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Modeling Sustainable Urban Logistics Plans (SULP): Integrating Theoretical Foundations, Economic Practice, and Socio-Environmental Dimensions

Abstract

Research background and purpose: Contemporary cities are facing increasing economic, social, and environmental challenges caused by rapid urbanization and the concentration of populations in urban areas. These dynamics intensify freight transport, leading to traffic congestion, air pollution, greenhouse gas emissions, and traffic accidents. Therefore, cities must seek sustainable solutions to improve freight flows and reduce negative externalities. The aim of this study is to establish the basis for a Sustainable Urban Logistics Plan (SULP) for Częstochowa. The primary objective is to define the purpose and scope of sustainable urban logistics while addressing key economic, social, and environmental goals. The study aligns with legal frameworks and aims to support the development of energy-efficient and environmentally friendly logistics systems.

Design/methodology/approach: The research methodology includes a strategic review of regulations, scenario development, and identification of urban mobility priorities. The study involves analyzing the current state of logistics in Częstochowa, evaluating the integration of various transport modes, and proposing intelligent and sustainable logistics solutions. The concept also includes a promotion plan to raise awareness and encourage stakeholder engagement, as well as a proposed business model and implementation strategy.

Findings: Key findings indicate that sustainable urban logistics requires a comprehensive, systemic approach based on data analysis, intermodal integration, policy alignment, and collaboration among stakeholders. The research underlines the importance of long-term vision and coordinated actions in developing effective logistics solutions.

Value added and limitations: The added value of this study lies in its structured approach to creating a tailored SULP for Częstochowa. While the current work is conceptual, it forms a solid foundation for further detailed research and empirical studies necessary for the full implementation of a sustainable logistics strategy in the city.

Keywords: *modeling, SULP, urban transport management*

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1. Introduction

Contemporary cities and urban areas face numerous economic, social, and environmental challenges arising from their dynamic development in recent years (Mitlin & Satterthwaite, 2014). As statistics indicate, the human population is increasingly concentrating in cities (Satterthwaite, 2007). By 2050, it is projected that approximately 68% of the global population will reside in urban areas, presenting cities with new challenges related to ensuring sustainable development (Hall, 1999; Un-Habitat, 2008). In light of this trend, cities are seeking solutions and methods to improve freight flows, as freight transport crosses many boundaries, often generating undesirable effects related to traffic, including congestion, air pollution, greenhouse gas emissions, road accidents, and other negative consequences. One of the most effective approaches to addressing these challenges is the development and implementation of a Sustainable Urban Logistics Plan (SULP) (Macário et al. 2023). SULP is a strategic document aimed at optimizing freight transport in cities, minimizing its negative impact on the environment and society while simultaneously supporting economic growth (Fossheim & Andersen, 2017). This plan integrates aspects of transport management, urban planning, and modern technologies to create more efficient and eco-friendly logistics systems.

The purpose of this article is to present the principles of creating and best practices for generating SULP. The article will discuss the theoretical foundations behind the concept of sustainable urban logistics, as well as practical examples of implementations from various cities around the world. Specific steps that should be taken during the development of SULP will be outlined, including preliminary analysis, modeling, evaluation and selection of solutions, as well as planning and monitoring of implementation. In the context of the city of Częstochowa, which serves as a case study in this article, specific logistical challenges and proposed solutions that can be applied within the SULP framework will be presented. Częstochowa, like many other medium-sized cities in Poland (Matusiewicz et al. 2019; Matusiewicz, 2019), struggles with issues such as traffic congestion, air pollution, and the need to integrate different modes of transport.

The principles and practices presented in this article aim not only to provide a theoretical understanding of the topic but, more importantly, to deliver practical tools and guidelines for decision-makers, urban planners, and other stakeholders involved in the process of creating sustainable urban logistics. Through in-depth analysis and the presentation of concrete examples, this article aims to support cities in their pursuit of a more sustainable future.

2. Theoretical Assumptions, Economic Practice, and Socio-Environmental Dimensions - literature review

In the literature on sustainable urban logistics, theoretical assumptions dominate, focusing on the integration of the three main pillars of sustainable development: economic, social, and environmental (Maltese et al. 2023; Bosona, 2020). This theory posits that effective management of urban freight flows can bring not only economic benefits but also contribute to improving residents' quality of life and environmental protection (Arvidsson et al. 2013; Morfoulaki et al. 2016). The first significant element is the economic aspect. As noted by Badami and Haider (Haider & Badami, 2010), sustainable urban logistics can reduce operational costs for businesses by optimizing delivery routes, reducing fuel consumption, and decreasing the number of trips. Contemporary research, such as the work of Rodrigue (Rodrigue & Notteboom, 2020), suggests that investments in logistics infrastructure, such as freight consolidation centers, can significantly increase the efficiency of urban freight transport (Nordtømme, 2015; Thompson & Taniguchi, 2017). On the other hand, the social aspect of sustainable urban logistics focuses on minimizing negative impacts on residents, such as noise, air pollution, and traffic congestion. Geels (2012) highlights that promoting alternative modes of transport, such as cargo bikes or electric vehicles, can contribute to improving the quality of life in cities. Moreover, the introduction of low-emission zones, as seen in London, demonstrates that such measures can significantly reduce pollution levels and improve public health. The environmental aspect is equally important in the context of sustainable urban logistics. As Banister (Givoni & Banister, 2013; Banister & Anable, 2009) points out, freight transport accounts for a significant portion of CO2 emissions in cities. Therefore, it is necessary to implement solutions that reduce the environmental impact of logistics. Examples of best practices include the development of infrastructure for electric vehicles, supporting green transport corridor initiatives, and using intelligent traffic management systems that optimize freight flows and reduce emissions (Barth et al. 2015). The literature analysis also highlights the importance of cross-sector collaboration and a multi-level approach to urban logistics planning. Holguín-Veras (Holguín-Veras et al. 2013) emphasizes that effective logistics strategies require the involvement of municipal authorities, private enterprises, and local communities. This cooperation is crucial for implementing innovative solutions that can meet the challenges of rapidly developing cities.

The modeling of a Sustainable Urban Logistics Plan (SULP) for the city of Częstochowa is based on theoretical and practical assumptions derived from the analysis of existing literature. The theoretical foundations of sustainable urban logistics planning encompass an interdisciplinary approach that combines economics, ecology, and management. Economic practice, on the other hand, provides examples from the actual implementation of such plans, allowing for conclusions to be drawn and recommendations to be formulated. The first important theoretical assumption is the concept of sustainable development, which involves balancing three key aspects: economic, social, and environmental. In the literature, for example, in the works of David Banister, it is emphasized that sustainable urban mobility should minimize negative environmental impacts while ensuring accessibility and transport efficiency (Banister & Givoni, 2013). Another theoretical pillar is mathematical and simulation modeling, which allows for predicting the outcomes of various planning scenarios. Models such as system dynamics, graph theory, or agent-based models are commonly used in urban logistics research. For instance, studies by Rodrigue and Notteboom (Rodrigue & Notteboom, 2013) utilize transport network modeling to analyze goods flows and highlight the benefits of route optimization and sustainable resource management. Economic practice provides numerous examples of implementing SULP in various cities around the world (Fossheim & Andersen, 2017).

Sustainable urban logistics is a key element in the development of modern cities. Implementing such plans requires not only theoretical preparation but, most importantly, practical solutions that bring real benefits to residents and the environment. Below, the author presents several examples of cities that have successfully implemented sustainable urban logistics plans (Table 1).

Table 1. **Cities and Examples of Solutions within Sustainable Urban Logistics Plans**

City	Example of a solution	Source
London	Ultra Low Emission Zone (ULEZ)	(Hajmohammadi & Heydecker, 2022) (Ding et al. 2023) (Tsocheva et al. M., 2023) (Wood et al. 2024) (Prieto-Rodriguez, 2022) (Xiao et al. 2022) (Chamberlain, 2023) (Bishop et al. 2022) (Beshir & Fichera, 2022)
Vienna	Advanced Intelligent Transport Systems (ITS)	(Götzenbrucker, 2012) (Ausserer & Risser, 2005) (Perallos et al. 2015) (Creß et al. 2023) (Weber et al. 2014) (Russo & Comi, 2023)

Amsterdam	Electric Cargo Bikes / Integrated Urban Delivery Management	(Milenković et al. 2020) (van Amstel et al. 2018) (Bell, 2021) (Arnold et al. 2018) (Narayanan & Antoniou, 2022) (Bell et al. 2022) (Moolenburgh et al. 2020) (Llorca & Moeckel, 2021) (Rudolph & Gruber, 2017) (Quak, 2008) (Van Rooijen & Quak, 2010)
Copenhagen	Integrated Public Transport System / Promotion of Bicycle Transport.	(Gössling, 2013) (Lee, 2010) (Gössling & Choi, 2015) (Zhao, 2018) (Koglin, 2015) (Wolniak, 2023) (Carstensen et al. 2015) (Larsen, 2017) (Nilsson, 2019) (Colville-Andersen, 2018) (Snizek et al. 2013)
Paris	Urban Logistics and Delivery Zones	(Heitz & Beziat, 2016) (Heitz, 2015) (Diziain et al. 2012) (Debrie & Heitz, 2016) (Dablanc, 2013) (Patier & Abdelhai, 2023) (Dablanc, 2019) (Dablanc et al. 2011) (Heitz & Dablanc, 2015) (Dablanc & Frémont, 2012)
Barcelona -	Superblocks	(Mueller et al. 2020) (Zografos et al. 2020) (López et al. 2020) (Rueda, 2019) (Rueda - Palenzuela, 2019) (Mehdipanah et al. 2019) (Nieuwenhuijsen et al. 2024) (Benavides, 2022) (De Boeck, 2025)
Stockholm	Low Emission Zone and Traffic Management	(Beevers et al., 2016) (Boogaard et al. 2012) (Bergeling, 2024) (Bernardo et al., 2020) (Lund & Wang. 2024) (Holman et al. 2015) (Boogaard et al. 2012) (Schusser, 2012)

Source: own elaboration based on the cited literature

London is a pioneer in the field of sustainable urban logistics, particularly through the introduction of the Ultra Low Emission Zone (ULEZ) (Hajmohammadi & Heydecker, 2022; Tsocheva et al., 2023). Implemented in April 2019, the ULEZ aims to significantly reduce harmful emissions. This zone enforces strict emission standards for vehicles, compelling drivers to use more environmentally friendly modes of transportation. The results of the ULEZ implementation are impressive – nitrogen dioxide levels in central London decreased by 44% within the first year (Gustafsson, 2022; Ding et al. 2023; Wood et al. 2024). This has greatly improved air quality and the health of the city's residents (Wood et al. 2024, Prieto-Rodriguez, 2022). ULEZ imposes charges on vehicles that do not meet stringent emission standards (Xiao et al. 2022; Chamberlain, 2023). Thanks to ULEZ, London has also reduced particulate matter, further enhancing air quality and public health (Bishop et al. 2022; Beshir & Fichera, 2022).

Vienna has implemented advanced Intelligent Transport Systems (ITS) that monitor and manage traffic in real-time (Götzenbrucker, 2012). ITS utilize data from various sources, including surveillance cameras, traffic sensors, and mobile applications, to optimize traffic flow and minimize congestion (Ausserer & Risser, 2005; Perallos et al. 2015). Vienna has also introduced fleet management systems that help coordinate deliveries and reduce empty vehicle runs (Creß et al. 2023). Through ITS, the city has improved traffic fluidity, reduced travel times, and cut down on pollution emissions (Weber et al. 2014). Research conducted in Vienna shows that involving residents, businesses, and local authorities in the planning and implementation process of SULP increases community acceptance and the effectiveness of the actions taken (Russo & Comi, 2023).

Amsterdam is globally recognized for its extensive use of bicycles as a primary mode of transportation, but the city has also pioneered advancements in urban logistics by integrating electric cargo bikes and electric delivery vehicles into its delivery systems. This initiative reflects Amsterdam's commitment to sustainability and its efforts to address the environmental challenges posed by urban freight transport. The introduction of electric cargo bikes and electric delivery vehicles has revolutionized the way goods are delivered in Amsterdam's city center. These eco-friendly vehicles are specifically designed for navigating the narrow streets and dense urban areas that characterize Amsterdam (Rudolph & Gruber, 2017). Unlike traditional delivery trucks, electric cargo bikes are nimble, allowing for faster and more efficient deliveries without contributing to traffic congestion. These bikes are often equipped with large storage compartments, making them suitable for transporting a wide range of goods, from parcels to groceries (Llorca & Moeckel, 2021). Electric delivery vehicles, on the other hand, offer a more substantial alternative to traditional trucks, providing the necessary capacity for larger deliveries while maintaining a low environmental footprint. Both electric cargo bikes and delivery vehicles run on electricity, which means they produce zero tailpipe emissions. This transition to electric vehicles has significantly reduced the volume of truck traffic in the city center, leading to lower CO2 emissions, decreased noise pollution, and improved air quality (Moolenburgh et al., 2020). To support the efficient operation of these electric vehicles, Amsterdam has established specialized "logistics hubs" located on the outskirts of the city. These hubs serve as transfer points where goods arriving in large trucks are consolidated and then redistributed onto smaller, eco-friendly vehicles, such as electric cargo bikes and delivery vans, for final delivery into the city center. This system not only reduces the number of large trucks entering the congested urban core but also optimizes the last-mile delivery process (Bell, 2021). The logistics hubs are strategically placed to minimize the distance between the hubs and delivery points within the city, thereby reducing the time and energy required for each delivery (Quak, 2008; Van Rooijen & Quak, 2010). This approach also allows for better coordination and scheduling of deliveries, which further reduces the overall traffic burden in the city. Additionally, by centralizing the transfer of goods at these hubs, Amsterdam can better manage and monitor the flow of goods into the city, ensuring that deliveries are made more efficiently and sustainably (Arnold et al., 2018). The combined use of electric cargo bikes, electric delivery vehicles, and logistics hubs has had a profound impact on Amsterdam's urban environment. The reduction in truck traffic has eased congestion, making the streets safer and more accessible for cyclists and pedestrians. The decrease in CO2 emissions aligns with the city's broader goals of combating climate change and achieving carbon neutrality in the coming decades. (Narayanan & Antoniou, 2022; Llorca & Moeckel, 2021). Moreover, these initiatives have set a precedent for other cities looking to modernize their urban logistics systems in a way that prioritizes sustainability and livability (Benavides, 2022; De Boeck, 2021). Amsterdam's approach demonstrates that it is possible to maintain efficient goods delivery services while also reducing the environmental impact of urban logistics, contributing to a healthier and more sustainable urban environment (Milenković et al., 2020; van Amstel et al., 2018). The success of these efforts positions Amsterdam as a leader in sustainable urban logistics, inspiring other cities to adopt similar measures.

Copenhagen has implemented an advanced integrated public transportation system that connects buses, metro, and city bikes into a cohesive network (Lee, 2010; Gössling, 2013). Electronic city cards allow easy transfers between different modes of transport, encouraging residents to opt for public transport over cars (Snizek et al., 2013). Additionally, the city invests in expanding bicycle infrastructure, making Copenhagen one of the most bike-friendly cities in the world (Wolniak, 2023; Nilsson, 2019). Copenhagen is also known for its policies promoting cycling (Gössling & Choi, 2015; Zhao, 2018). The city has created an extensive bike infrastructure, including dedicated bike lanes, cyclist bridges, and special bike parking (Carstensen et al., 2015). Copenhagen has also introduced educational programs and campaigns promoting cycling, which has increased the use of bicycles in daily transport

(Colville-Andersen, 2018). Currently, over 40% of Copenhagen residents commute by bike (Larsen, 2017; Koglin, 2015), significantly reducing car traffic and pollution emissions.

Paris has implemented a comprehensive urban logistics plan that includes the creation of special delivery zones and truck access restrictions during certain hours. The city promotes the use of electric delivery vehicles through tax incentives and access to special parking spaces. Additionally, Paris has introduced a system of "micro logistics hubs" strategically distributed across the city to enhance the efficiency of urban deliveries and reduce the environmental impact of logistics operations (Heitz & Beziat, 2016). These hubs serve as small, decentralized storage and distribution centers where goods can be consolidated and then delivered to their final destinations using environmentally friendly means, such as electric cargo bikes or small electric vehicles (Heitz, 2015; Diziain et al., 2012). This system significantly decreases the need for large trucks to enter the city center, which helps reduce congestion, lower emissions, and improve air quality (Debrie & Heitz, 2016). The micro logistics hubs are designed to optimize the last-mile delivery process, which is often the most challenging and costly part of the supply chain (Dablanc, 2013). By situating these hubs close to high-demand areas, Paris can minimize the distance and time required for deliveries, making the process more efficient and sustainable (Patier & Abdelhai, 2023). This approach not only supports the city's goals for reducing carbon emissions but also aligns with broader initiatives to promote livable urban spaces by reducing noise and traffic associated with large delivery vehicles (Dablanc, 2019). Furthermore, the implementation of micro logistics hubs in Paris is part of a broader trend in urban logistics, where cities are exploring innovative solutions to manage the growing demand for e-commerce deliveries in a sustainable manner (Dablanc et al., 2011; Heitz & Dablanc, 2015; Dablanc & Frémont, 2012). The success of these hubs in Paris could serve as a model for other cities looking to balance the need for efficient logistics with environmental and quality-of-life concerns.

Barcelona has implemented an innovative urban design solution known as "superblocks" (superilles in Catalan), which represents a radical shift in how urban spaces are utilized and managed (Mueller et al., 2020). The concept of superblocks involves grouping several adjacent city blocks together, creating a larger area where car traffic is significantly restricted or even completely banned from most interior streets (Zografos et al., 2020). Vehicle traffic is redirected to the periphery of these superblocks, allowing the interior streets to be repurposed as pedestrian-friendly and cycling zones (López et al., 2020). The creation of superblocks has transformed these urban areas into vibrant public spaces, prioritizing the needs and well-being of residents over vehicular traffic (Rueda, 2019). These spaces are designed to encourage walking, cycling, and other forms of sustainable transportation, making the neighborhoods more livable and environmentally friendly. The reclaimed space within superblocks is often used for parks, playgrounds, community gardens, and seating areas, providing residents with much-needed green spaces and areas for social interaction (Rueda - Palenzuela, 2019). One of the most significant benefits of the superblock model is the substantial reduction in noise and air pollution. By minimizing car traffic, the noise levels in these areas decrease dramatically, creating a quieter and more peaceful urban environment. Additionally, with fewer vehicles on the roads, emissions from cars and trucks are reduced, leading to improved air quality and a healthier atmosphere for residents. Superblocks also contribute to a safer urban environment by reducing the likelihood of traffic accidents. The emphasis on pedestrian and cyclist priority within these zones encourages a slower pace of life and fosters a sense of community among residents. (Mehdipanah et al., 2019) Moreover, the increase in public space within superblocks supports local businesses, as people are more likely to walk or cycle to nearby shops and cafes (Nieuwenhuijsen et al., 2024). The implementation of superblocks in Barcelona is part of the city's broader strategy to combat climate change, reduce its carbon footprint, and improve the overall quality of life for its residents (Benavides, 2022; De Boeck, 2021). The success of this initiative has inspired other cities around the world to explore similar approaches to urban planning. Superblocks have demonstrated that it is possible to reimagine urban spaces in a way that prioritizes people over cars, creating more sustainable, resilient, and enjoyable cities for everyone.

Stockholm has been at the forefront of implementing innovative solutions to address urban traffic congestion and environmental challenges, notably through the introduction of low-emission zones (LEZs) and congestion charges. These measures have played a crucial role in transforming the city's transportation landscape and enhancing the overall quality of life for its residents (Beevers et al., 2016). Stockholm's low-emission zones are designated areas where access is restricted for vehicles that do not meet specific emission standards. These zones are part of the city's broader strategy to reduce air pollution and promote cleaner, more sustainable forms of transportation (Boogaard et al.,2012). Vehicles that fail to comply with the emission standards, typically older diesel cars and trucks, are either banned from entering these zones or subject to significant penalties (Boogaard et al., 2012). The LEZs are strategically implemented in areas with high pedestrian traffic, such as the city center and other densely populated neighborhoods (Bergeling, 2024). By limiting the entry of high-emission vehicles, Stockholm has significantly reduced levels of harmful pollutants, such as nitrogen dioxide (NO2) and particulate matter (PM10), which are known to have adverse effects on human health. This reduction in air pollution has been particularly beneficial for vulnerable populations, including children, the elderly, and those with respiratory conditions (Bernardo et al., 2020). In addition to low-emission zones, Stockholm has introduced a congestion charge system that targets vehicles entering the city center during peak hours. This dynamic pricing model charges drivers based on the time of day and the level of traffic congestion, with higher fees during rush hours. The congestion charge aims to discourage unnecessary car trips, reduce traffic volumes, and encourage the use of public transportation, cycling, and walking (Lund & Wang, 2024). Since its implementation, the congestion charge has led to a substantial decrease in traffic congestion, particularly during peak hours. This reduction in traffic has not only improved travel times and reduced stress for commuters but has also contributed to a significant drop in greenhouse gas emissions and other pollutants. The revenue generated from the congestion charges is reinvested into the city's public transportation system, further enhancing its efficiency and accessibility (Holman et al., 2015). The introduction of low-emission zones and congestion charges in Stockholm has brought numerous economic benefits. One of the most significant is the reduction in healthcare costs associated with air pollution-related illnesses. With cleaner air, residents experience fewer respiratory problems, cardiovascular diseases, and other health issues linked to poor air quality, leading to lower public healthcare expenditures (Boogaard et al., 2012). Moreover, these measures have contributed to an overall improvement in the quality of life for Stockholm's residents. The cleaner environment and reduced noise pollution have made the city more attractive and livable. Public spaces have become more enjoyable, and the reduction in car traffic has made streets safer for pedestrians and cyclists. Additionally, the enhanced public transportation system, funded by congestion charge revenues, has provided residents with more reliable and sustainable mobility options (Boogaard et al., 2012). Stockholm's approach to traffic and environmental management serves as a model for other cities around the world. By integrating low-emission zones with congestion pricing, Stockholm has effectively tackled the challenges of urban pollution and congestion, demonstrating that it is possible to create a healthier, more sustainable urban environment while also achieving economic gains. These initiatives are a testament to the city's commitment to fostering a greener and more equitable future for its residents (Schusser, 2012).

The practical implementations of sustainable urban logistics plans (SULP) in cities such as London, Amsterdam, Copenhagen, Paris, Vienna and Barcelona, Stockholm demonstrate that an integrated approach, considering environmental, social, and economic aspects, yields tangible benefits. Improved air quality, noise reduction, decreased congestion, and increased public space are just some of the outcomes that can be achieved through such initiatives. These cities serve as inspiring examples for other metropolises, including Częstochowa, in their pursuit of sustainable development and the improvement of residents' quality of life. Implementing SULPs is a complex process that requires the involvement of various stakeholders, as well as the application of modern technologies and innovative solutions. In conclusion, the theoretical assumptions of sustainable urban logistics are confirmed by the economic practice of many cities worldwide (Schliwa et al, 2015). The literature indicates that integrating the economic, social, and environmental aspects of urban logistics is essential for achieving sustainable development (Lagorio et al. 2016).

3. Methodology of the research

The development of the Sustainable Urban Logistics Plan (SULP) for the city of Częstochowa required a structured and interdisciplinary approach, integrating theoretical research, empirical data collection, and simulation-based analyses. Below is a revised and detailed explanation of the methodology, sources, and connections between the collected data and the developed model (Table 2).

Table 2. **Methodology for Developing the SULP for Częstochowa**

Stage of the SULP Development Process	Objective:	Methods	Sources	Output
Literature Review (February–March 2024)	Identify best practices, theoretical models, and prior studies on sustainable urban logistics to establish a knowledge base.	Systematic review of peer-reviewed journal articles, industry reports, strategic urban planning documents, and international guidelines. Comparative analyses and meta-analyses of urban logistics plans implemented in other cities.	Academic databases (e.g., Scopus, Web of Science). Publications by international organizations (e.g., OECD, UNECE). Governmental reports and urban development strategies.	A synthesized framework of sustainable urban logistics practices to inform subsequent phases of the research.
Current State Analysis (March–April 2024)	Evaluate the existing logistics infrastructure, transportation dynamics, and environmental impact in Częstochowa.	Field Studies: On-site observations of logistics operations and traffic patterns. Interviews: Conduct structured and semi-structured interviews with key stakeholders, including city officials, business owners, and residents. Data Analysis: Review and analyze transport-related data such as traffic volume, emission levels, and road safety statistics.	Field Studies: On-site observations of logistics operations and traffic patterns. Interviews: Conduct structured and semi-structured interviews with key stakeholders, including city officials, business owners, and residents. Data Analysis: Review and analyze transport-related data such as traffic volume, emission levels, and road safety statistics.	A detailed assessment of logistical challenges and opportunities within Częstochow

Modeling and Simulation (May–June 2024)	Predict the potential outcomes of different implementation scenarios for the SULP.	Cost-Benefit Analysis (CBA): Evaluate economic, environmental, and social impacts of proposed solutions. Scenario Modeling: Use simulation software to model various urban logistics configurations and their effects on traffic flow, emissions, and stakeholder satisfaction.	Transport databases and GIS data. Specialized simulation tools (e.g., AnyLogic, PTV Vissim). Literature on transport modeling methodologies.	Quantified insights into the feasibility and impact of each proposed measure, guiding decision-making.
Consulting and Public Participation (June–July 2024)	Ensure stakeholder alignment and gain public acceptance for the proposed SULP measures.	Workshops: Collaborative sessions with stakeholder groups to discuss findings and proposed solutions. Surveys: Gather input from residents on their priorities and concerns. Public Consultations: Organize forums to present and refine the SULP based on feedback. Focus Groups: Targeted discussions with key road users and businesses to address specific challenges.	Feedback from consultation platforms and workshops. Reports documenting stakeholder input.	A finalized SULP that reflects community and stakeholder needs while maintaining strategic coherence.

Source: own elaboration

The methodology for developing the Sustainable Urban Logistics Plan (SULP) was based on a complex and interdisciplinary approach that integrated various research methods, including theoretical, empirical, and simulation analyses. The process began with a literature review in February and March 2024, which enabled the identification of best practices and theoretical models in the field of sustainable urban logistics. Following this, in March and April 2024, a current state analysis was conducted to assess the existing logistics conditions in the city and to identify key problems and potentials. Based on the collected data, modeling and simulations were carried out in May and June 2024 to predict the outcomes of different SULP implementation scenarios, utilizing cost-benefit analyses. Finally, in June and July 2024, consulting and public participation were organized to gain support and acceptance from the local community and stakeholders through workshops, public consultations, and surveys.

4. Results - Modeling SULP

The research methodology and project procedure for developing the Sustainable Urban Logistics Plan (SULP) are crucial for creating an effective and efficient urban logistics plan. By employing a systematic approach that includes preliminary analysis, modeling, evaluation, implementation planning, and monitoring, it is ensured that the SULP will not only be theoretically coherent but also practically feasible and deliver tangible benefits for the city of Częstochowa. The methodology and project procedure outlined above provide a comprehensive and integrated approach to the development and implementation of the Sustainable Urban Logistics Plan for Częstochowa, aligned with best practices and the latest trends in urban logistics. The model is developed across three levels of detail (Figure 1):

- the first level comprises the main areas of action (information, support, ecology, integration),
- the second level includes the activities identified within the main areas of action (specific actions),
- the third level consists of the stakeholder groups of the Sustainable Urban Logistics Plan for the city of Częstochowa (key road users, local government units, organizations providing technical solutions, organizations providing conceptual solutions).

The model includes the main areas of action, within which further analyses were conducted to identify the activities undertaken in each area. These activities should be evaluated in the subsequent stages of implementation in terms of their significance and priority for execution. Each activity can thus be treated as a goal to be achieved in either the short or long term and as either crucial or non-essential in meeting the expectations of various stakeholders.

Within the INFORMATION area, activities were identified that allow road users to easily and almost intuitively access desired information:

- weather and road condition monitoring,
- city monitoring system including parking spot monitoring,
- information system about parking possibilities and conditions on streets,
- monitoring system in public transport vehicles paired with an app showing the current number of passengers,
- information system showing the locations of city bike stations along with the current number of available bikes,
- convenient payment in paid parking zones without the need to search for a parking meter and accurately determine the parking time, thanks to the START-STOP function,
- information and promotion campaign for telematics solutions for road users.

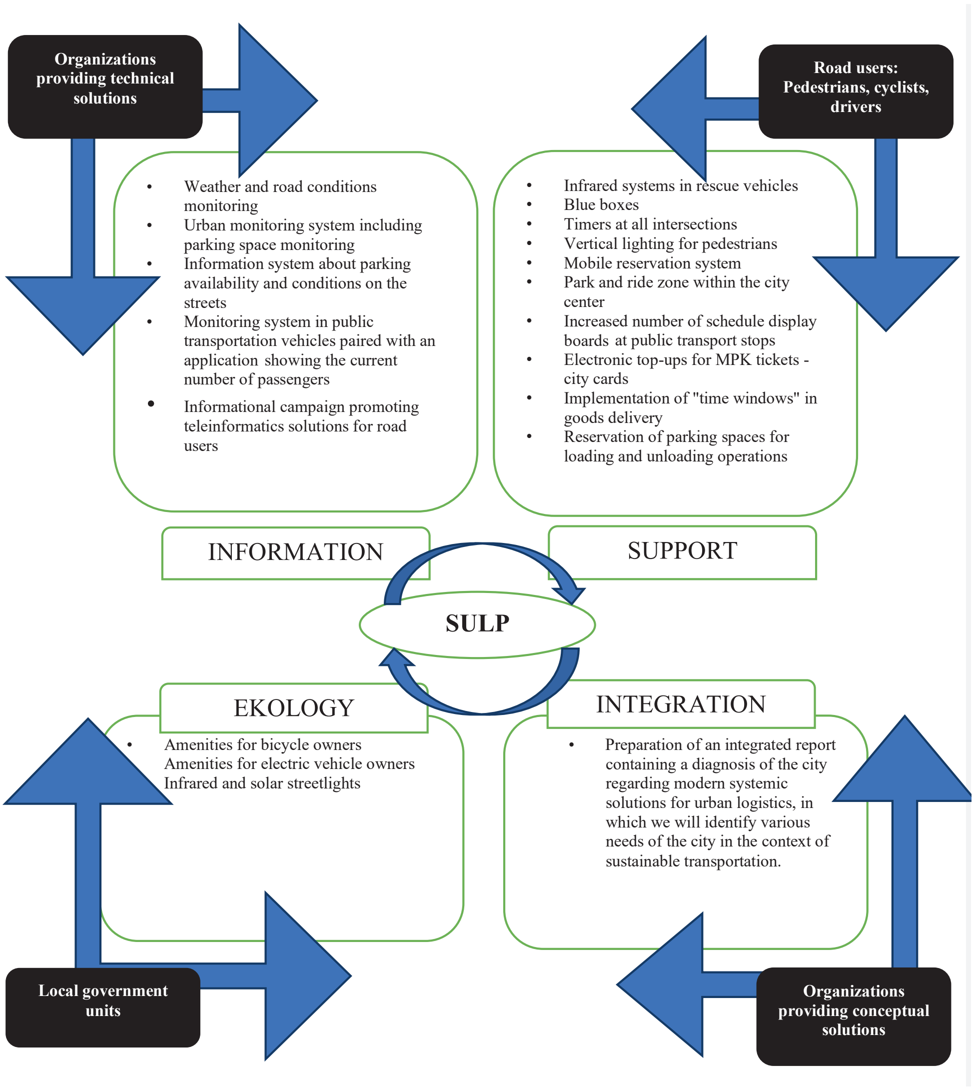

Figure 1. **Model Representation of the Sustainable Urban Logistics Plan for the City of Częstochowa**

Source: own elaboration

Within the SUPPORT area, activities were identified that, through technological advancements and new organizational solutions, will improve safety and the efficient use of roads. These include:
- actions to improve safety for pedestrian and vehicular traffic,
- infrared systems in rescue vehicles,
- blue boxes,
- timers at all intersections,
- vertical lighting for pedestrians,
- mobile reservation system for parking spots,
- park and ride zone within the central area,
- increasing the number of timetable display boards at public transport stops,
- facilitating journey planning for travelers through a mobile app with real-time updates (including traffic conditions) on the departure and arrival times of public transport vehicles,
- electronic recharging of public transport tickets - city cards,
- implementation of "time windows" for delivery operations,
- reservation of parking spots for loading and unloading operations.

Within the ECOLOGY area, activities were identified that will lead to a reduction in carbon dioxide and other air pollutant emissions:
- facilities for bicycle owners,
- facilities for electric vehicle owners,
- elimination of paper tickets for public transport and paid parking zones,
- infrared and solar-powered streetlights.

Within the INTEGRATION area, activities have been identified that will allow for greater integration and interactivity of the entire Sustainable Urban Logistics Plan (SULP) and all its stakeholders:
- preparation of an integrated document that includes a diagnosis of the city in terms of modern systemic solutions for urban logistics, highlighting various needs of the city in the context of sustainable transportation - the SULP document.

The identified areas of SULP complement and condition each other, forming a cohesive whole. All informational activities translate into specific support solutions and are inherently linked to them. It is important to emphasize that the implementation of activities in the INFORMATION and SUPPORT areas is aimed at supporting activities in the ECOLOGY area. The INTEGRATION area serves to logically connect all areas, and without its involvement, no sustainable plan or system can be realized.

The identified stakeholders (key road users, local government units, organizations providing technical solutions, organizations providing conceptual solutions) are groups interested in the implementation of the Sustainable Urban Logistics Plan for Częstochowa, and only their cooperation across divisions can lead to success. The entire process of initiating, conceptualizing, implementing, and improving the

Sustainable Urban Logistics Plan for Częstochowa involves all stakeholder groups. However, within each area, one or two key groups can be identified for that particular area.

KEY ROAD USERS are essential at the stage of identifying needs that are the source of activities included in the SULP, and they play an important role in the phase of improving existing solutions.

LOCAL GOVERNMENT UNITS are crucial throughout the entire process, from the project initiation stage, serving as the approving authority for the successive stages of the project. Moreover, as an advisory body, they directly shape the entire plan, are responsible for ecological elements, and integrate all stakeholders.

ORGANIZATIONS PROVIDING TECHNICAL SOLUTIONS are particularly important in the areas of information and support, as these entities are responsible for the technical assessment and implementation of solutions/activities that are the foundation of the SULP.

RGANIZATIONS PROVIDING CONCEPTUAL SOLUTIONS are responsible for the conceptualization of the Sustainable Urban Logistics Plan, and in terms of the areas presented in the developed model, they play a key role in the INTEGRATION area.

5. Discussion

The essence of the Sustainable Urban Logistics Plan (SULP) concept is to create a framework for the development of logistics, including transportation, with consideration for the need to identify and analyze the causes of excessive exploitation and environmental degradation, and then to gradually eliminate these causes through the implementation of appropriate solutions. These solutions aim to improve and develop logistics while addressing needs in three key areas: economic, environmental, and social. The economic area is related to increasing the efficiency of transport resources, which can both enhance capacity and reduce congestion and waste of available resources. The environmental aspect focuses mainly on reducing pollution emissions, while the social aspect is centered on solutions aimed at meeting social needs. The above-mentioned areas and their requirements guided the work on modeling the Sustainable Urban Logistics Plan for Częstochowa (Table 3). It was determined that the key priorities of the SULP for Częstochowa will be:

- increasing traffic safety and developing measures to improve street capacity,
- enhancing environmental protection by eliminating paper tickets for transportation and parking in favor of payment through a mobile application,
- creating solutions tailored to social expectations (for residents of Częstochowa, tourists, and others). The mobile application, through the integration of various communication and transport services (purchasing tickets for public transport, railways, parking, highways) in cities across the country, allows for easy movement

both within the city of residence and during tourist or business travel. An additional trip planner feature utilizing public and intercity transport facilitates convenient travel to designated destinations, even in unfamiliar cities. This service is particularly useful for tourists and students starting their studies away from their hometowns.

These priorities are reflected in the model representation of the SULP for Częstochowa.

Table 3. **Responsibilities and Implementation Plan**

Area	Responsibility for Development and Implementation	Task to be Accomplished
Information	Organizations Providing Technical Solutions Local Government Units	Weather and Road Conditions Monitoring
		Urban Monitoring System, including Parking Spot Monitoring
		Information System on Parking Availability and Conditions on Streets
		Monitoring System in Public Transport Paired with an App Showing the Current Number of Passengers
		Information System Showing Bike Parking Spots Along with the Current Number of Available Bikes
		Information and Promotion Campaign for ICT Solutions for Road Users
Support	Organizations Providing Technical Solutions	Actions to Improve Safety for Pedestrian and Vehicular Traffic
		Infrared Systems in Rescue Vehicles
		blue boxy
		Timers at All Intersections
		Vertical Lighting for Pedestrians,
		Mobile Reservation System
		Park and Ride Zone in the Central Area
		Increasing the Number of Timetable Display Boards at Public Transport Stops
		Electronic Top-Up for MPK Tickets (City Cards)
		Use of „Time Windows" for Goods Deliveries
		Reservation of Parking Spots for Loading and Unloading Operations

Ecology	Local Government Units, Road Users	Amenities for Bicycle Owners
		Amenities for Electric Vehicle Owners
		Infrared and Solar-Powered Streetlights
Integration	Organizations Providing Conceptual Solutions	Preparation of an integrated study containing a diagnosis of the city in terms of modern system solutions for urban logistics, in which we will identify various city needs in the context of sustainable transport - SULP document.

Source: own elaboration

The pace of implementing the Sustainable Urban Logistics Plan (SULP) in Częstochowa will depend on the synergy and collaboration between the identified areas of action and the involved stakeholders. The key areas—INFORMATION, SUPPORT, ECOLOGY, and INTEGRATION—complement each other, forming a cohesive whole. Information and support directly enhance ecological efforts, while integration ensures the coherence and sustainability of the entire plan, serving as the foundation of every initiative.

In the process of implementing SULP, various stakeholder groups play specific roles that are crucial for different stages of the plan's execution (Hitchcock et al. 2012). Key road users significantly influence the identification of needs and the refinement of solutions, while local government units play a vital role throughout the process, from initiation to approval of subsequent stages and integration of all stakeholders' efforts. Organizations providing technical solutions are essential in the areas of information and support, as they are responsible for technical assessment and the implementation of solutions. On the other hand, organizations providing conceptual solutions are responsible for the conceptualization of the plan, with a focus on the area of integration.

Therefore, the success of SULP implementation depends on the effective collaboration between these groups, their commitment, and their ability to harmoniously combine the different aspects of the plan (Velasquez & Piest, 2003). Implementing the plan is a complex process that requires not only cross-sectional collaboration but also an appropriate pace of action, which arises from the dynamic interaction between all involved parties.

The model for the development of the Sustainable Urban Logistics Plan (SULP) presented here demonstrates a well-structured and systematic approach, yet there are both commendable and missing elements that should be addressed to enhance its comprehensiveness and effectiveness. The existing structure, organized across three levels—main areas of action, specific activities, and stakeholder groups—provides a solid foundation. The identification of the primary areas of action (Information, Support, Ecology, and Integration) and the detailed listing of specific activities within each area ensure the model's practical orientation and relevance to sustainable urban logistics challenges. Additionally, the inclusion of diverse stakeholder groups, such as local government units, technical solution providers, conceptual solution providers, and road users, emphasizes the importance of collaboration across sectors, which is critical for the successful implementation of SULP. The model also demonstrates an alignment with ecological goals, particularly through activities aimed at reducing emissions, promoting renewable energy, and supporting sustainable transport solutions. The systematic process delineating stages from preliminary analysis to monitoring further underscores the methodical nature of the approach. Furthermore, the focus on actionable measures, such as mobile reservation systems and public transport applications, enhances the model's feasibility and practical utility. However, the model could benefit from several enhancements to address certain missing elements. First, it lacks a quantification of objectives. Defining specific, measurable targets—such as percentage reductions in emissions or improvements in traffic flow—would enable precise tracking and evaluation of progress. Additionally, the absence of a financial framework poses a significant gap; identifying potential funding mechanisms, such as public-private partnerships or municipal grants, and outlining a financial timeline is essential for practical implementation. Another key omission is a temporal framework. While the stages are outlined, the model does not provide detailed timelines or deadlines for activity execution. A phased implementation plan with milestones would enhance clarity and ensure accountability. Technological integration, though partially addressed, could be expanded to include advanced tools such as Artificial Intelligence (AI) for predictive traffic management and Blockchain for logistics transparency, thereby modernizing the approach. The model also lacks robust public engagement strategies. While public consultations are mentioned, there are no specifics on sustained engagement methods, such as participatory planning workshops or iterative feedback mechanisms. Incorporating these strategies would foster stronger community involvement and acceptance. Furthermore, a comprehensive risk assessment and mitigation plan is notably absent. Identifying potential risks, such as stakeholder resistance or technological challenges, along with strategies to address them, would improve the model's resilience. Sustainability impact assessment, another critical aspect, is not explicitly integrated into the model. Utilizing tools like Life Cycle Assessment (LCA) or Environmental Impact Assessment (EIA) would provide a deeper understanding of the long-term impacts of proposed activities, thereby strengthening the model's alignment with sustainability principles. Lastly, the model does not consider inter-urban collaboration. Exploring synergies with neighboring cities or regions, such as shared logistics hubs or inter-city freight corridors, could significantly enhance scalability and resource optimization.

In summary, while the presented model offers a robust and methodical framework for developing a Sustainable Urban Logistics Plan, addressing these identified gaps would ensure its comprehensiveness, adaptability, and alignment with contemporary urban logistics challenges. These improvements would not only enhance the practical implementation of SULP in Częstochowa but also serve as a replicable model for other cities striving for sustainable development.

6. Conclusion

The Sustainable Urban Logistics Plan (SULP) serves as a specific plan for managing urban logistics processes and designing solutions from a medium-term perspective. It is also:

- a tool for defining a shared vision, needs, and priorities,
- a tool for designing a set of appropriate measures/solutions/services,
- a tool for reducing air and noise pollution, as well as energy consumption,
- a tool for building consensus among different stakeholders,
- a tool for defining an action plan for potential institutional adoption.

A sustainable urban freight plan is a strategic plan with a detailed action plan or part of an urban mobility strategy in cities. It should be designed with a view towards sustainable urban delivery to define regional or local visions determined by stakeholders and decision-makers in cities, aiming to meet the transportation needs of people and the surrounding industry. Identified urban freight transport plans form part of the concept of a sustainable urban logistics plan. The aspect of sustainability is a strategic goal in urban logistics plans, depending on the city's specific characteristics, particularly its plans for economic growth, environmental protection, and social development.

When developing freight transport plans, special attention is paid to integrated transport planning from regional perspectives in relation to urban perspectives. Government guidelines are important in setting the goals and methodology for urban freight transport planning and serve as a basis for locally made decisions. Both the structural and organizational elements of the European SULP methodology are fundamental components of existing urban transport plans. To enhance the development of urban freight transport, the plans incorporate transportation issues within local contexts. Urban transport planning increasingly considers electromobility and the use of other alternative energy sources for transport (e.g., so-called green hydrogen). The SULP methodology is a process that should be continuously implemented. When comparing various solutions or evaluating an individual plan, periodic evaluations should be conducted to allow for adjustments if the proposed solutions do not achieve the expected outcomes.

In conclusion, this analysis provides practical recommendations that can aid in the design and implementation of a Sustainable Urban Logistics Plan (SULP) for cities like Częstochowa. First and foremost, it is crucial to adopt a comprehensive approach that integrates the three main pillars of sustainable development: environmental, social, and economic. Such an approach enables the effective balancing of stakeholder needs and the optimization of urban freight flows while simultaneously minimizing the negative impact of transport on the environment and residents' quality of life. Inspiration can be drawn from the best practices of other cities that have successfully implemented innovative logistics solutions. For example, London's introduction of the Ultra Low Emission Zone (ULEZ) significantly reduced air pollution levels, contributing to improved public health. Similarly, Amsterdam's adoption of electric cargo bikes and logistics hubs optimized the last-mile delivery process, reducing CO2 emissions and enhancing the efficiency of urban logistics. Barcelona, on the other hand, has transformed urban spaces through the implementation of superblocks, limiting car traffic and enhancing safety for pedestrians and cyclists. These innovative approaches should be adapted to the local conditions and specificities of cities like Częstochowa, which face unique transport challenges. A key element of SULP success is the collaboration of all stakeholders. The involvement of local authorities, organizations providing technical solutions, the private sector, and local communities is essential at every stage of the plan's implementation, from diagnosis to monitoring of outcomes. Additionally, the use of advanced technologies, such as Intelligent Transport Systems (ITS), is crucial for enabling real-time traffic management and optimizing delivery routes. Another essential step in SULP implementation is the establishment of monitoring and evaluation mechanisms. Regular assessments of the effectiveness of implemented solutions allow strategies to be adjusted to changing conditions and needs, ensuring their sustainability and long-term efficiency. It is also important to focus on changing user behavior through the introduction of incentives, such as tax breaks for companies adopting low-emission vehicles, and conducting educational campaigns promoting sustainable transport modes. In summary, SULP should be perceived not only as a tool for managing urban logistics but also as a component of a broader strategy for transforming cities toward sustainable development. Integration with other urban plans and striving for synergy between environmental, social, and economic aspects will enable the creation of modern, friendly, and sustainable urban spaces. Częstochowa, like other medium-sized cities, has the opportunity to become a leader in this field by implementing innovative solutions tailored to its local needs and capabilities.

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