

Review

Design of a Sustainable Last Mile in Urban Logistics—A Systematic Literature Review

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Abstract: This paper provides a systematic and up-to-date review and classification of 87 studies on green last-mile business for sustainable management. In particular, the most important study areas and results are highlighted and an outlook on future research opportunities in the field of sustainable stock management is given. Sustainability in logistics depends on many factors, and elementary differences in the orientation of the logistics sector can bring further challenges. This is shown by the number of published papers. This paper examines the literature that does not focus on courier, express or parcel delivery (CEP). For this purpose, a systematic literature search was conducted on the topic of sustainability in the last-mile business. Publications for the period from 2014 to 2021 were identified as significant. It becomes clear that the logistics industry must further differentiate itself to be able to act in a future-oriented manner. The effects of the logistics industry and the technologies used in it have far-reaching consequences for social coexistence and should therefore be included. Challenges lie not only with logistics companies, but also with consumers and government authorities. In the paper it becomes clear that the logistics concept of the last mile is applied in all forms, but the research area of one-person delivery or two-person delivery is on a different level. Here, the concept of two-person delivery will be pursued further, as it functions similarly to a CEP service provider, but the framework conditions differ greatly. The two-person loading system makes it possible to transport large and bulky goods such as furniture without the risk of damage during delivery. Furthermore, the specifics of sustainable management of the last mile as well as the limits of the topic are discussed. This should stimulate future research.

Keywords: last-mile business; urban logistics; systematic literature review; differentiation from the CEP



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1. Introduction

Online commerce allows people in the city and in the countryside to order products with the click of a mouse without leaving home. The last click of an online order often triggers the action of a large network in the value creation of a product [1]. At the end of this network is the delivery of the goods over the last mile. In this last part of the value chain, there is a high proportion of CO₂ and many decision-making factors as to what a successful sustainable last mile can look like [2,3]. Which factors are relevant for a sustainable last mile today? This business model faces sustainability challenges, especially in urban logistics, and is increasingly considered in academic disciplines [4,5]. Through the involvement of diverse stakeholders—municipalities, customers, the interested public and clients—the topic of sustainability is also being pushed [6,7]. In addition, the factors of the goods for transport with alternative vehicles must be taken into account, so the complexity is expanded by the inclusion of new interest claims of diverse stakeholders [8].

The aim of this paper is to present the characteristics of a sustainable last-mile business and to further look at what difference the literature makes between one-person and two-person delivery.

To highlight the characteristics, a systematic literature review is conducted. The reputation of the truck last-mile business model is considered to be one of the most inefficient and environmentally damaging parts of the supply chain [4,9]. Various factors are responsible for this reputation: Consumer decisions, time slots [10,11], lack of staff [12], goods in a wide variety of variations [13] and additional air and noise pollution [14–16].

A few significant aspects for the interest of science for this small part of the supply chain are: Fast development of e-commerce [3,17], growth of population [18], growth of urbanisation areas [19], integration of technology [20] and the rising importance of sustainability for the society [21]. In view of these many challenges, it seems relevant to structure the current discourse.

The literature review is quantitatively limited due to the combination of last-mile business and sustainability in different topics. To this end, the literature review will pursue the following questions: (1) How is the topic of sustainability discussed in the specialist literature over the last mile? (2) What research methods are used to analyze this area?

2. Cornerstones of the Sustainable Last Mile

The first step is to achieve a common understanding of the essential terms. The last-mile delivery business is defined as: The transport of goods from a transportation hub to the customer [22], and the business includes B2C and B2B delivery [23]. The definition of the last mile is now to be linked to the topic of sustainability. The focus of the work will be on the environmental aspect. Thus, the area to be discussed will be more in the efficiency and consistency approach [24].

Figure 1 clearly shows the way of good urban logistics. In the context of this work only the last-mile delivery is considered, beside the operation challenges: Avoidance Bullwhip effect [25], meeting customers at home at the agreed time [26], infrastructure of a city and the individual driver [12]. The business has to integrate the triple bottom line, a life cycle assessment of their services, and to have a close contact with stakeholders [27]. These new tasks show the challenge of data acquisition [28].

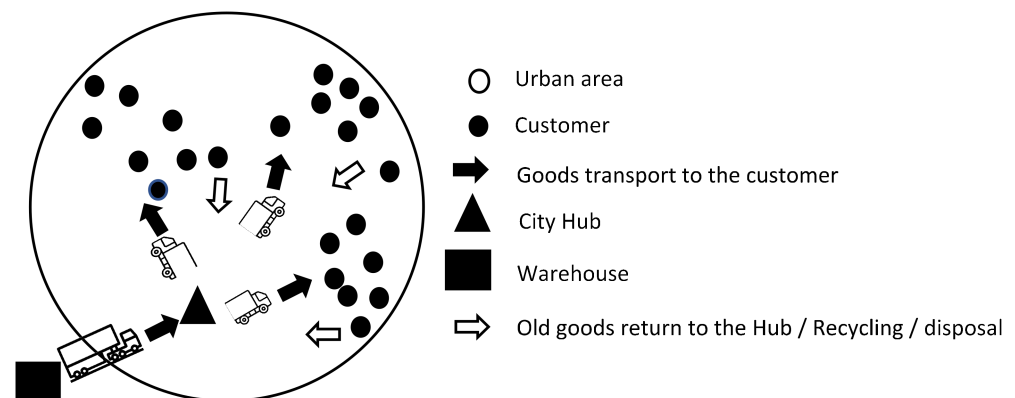


Figure 1. Transport of goods Source: Own composition based on [29].

Therefore, one major topic of this paper will define the sustainable last-mile management. The open definition makes it possible to use synonyms, e.g., green logistics or green vehicle in our analysis.

In a literature review, it is particularly important to define clear boundaries to delineate the research. During this clear delineation, the systematic literature review according to Tanfield et al. [30] can be divided into three steps: (1) Planning; (2) implementation; and (3) communication and presentation (see chapter 3). Therefore, the question is, how can we represent a sustainable last mile in the urban space? This complex activity is shaped by how the last mile is shaped in its physical distance, which is defined by practitioners [31].

Likewise, the expansion of communication within the network takes on great importance. It is no longer just communication between the customer and the trader, but the

local logistics service provider and local politics must also be included in the communication [32–36]. On the one hand, we want to bring the existing studies up to date. On the other hand, we would like to add another facet to the business model by considering the special feature of two-person transport within the text. This special feature is used in practice for heavy objects to be handled. This makes it possible to deliver large and bulky goods such as furniture, white goods, consumer electronics or leisure and garden articles professionally to the customer [37,38].

3. Systematic Literature Review

A multi-stage procedure is used for a transparent systematic literature search on sustainable last-mile logistics. Every level is part of a protocol [30,39]. In the following section, the protocol is presented, which is based on the structure of the publication by Lagorio et al. [34] and Amad Saeed and Kersten [40], to make it comparable within the scientific discipline.

3.1. Definition of Search Criteria

For this study, there is a body of literature that was used to define the research subject "last mile". The systematic literature review confirmed the gap in a coherent consideration of sustainable last-mile logistics. Below is a list of the criteria that are considered when designing a study and those that are not, as shown in Table 1. It was important to define the goods to be transported, i.e., that the goods had to be transported in a truck and that the destination could be B2B or B2C, e.g., furniture.

Table 1. Inclusion and Exclusion of criteria.

Type	Criteria	Rationale
Inclusion	Title, abstract and keywords serve as indices for a paper with a research focus on last-mile logistics in urban areas.	There is no limitation to certain journals. Due to the interdisciplinary topic, journals from other Subject area may also be important. However, it must be evident that the paper clearly focuses on the last mile in urban areas with goods transport.
	Focusing on the transport of goods.	The digital trade has greatly increased the movement of goods in urban areas. At the same time climate change makes it necessary to call for sustainable supply systems.
	Articles must be written in English.	English is the main language in the academic world, also in logistics research.
	Articles are published in peer-reviewed journals.	These papers are subject to an audited quality level.
Exclusion	Studies focusing on humanitarian logistics, tourism, shipping, feeder services, public transport, passenger transport, hospital, crisis management, agriculture, food, telecommunications network, and pure engineering for efficiency of the drive types	This review is focused on the design and the transport of goods in urban areas.

3.2. Destination of the Sample and Selection of Literature

Four databases are used for the review, Web of Science, Springer Link, Emerald insight, Wiley [35], and the process was restricted to the year 2014, but there was no restriction to specific journals or publishers. The time frame is based on the publication of Olsson et al. [4]. The analysis shows that the research focus has only prospered since 2015. All other parameters were left open to obtain the most comprehensive overview of publications possible. Of course, there is a lot of literature in the field of green logistics in the CEP service provider's research. Differences in parameters as well as business areas and requirements are considerable [4]. Therefore, it was important for us to include the definition of the good.

In line for a systematic literature review there are defined keywords as search criteria, which are created out of other literature reviews [4,40–42]. The search was carried out until the end of the year 2021. A combination of keywords was used. An illustration can be seen in Table 2.

Table 2. Search String for database search in Web of Science.

Web of Science	TOPIC: (Last Mile) AND TOPIC: (Sustainability Last Mile) OR TOPIC: (Green Vehicle) OR TOPIC: (Green Logistic) OR TOPIC: (Urban freight Transport) OR TOPIC: (Smart Cities) AND NOT TOPIC: (Public) NOT TOPIC: (Passenger) YEAR PUBLISHED: (2014–2021) AND LANGUAGE: (English)
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At the beginning of the analysis, 3,512 articles containing these keywords were identified. This large number of articles includes articles which are not focused on the key questions or were present multiple times. In a first step, duplicates are deleted. In a second step, the title, keywords, abstract and references used for a quick check were considered. This second step served to analyze whether the work was useful for the key questions. As the manual review of the literature revealed deviations from the subsequent target group, further papers were removed from the systematic literature review, for example, if the abstract is about last-mile transport but the main body mentions food transport as the target group, or if the focus of the paper is purely on traditional CEP service providers. As already mentioned, there is a wide range of literature in CEP services. This does not yet seem to be the case in two-person delivery. Therefore, the research was kept very quantitative and differentiated more precisely in the manual investigation. Thus, only papers that do not focus only on CEP service providers were considered. Furthermore, sectors in which food or passengers are transported can be excluded, because they are not transported with the goods in the last mile. The focus is placed on the transport of goods.

Here, the conditions are different from those that are usual in the transport of goods. This selection is also made by Graneheim and Lundman [43] this section is considered necessary in order to be able to answer the research question. Thus, manual evaluation is necessary and makes credibility the measure of all things. After the basic creation, exactly 87 articles were still part of the systematic analysis.

The first step of the content analysis was a descriptive dimension on how to classify the articles. The articles were assessed by a descriptive analysis: (1) How is the distribution on a timeline? (2) Which journals are important for the articles? (3) What research methods are used? (4) Which areas are affected by sustainability? These questions are based on the paper by Seuring and Müller [7]. For classification purposes, each article can only be assigned once to a category. The growing numbers of papers over the years show the development from a niche research field to an established research field, see Figure 2.

The growing number of articles published over the years shows the increasing relevance of the topic. Furthermore, there is no scientific journal that deals exclusively with the topic of sustainability in the last mile. The classic transport journals were important in this analysis: *Sustainability* (14), *European Transport Research Review* (6), *Journal of Cleaner Production* (6), *Transportation Research Part E: Logistics and Transportation Review* (4), *European Journal of Operational Research* (3), *Transportation* (3) and *International Journal of Physical Distribution & Logistics Management* (3). In total 43 cumulated journals were needed for all 87 published papers.

All 87 papers have the same main topic, but they have different ways of researching methodology concerning their aims. This paper distinguishes between five categories of research methods, (1) theoretical or conceptual publications; (2) case studies; (3) surveys; (4) modeling or simulation of last-mile business and (5) literature reviews (see Figure 3), which shows the distribution of publications on research methods. The categories were defined on the basis of [4,7].

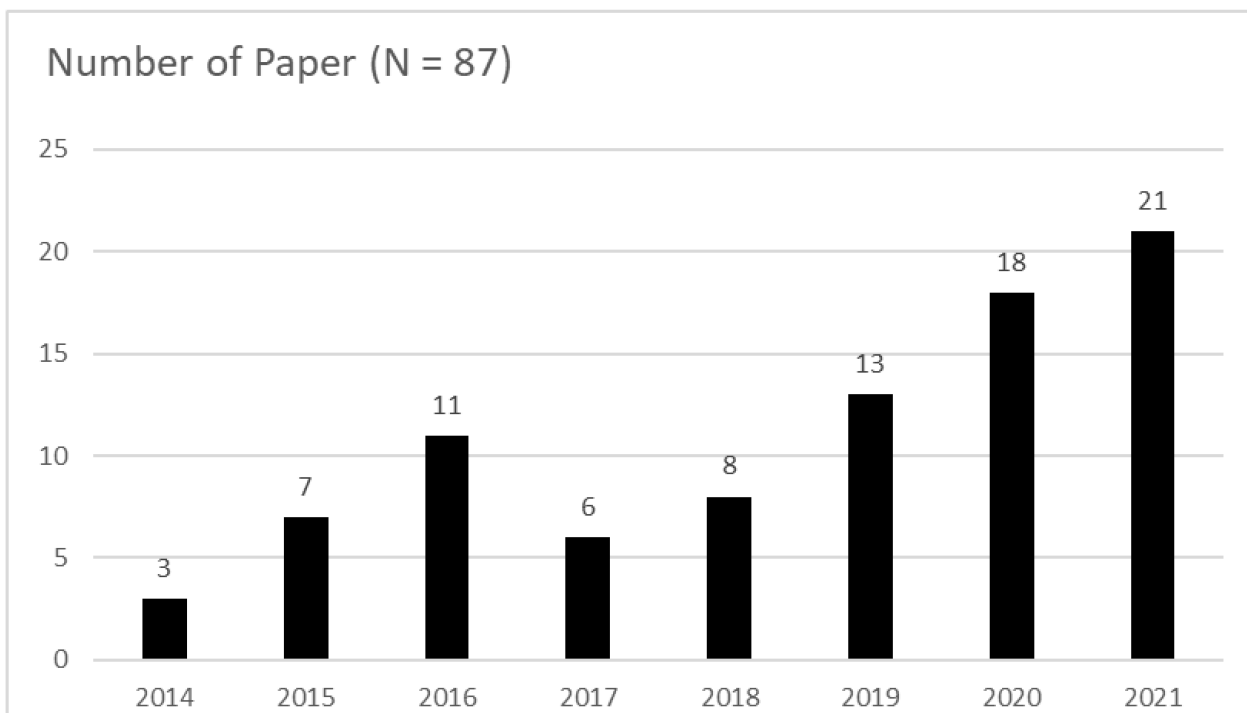


Figure 2. Distribution of published paper of a timeline.

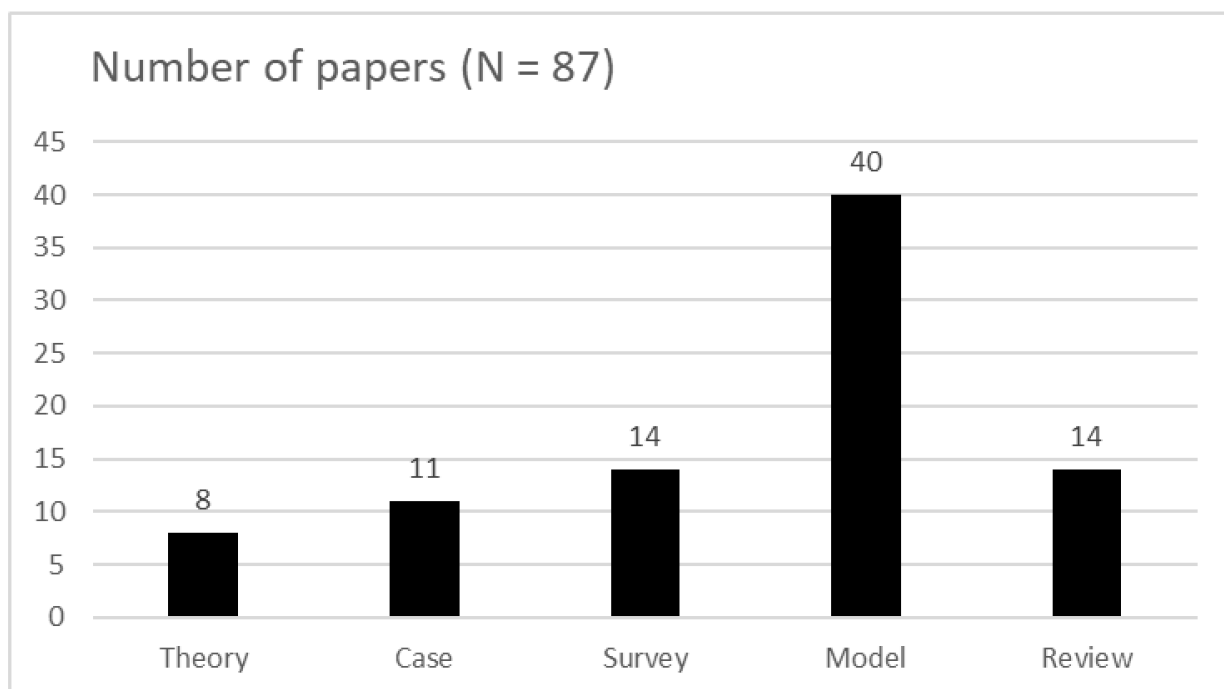


Figure 3. Distribution of published paper by research methodology.

To illustrate each analyzed paper in the bibliography, the research methodology and the handling of sustainability criteria are described. Furthermore, many papers have a multi-method approach.

3.3. Sustainable Dimensions and Literature Landscape

In this paper, the triple bottom line by Elkington [44] is divided into two categories only: Environment and social. The economic perspective is taken as the foundation because

service providers are profit-oriented companies. Moreover, the overview shows papers which handle both categories (mixed variant), see Table 3. The mixed variants focus on the strong interpretation of sustainability. Characteristic of strong sustainability is the loss of substitution possibilities for resources [45].

Table 3. Overview sustainability dimensions.

Sustainable Dimension	Number of Papers (N = 87)
Environmental	53
Social	5
Mixed variant	29

The environmental perspective is significant for the most part in the last-mile delivery. This can be due to various factors: Legal requirements especially in OECD countries [46], certification systems (ISO 14001 or EMAS) [47] and contractual commitments by the focal company [48].

3.4. Mobility Models from a Theoretical Perspective

The different methods are not questioned further, but the models are based on them. In the following, an overview of the results of the different research methods is given. Each research method is presented individually.

3.4.1. Theoretical Framework

The changes in the business model of the last mile are both in the area of effectiveness and efficiency. This is partly due to new technologies to distribute the goods, but also due to new stakeholders [49]. Due to these external factors, additional parameters are required in the route planning. This makes planning more complex and results in further routing costs. This also includes fuel, labour and battery depreciation [50,51]. The last-mile needs a new perspective through Life Cycle Assessment (LCA), as well as communication among stakeholders [51].

New technology and new methods of evaluation facilitate and improve cooperation between the logistics service provider, clients and municipalities [52]. Furthermore, the challenges of vehicle manufacturers and smart city tasks are transferred to the service providers: E-mobility, multimodality or urban planning. As a service provider, this input must be processed and adapted to the regional challenges [53,54]. In this new complexity, infrastructures, transport systems and policies and the management of logistics service provider are involved [33,55]. In the following, interviews with the stakeholders are analysed.

3.4.2. Surveys on the Design of The Last Mile

Many of the studies identified the need to strengthen stakeholder communication. This applies in particular to the logistic service provider (LSP), buyers, retailers and municipalities [43,56–63]. This communicative task does not always seem to be possible due to the activity and working circumstances on the last mile.

In order for the LSP to approach the issue of sustainability, five factors appear to be relevant: 1. Company size, 2. structure/volume of goods, 3. traffic situation, 4. pressure from customers and 5. organisational support. These are given priority over the business challenges of management: 1. Development of infrastructure networks, 2. size and composition of hybrid fleets with traditional vehicles, 3. strong limitation of the vehicles in the planning (with regard to range), 4. consideration must also be given to the charging time, which has an impact on the time windows, 5. introduction of e-vehicles or other alternative vehicles has an impact on the costs per consignment per tour [60].

In terms of sustainable delivery, some customers would pick up the order themselves or wait longer for it [2]. From a business perspective, optimising the last mile therefore seems to be much more interesting in order to achieve a sustainable impact on the last mile [64]. The integration of alternative vehicles are thus of secondary importance. Only

when the vehicles become substitutes for a conventional vehicle do they appear interesting [62,65].

3.4.3. Design of the Business Cases

The case studies show that the contribution of one LSP to the sustainable last mile is not enough, many stakeholders (for example, end customer, municipalities, vehicle manufacturers, etc.) need to be involved. Companies are dependent on feedback and cooperation [66–69]. The service providers see a particular need to catch up in the development of smart technologies on the last mile. This directly affects the vehicle manufacturers as well as the regional infrastructure [70].

In addition, alternative vehicles, especially electric mobility, increase the complexity of the routing problem [71]. Different distribution strategies are gaining in importance, especially through e-commerce [72].

At the end of the supply chain, this also means environmentally conscious driving. Employees have to adapt their behaviour to save energy and thus also costs [73]. Another conclusion is that logistics service providers see cost and time as the most important factors for their customers. Environmental issues are not yet factored in by the end consumer [74,75].

The preferences are shown in the next section. This is also evident in the surveys, although other parameters also play a relevant role here.

3.4.4. Last-Mile Model and Simulation

The surveys show that the challenges of efficiency are particularly important. It underlines the essential perspective for a logistics service provider is the economic view, followed by environmental packages or social pacts [75,76]. To make the models as realistic and practical as possible, the technologies used must be smart, flexible and efficient [77–79]. This makes it possible to compare the data and thus optimise last-mile delivery and determine the impact on the environment. Some models clearly show that simply consolidating goods to be delivered to the city is not enough to reduce congestion and emissions. Alternative vehicles are therefore necessary for future-oriented action. Individual business characteristics have to be taken into account, for example, type of drive, goods and scheduling method [80–82].

An important part of touring optimisation is planning with different types of propulsion. To keep this planning realistic, the entire vehicle fleet must be planned [83]. As a result, these vehicles have to return to the depot more often. Routes must be adapted accordingly; these routes run close to the depot, and evening or night deliveries may also have to be planned. However, regional as well as client-related characteristics must be taken into account: Network restrictions, energy costs, FRD charges and fixed client charges offer [84].

The route problem is an essential problem for LSPs in the last mile. Many variables are necessary to give the end customer a real picture of when his goods will arrive at home. Overall, the parameters are from the areas of environment, health, space use and logistics operating costs [85]. These parameters are particularly relevant for planning in urban areas with vehicles with alternative vehicles [86–88]. By taking these parameters into account, the modelling can have a positive influence on the environment by avoiding harmful gas emissions [89,90]. In addition, these models offer the various stakeholders the opportunity to work together more effectively and thus use the commercial vehicle fleet more efficiently [91–93].

Adapting the vehicle fleet is a major task for many LSPs. Therefore, the models must not only focus on the assessment of one vehicle, but the fleet must be assessed and requires active management [94]. Only from this can optimisation strategies for the LSP be derived [95]. The route optimisation problem also offers the opportunity to optimise a resource in terms of collection [96,97]. An important planning point in route optimisation is the start of a route [98]. With a mobile access point, the emission impact changes as

the access point can be located in a demand zone. A mobile access point is particularly profitable when the access node is variable [99]. Particularly with regard to the division between urban and rural transport, it is important to differentiate more precisely and to take the framework into consideration [100].

Route planning needs to take into account characteristics such as their battery capacity, on-road battery charging at charging stations and charging time when planning routes and time windows [101]. Combining different types of propulsion, including fuel vehicles, can optimise carbon emissions and distribution costs for companies [102,103]. The same applies to the integration of cargo bikes.

This form of transport is increasingly used in logistics. The cargo bike system is strongly promoted by municipalities [104]. For LSPs, there are some caveats in modelling as only small packages can be transported [105]. Cargo bikes have a limited number of goods, but have been shown to be cheaper than delivery vans, as long as the delivery is close to the distribution centre. Due to urbanisation, the models have a lot of potential, but are not an all-purpose solution [106,107]. Similarly, vehicles can be differentiated in planning based on these factors [11,108].

By planning for idling and waiting times, both at the customer's and on the road, environmental impacts can be avoided [109]. This is particularly evident in the models during peak hours when parking spaces are scarce. The models clearly show that the time windows are difficult to maintain [110,111]. The models show that different types of vehicles are not equally suitable for the last-mile business model. The more vehicle types that are used, the more complex the last mile becomes.

3.4.5. Last Mile in Existing Literature Reviews

The studies see the changes starting with the initial situation, where it is no longer just dealers, service providers and end customers in a relationship, but also urban development, local regulations and technical innovations from the vehicle manufacturers [32,34,35,41,42,112,113]. In this context, the exchange between logistics service provider and municipal authorities deserves special attention and requires many decisions that cannot be made by one company alone [114]. Without this network, technical achievements and regulations cannot be harmonised with each other, for example: Loading and unloading parking spaces, parking conditions or testing of new vehicles [36,115].

Above all, technical innovations should ensure more sustainable development on the last mile. The focus of research is primarily on goods that can be described as "classic CEP goods" [42]. Similarly, innovation is driving route optimisation, incentive-based planning and real-time electronic tracking and communication [5]. Optimisations are made by LSPs in the following areas to design a more sustainable last mile: Demand consolidation, collaborative transport planning and full load strategies reduce transport emissions [41,42]. New factors need to be incorporated into the individual shipment price: The resource consumption and semi-fixed cost share of the transport mode, the specialisation of the driver, the degree of automation of both the transport and delivery activities, the problems or obstacles on the delivery route, the customer density, the likelihood of misdeliveries and the distance between the delivery point and the customer's home [32,42].

This overview shows that LSPs face many challenges: Alternative vehicles, network design and location of the hub area and big data [116]. The target group is also relatively rigid, as CEP service providers often participate in the studies and can more easily adopt new technologies due to their standardised goods.

4. Discussion

As the systematic literature research shows, there is still a need to catch up around the last mile. The current state of research on the impacts of last-mile logistics in the context of urban sustainability shows that, while not all types of impacts have been addressed to the same extent in the literature, all dimensions (economic, social, environmental) have been addressed at least in part [113]. Environmental impacts are the most frequently addressed

dimension, followed by social and economic impacts. However, it has become apparent that the companies that produce a lot of CO₂ participate less often in the studies or are explicitly asked [2,57,60,63].

New technologies are not only relevant for the logistics companies but have a great importance in the whole network. They change the network and can especially pass on the ideas of efficiency and consistency [1]. The main function of the new technology is to increase transparency and improve business efficiency [7]. The approach is thus very intrinsically motivated and shows that companies that are active in the last mile have a strong environmental awareness based on the efficiency approach. At the same time, current propulsion technologies are still far away. Stakeholders need to increase their efficiency, especially in urban logistics, to avoid becoming a trigger point with their vehicles (LCA and models paper) [116]. The last mile is thus a means to an end at any point in time. However, the literature review repeatedly revealed that the methods are mainly limited to one-person delivery (CEP). Therefore, much of the literature was removed from the analysis. The relevance and parameters for two-person delivery are not addressed at all. The frameworks, models and the interviews have repeatedly shown that it is a very flexible and at the same time a very time-window and fixed-point oriented business. As recognised in the systematic literature review, there is a discrepancy between propulsion technology, topography, infrastructure, communication systems and the way goods are transported. The systematic literature review has thus provided the basis for defining the necessary variables and laying the groundwork.

Alternative propulsion systems play a major role, but they are not a universal remedy on their own, and the bridge to a one-to-one replacement for last-mile logistics is still missing. Limiting the focus to an alternative vehicle technology would not be the right approach. Measures that promote the social and environmental sustainability of urban freight transport are more appropriate. Furthermore, the LCA can be perceived as an evaluation of efficiency in day-to-day business. Key figures from LCA, route planning and business management are intertwined. Thus, the matching of alternative vehicle technology and goods, for example, furniture, is also an essential role. In the future, it will be necessary to pay much more attention to the last mile than has been done so far.

4.1. Conclusions

This paper provides an integrated overview of the various relevant issues raised by sustainability related to last-mile logistics in urban areas. It provides an overview of the issues addressed in the literature. It offers an overview of the topics covered in the literature and proposes a framework to classify the topics. This theoretical framework helps to identify the issues involved and to improve the current understanding of the different types of impacts on the different actors involved and their relationships with each other.

In the future, public authorities must communicate clearly and take a leading role in shaping sustainability in urban logistics. The framework conditions for major changes must be created so that companies can fully assume their responsibilities. The work has shown that LCAs can be used to assess corporate behaviour. The processing of data and the creation of a monitoring system is a task that can already be actively pursued in companies. Research also needs to take a closer look at the differentiation of the last mile. Equating CEP service providers, which are engaged in the one-person delivery area, must be differentiated from two-person delivery. A field study with companies focusing on two-person delivery would be a forward-looking step. To better understand and further differentiate the challenges for this business model. The field study could, on the one hand, substantiate that the technological standards are currently only suitable for the CAP market and, on the other hand, it could reveal further blind spots in the solution of the problem. Companies and research need to work more closely together to better differentiate the parameters. The network of value creation must therefore be expanded and involve the public authorities more.

4.2. Limitation

Of course, every examination has its limitations, including this one. Firstly, many restrictions were imposed in the analysis, and at the same time the restrictions were even more limited in the individual review. However, the limitations made it possible to thoroughly discuss papers that were well-suited to the subject matter; in conclusion, this may also have meant that relevant contributions were not included. Other types of urban logistics may have been overlooked, although this was not the intention. The aim was to increase our focus on practices related to sustainable last-mile logistics. The individual review of the papers may also have resulted in literature being included and omitted because the focus of the work was misinterpreted. The results of this study clearly show that more research is needed. There is also a need for more differentiated research on what type of last mile and what type of goods are being transported. This would give a clearer picture of where the trade-offs of sustainable last-mile logistics exist in urban areas.

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