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Sustainable Urban Logistics: Analysis and Bibliometric Review

Abstract

Sustainable urban logistics is imperative in view of the increasing demands related to sustainability and the satisfaction of requirements related to sustainability, and it supports the implementation and use of solutions based on the application of electric vehicles when talking about transport logistics, ensuring all the resources necessary for the development of the basic urban process, and similar. In order to analyze the current situation related to the progress of researchers, in this paper, a bibliometric analysis of existing papers and research in the field of sustainable urban logistics was carried out. According to the findings, there is a significant lack of research dealing with urban logistics from the perspective of the supporting process, and a large number of authors summarize urban logistics solely from the perspective of transportation and storage.

Keywords: urban logistics, sustainable development, sustainable logistics, sustainable transport

1. Introduction

Urban logistics is a branch of logistics that is responsible for the normal functioning of the urban area, which means the timely delivery of a sufficient amount of resources as well as the provision of all mechanisms necessary for the normal functioning of urban processes [1]. Considering the complexity of an urban area, the demands placed on urban logistics, which must be fulfilled by urban logistics, are numerous and primarily relate to reducing negative impact on the environment, i.e., reducing negative impact on noise pollution, slowing down of traffic flows due to the transportation of resources,

etc. [2]. Considering the increasing number of inhabitants living in cities, there is an increase in the aforementioned requirements as well as an increase in the amount of resources that urban logistics must provide so that all social processes in the urban area can take place normally [3]. In addition, with the development of Industry 4.0 and increasing concerns about the pollution caused by the traffic of vehicles fueled by fossil fuels in urban areas, there is an imperative to develop new approaches to the functioning of urban logistics, which include the use of vehicles fueled by electricity, cargo bikes, etc., so, in conclusion, the development of so-called SMART logistics, which includes technologies such as the Internet of Things, Cyber Physical Systems, drones, robotic delivery systems, and other technologies [4]. The development of SMART logistics has a significant impact on the reduction of environmental pollution, whether it is the impact on exhaust gases or noise pollution. But, in addition, the development of SMART logistics has a significant impact on the creation of new jobs, the satisfaction of urban residents with logistics services, and other. All this has a positive impact on the economic component of sustainability, which is particularly influenced by the efficiency and effectiveness of the urban logistics process. Certainly, the development of SMART logistics also affects the development of smart cities since these two components are intertwined and one affects the other [5].

Despite the benefits of sustainable urban logistics in terms of a positive impact on the economic, ecological, and social components of sustainability, it is necessary to transform the existing logistics paradigm based on the use of fossil fuel vehicles, primarily due to the autonomy that such vehicles have, to the use of electric vehicles [6]. In addition, it is necessary to approach the development of infrastructure that will enable the development of operations that are an integral part of the urban logistics process, such as logistics and distribution centers within the urban area that are used for the consolidation and deconsolidation of goods, which raises the question of their optimal positioning in the urban area [7]. Likewise, it is necessary to change the organization of the delivery process itself, in the context of planning night deliveries, to create plans for sustainable urban logistics, which must be interpolated into the urban area development strategy [8]. It should be emphasized that everything described must be sustainable; that is, it must not have a significant negative impact on the components of sustainability.

Considering the importance and complexity of sustainable urban logistics, the aim of this paper is to analyze the existing achievements of the author in the field of sustainable urban logistics and to analyze the link between the functioning of the urban area and urban logistics. The work is divided into chapters. In the first chapter, an introduction to the topic and the significance of the topic are given. In the second chapter, the most important concepts are conceptually defined, while in the third chapter, the methodology is described. The fourth chapter refers to the research results, while the fifth chapter discusses the results. The sixth chapter is the concluding chapter.

2. Theoretical framework

2.1 Urban logistics

Logistics can be defined as a set of activities that are planned and directed towards meeting the requirements of interested parties and ensuring a sufficient amount of resources necessary for the normal functioning of the process. In this context, the delivered resources must be provided on time, in the right amount, and in the right place [9]. If the conceptual definition of logistics is seen in the context of the urban area, then it can be said that urban logistics is a set of activities aimed at ensuring the normal functioning of the urban area [10]. Considering the complexity of the urban area, the demands placed on logistics in the urban area are the provision of a sufficient amount of energy, water, regular garbage collection, the provision of the normal development of public urban passenger transport, etc. [11]. Thus, urban logistics is a complex term, and urban logistics itself, as such, to fulfil all defined requirements, uses a wide range of different mechanisms that can have a different impact on the environment, i.e., sustainability.

One of the fundamental challenges faced by urban logistics is the cost of the last mile, which is particularly pronounced in urban areas. The reason for this is the very nature of the urban area, which implies the need to use different modes of transport, frequent stops of the means of transport, traffic congestion caused by logistics activities, etc. [12]. The high costs of last-mile logistics must also be seen in the context of the significant impact that logistics can have on sustainability components, primarily the ecological component, and then the social component, in the context of impaired quality of life due to the operation of vehicles used in the logistics process [13]. This is a particularly significant problem for organizations that deal with the provision of logistics services since high costs can affect the profitability of the provision of logistics services; that is, they can result in an increase in the price of products and services. With this in mind, the phenomenon of last mile logistics as a service is emerging, which implies entrusting the performance of logistics services to specialized organizations or the use of privately-owned vehicles for transportation [14].

Urban logistics and the functioning of the urban logistics process changed significantly with the appearance of the fourth industrial revolution, which brought with it the appearance of drones that enable the transport of packages over short distances within the urban environment by air. The use of drones is particularly significant since drones are powered by electricity and are autonomous, which means they can be used without significant operator intervention. However, the use of drones to carry out the urban logistics process also brings with it challenges related to the potential congestion of the airspace with a large number of drones, due to which there is a risk of a drone collision and a drone falling into a populated area. However, in addition to drones, the development of Industry 4.0 also brings with it the possibility of using autonomous systems such as robots that can similarly make deliveries without the need

for significant human intervention.

It is necessary to note that urban logistics must not be viewed exclusively through the context of delivery but must also include the provision of everything necessary for the normal functioning of public administration, police, fire brigade, health organizations, educational institutions, and all other significant institutions whose functioning efficiency determines the quality of life in the urban area.

2.2. Sustainable logistics

Sustainable logistics is often associated with the term "green logistics." As such, green logistics implies closing the link between consumption and re-production; that is, it is the basis for creating a circular economy [15]. In other words, green or sustainable logistics implies the collection of used products and their return to processing areas, i.e., recycling, so that they can be used again for the production process. However, green logistics does not refer exclusively to what has been described but also refers to the application of sustainable modes of transport, which implies the use of electric vehicles as the dominant means of transport [16], which is a particularly significant trend when it comes to last-mile logistics. Furthermore, "green logistics" also refers to a different organization of transport in urban areas, which implies the use of privately-owned vehicles. Examples of this are business models that include the use of bicycles and electric scooters for food delivery and also the use of them for package delivery [17]. This approach greatly reduces the load on the road with transport vehicles and significantly positively affects the economic component of sustainability, since it increases the engagement of residents of the urban area, which means greater business activity. However, it should be emphasized that such services often imply the need to use a car, especially in cases where the distances between the starting point of delivery and the end user are significantly long.

Sustainable logistics also refers to the possibility of using kiosks where packages can be left, and such kiosks are often located in the areas of large shopping centres, i.e., areas with a high turnover of people. This allows users to pick up the packages they ordered themselves, which reduces the need for transportation, i.e., the use of a vehicle to deliver the ordered packages to users. This type of sustainable logistics implies organizational changes that are particularly significant if we talk about a different definition of the itinerary, which refers to the delivery of packages, i.e., all resources in the night hours when there are significantly fewer cars on the road, which also means less traffic congestion [18].

It should be emphasized that sustainable logistics also refers to the different functioning of procedures within the process itself, which implies digitalization. Through digitization, the need for paper is reduced, which can cumulatively significantly affect environmental pollution due to the need to use a significant amount of paper for printing documents. The same applies to the recycling of paper such as cardboard or wrapping,

which is often used as one of the means for packaging and is expressed in storage systems [19]. Therefore, sustainable logistics must be viewed in a systematic way, which implies an analysis of all activities and the impact that the activities performed within the logistics process have on sustainability and sustainability components.

Sustainable urban logistics primarily refers to recycling and creating the basis for the creation of a circular economy and the use of transport vehicles that do not have a significant negative impact on the environment. Furthermore, sustainable urban logistics also refers to a change in the logistics paradigm, which primarily involves the engagement of people who will use their privately-owned vehicles for delivery.

3. Methodology

The research was conducted by analysing literature references indexed in the WOS database in the period from 2003 to 2022 according to the key words "Urban logistics" and "Sustainability". A total of 974 papers were included in the research, of which 748 were scientific papers, 17 book chapters, 16 early access articles, 144 proceedings papers, and 49 reviews. The analysis identified that the average interest of researchers in the field of urban logistics is growing by 26.5% per year. Out of the total number of papers included in the research, 29.88% of the papers were created through international collaboration of authors, while the average number of authors per paper is 3.99. The average number of citations per work is 12.47, and the average age of works is 3.52.

The research methodology is shown in Figure 1. It should be emphasized that when conducting research, the parameters of productivity of countries, productivity of authors, journals in which the most papers are published, analysis of papers according to their contribution, and ultimately mutual cooperation between authors should be taken into consideration.

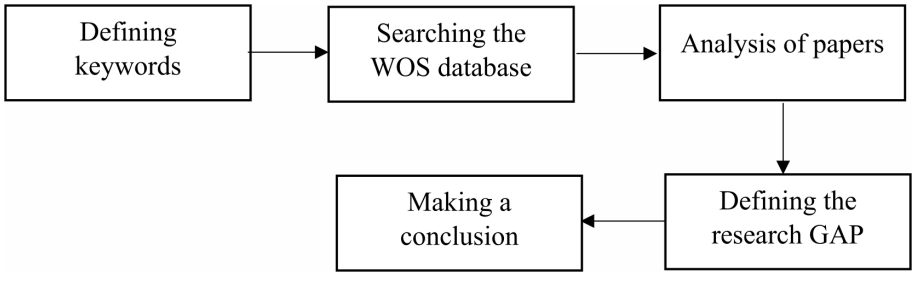


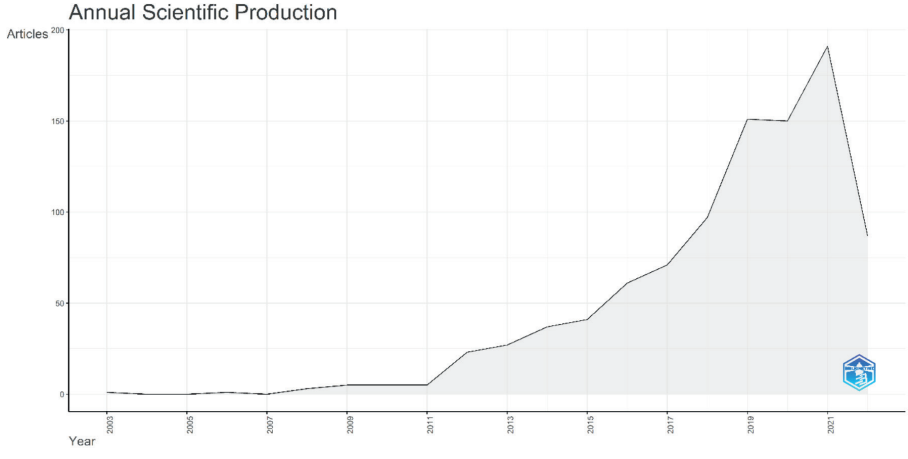
Figure 1. Research methodology

The "R" programming language with bibliometric addition was used to conduct the research.

4. Research results

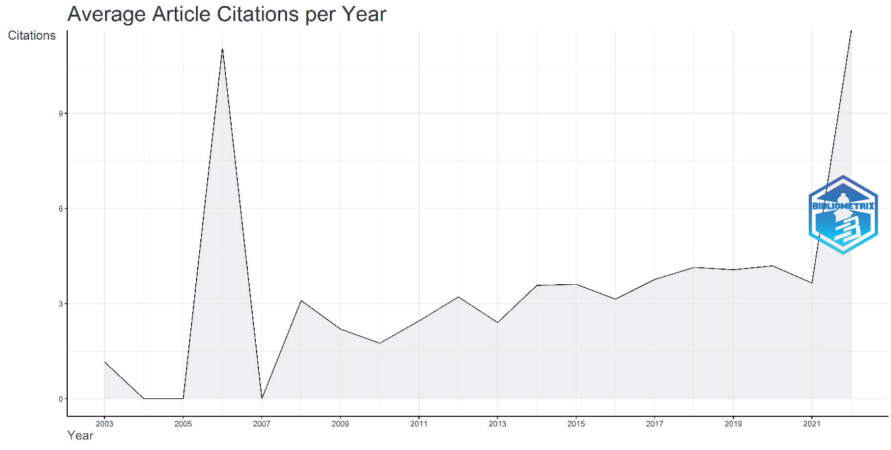
4.1 Trend analysis

Graph 1. shows the analysis of the average number of researches produced in the period from 2003 to 2022. As can be seen, the total number of researches produced in the observed period is growing, and it can be stated that the interest of researchers in the field of sustainable urban logistics is growing, which can be commented on by the fact and imperative of sustainability imposed by climate change as well as the goals of sustainable development defined by the UN. It should be emphasized that a visible decline was recorded in 2021, while data for 2022 is not yet available for the entire year.



Graph 1. Annual Scientific production

Graph 2. shows the average citation of researches. It is evident that the number of total citations by authors is increasing in the period from 2003 to 2021, and that there is a significant peek of the total number of citations recorded during 2006.



Graph 2. Average Article Citations per Year

4.2 Source analysis

Table 1. shows the analysis of journals in which the authors publish the most works in the field of sustainable urban logistics. It can be seen that the journal with the largest number of published papers is Sustainability (341), followed by Sustainable cities and society (17) and Journal of cleaner production (14). It should be emphasized that all journals, regardless of their order in the table, have the same importance in the case when they have the same number of papers.

Table 1. Source analysis

Sources	Articles
Sustainability	341
Sustainable Cities and Society	17
Journal of Cleaner Production	14
Energies	9
Environment Development and Sustainability	9
Science of the Total Environment	9
Transportation Research Part D-Transport and Environment	9
Seventh International Conference on City Logistics	8
European Transport Research Review	7
Journal of Transport Geography	7

4.3 Author's analysis

When conducting author's analysis, Table 2. shows the analysis of the most productive author's in the field of sustainable urban logistics. Yiming Wang stands out as the author with the largest number of researches with a total of 16 articles and articles fractionalized 3.54. The second most productive is Antonio Comi, who has a total of 14 papers and article fractionalized 5.78. It should be emphasized that authors who have the same number of papers have equal importance regardless of their position in the table.

Table 2. Author analysis

Authors	Articles	Articles Fractionalized
Yiming Wang	16	3.54
Antonio Comi	14	5.78
Cathy Macharis	14	4.33
Yong Liu	12	2.30
Xuefeng Wang	12	2.79

4.4. Analysis of productivity of institutions

The analysis of productivity of institutions is shown in the table. "Maritime University of Szczecin" from Poland stands out as the institution with the largest number of papers with a total of 28 papers, while "Vrije Universiteit Brussel" from Belgium is in second place with a total of 27 papers. In third place is "Beijing Jiaotong University" from China with a total of 25 papers. It should be emphasized that institutions have the same importance regardless of their position in the table in the context of the number of papers they have published.

Table 3. Most productive institutions

Affiliation	Country	Articles
Maritime University of Szczecin	Poland	28
Vrije Universiteit Brussel	Belgium	27
Beijing Jiaotong University	China	25
Università degli Studi di Roma Tor Vergata	Italy	24
Universidade Federal de Minas Gerais	Brazil	20
University of Thessaly	Greece	20

4.5 Citation analysis of countries

The table shows the citation analysis of countries. It is evident from the table that the country with the largest number of citations is China, with a total of 1,725 citations and an average citation per paper of 10.03. In second place is the USA, with a total of 1,239 citations and an average number of citations per paper of 14.75. Third place is taken by Italy, with a total of 1,218 citations and an average number of citations per paper of 16.25.

Table 4. Most productive countries

Country	TC	Average Article Citations
China	1725	10.03
USA	1239	14.75
Italy	1218	16.24
Netherlands	752	37.60
Belgium	597	21.32

4.6 Analysis of citations of papers

The table shows the analysis of the papers with the highest number of citations and the contribution that each paper has. The work entitled "Exploring Industry 4.0 technologies to enable circular economy practices in a manufacturing context: A business model proposal" has the largest number of citations in the observed period, with a total of 225 citations, followed by "Sustainable urban transport: Four innovative directions" with a total of 177 citations. The paper "Factors influencing bike share membership: An analysis of Melbourne and Brisbane" with a total of 175 citations is in third place in terms of the total number of citations.

Table 5. Analysis of the papers

Name of paper	TC	Contribution
Exploring Industry 4.0 technologies to enable circular economy practices in a manufacturing context: A business model proposal [20]	225	In the paper, the authors analyse the impact that Industry 4.0 has had on the development of the electronic industry as well as the management of electronic waste. In the paper, the authors present a model that is the basis for the development of return logistics, i.e., the collection and reuse of used products from the field of electronics.

Sustainable urban transport: Four innovative directions [21]	177	In the paper, the authors analyse the possibilities of implementing sustainable transport systems and describe the possible directions of development, namely the development of a new type of mobility in the urban area, the development of urban logistics, and the development and implementation of intelligent management systems, and consider how the described affects life and the quality of life in the urban area.
Factors influencing bike share membership: An analysis of Melbourne and Brisbane [22]	175	In the paper, the authors analyse the variables that influence the respondents' motivation to use and share electric bicycles. The authors come to the realization that one of the basic motivators for using electric bicycles is the existence of a charging station for electric vehicles, that is, a space where electric bicycles can be left and picked up later.
Location selection of city logistics centers under sustainability [23]	152	In the paper, the authors analyse the optimal location of logistics centres within the urban area in order to be able to meet the demands of interested parties in order to ensure fast and high-quality delivery of packages. The authors use fuzzy logic to carry out the analysis and show the impact that the location of logistics centres in an urban area has on the components of sustainability.
A hybrid approach integrating Affinity Diagram, AHP and fuzzy TOPSIS for sustainable city logistics planning [24]	125	Using operational research methods, the authors analyse the optimal positions in urban areas for the construction of logistics centres. They emphasize that it is necessary to first define the criteria that will be used and their weighting values, and only then approach the evaluation of the location. The paper defines a new model of area potential analysis that has been tested in practice.

Challenges in urban freight transport planning – a review in the Baltic Sea Region [25]	120	In the paper, the authors analyse how urban freight transport affects the sustainability of the urban area and emphasize that there is a negative impact, i.e., how it is necessary to separate the transport of large quantities of freight from the urban area and the construction of centres that will be used as a basis for transporting packages in smaller units to the urban area.
Crowd logistics: an opportunity for more sustainable urban freight transport? [26]	117	In the paper, the authors present the possibility of using cars to transport packages in urban areas. They analyse the capacity and capacity utilization of cars and conclude that there is significant potential for the use of privately-owned cars in the context of urban logistics.
Home Delivery and the Impacts on Urban Freight Transport: A Review [27]	113	Research is analysing how increased consumption in urban areas affects the phenomenon of increased demand for logistics services and how the increase in vehicles used to transport packages affects environmental pollution in urban areas is published.
A Review of Last Mile Logistics Innovations in an Externalities Cost Reduction Vision [28]	112	In the paper, the authors analyse innovative technologies and innovative approaches that can be used in the last mile. They conclude that there is a significant negative impact that last-mile transport has on the urban area. They come to the realization that the costs of the last mile can be reduced through the development of innovative vehicles, a different organization of transport in the urban area, and by involving the inhabitants of the urban area in transport, that is, by creating cooperative urban logistics.
Delivering Goods in Urban Areas: How to Deal with Urban Policy Restrictions and the Environment [29]	105	The authors analyse the challenges that arise due to restriction policies and those related to the delivery and transport of goods in urban areas. They come to the realization that fossil fuel vehicles have significantly greater restrictions compared to vehicles powered by electricity and that significantly larger vehicles have restrictions due to their size compared to smaller vehicles that are often electric.

City characteristics and urban goods movements: A way to environmental transportation system in a sustainable city [30]	85	In the paper, the authors conduct an analysis through simulation of the influence that the size of the urban area has on the functioning of urban logistics, that is, the characteristics of urban logistics. They come to the realization that with the increase in demand for logistics services comes an increase in the total amount of carbon dioxide produced by burning fossil fuels.
Concepts of city logistics for sustainable and liveable cities [31]	83	The paper emphasizes the need and importance of using information and communication technologies to influence the attitudes of logistics managers towards the engagement of public-private partners to ensure the normal functioning of the urban logistics system. In addition, the authors presented a system of urban logistics based on the PDCA method; that is, they emphasized the development of a system of urban logistics consolidation centres.
Urban freight demand forecasting: A mixed quantity/delivery/vehicle-based model [32]	72	The paper analyses the variables that have a significant impact on the demand for goods, that is, determines the amount of cargo that will pass through the urban area. The paper presents models that can be used to perform predictive analyses and which can become the basis for developing plans and adapting infrastructure.
Impact of drone delivery on sustainability and cost: Realizing the UAV potential through vehicle routing optimization [32]	67	The authors consider the possibilities that the use of drones has in package delivery. The paper emphasizes the advantages of using such systems and explains how the use of such systems, along with the proper optimization of transport routes, can have significant benefits for reducing the negative impact that urban logistics can have on sustainability and sustainability components.
Impact of the use of electric vehicles in collaborative urban transport networks: A case study [33]	64	The authors review and investigate the impact of electric vehicles on the transport of packages in urban areas, in the context of the existence of a fleet of electric vehicles used for transport. The paper presents a case study and describes the advantages and benefits of using electric vehicles in the context of urban logistics.

Through the analysis of the most significant papers, i.e., the papers with the largest number of citations, it was identified that the largest number of researchers are engaged in the analysis of the layout of logistics centres in urban areas and the selection of the optimal location that will enable the satisfaction of all the requirements of interested parties without negatively affecting sustainability. A particularly significant work is the work [26] that can change the paradigm of logistics since it includes the residents of the urban area in the logistics process itself, i.e., the work [22], considering that it can be used as a basis for understanding the fundamental motivators that influence the use of public bicycles and sharing of means of transport, which reduces traffic congestion and can affect urban logistics. In addition, the paper [32] should also be mentioned, which examines the possibility of predictive analysis, which is particularly important for planning and creating plans for sustainable urban logistics.

4.7 Research GAP

Through the analysis of the papers, it was identified that an insufficient number of authors analyse the plans of sustainable urban logistics and that the majority of authors deal with looking at the logistics of the last mile and the costs that logistics of the last mile has. In the same way, it was identified that an insufficient number of authors are concerned with looking at logistics from the aspect of supporting activities of the urban area; that is, that the majority of authors focus exclusively on looking at transport logistics, which represents a significant problem since logistics as such is a much broader term in relation to transport and storage, and especially if we are talking about urban logistics.

It was also identified that an insufficient number of authors deal with the field of air transport in urban areas using drones, as well as the standardization of the field of air transport. Standardization is of particular importance since the increase in the number of aircraft in the air can lead to airspace congestion, which will result in significantly greater risks for drones and the citizens of urban areas. There is no doubt that there is an interest of researchers for the inclusion of residents of urban areas in the functioning of urban logistics, i.e., transport itself, which is certainly a particularly important area that can influence the increase in the sustainability of urban areas.

Therefore, the basic research gap refers to the under-researched area of creating sustainable urban logistics plans and implementing sustainable urban logistics plans in the city development strategy. The plan of sustainable urban logistics is particularly significant in infrastructural and other measures that can be the basis for ensuring the normal functioning of urban logistics and imply an investment cycle in acquiring the necessary equipment, i.e., adjusting the existing infrastructural state.

5. Discussion

Based on the conducted research, it was identified how the authors recognize the importance of urban logistics and how they emphasize the importance of optimizing routes in order to reduce the cost of the last mile as much as possible. Likewise, the authors emphasize the importance of using electric vehicles that replace conventional vehicles that use fossil fuels for propulsion. However, it was identified that urban logistics is exclusively seen in the context of ensuring delivery, i.e., resources, without seeing it as a supporting process for urban processes. This is a significant problem since logistics, as such, is a supporting process responsible for the efficient running of the core process.

If we look at the division of logistics emphasized and described by [35], it is evident that logistics can be divided according to sectors, and therefore urban logistics contains several different sectors within it, such as the fifth sector, that is, the quaternary and tertiary sectors. In other words, urban logistics implies security logistics, which can include police logistics, fire department logistics, health logistics, and other. Furthermore, if we look at the tertiary sector, i.e., primarily trade and trade logistics; within trade logistics, transport logistics can be identified as one of the components, since it is necessary to ensure the timely delivery of a sufficient amount of goods for the normal functioning of trade.

Based on everything described, urban logistics represents a dynamic system that is interpolated within the urban area and its component that enables the efficient development of all processes, so there is a need to define a new paradigm of urban logistics, which by its nature will be a much broader concept in relation to the previous understanding and the previous paradigm. Such a paradigm can be symbolically represented by Figure 2., where it is visible how the logistics processes are directed vertically upwards and refers to the satisfaction of the requirements of all interested parties in the urban area. So, processes in urban areas are subject to a wide range of requirements that can be related to the safety of moving around the city, ensuring a sufficient amount of food for stores, ensuring the delivery of packages, and similar. All the mentioned requirements determine the perception of the quality of life in the urban area; that is, life satisfaction, which urban logistics is responsible for ensuring.

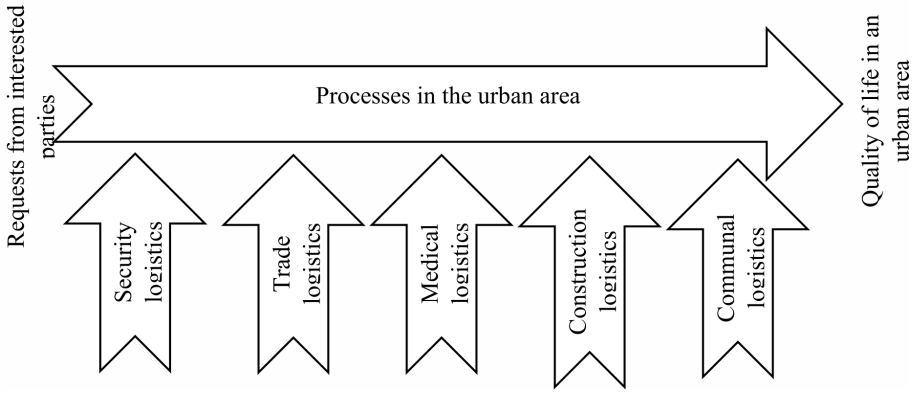


Figure 2. Urban area processes

When discussing urban logistics in more detail, within each of the logistics involved in urban logistics, mechanisms can be defined that affect the sustainability of each branch of logistics, and such mechanisms can include the use of drones for package delivery, the use of electric bicycles, the use of last-mile logistics as a service, and similar. However, it is necessary to emphasize that the mechanisms that will increase the sustainability of logistics depend on the type of logistics that is considered, as well as on the demands of interested parties that are placed on the basic process in the urban area, and for the normal functioning of which individual branches of logistics must provide resources to ensure the efficient development of the process. Therefore, the efficiency assurance mechanisms and their sustainability in all components of sustainability depend on the requirements.

An example of this should be medical logistics, which is primarily responsible for ensuring the social sustainability of the urban area. On the other hand, construction logistics is responsible for ensuring environmental sustainability since timely waste removal is imperative in order to reduce the negative impact on the ecological component of sustainability. The same applies to communal logistics, which is responsible for ensuring ecological and social sustainability.

When discussing plans for sustainable urban logistics, such plans must contain infrastructural measures that include defining locations where urban logistics centres will be built and where goods will be deconsolidated. Such centres should be located near traffic junctions, i.e., at the entrances to urban areas, in order to avoid the entry of heavy vehicles into the urban area. Furthermore, it is necessary to define the urban logistics policy, which implies the determination of delivery for all business entities, i.e., the time at which delivery will be made, the type of packaging that will be used, the type of means of transport that will be used, etc.

6. Conclusion

Through the research, it was identified that there are a large number of researches that viewed urban logistics in a partial way, which implies looking at logistics exclusively through the aspect of delivery. Partial insight leads to wrong conclusions about the way the system functions, which can result in later insufficiently good decisions that can imply the later performance of the entire system. There is no doubt that urban logistics is a dynamic system that is extremely complex and has a significant impact on the functioning of the system. Insufficiently effective development of the urban logistics process can also imply a decline in the quality of life in the urban area, i.e., it can affect the potential dissatisfaction of the inhabitants of the urban area.

The fundamental conclusion of this research is that it is necessary to change the paradigm of the previous perception of logistics and that logistics must be viewed significantly more broadly than the existing perception of logistics. This is also a recommendation for future researchers in this area, who are recommended to take a closer look at sustainable urban mobility plans and define strategies instead of operational plans that only include the implementation of partial solutions in the system. Strategic thinking, on the other hand, includes long-term infrastructure planning that will enable the transformation of the existing way of securing resources into a sustainable one.

This research has limitations that are primarily visible in the focus exclusively on the WOS base as well as the potential subjectivity of the author with regard to the works that were chosen as the most significant works, which were commented on and described in the paper.

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