti

1. LITERATURE REVIEW / *Pregled literature*

Review and analysis of the publications, as well as results of current scientific studies in the field of sustainable development, [1 - 3], green logistics [3], [4] and integration of environmental factor into the practice of logistics management [5 - 7] show that:

- concepts and terminology apparatus of green logistics and green supply chain management have developed, approaches and principles of sustainable development have formulated, the system of indicators for assessing this activity and legal framework for its implementing have created;
- environmental conscience and skills of ecological behaviour have been actively forming in business and private life; training, development of competencies for sustainable development are being implemented;
- different kinds of environmental programs and projects are performed with the support of public and state institutions, business structures, research institutions and international associations.

However, generally accepted principles of green logistics have not been formulated yet, and there is a lack of a unified system of methods and tools for implementing these principles. Many researchers have noted the problem of implementation of green principles in practice , because there is the contradiction between the logistics principles aimed to maximise profits and to achieve economic growth and activity related to the reduction of the harmful impact on the environment [8], [9].

Review of existing and prospective instruments of green logistics [10] combined these instruments in 4 groups:

- economic instruments aimed at minimising the transport costs for example as a result of using cheaper and environmentally friendly modes of transport, optimisation of rolling stock' loading, optimisation of the size of transport shipments, selection of efficient routes and transportation schemes;
- legal instruments represent the established in advance and adopted in the prescribed manner regulatory limits;
- instruments of social policy based on the complex

application of economic and legal instruments with the aim to create and operate the transport infrastructure by social and environmental requirements, for example, through the implementation of intellectual transport systems, rational organisation of passenger transportation;

- information and analytical tools, providing information support of the application of other instruments of green logistics include, for example, scientific studies, training, dissemination of best practices of environmental education and education for sustainable development, benchmarking, consulting, the use of carbon calculators and eco-labelling.

Authors reviewed the methods of green logistics regarding business and included in it: management of transport system (combined transport, 3PL-logistics), packaging management (to reduce the impact of packaging materials on environment), an organisation of green communications and production; warehouse management and waste management [11]. The matrix of green logistics methods, presented in studies [12], is systemized in levels of transportation management, warehousing and the provision of additional services.

The ways to reduce the harmful impact on logistics companies, outlined in the study [13], are systemized in three directions: technical, operational (operating) and logistical. Authors have classified ten ways according to the complexity and efficiency, as the priority actions of the sustainability of logistics systems [14].

Studies [15], [16] reflect the analyses of the logistics operation of green supply chains' management (designing, planning and controlling the objects of the logistics infrastructure, as well as the processes of delivery and storage of products) from the perspective of strategic, tactical and operational management.

Thus, the analysis of scientific studies in the field of sustainable development leads to the conclusion that there is a wide variety of approaches and views on contents of methods and instruments of green logistics that caused the thin consistency of its implementation. In the practice of logistics companies, it reduces the efficiency of these methods and instruments separately, does not contribute to the planned reduction of the harmful impact of transport on the environment in case of the increased economic efficiency of supply chains' operation.

2. SYSTEM OF GREEN LOGISTICS METHODS AND INSTRUMENTS / *Sustav metoda i instrumenata zelene logistike*

Authors have carried out the systematization of methods and instruments of green logistics with the application of structural-functional [17] [18] and systemic approaches [19] to describe logistics and transport system. These methods are based on the selection of fundamental (basic) functions of the elements of the logistics systems.

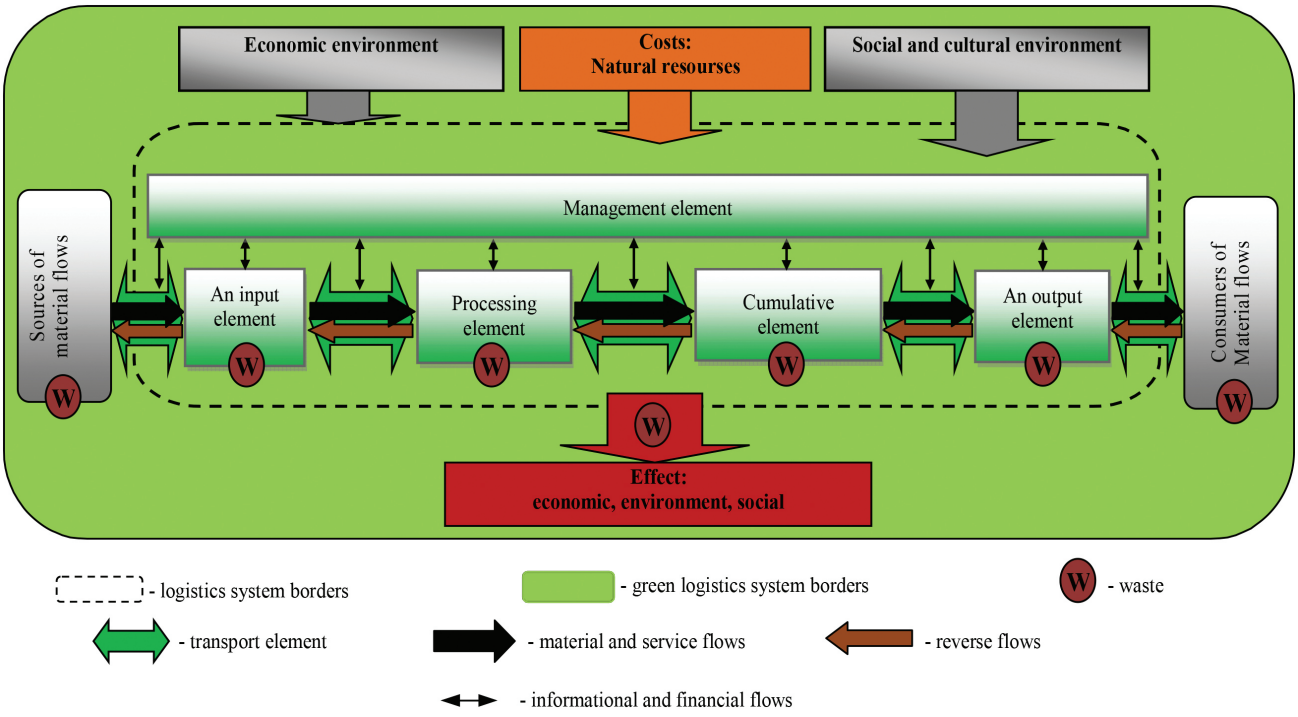
According to this approach, the following elements of logistics systems were identified, (Fig. 1): input flow, applying the basic function of material flow's entering into logistics system and providing purchase, supply of logistics system with raw materials, materials or services. Cumulative element, providing the management function of material flows' speed as a result of it braking, accumulation and storage. Transport element implements the basic function of expediting and braking material flows. Processing element provides the function of changes in the qualitative properties of material flows, its transformation from raw materials to the finished products. Output element ensures the removal of material flow from logistics system, sales and distribution of finished products and services. Management element provides information and financial relationship between the elements of the logistics system, monitors the implementation of its functions and operations, regulates the promotion of information and financial flows in the logistics system.

The structural-functional approach, used by authors to systematise well-known methods of green logistics, is fundamentally different from the standard way to select functional areas of logistics: transport logistics, transport, distribution logistics, industrial logistics, supplying logistics and warehouse logistics [24]. The disadvantage of this functional approach is «linking» of logistics functions and operations to the infrastructure elements of supply chains – warehouses, industrial enterprises, supply, sales and transport departments. Moreover, there is a situation in the use of a functional approach to solving the problems of systemizing logistics methods, when the same management method of logistics flows is implemented in different functional areas of logistics.

It is one of the leading causes of non-harmonized application of methods and instruments of green logistics when same methods and instruments are applied in different methodical basis, supported by different normative-legal documents, sometimes conflicting between each other. A typical example is the selection of the separate functional area in green logistics – also called «reverse logistics». In our view, this choice is excessive, since the object of reverse logistics management is material flow consisting of waste products, packaging, package, secondary raw materials, but different from the main material flow only by direction – it moves towards with the main one. Green methods of reverse flow management are being implemented by the same logistics elements, where management object is the material flow.

It is quite evident that means of transport are one of the main supports of any logistics systems. Therefore, if we talk about green logistics, we should understand that it should be based on environmentally friendly modes of transport. It is obvious that bicycle transport fully meets the principles of green logistics and should be used as much as possible, especially in urban conditions [20]. However, for the delivery of heavy and bulky cargo, it is not adapted. A good solution is the use of inland waterways [21], yet, the application of this mode of transport also has limitations. A radical environmental solution for urban transport is the widespread use of electric or solar cars for the delivery of goods [22, 23]. However, this answer is more for not so distant future. At present, great importance is the use of gaseous fuels (compressed or liquefied gas). Also, the additives for traditional engines, for example, the use of hydrogen, can now be considered [25]. These solutions can help ensure that modern transport meets the principles of green logistics.

Consequently, one of the leading advantages of the structural-functional approach to the systematisation of different green logistics methods is the possibility to group all well-known green methods in two main signs. First sign based on membership to the logistics element, realising one of the fundamental logistics functions, and the second one based



Source: own elaboration

Figure 1 Scheme of green logistics system
Slika 1. Shema sustava zelene logistike

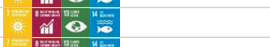
on membership to the effects-based methods on one of the logistics elements, or on material flow and flow of services, either on information and financial flows. Described systematisation approach allows not only identify the cases of green methods' duplication at different stages of logistics process, but also to determine missing perspective methods and tools that are successfully applied in traditional logistics, but not considered as the green methods because of misunderstanding of the sources of its environmental effect.

Table 1 presents the results of systematisation of methods and instruments of green logistics by the structural-functional approach. Formulation of methods and instruments is similar to the formulation of traditional logistics methods in the table, however, it is necessary to consider these methods as the methods and instruments for achieving sustainable development goals in terms of green logistics.

For example, the instrument «analysis of suppliers' market» that generally used for selecting the optimal suppliers according to the criterion «quality/price» (goal 8), must take into account the requirements of rational use of water (goals 6 and 14) and forest resources (goal 15) in green logistics. Moreover, this instrument forms mutually beneficial logistics networks with suppliers of raw materials, engaging them in the process of implementing green logistics methods (goal 17).

Table 1 System of green logistics methods and instruments
Tablica 1. Sustav metoda i instrumenata zelene logistike

Element of LS	Green logistics methods	Green logistics instruments	Achieved goals of sustainable development
Input element (procurement logistics)	1. Suppliers market research	Analysis of suppliers	
		Analysis of raw materials, goods and services	
		Analysis of the procurement system	
		Life cycle analysis (LCA)	
	2. Ecologically acceptable raw materials, containers and packaging	Selection of ecological raw materials	
		Selection of raw materials taking into account the possibility of recycling	
		System of eco-labelling (eco-labels)	
	3. The selection of suppliers	Selection of eco-friendly suppliers	
		Selection of nearby suppliers	
	4. Procurement planning, execution and supply controlling	Minimization of purchasing volume	
		Combined purchasing	
		Electronic document management with organizations-suppliers	
		Selection of delivery modes with minimal impact on the environment	
		Adjustment of the flows' parameters (quality) or need for flows	

Cumulative element (warehouse logistics)	1. Environmental design of warehouse complexes	The use of environmentally friendly material in the construction of warehouses	
		Environmentally sound spatial organization of elements of a warehouse complex	
		Optimization of warehouse capacity	
		The use of renewable energy sources	
		Thermal insulation of warehouses	
		The use of engineering systems of environmental protection	
	2. Use of environmentally acceptable handling equipments and vehicles	The use of energy - saving equipment	
		The use of the handling equipments with minimal impact on the environment	
	3. Loading/unloading and warehouse operations	Optimization of loading/unloading and warehouse operations	
		Optimization of warehouse transportation	
		Mechanization and automation of loading-unloading and storage operation	
		Vehicle engine shutdown during loading and unloading operations	
		Selection of friendly packing strategies to the environment	
	4. Material flows management	Optimization of inventory levels using inventory management systems and modern logistics concepts (JIT, Kanban, Lean Production etc.)	
		Operational control of parameters of inventory management system	
		Placement and storage of finished products and waste	
		Unitization of party shipment (consolidation of traffic)	
Transport element (transport logistics)	1. Selection of cargo delivery scheme	The selection of environmentally friendly modes of transport	
		The use of intermodal technologies and multimodal transport	
		Selection of rational basic conditions of delivery	
	2. Selection of environmentally friendly vehicles	Vehicles with the least impact on the environment	
		Selection of vehicles relevant requirements in the field of ecology	
		Selection of vehicles with larger carrying capacity (cargo capacity)	
		Environmentally friendly fuels and lubricants (fuels)	
	3. Transport management and transport planning	Provision of technological unity for transport and warehouse process	
		Reduction of iterations and links in the supply chain (reduction of transfer and storage points)	
		An increase in level of vehicles utilization	
		Optimization of traffic route of vehicles movement	
		Optimization of vehicles' speed	
		Decrease in the reverse empty run	
		Eco-driving	
	4. Material flows management	Consolidation of traffic flows to the directions	
		Reducing the frequency of deliveries	
		Optimization traffic flows structure	
		Operational management of material flows' parameters in order to ensure uniform load of transport infrastructure elements and decrease congestion and stocks	
Processing element (production logistics)	1. The use of ecologically acceptable raw materials	Selection of organic raw materials in the product design	
		Replacement of harmful/hazardous raw materials with less harmful in the product design	
		Selection raw materials with the possibility of their reuse and/or recycling in product design	
	2. The use of environmentally sound equipment and technologies	Energy - saving equipment and technologies	
		Equipment with minimal impact on the environment	
		Systems of environmental protection	
		Maximum utilization of raw materials with aim to minimize waste production	
	3. Industrial waste management (reverse logistics)	Waste prevention	
		Recycling and reuse of waste	
		Improvement of technologies of final disposal and waste monitoring	
	4. Technological flows management	Optimization of technological flows' parameters	
		Operational management of production processes in order to minimize the impact on the environment	
		Production in accordance with the requirements of the eco design	
	5. Work with staff	Eco-training of employees at all levels of management	
		Stimulation in the applying green methods	
		Provision of comfortable and environmentally friendly working conditions	
		Development of corporate social responsibility	

Output element (sales logistics)	1. Marketing analyses of distribution	Needs analysis in the environmental services and products	
		Analysis of the readiness of market consumption to using green technologies and solutions	
		Analysis of a distribution system from the point of view of impact on the environment	
	2. Management of packing and packaging (reverse logistics)	Decrease in the use of packaging materials	
		Eco-friendly packaging materials	
		Eco-friendly packaging materials	
		Accumulation of used packaging and tare with it further processing	
	3. Selection of distribution channels	Selection of environmentally friendly distribution channels	
		Evaluation and monitoring the environmental performance of distribution channels	
		Formation of channels and distribution network with minimal impact on the environment	
		Location of distribution centres with minimal impact on the environment	
	4. Work with consumers of products and services	Electronic document circulation in the organization of interaction with consumers	
		Stimulation of the use of green products and service	
		The use of eco-labelling	
	5. Management technology of return and reverse material flows	Reuse, reprocessing, recycling	
		Elimination of defects, repair, restoration, modernization	
		Use for charitable purposes	
		Selling through special shops	
Management element (information logistics)	1. Environmental management	Introduction of environmental aspects into the strategy of the organization	
		Implementation of programs to audit compliance with environmental requirements	
		Development of corporate social responsibility	
		Evaluation and control of environmental performance	
	2. Development and implementation of corporate information systems	ERP (Enterprise Resource Planning System)	
		CRM (Customer Relationship Management System)	
		MES (Manufacturing Execution System)	
		WMS (Warehouse Management System)	
		EAM (Enterprise Asset Management)	
		HRM (Human Resources Management)	
	3. Selection of systems for identification and positioning of rolling stock and cargo	Local positioning systems	
		Satellite navigation systems (GPS, GLONASS, BeiDou, Galileo, etc.)	
		Radio frequency identification technology	
	4. Development and implementation of intelligent transport systems	Data Mining methods	
		Methods and models of artificial intelligence	
		Methods of situational control of traffic flows and vehicles	
		Implementation of advanced information technologies (RFID, GPS, GIS, EDI, GPRS, GSM)	
	5. Development and implementation of information and communication technologies	Information Management Systems (IMS)	
		Electronic Data Interchange (EDI)	
		Freight Operation Information System (FOIS)	
		Cold Chain Logistics (CCL)	

Source: own elaboration

3. THE RESULTS OF THE ANALYSES ON SYSTEMATIZATION OF GREEN LOGISTICS METHODS AND INSTRUMENTS / *Rezultati analiza sistematizacije metoda i instrumenata zelene logistike*

The analysis of the frequency of using methods and instruments of green logistics to achieve the goals of sustainable development in elements of logistics system allows to make the following conclusions: the implementation of identified 27 methods and 104 instruments of green logistics achieves thirteen goals of sustainable development from seventeen. The highest number of instruments are implemented by management flow of logistics system (21 instruments with achievement goal' frequency equal to 164), but the smallest number of instruments implements by input element (13 instruments with achievement goals' frequency equal to 71). Indicators of instruments' number and frequency of its usage in other logistics elements are quite similar (17-18 instruments with achievement goal' frequency of sustainable development in a range of 94 to 108).

It should be pointed out that input logistics element together with output element, is a boundary element of the logistics system, providing the connection with this system and external environment. This element also determines the properties of material flow in a system and eventually defines the impact of this flow on abilities of other logistics elements to achieve the goals of sustainable development. Therefore, in our opinion, it is necessary to carry out intensive research

efforts to search and develop new methods and instruments of green logistics, specific only for input logistics element. The most number of popular instruments are applied for achieving the goals No. 8 (decent work and economic growth), No. 9 (industrialisation, innovation and infrastructure) and No. 13 (climate change).

These goals coincide with the traditional economic and infrastructure goals of logistics, but goal No. 13 corresponds to current normative-legal restrictions and requirements in the field of ecology that should observe by companies, operating on the market of logistics services. Instruments of green logistics are little used for achieving the goals No. 3 (good health and well-being), No. 4 (quality education) and No. 16 (peace, justice and effective institutions) due to indirect impact of these instruments on achieving the goals which are priority for that kind of areas such as health, education and law. Instruments of green logistics do not directly impact on achieving the goal No. 1 (elimination of poverty), No. 2 (elimination of hunger), No. 5 (gender equality) and 10 (reducing inequality). The main reason for that is solving these problems related to global and national priorities at the state level. Authors didn't identify logistics methods and instruments, ensuring direct achievement of these goals. It is necessary to carry out additional research for establishing the impact of instruments of green logistics on such common goals, as well as to develop appropriate new instruments and methods.

4. CONCLUSION / *Zaključak*

The paper has presented a new approach to achieve the goals of sustainable development at the operation of logistics and transport systems by the originally developed system of methods and instruments of green logistics. The structural-functional and system approaches are applied at the systematisation of methods involving allocation of (basic) functions of elements of logistics systems. Grouping of instruments is carried out by the purpose of each method, green logistics and taking into account the functions to pass and process logistics flows.

Application of proposed approach could be used form balanced programs of improving the sustainability and efficiency of supply chains' operation. The systematic implementation of methods and instruments of green logistics will ensure achieving the goals of sustainable development. Moreover, the developed system of methods

could assess green supply chains and its elements compatibility with principles of sustainable development, identify gaps in recommended methods. In authors opinion, further development of presented approach in the paper is to develop the mathematical apparatus allowing to globally optimise the parameters of logistics flows with the aim to ensure sustainable development of supply chains by coordinated selection and realisation of methods and instruments of green logistics.

Table 2 The analysis of usage frequency of methods and instruments of green logistics to achieve the goals of sustainable development in elements of logistics system

Tablica 2. Analiza korištenja učestalosti metoda i instrumenata zelene logistike da bi se postigli ciljevi održivoga razvoja u elementima sustava logistike

Indicators		Elements of logistics system						
		Input	Cumulative	Transport	Processing	Output	Management	Total by elements
Number of green logistics methods		4	4	4	5	5	5	27
Number of green logistics instruments		13	17	18	17	18	21	104
The sequential number of the goal of sustainable development (see tabl. 1, pat 1 of this article)	1							
	2							
	3				2			2
	4				2			2
	5							
	6	4	4		7	7	5	27
	7	5	16	16	6	11	16	70
	8	13	17	19	16	18	20	103
	9	8	17	12	17	11	21	86
	10							
	11	3	3	14	4	2	11	37
	12	9	9	2	10	10	15	55
	13	10	15	18	13	9	18	83
	14	6	4	17	13	7	16	63
	15	5	8	2	12	13	18	58
	16				1		6	7
	17	8	1	5	5	15	18	52
Frequency of instrument usage		71	94	105	108	103	164	645
Number of achieved goals		10	10	9	13	10	11	

Source: own elaboration

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