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A stakeholder-led sustainability framework for analysing last-mile transport and delivery

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ABSTRACT

Interest in the last mile, considered the most critical factor in e-commerce, has grown as the recognition of its challenges and its negative effects on sustainability have increased. In this paper, we provide a comprehensive review of the literature on the last mile based on the systematic analysis of 169 articles classified according to their research method and contribution from which eight research gaps emerge. We also propose a novel last-mile framework for the design of sustainable last-mile strategies that focuses on the interplay amongst sustainability, logistics and relevant stakeholders.

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Last mile; sustainability; e-commerce; stakeholders; literature review

1. Introduction

The last mile in e-commerce is the transport of physical goods from the e-retailer's last point of contact with the package (last warehouse or transit point) to its point of consumption (Halldorsson and Wehner 2020). There are two main parts: last-mile transport and last-mile delivery (Olsson, Hellström, and Pålsson 2019). The former is the link between order preparation and delivery, i.e. transport decisions pertaining to the point of origin, vehicle, delivery route, etc. The latter is the link to the customer. With the exponential growth in e-commerce and the number of packages delivered (Halldorsson and Wehner 2020), and e-retailers aiming to match or surpass the retailer service and experience consumers receive, the last mile is regarded as the most important factor for e-commerce sales (Rai 2019) and one of the most significant influences on online supply chains.

The desire to offer a complete service has turned the last mile into a major challenge for online supply chains. It also significantly impacts sustainability and each of its three pillars (economic, environmental, and social) (Rai 2019). Although the last mile only represents a portion of the total kilometres that products travel, it is disproportionately responsible for the costs of online logistics and transportation's environmental and social impacts (Brown and Guiffrida 2014). Thus, from an economic point of view, the last mile accounts for 13% to 75% of total logistics costs (Rai 2019). From the environmental perspective, it produces harmful effects by increasing polluting gas emissions. The last mile is responsible for 36.4% of total transport emissions (Rai 2019) and significantly impacts noise pollution and congestion in cities. Furthermore, in social terms, the last mile is linked to worsening working conditions and an increase in hazards and dissatisfaction to members of society (Viu-Roig and Alvarez-Palau 2020).

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Given this situation, interest in the literature on last-mile sustainability is increasing. However, publications generally refer to specific problems, such as analysing the impact of the last-mile operation on an aspect of sustainability (De Mello Bandeira et al. 2019; Wang et al. 2021), studying customer opinions on specific sustainable last-mile alternatives (Caspersen and Navrud 2021; Rai, Verlinde, and Macharis 2021) or the creation of optimisation models to address the problem of the sustainable last mile (Ehrler, Schöder, and Seidel 2021; Serrano-Hernandez, Ballano, and Faulin 2021), and, very rarely, providing a global view of the last mile through the prism of the three pillars of sustainability (Ha, Akbari, and Au 2022). In terms of literature reviews, Mangiaracina et al. (2019) conducted a literature review that identified innovative solutions to improve last-mile efficiency and established lines for future research. Viu-Roig and Alvarez-Palau (2020) developed a literature review to classify the impact of the last mile on cities (from economic, social, environmental, and technological perspectives), concluding that there needs to be more analysis of such impacts. Kiba-Janiak et al. (2021) reviewed the literature on the sustainable last mile in e-commerce, focusing on the scope of cities and different stakeholders. Despite their detailed analysis, they did not segment their contribution according to the three pillars of sustainability, nor do they analyse the various logistics factors associated with the last mile. Ha, Akbari, and Au (2022) provided a systematic literature review on the last mile, identifying gaps and proposing a framework for future research. Although the literature provides a detailed analysis, the integration of the last mile with the three pillars of sustainability remains inadequate. While the literature acknowledges the importance of this integration and has begun to study last-mile implications on sustainability, it has primarily focused on certain pillars (economic and environmental) and elements (costs, level of service, and CO_2 emissions) of sustainability, neglecting a holistic approach to sustainability. In the context of literature reviews, while some aspects of last-mile sustainability have been examined, a comprehensive view of sustainability from the perspective of various stakeholders and logistics factors has not been provided. Thus, their contributions are not segmented according to stakeholders, the impacts on sustainability and logistics factors. Linking these three aspects is essential for further progress in improving sustainability in the last mile (Ha, Akbari, and Au 2022).

This paper has a dual aim. First, to provide a comprehensive and critical review of the literature on the last mile, focusing on three basic dimensions: (i) the three pillars of sustainability (economic, social and environmental), (ii) the logistics factors that affect last-mile delivery and last-mile transport, and (iii) the involved stakeholders, and, secondly, to develop a framework for examining the interplay amongst (i), (ii) and (iii).

As a result, a thorough examination of the literature will facilitate the understanding of the role of sustainability in the last mile. The literature is examined through a coverage analysis, providing a detailed description of the level of analysis of each dimension on the literature. After that, these dimensions are structured into a framework that provides connection to all relevant published works. Finally, gaps and lines for future research are also detailed.

2. Problem statement

The gradual increase in last-mile deliveries, linked to the exponential growth of e-commerce (Peppel, Ringbeck, and Spinler 2022), has significant sustainability implications (Halldorsson and Wehner 2020). The acknowledged three pillars of sustainability have often been addressed separately in the literature. Most researchers have focused on the environment, researching air-polluting emissions and particulate matter (Brown and Guiffrida 2014; Figliozzi 2020), resource management (Sivaraman et al. 2007) or congestion (Alves et al. 2019). Such consequences have been examined in relation to the reception point (home delivery, store pickup or parcel lockers) (Brown and Guiffrida 2014; Melkonyan et al. 2020) or the type and size of the vehicle used (Ehrler, Schöder, and Seidel 2021; Serrano-Hernandez, Ballano, and Faulin 2021). Other authors have concentrated on the effect of the economic pillar. They focused on analysing the delivery costs or service levels on offer (Marujo et al. 2018; Seghezzi and Mangiaracina 2021; Siragusa et al. 2022). The effect of the last mile on

the social pillar (accidents, quality of life, infrastructure deterioration, etc.) has been analysed to a lesser extent (Mommens et al. 2021). However, some works have focused on the effect of all three pillars of sustainability (De Mello Bandeira et al. 2019; Melkonyan et al. 2020; Resat 2020; Wang et al. 2021). In these articles, this approach has been used to analyse specific logistics factors (e.g. delivery area, time slots, delivery speed, or available information) and therefore does not provide a comprehensive view of last-mile sustainability.

Through the prism of sustainability, other papers have focused mainly on the study and design of the logistics factors that make up the last mile. First, a group of articles focused on establishing classification frameworks for the last mile. Olsson, Hellström, and Pålsson (2019), for example, researched the stages that make up order preparation and the last mile. Second, many researchers concentrated on analysing different sustainable logistics alternatives by using modelling and simulations or by analysing the impact and benefit of these novel alternatives on sustainability. In the former case, some authors focused on designing the last-mile distribution structure, creating optimisation models for the location of the most appropriate point of origin for the order (Settey et al. 2021). The vehicle-routing problem or 'travelling salesman' problem was also addressed from a sustainable perspective (Jiang et al. 2019a; Kancharla and Ramadurai 2018). Authors such as Seghezzi et al. (2021) and Vincent, Jodiawan, and Redi (2022) focused on modelling last-mile systems based on crowd logistics or crowdshipping, taking into account the order features of the online channel.

Research has also focused on identifying the implementation of alternatives for order consolidation, improvements in delivery reliability, the type of vehicle used, or the point of order reception (Al-dal'ain and Celebi 2021; Arrieta-Prieto et al. 2022; Florio, Feillet, and Hartl 2018; Leyerer et al. 2020; Zhang et al. 2019). Finally, specific authors have focused on creating models that would allow a choice of the best last-mile strategy (Comi and Savchenko 2021) or the most sustainable logistics providers (Baldi et al. 2019) by minimising total cost or maximising service quality. In the second case, the authors studied the impact on the sustainability of novel outsourcing strategies for vehicles e.g. crowd logistics (Frehe, Mehmann, and Teuteberg 2017), vehicle type (Iwan et al. 2021), delivery point (Peppel, Ringbeck, and Spinler 2022), management of returns and reverse logistics (Allen et al. 2018) or the price of deliveries in a crowdshipping context (Gatta et al. 2019), among others.

From the stakeholders' point of view, researchers have highlighted approaches related to e-retailers (Kancharla and Ramadurai 2018), transport companies (Settey et al. 2021), consumers (Li et al. 2019) and institutions (Rosenberg et al. 2021). To a much lesser extent, citizens and drivers were also highlighted (Xiao and Ke 2019). Most papers focused on the consumer, investigating how customer attitudes change when they learn about the sustainability implications of various logistics factors (speed of deliveries, reception point, delivery slots, or price) (Ignat and Chankov 2020; Nogueira, de Assis Rangel, and Shimoda 2021; Rai, Verlinde, and Macharis 2018). There is also work on consumer willingness to adopt different sustainable last-mile strategies, such as green choice options or longer delivery times, higher shipping costs, or restricted choice regarding the delivery point (Caspersen and Navrud 2021; de Oliveira et al. 2017; Rai, Verlinde, and Macharis 2021). Finally, authors have addressed customer expectations regarding the sustainable last mile from the perspective of delivery speed or point of receipt (Lai et al. 2022; Otter et al. 2017). Regarding all other stakeholders, to a much lesser extent, specific articles have focused on the relationships amongst the different actors and the coordination between them (de Kervenoael, Schwob, and Chandra 2020; Szmelter-Jarosz and Rześny-Cieplińska 2019).

The research also found articles that aimed to identify and compile innovations, challenges, opportunities, and gaps in the literature on the sustainable last mile in e-commerce. Fifty-four literature reviews on sustainable last mile have been published. To a lesser extent, conceptual frameworks have also been developed as design tools for the sustainable last mile (Guo et al. 2019; Halldorsson and Wehner 2020); frameworks for analysing the effectiveness of different strategies to mitigate sustainability issues (Garus et al. 2022); studies on the influence of certain factors, such as the convenience of returns, delivery cost, advance booking of order pickup or dispatch time slots, on the sustainability of last-mile delivery (Jiang et al. 2019b; Na, Kweon, and Park

2021); and analyses of how the sustainable last mile should be structured (Mkansi and Nsakanda 2021).

The review grouped the findings into three basic dimensions (following the example of Nenni, Sforza, and Sterle (2019)). The first dimension comprises the three pillars of sustainability and has 28 elements. The following elements were considered for each sustainability pillar:

1. Economic: cost, profits and savings, level of service, operational capabilities, and risk management (i.e. Ghaderi et al. 2022; Marujo et al. 2018; Wang et al. 2021).
2. Environmental: pollutant emissions, particulate emissions, resource management, congestion, visual impact, weather adaptability, climate change, global warming, habitat loss, and noise pollution (i.e. Alves et al. 2019; Cárdenas, Beckers, and Vanelslander 2017; Mucowska 2021; Serrano-Hernandez, Ballano, and Faulin 2021; Sivaraman et al. 2007; Švadlenka et al. 2020).
3. Social: accidents, safety and security, quality of life, infrastructure deterioration, vibrations, nighttime disruptions, accessibility and mobility, working conditions, health, information security and transparency, acceptance, equality, and legislation (i.e. Harrington et al. 2016; Mommens et al. 2021; Moncef and Dupuy 2021; Oliveira et al. 2019; Serrano-Hernandez, Ballano, and Faulin 2021; Szmelter-Jarosz and Rześny-Cieplińska 2019).

The second dimension relates to the logistics factors that make up the last mile. The elements have been organised into transport and delivery (e.g. Olsson, Hellström, and Pålsson 2019):

1. Transport: order characteristics, order consolidation, vehicle type and size, fleet, vehicle ownership, order origin, dispatch time slots, routing, crowd logistics, reverse logistics (i.e. Kiba-Janiak et al. 2021; Mommens et al. 2021; Rai, Verlinde, and Macharis 2019; Ranieri et al. 2018; Seghezzi et al. 2021).
2. Delivery: delivery area, reception point, speed, time slots, reliability, returns, green choice options, price and information (i.e. Caspersen and Navrud 2021; Edwards, McKinnon, and Cullinane 2010; Harrington et al. 2016; Iwan et al. 2021; Mkansi and Nsakanda 2021; Sallnäs and Björklund 2020).

Finally, the third dimension focuses on stakeholders. The selection has been based on those already identified in other articles, such as Harrington et al. (2016) and Kiba-Janiak et al. (2021), in addition to other stakeholders mentioned in this state-of-the-art. The stakeholders are retailers, transportation companies, customers, governments and institutions, residents and citizens, and drivers (Paddeu and Parkhurst 2020; Xiao and Ke 2019).

Table 1 summarises the topics addressed in the last-mile literature. The analysis led to 3 dimensions (sustainability, logistics factors, and stakeholders), 11 axes (economic, environmental and social pillar; transport and delivery; retailers, transport companies, customers, institutions, residents and citizens, and drivers) and 53 elements.

The dimensions, axes and elements identified in Table 1 define the scope of this paper. Thus, to develop their analysis, a comprehensive review of the literature on sustainable last mile is undertaken, paying special attention to the scope already defined. Then, a content, methodological and coverage analysis of the selected papers is undertaken. Thus, this study provides a detailed description of the current state of the literature about this topic and, furthermore, structure and connection are given to this knowledge through a framework.

3. Methodology

A systematic literature review should consist of three stages: planning, carrying out the review, and presentation of the results (Tranfield, Denyer, and Smart 2003). The structure followed in this research can be seen in Figure 1.

Table 1. Topics identified in the literature on the last mile in the areas of sustainability, logistics factors and stakeholders.

Dimension	Axis	Element	Study
Sustainability	Economic	Cost	Marujo et al. 2018; Wang et al. 2021
		Profits and savings	Ghaderi et al. 2022
		Level of service	Marujo et al. 2018
		Operational capabilities	Wang et al. 2021
		Risk management	Wang et al. 2021
	Environmental	Pollutants emissions	Alves et al. 2019; Cárdenas, Beckers, and Vanelslander 2017; Sivaraman et al. 2007; Švadlenka et al. 2020
		Particulate emissions	Alves et al. 2019; Sivaraman et al. 2007
		Resource management	Sivaraman et al. 2007; Švadlenka et al. 2020
		Congestion	Alves et al. 2019; Cárdenas, Beckers, and Vanelslander 2017; Švadlenka et al. 2020
		Visual impact	Serrano-Hernandez, Ballano, and Faulin 2021
		Weather adaptability	Švadlenka et al. 2020
		Climate change	Cárdenas, Beckers, and Vanelslander 2017
		Global warming	Švadlenka et al. 2020
		Habitat loss	Mucowska 2021
		Noise pollution	Alves et al. 2019; Švadlenka et al. 2020
	Social	Accidents	Cárdenas, Beckers, and Vanelslander 2017; Mommens et al. 2021
		Safety and security	Szmelter-Jarosz and Rześny-Cieplińska 2019
		Quality of life	Serrano-Hernandez, Ballano, and Faulin 2021
		Infrastructure deterioration	Mommens et al. 2021
		Vibrations	Harrington et al. 2016
		Nighttime disruptions	Harrington et al. 2016
		Accessibility and mobility	Oliveira et al. 2019
		Working conditions	Moncef and Dupuy 2021
		Health (public and workers)	Szmelter-Jarosz and Rześny-Cieplińska 2019
		Information security and transparency	Szmelter-Jarosz and Rześny-Cieplińska 2019
		Acceptance	Harrington et al. 2016
		Equality	Harrington et al. 2016
		Legislation and green policies	Harrington et al. 2016
Logistics	Transport	Order characteristics	Seghezzi et al. 2021
		Order consolidation	Kiba-Janiak et al. 2021; Ranieri et al. 2018
		Vehicle type and size	Kiba-Janiak et al. 2021; Ranieri et al. 2018
		Fleet	Rai, Verlinde, and Macharis 2019
		Vehicle ownership	Seghezzi et al. 2021
		Order origin	Ranieri et al. 2018
		Dispatch time slots	Mommens et al. 2021
		Routing	Mommens et al. 2021; Ranieri et al. 2018
		Crowdlogistics	Ranieri et al. 2018
		Reverse logistics	Rai, Verlinde, and Macharis 2019
	Delivery	Delivery area	Iwan et al. 2021; Mkansi and Nsakanda 2021
		Reception point	Harrington et al. 2016; Iwan et al. 2021; Sallnäs and Björklund 2020
		Speed	Harrington et al. 2016; Sallnäs and Björklund 2020
		Time slots	Caspersen and Navrud 2021; Harrington et al. 2016; Mkansi and Nsakanda 2021
		Reliability	Edwards, McKinnon, and Cullinane 2010; Harrington et al. 2016
		Returns	Caspersen and Navrud 2021; Edwards, McKinnon, and Cullinane 2010; Harrington et al. 2016
		Green choice options	Harrington et al. 2016
		Price	Harrington et al. 2016; Sallnäs and Björklund 2020
		Information	Caspersen and Navrud 2021
Stakeholders		Retailers	Harrington et al. 2016; Kiba-Janiak et al. 2021
		Transportation companies	Harrington et al. 2016; Kiba-Janiak et al. 2021
		Customers	Harrington et al. 2016; Kiba-Janiak et al. 2021
		Institutions	Harrington et al. 2016; Kiba-Janiak et al. 2021
		Residents and Citizens	Paddeu and Parkhurst 2020
		Drivers	Kiba-Janiak et al. 2021

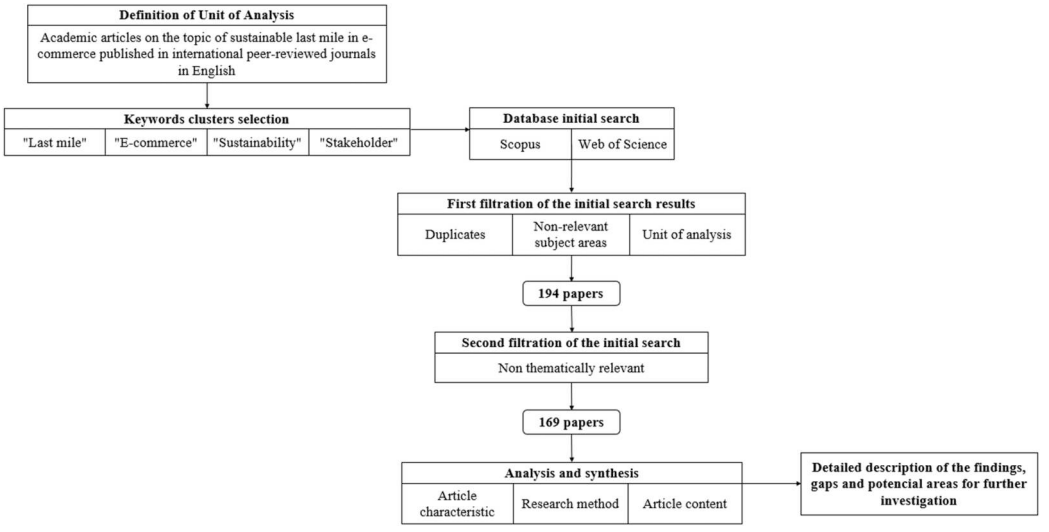

Figure 1. Systematic literature review methodology.

The planning stage is based on a clear definition of the scope of the research and the selection of the method to be used for the collection of articles. Regarding the definition, the research context is the literature related to the sustainable management of the last mile in e-commerce. The unit of analysis was academic articles on the sustainable last mile in e-commerce published in international peer-reviewed journals in English. Conference proceedings, working papers and research reports are not included.

In order to compile publications, following Perego, Perotti, and Mangiaracina (2011), and in concert with the scope of the analysis, a keyword search was performed using bibliographic databases (Scopus and Web of Science). The main keywords used in the search were: 'last mile', 'last-mile transport', 'last-mile delivery', 'e-commerce', 'sustainability', and 'stakeholder'. The search revealed a total of 652 published papers. An additional two-step screening process was carried out to filter these articles and generate a refined list that would fit the scope of the research. First, the number of papers was narrowed considerably by examining the titles and excluding those contributions that were outside the scope. Thus, all titles that did not mention or refer to the sustainable management of the last mile in e-commerce were excluded. The result was a list of 194 papers. Then, the selection process continued by analysing the abstracts to ensure the central theme was relevant (Mangiaracina, Song, and Perego 2015). Two different researchers reviewed the abstracts to confirm that the papers selected were consistent with the scope. Furthermore, if discrepancies between researchers appeared, the full paper was read to define whether the article complied with the scope (Mangiaracina, Song, and Perego 2015). Finally, 169 articles were selected for in-depth review.

Stage two involved an exhaustive analysis of the selected literature. For this purpose, we followed a review method used in previous articles (e.g. Mangiaracina, Song, and Perego 2015). First, the general characteristics of the collected articles and journals were identified. Second, the articles were classified according to content (sustainability pillar addressed, logistics factor investigated, and stakeholder analysed) and the research method adopted. Finally, the review's third stage presented the results and included a detailed description of the articles' findings. Potential areas for further study were also identified.

The articles were grouped by year of publication to observe the evolution of research into the sustainable last mile in e-commerce (Table 2). The first articles (2 papers) on this topic were published in 2007. The first, by Sivaraman et al. (2007), used a life-cycle assessment (LCA) to compare

Table 2. Number of papers that analysed each element by year of publication.

		2007	2009	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022
Sustainability	Economic	1	1	0	0	1	2	9	17	22	24	33	20
	Environmental	1	0	1	1	1	0	9	10	20	21	35	15
	Social	0	0	0	0	1	0	3	1	4	9	15	8
Logistics	Transport	1	1	1	1	1	3	10	16	24	30	42	21
	Delivery	2	1	1	1	0	2	6	15	21	23	34	16
Stakeholders	Retailers	2	1	1	1	1	3	5	10	15	17	27	18
	Transportation companies	0	1	1	0	1	2	7	14	22	27	34	20
	Customers	1	0	0	0	1	2	5	6	13	11	21	9
	Institutions	0	0	0	0	1	1	2	5	5	4	10	5
	Residents and Citizens	0	0	0	0	0	0	0	0	0	3	4	1
	Drivers	0	0	0	0	0	0	0	0	1	1	0	1
	Total (number)	2	1	1	1	1	3	11	21	28	31	45	24
	Total (%)	1.2	0.6	0.6	0.6	0.6	1.8	6.5	12.4	16.6	18.3	26.6	14.2

Table 3. Top 10 countries by first authorship.

Country	Number of papers	%
Italy	20	12
USA	20	12
China	14	8
Germany	13	8
United Kingdom	10	6
Spain	10	6
Belgium	10	6
Brazil	9	5
Sweden	7	4
Poland	7	4

Table 4. Top 10 journals.

Journal	Number	%
Sustainability	36	21
Journal of Business Logistics	9	5
Transportation Research Part D: Transport and Environment	8	5
Transportation Research Part E: Logistics and Transportation Review	7	4
Sustainable Cities and Society	7	4
IEEE Access	6	4
Research in Transportation Business and Management	5	3
Asia Pacific Journal of Marketing and Logistics	5	3
International Journal of Logistics Research and Applications	5	3
International Journal of Retail and Distribution Management	4	2

online shopping with home delivery and traditional shopping with in-store customer pickup. Between 2009 and 2016, seven new articles were published. From 2017 on, there was a gradual increase in publications, from 11 in 2017 to 45 in 2021 (136 papers). Up to May 2022, 24 new papers were published.

A total of 132 authors participated in the publication of the 169 articles. The vast majority have only participated in one article, eleven participated in three, and one author, Heleen Buldeo Rai, published 6 papers. The 132 authors are affiliated with 107 institutions or companies located in 29 different countries. Of these, Italy (20 papers), the USA (20 papers), China (14 papers), Germany (13 papers), the United Kingdom (10 papers) and Spain (10 papers) account for 51% of those published (Table 3).

Finally, the 169 papers considered here were published in 29 journals. Half of all the papers were published in the following eight journals: Sustainability, Journal of Business Logistics, Transportation Research Part D: Transport and Environment, Transportation Research Part E: Logistics and Transportation Review, Sustainable Cities and Society, IEEE Access, Research in Transportation Business and Management, and Asia Pacific Journal of Marketing and Logistics. Table 4 shows the top 10 journals with the most published articles.

4. Analysis of results

In this section, a detailed analysis of the literature is presented. The main topics identified in section 2 are studied, detailing how the literature has addressed each of them. The main subjects used in the literature to study the previous topics are also analysed.

4.1. Logistics factors

The features of e-commerce orders (order weight and units) were highlighted as a determining factor when defining which last-mile strategy should be implemented from a cost perspective (Seghezzi et al. 2021). However, much greater attention was paid to the correct selection of the type and size of

vehicle used, such as traditional (truck, van, car), smaller (bicycle, motorcycle, on foot), aerial or ground autonomous or robotic vehicle, the type of fuel (electric, diesel, petrol), and its ownership (privately-owned fleet, outsourced fleet, shared mobility) (e.g. Ranieri et al. 2018). Relevant elements, although less studied, are also the fleet size (small, medium or big) and type (traditional, mixed or innovative) (e.g. Ranieri et al. 2018).

Logistics research paid also special attention to order consolidation (made at store, micro-hub, mobile hub, consolidation centre, or trans-shipment node) as a method of reducing empty space in vehicles and optimise vehicle loading to the maximum (increasing the load factor) (e.g. Kiba-Janiak et al. 2021). Furthermore, one of the most analysed factors was delivery routes management (short, medium or long distance), as the green vehicle routing problem (e.g. Ranieri et al. 2018). In this sense, although less analysis has been conducted, some attention has been given to how certain optimisation tools can improve route management (e.g. Kiba-Janiak et al. 2021; Peppel, Ringbeck, and Spinler 2022). Machine learning and artificial intelligence tools have been proposed as potential solutions for developing more sustainable routes (e.g. Kiba-Janiak et al. 2021; Peppel, Ringbeck, and Spinler 2022).

Even though its importance is critical, only a few authors analysed the origin or dispatch point of the order (dispatch being the last point of contact between the order and the retailer's facilities) (e.g. Kiba-Janiak et al. 2021). In this regard, this research highlighted the usefulness of micro-hubs (as an alternative to warehouses, distribution centres, or hubs located far from the delivery points) to reduce the impact on the three pillars of sustainability. Other options to consider when defining the order origin are dispatch from stores, mobile hubs, consolidation centres or trans-shipment nodes. Linked to these logistics factors, the need to define departure times for shipments (by number of orders or predefined hours) to reduce environmental (CO_2 emissions, congestion, noise pollution) and social impacts (accidents, infrastructure deterioration) was also highlighted (Mommens et al. 2021).

Finally, multiple authors highlighted the importance of the design of return or reverse logistics (e.g. Rai, Verlinde, and Macharis 2019). This design must consider the return collection point (parcel lockers, pickup, store), as well as the subsequent management of the product (return to the store, to the distribution centre to provider) to reduce service price and emissions.

When designing the last-mile delivery, it is important to consider the delivery area, which can be local, national, or international (Iwan et al. 2021; Mkansi and Nsakanda 2021). The delivery point (or reception point) is also considered relevant. This factor refers to the place where the package meets the customer and can be the customer's home, a retailer's store, lockers, delivery stations, pickup or collection points, among others. In addition to the delivery point, retailers must define the speed and time slots in which the shipment will be made. Thus, delivery speed can be characterised from less than one day to more than 4 days and time slots from less than one hour to no time slots offered (Harrington et al. 2016).

Finally, the price of delivery was highlighted as a relevant factor (e.g. Harrington et al. 2016; Sallnäs and Björklund 2020). This price can be fixed, variable – depending on the selected speed or time slot – or zero (depending on the price of the order). It may also depend on whether the customer selects more sustainable delivery services, known as green choice options. Caspersen and Navrud (2021) focused on the importance of providing consumers with complete and reliable information to improve their shopping experience and, above all, increase delivery reliability. Finally, certain authors identified the returns policy as a relevant factor (e.g. Edwards, McKinnon, and Cullinane 2010). Here, the most relevant decisions are based on the price of the service (free versus return fee) and the collection place for returned products (home pickup, store delivery, locker, or pickup or collection point).

Table 5 summarises the main topics on logistics factors dealt with in the literature.

Much of this research has focused on redesigning these logistical factors, particularly with regards to certain technological advances (e.g. micro and mobile-hubs, crowd logistics, optimisation tools or aerial and ground autonomous vehicles). Thus, the literature is increasingly analysing

Table 5. Summary of the main topics on logistics factors.

Dimension	Axis	Element	Choices	Papers
Logistics factors	Last-mile Transport	Order characteristics	Weight Units 3	Seghezzi et al. 2021
		Order consolidation	Store Micro-hub Mobile hub Consolidation centre Transhipment node	Kiba-Janiak et al. 2021; Ranieri et al. 2018
		Vehicle type and size	Traditional (truck, van, car) Smaller (bicycle, motorcycle, on foot) Fuel (electric, diesel, petrol) Aerial or ground autonomous or robotic vehicle	Comi and Savchenko 2021; Kiba-Janiak et al. 2021; Ranieri et al. 2018; Seghezzi et al. 2021
		Fleet	Size (small, medium, big) Type (traditional, mixed, innovative)	Ranieri et al. 2018
		Vehicle ownership	Privately owned fleet Outsourced fleet Shared mobility	Kiba-Janiak et al. 2021; Ranieri et al. 2018
		Order origin	Store Micro-hub Mobile hub Consolidation centre Transhipment node Distribution centre	Kiba-Janiak et al. 2021
		Dispatch time slots	By number of orders Predefined hours	Mommens et al. 2021
		Routing	Short distance Medium distance Long distance Optimisation tools	Kiba-Janiak et al. 2021; Ranieri et al. 2018
		Crowdlogistics		Seghezzi et al. 2021
		Reverse logistics	Return collection point (parcel lockers, pick-up, store) Management of the product (return to store, to distributions centre, to provider)	Rai, Verlinde, and Macharis 2019
	Last-mile Delivery	Delivery area	Local National International	Iwan et al. 2021; Mkansi and Nsakanda 2021
		Reception point	Customer's home Store Locker Delivery station Pickup or collection point	Iwan et al. 2021; Mkansi and Nsakanda 2021
		Speed	Express (less than one day) 24 h 48–72 h 4 days or more	Harrington et al. 2016
		Time slots	Less than one hour 2–4 h Morning or afternoon Without time slots	Harrington et al. 2016
		Returns	Price (free, return fee) Collection place (customer's home, store, locker, pickup or collection point)	Edwards, McKinnon, and Cullinane 2010
		Green choice options		Harrington et al. 2016; Sallnäs and Björklund 2020
		Price	Fixed Variable (depending on the selected speed or time slot) Zero (depending on the price of the order)	Harrington et al. 2016; Sallnäs and Björklund 2020
		Information and Reliability	Trace and tracking	Caspersen and Navrud 2021

the impact of this innovations on elements related to the economic (costs and operational capabilities), environmental (pollutant emissions, congestion, and noise pollution), and social (safety and acceptance) pillars of sustainability. However, previous research has not considered the implications of these innovations on other relevant elements, such as service level, risk management, energy efficiency, visual impact, infrastructure deterioration, and legislation, which are crucial for their future implementation. For example, the topic of crowd logistics is of great interest in sustainable last-mile literature. Its economic and environmental benefits have been widely analysed and demonstrated (e.g. Buldeo Rai et al. 2017; Melkonyan et al. 2020). However, its social and legislative implications have been neglected, as its implementation may have a negative impact on these aspects (Buldeo Rai et al. 2017). Therefore, the absence of research distorts the true benefits and impact of this innovation on sustainability, impeding its proper implementation.

In the same way, air and ground autonomous vehicles have been extensively analysed, with a particular focus on their potential to reduce last-mile costs, improve service level, or reduce CO_2 emissions (e.g. Garus et al. 2022). The importance of legislation regulating these delivery systems has also been mentioned. However, potential safety and equity issues have not yet been fully identified, addressed, and resolved (Garus et al. 2022).

In contrast, research on micro-hubs and mobile-hubs has focused on their impact on the three pillars of sustainability, facilitating implementation and ensuring overall benefit (e.g. Comi and Savchenko 2021). Thus, a larger number of pilot projects allows for more in-depth studies and analysis of innovations. The same applies to research on optimisation tools. There is a significant body of research dedicated to developing tools that can optimise the last mile while considering the three pillars of sustainability (e.g. Serrano-Hernandez, Ballano, and Faulin 2021). Specifically, this development has concentrated on tools for redesigning routes (e.g. Kancharla and Ramadurai 2018).

In conclusion, research typically concentrates on innovations that arise in the last mile. However, their practicality in the real world largely determines the level of detail used for sustainable analysis.

4.2. Sustainability

Costs are of great concern to stakeholders (mainly retailers and transport companies) and so most of the articles related to the economic pillar focused on this indicator. Authors such as Skiver and Godfrey (2017), Perboli and Rosano (2019) and Rai, Verlinde, and Macharis (2019) analysed the cost of elements such as labour and training, fuel, vehicles used, vehicle maintenance, necessary land, insurance, taxes, investment, operational cost, or opportunity cost, among others. Along the same lines, only three papers analysed the importance of savings and profits in terms of the choice or evaluation of the delivery method. Thus, Szmelter-Jarosz and Rześny-Cieplińska (2019) identified the priorities to launch a crowd logistics system. Simić, Lazarević, and Dobrodolac (2021) evaluated different delivery methods (cargo bicycles, drones, autonomous vehicles, tube transport). Finally, Garus et al. (2022) assessed the implementation of automated droids. Economic research also focused, to a large extent, on the level of service offered by last mile strategies (e.g. Chen et al. 2019; Peppel, Ringbeck, and Spinler 2022). Research here highlighted the level of customer satisfaction, late deliveries and the percentage of failed deliveries, customer service time, or convenience of delivery. Finally, only one paper analysed operational capabilities and risk management (Wang et al. 2021).

Regarding the environmental pillar, researchers focused on studying and quantifying the effect of the last mile in e-commerce on air pollution through pollutant gases or particulates (e.g. Caspersen and Navrud 2021; Ramirez-Villamil, Jaegler, and Montoya-Torres 2021). Analysis focused on the impact of gases such as CO_2, NO_X, or greenhouse gases. Other authors looked at resource management and energy efficiency when implementing last-mile strategies. Thus, Halldorsson and Wehner (2020) focused on the energy efficiency of deliveries, considering the space used in the vehicle, the distance travelled by commercial and private vehicles, and the delivery time. In turn,

Simić, Lazarević, and Dobrodolac (2021) and other authors analysed the consumption of resources such as fuel or energy depending on the logistics strategy employed, as well as waste generation.

To a lesser extent, the research also concerned impacts such as congestion in cities or noise at delivery points produced by the volume of deliveries of e-commerce packages. Comi and Savchenko (2021) included these elements in the calculation of the environmental cost assignable to the delivery operation. Finally, more general elements such as visual impact, weather adaptability, climate change or global warming, where the effect of the last mile is more complex to calculate, are the least analysed, only addressed by a small number of papers (five out of the total) (e.g. Cárdenas, Beckers, and Vanelslander 2017; Ignat and Chankov 2020; Ranieri et al. 2018; Serrano-Hernandez, Ballano, and Faulin 2021; Švadlenka et al. 2020).

Although research has pointed to the importance of the social pillar, it has been studied to a lesser extent than the other two. Research highlighted infrastructure deterioration, accidents, and safety. Referring to deterioration, authors such as Mommens et al. (2021) analysed the wear and tear and degradation of infrastructures such as roads, as well as the inadequate use of public space by vehicles destined for last-mile deliveries. In the case of accidents, safety and security, prominent authors such as Ranieri et al. (2018) or Peppel, Ringbeck, and Spinler (2022) focused on describing and quantifying the increasing danger in cities as last-mile deliveries grow in number. Research also analysed worker benefits and working conditions (job opportunities, employee satisfaction, availability of workforce), the quality of life and health of consumers and citizens (wages, road safety, traffic, pollution), equality and accessibility of the service on offer, citizen acceptance of the service, vibrations and night-time disruptions, and security and transparency of information provided to customers and citizens (e.g. Seghezzi et al. 2021; Simić, Lazarević, and Dobrodolac 2021; Szmelter-Jarosz and Rześny-Cieplińska 2019). Finally, due to the increased concern shown by institutions, some works have focused on legislation and green policies established to reduce societal impacts (e.g. Simić, Lazarević, and Dobrodolac 2021).

Table 6 summarises the main topics on sustainability dealt with in the literature.

The analysis of sustainable elements has not only been conducted individually but also collectively, albeit to a lesser extent. Thus, some works have focused on the effect of the three pillars of sustainability (De Mello Bandeira et al. 2019; Melkonyan et al. 2020; Resat 2020; Wang et al. 2021). As mentioned before, these articles focused on analysing specific logistics factors (e.g. delivery area, time slots, delivery speed, or available information) from a sustainable perspective and therefore does not provide a comprehensive view of last-mile sustainability. However, the analysis of specific issues reveals the challenges of integrating the three pillars of sustainability in the last mile. Comi and Savchenko (2021) created a methodology to evaluate and select the most sustainable last-mile strategy from the perspective of the three pillars of sustainability. In this study, they highlighted how the inclusion of social and environmental impacts can alter the final selection, as opposed to a purely economic study. By including the environmental and social pillars when selecting last-mile strategies, the solution may not always be the most economically beneficial. Therefore, opting for a sustainable last-mile strategy may require a higher economic effort for certain stakeholders (e.g. e-retailers, transport companies, and customers).

The social pillar can also be negatively affected. According to studies by Buldeo Rai et al. (2017) and Garus et al. (2022), selecting economically and environmentally favourable solutions, such as crowd logistics and autonomous vehicles, may have a negative impact on the social aspect. Garus et al. (2022) noted that the use of autonomous vehicles may have negative implications for social sustainability, particularly in terms of safety and equity.

Finally, it is important to note that while these studies aim to provide a comprehensive view of sustainability by analysing specific logistics aspects, many of them fall short by selecting only a small number of indicators for each pillar, particularly for the social pillar. For instance, Melkonyan et al. (2020) analysed the sustainable impact of various last-mile strategies and concluded that a distributed network strategy based on crowd logistics could be the most beneficial for all three pillars. However, this study only considered two social indicators – social interaction and convenience

Table 6. Summary of the main topics on sustainability.

Dimension	Axis	Element	Papers
Sustainability	Economic pillar	Logistics cost Labour and training, fuel, vehicles used, vehicle maintenance, necessary land, insurance, taxes, investment, operational cost, or opportunity cost	Perboli and Rosano 2019; Rai, Verlinde, and Macharis 2019; Skiver and Godfrey 2017
		Profits and savings	Garus et al. 2022
		Level of service Level of customer satisfaction, late deliveries and the percentage of failed deliveries, customer service time, or convenience of delivery	Chen et al. 2019; Peppel, Ringbeck, and Spinler 2022
		Operational capabilities	Wang et al. 2021
		Risk management	Wang et al. 2021
	Environmental pillar	Pollutants and Particulate emissions CO2, NOX, greenhouse gases	Caspersen and Navrud 2021; Ramirez-Villamil, Jaegler, and Montoya-Torres 2021
		Resource management and Energy efficiency	Halldorsson and Wehner 2020; Simić, Lazarević, and Dobrodolac 2021
		Visual impact	Ignat and Chankov 2020
		Congestion	Comi and Savchenko 2021
		Global warming, climate change, weather adaptability, and habitat loss	Cárdenas, Beckers, and Vanelslander 2017; Švadlenka et al. 2020
		Noise pollution	Comi and Savchenko 2021
	Social pillar	Infrastructure deterioration Degradation of roads, or inadequate use of public space	Mommens et al. 2021
		Accidents, Safety, and Security Danger in cities or at delivery points	Ranieri et al. 2018; Peppel, Ringbeck, and Spinler 2022
		Working conditions Job opportunities, employee satisfaction, or availability of workforce	Simić, Lazarević, and Dobrodolac 2021
		Quality of life, Health, Citizen's welfare, Accessibility and mobility, and Acceptance and equality Wages, road safety, traffic, pollution	Simić, Lazarević, and Dobrodolac 2021
		Vibrations, and Nighttime disruptions	Seghezzi et al. 2021
		Information security and transparency	Szmelter-Jarosz and Rześny-Cieplińska 2019
		Legislation and green policies	Simić, Lazarević, and Dobrodolac 2021

of delivery – and did not consider important factors such as drivers' working conditions. Thus, further research may alter the final outcomes of these articles.

4.3. Stakeholders

Stakeholder theory advances the argument that value should be considered for all stakeholders not just shareholders (Phillips 2003). Our study embraces the notion of stakeholder theory examining value from multiple perspectives. Retailers are the most studied group of stakeholders. Research has focused on analysing the role of the retailer in defining and redesigning its own last-mile strategies. Consequently, researchers have analysed and quantified the impact of current strategies. Furthermore, they have also proposed new, more sustainable strategies adapted to new needs (from the perspective of costs, service level, air emissions and pollutants, and infrastructure deterioration). The literature reveals that the design of these strategies often prioritises reducing costs and increasing service levels, without considering their environmental and social impact (e.g. Otter et al. 2017). Therefore, retailers tend to focus on providing high service levels (e.g. multiple reception points, or deliveries in less than 1 h) while keeping costs low. To address this situation, researchers have also tried to restructure last-mile logistics, defining the best sustainable alternatives in specific situations, and differentiating between retailers with their own delivery service and those outsourcing the service. Researchers such as Kancharla and Ramadurai (2018), Simoni et al. (2020), or Al-dal'ain and

Celebi (2021) studied the impact of traditional strategies and designed new structures: for example, the green vehicle routing problem, a last-mile system based on crowdsourcing, or a mixed fleet employing electric and conventional vehicles for e-commerce deliveries. Retailers could build on these new strategies to offer more sustainable last-mile deliveries by refocusing their priorities.

Related to service level, considering its importance to retailers, researchers have also examined those services which should be provided to customers with respect to last-mile delivery, indicating the implication of this offer on the three pillars of sustainability. Here, published articles have mainly focused on studying the impact of delivery speeds and time slots on sustainability (e.g. Kancharla and Ramadurai 2018) or on redesigning delivery structures by integrating collection and delivery points (e.g. Janjevic, Winkenbach, and Merchán 2019). Some articles have also discussed the importance of delivery reliability (e.g. Florio, Feillet, and Hartl 2018) or green choice options as a sustainable innovation for the last mile (e.g. Harrington et al. 2016). Thus, this research could guide retailers in creating new strategies that could offer a high service level.

As e-retailers, research on transportation companies has focused on their role in defining last-mile strategies and how their interest in low-cost delivery strategies influences final strategy selection. Thus, researchers have focused on defining the best delivery alternatives in specific situations from the perspective of transport companies. Here, the literature focused on identifying the logistics factors that transport companies typically prioritise when designing their last-mile strategies (e.g. delivery speed, receiving point, or return policy) and on how much impact these logistics factors have on the sustainability of transportation companies (e.g. Wang et al. 2021). Moreover, based on these impacts, some authors highlighted the level of influence transport companies have on the definition of delivery strategies established by e-retailers, with the aim of reducing their impact on sustainability (e.g. de Kervenoael, Schwob, and Chandra 2020). Thus, transport companies play a crucial role in designing and implementing last-mile strategies, making them indispensable for achieving sustainable deliveries. In this sense, due to this crucial role, the selection of transport companies is becoming increasingly important. In this sense, some researchers have begun to include sustainable aspects and criteria in this selection (e.g. Li et al. 2019).

Despite the importance of drivers within the last mile as the final deliverers of online orders, only two articles expressly analysed their role. In this sense, this literature pointed out the importance of drivers as a key factor for the success of the implementation of sustainable innovations. Thus, Xiao and Ke (2019) studied the influence mechanisms needed to ensure the continued intention of drivers to participate in crowdsourcing logistics platforms. Second, Paddeu and Parkhurst (2020) analysed the driver's role in the implementation of a delivery service using automated vehicles. In addition to the key role of drivers related to new implementations, this stakeholder also has a major impact on the service level provided to the customer and the overall sustainability of the last-mile strategy. First, drivers are the only point of contact between the e-retailer and the online customer, so their work has a clear impact on the service level perceived by the customer (e.g. Rai 2019). On-time deliveries, as well as the friendliness with which the customer is treated, will have an impact on the final satisfaction of the customer. Second, the working conditions of this stakeholder are key to the development of sustainable last-mile strategies (e.g. De Mello Bandeira et al. 2019). For example, the high pressure and workload they experience, as well as the lack of training, can be triggers for inadequate working conditions (and low sustainability of the last-mile system). Despite the importance of these two elements (impact on service level and working conditions), specific research on them is very limited. Specifically, research has emphasised the crucial role of drivers in the success of new sustainable strategies by requiring their acceptance. However, their impact and working conditions are not always considered when designing these new alternatives.

E-customers expect convenient and efficient delivery services that meet high standards of quality. In this context, research focused on analysing consumer behaviour in the face of different sustainable last-mile strategies. More specifically, authors such as Rai, Verlinde, and Macharis (2018) and Nogueira, de Assis Rangel, and Shimoda (2021) focused on analysing how customer attitudes change when they learn about the sustainability implications (pollutant and particulate emissions,

and resource management) of different last-mile strategies in e-commerce. Conversely, authors such as de Oliveira et al. (2017) and Caspersen and Navrud (2021) analysed how willing consumers are to adopt different sustainable last-mile strategies, such as automatic delivery stations or crowd logistics. Finally, the remaining articles focused on identifying customer expectations concerning the sustainable last mile, focusing on customer satisfaction with the different services offered (e.g. parcel lockers in the article by Lai et al. (2022)) or customer expectations in relation to logistics factors such as speed or delivery time (e.g. Otter et al. 2017). Overall, the research highlighted consumers' desire for adequate service without high costs. Additionally, consumers value information on delivery sustainability and options to modify service levels to reduce its sustainability impact.

By connecting citizens to the last mile, their power is related to the promotion of actions and legislation that limit strategies that may endanger their quality of life. Thus, research centring on citizens is so far very limited and has focused on how last-mile deliveries affect the quality of life, linked to the social (safety and infrastructure deterioration) and environmental (air emissions and noise pollution) pillars of sustainability. Thus, Viu-Roig and Alvarez-Palau (2020) identified changes in the quality of life of citizens, the infrastructures used, and the risk associated with noise and accidents, all of which are associated with an increase in last-mile deliveries. These results indicate a potential for citizen dissatisfaction and may be valuable to other stakeholders (e.g. e-retailers, transport companies or institutions) in developing more citizen-friendly strategies. Another part of citizen-centred research focuses on their role as actors in crowd logistics strategies. In this regard, Szmelter-Jarosz and Rześny-Cieplińska (2019) reflected on the importance of citizen involvement in becoming temporary carriers, to which e-retailers can outsource order delivery in order to ensure the success of this type of delivery strategy. As the role of citizens is important, this research should guide other stakeholders (e-retailers, transport companies, institutions) to develop last-mile strategies and legislation that could improve the quality of life of citizens without negatively affecting the sustainable interests of other stakeholders.

The role of institutions as regulators is driven by their concerns about the negative effects of the last mile on society. Thus, a variety of legislation has been implemented to alleviate the adverse impacts of the last mile in urban areas. These concerns and legislations have led to an increase in research into the role of institutions in the design of sustainable last-mile strategies for e-commerce. Some authors focused on analysing the elements of greatest concern for institutions (e.g. Cárdenas, Beckers, and Vanelslander 2017). At the same time, other researchers focused on measures institutions can take to try to reduce this impact. De Marco, Mangano, and Zenezini (2018) highlighted measures to reduce the number of freight vehicles, create low-emission zones or time windows for unloading, and set restrictions on the type and size of vehicle used for delivery and night deliveries. Other researchers investigated the role of institutions in establishing sustainable last-mile strategies such as urban hubs, crowd logistics systems or distribution centres. An example is the article by Allen et al. (2018), which defends the importance of the role of institutions in the implementation of innovations such as click&collect services, logistics hotels, or shared drop zones. As institutions are trying to create more sustainable cities and countries, all this research could help them to define elements of great interest, establish new regulation that could reduce last-mile impact and implement new infrastructure that could promote the creation of sustainable strategies.

Table 7 summarises the main stakeholder subjects dealt with in the literature.

4.4. Main subjects by research method

In addition to the three principal topics addressed in the previous sections, papers can also be classified by research method.

Accordingly, the articles have been grouped according to the category proposals made by Mangiaracina, Song, and Perego (2015):

1. Quantitative models (analytical and simulation models).

Table 7. Summary of the main stakeholder subjects.

Dimension	Axis	Subjects	Papers
Stakeholders	Retailers	Last mile strategy design, defining and selecting the best sustainable alternatives	Al-dal'ain and Celebi 2021; Simoni et al. 2020
		Selection of the services to offer in last-mile delivery, identifying their implications in the three pillars of sustainability	Florio, Feillet, and Hartl 2018; Harrington et al. 2016; Janjevic, Winkenbach, and Merchán 2019; Kancharla and Ramadurai 2018
	Transportation companies	Identification of the impact of certain logistics factors on the sustainability of transport companies	Wang et al. 2021
		Influence level of transport companies on the definition of last-mile strategies established by e-retailers	de Kervenoael, Schwob, and Chandra 2020
	Drivers	Active role in last-mile deliveries (participation in crowdsourcing logistics platforms, implementation of delivery services using automated vehicles, key actor on service level and working conditions)	Paddeu and Parkhurst 2020; Xiao and Ke 2019
	E-Customers	Change in customer attitudes when they learn about the sustainability implications of different last-mile strategies in e-commerce	Nogueira, de Assis Rangel, and Shimoda 2021; Rai, Verlinde, and Macharis 2018
		Consumer behaviour in the face of different sustainable last-mile strategies	Caspersen and Navrud 2021; de Oliveira et al. 2017
		Customer expectations concerning the sustainable last mile	Lai et al. 2022; Otter et al. 2017
	Residents and Citizens	Identification of the impact of last-mile deliveries on their quality of life	Viu-Roig and Alvarez-Palau 2020
		Active role as actors in crowd logistic strategies	Szmelter-Jarosz and Rześny-Cieplińska 2019
	Institutions	Identification of the logistics factors of greatest concern for institutions	Cárdenas, Beckers, and Vanelslander 2017
		Implementation of measures or policies to reduce the impact of these factors on sustainability	De Marco, Mangano, and Zenezini 2018
		Active role of institutions in favouring the implementation of sustainable last-mile strategies	Allen et al. 2018

2. Conceptual models (frameworks and general classifications).
3. Empirical models (interviews, case studies and surveys).

What follows is a description of the most relevant results.

A total of 68 papers based on quantitative models were identified. More than half (45 papers; 66%) corresponded to 'Modelling or simulation of different sustainable alternatives for the last mile in e-commerce'. Of these, 11 focused on designing the last-mile distribution structure (e.g. Janjevic, Winkenbach, and Merchán 2019), 30 studied the vehicle routing problem or travelling salesman problem from a sustainable perspective, modelled last-mile systems based on crowd logistics or crowd shipping and simulated or analysed the ideal model for implementing different alternatives such as drones, collection points or electric cargo bicycles (e.g, Jiang et al. 2019a). Four articles focused on creating models to select the most sustainable last-mile strategy – the last three established models for choosing the most sustainable logistics providers (e.g. Baldi et al. 2019).

Twenty-one quantitative articles focused on 'Quantification of the effect on the sustainability of the last mile in e-commerce'. Of these, nine papers quantified the effect on the environmental aspect (e.g. Edwards, McKinnon, and Cullinane 2010), five papers focused on the effect of sustainability's economic and environmental pillars (e.g. Marujo et al. 2018), another four papers focused on the effect of the three pillars of sustainability (e.g. De Mello Bandeira et al. 2019) and two articles analysed the impact on the

economic pillar of sustainability (e.g. Seghezzi and Mangiaracina 2021). The last paper studied the social and environmental pillars (e.g. Mommens et al. 2021). Finally, the remaining two articles analysed customer response to delivery price changes (e.g. Klein et al. 2018) and explored factors influencing the sustainability of last-mile deliveries in rural areas (e.g. Jiang et al. 2019b).

A total of 23 articles based on conceptual models were identified. Most of these (14 papers) focused on identifying and compiling innovations, challenges, opportunities, and gaps in the literature on the last mile in e-commerce (e.g. Mangiaracina et al. 2019). Five developed frameworks that serve as tools for creating sustainable last-mile strategies (e.g. Halldorsson and Wehner 2020), two papers focused on creating frameworks to analyse the effectiveness of different approaches to alleviate sustainability issues (e.g, Janjevic and Winkenbach 2020) and two articles provided a classification framework for the last mile (e.g. Garus et al. 2022).

Forty-nine empirical papers were identified. Twenty-four of these papers analysed consumer behaviour in the face of different sustainable last-mile strategies. In this regard, nine focused on investigating how customer attitudes change as they become aware of the sustainability implications of different last-mile strategies in e-commerce (e.g. de Oliveira et al. 2017). Eight articles analysed consumers' willingness to adopt different sustainable last-mile strategies (e.g. Rai, Verlinde, and Macharis 2018). The last seven articles analysed customer expectations related to the sustainable last mile (e.g. Nogueira, de Assis Rangel, and Shimoda 2021). Twenty-two papers analysed the impact and benefits on last-mile sustainability of using different novel strategies (electric vehicles, drones, cargo bikes, mobile depot, crowd logistics, or information and communication technologies) (e.g. Ehrler, Schöder, and Seidel 2021). Finally, two articles focused on analysing the role of stakeholders (e.g. de Kervenoael, Schwob, and Chandra 2020), and only one article developed research focused on determining how the sustainable last mile should be structured (e.g. Mkansi and Nsakanda 2021).

Table 8 summarises the main subjects according to their methodology and the number of papers identified in each.

5. Conceptual framework development

The elements and dimensions identified form a conceptual framework that encompasses the research on the sustainable last mile in e-commerce, considering the perspectives of the different stakeholders and the logistics factors. The framework's core is formed by the last mile itself, structured in terms of last-mile transport and last-mile delivery. From this core, the factors are related to the stakeholders and the three pillars of sustainability. Figure 2 depicts this conceptual framework, crystallising the literature reviewed on the sustainable last mile in e-commerce. It is important to note that the elements included are from the perspective of their impact on sustainable last-mile logistics, despite their impact having a broader scope such as cost impacts.

Following the development of the framework, in order to determine the current state of research and applications in this paper's study area and identify any existing gaps, following the example of Nenni, Sforza, and Sterle (2019), the relationships between the different dimensions and their constituent elements were assessed. To do so, the number of articles that studied the relationship between each pair of elements was quantified. Thus, Figure 3 was obtained by cross referencing the sustainable elements and stakeholders with the last-mile logistics factors and Figure 4 was obtained by cross referencing the sustainable elements and logistics factors with the stakeholders.

Figures 3 and 4 demonstrate that the extent of coverage is still low and partial. Contributions cover only 951 of the 1628 relationships defined. Only the groups related to costs, customer service, pollutant gas emissions and congestion, from the sustainability point of view, and to e-retailers, transport companies, consumers, and institutions from the stakeholder point of view, are found in a significant number of papers. At the same time, all of the other topics could be better developed. The logistics factors that stand out are the vehicle type and size, as well as the reception point.

Table 8. Summary of the main subjects according to the methodology used.

Research Method	Main subject	Papers	Total number of articles	%
Quantitative model	Modelling or simulation of different sustainable alternatives for the last mile in e-commerce	Baldi et al. 2019; Janjevic, Winkenbach, and Merchán 2019; Jiang et al. 2019a	48	28
	Quantification of the effect on sustainability of the last mile in e-commerce	De Mello Bandeira et al. 2019; Marujo et al. 2018; Mommens et al. 2021; Seghezzi and Mangiaracina 2021	21	12
	Analysis of consumer behaviour in the face of different sustainable strategies for e-commerce deliveries	Klein et al. 2018	2	1
	Study of factors influencing the sustainability of last-mile deliveries	Jiang et al. 2019b	1	1
Conceptual model	Compilation of innovations, challenges, opportunities, and gaps in the literature	Mangiaracina et al. 2019	31	18
	Framework that serves as a design tool for sustainable last-mile strategies	Halldorsson and Wehner 2020	7	4
	Classification framework for the sustainable last mile in e-commerce	Janjevic and Winkenbach 2020	6	4
	Framework allowing analysis of the effectiveness of different strategies to mitigate sustainability problems in the last mile	Garus et al. 2022	3	2
Empirical model	Analysis of consumer behaviour in the face of different sustainable strategies for e-commerce deliveries	de Oliveira et al. 2017; Nogueira, de Assis Rangel, and Shimoda 2021; Rai, Verlinde, and Macharis 2018	24	14
	Study of the impacts and benefits to last-mile sustainability of using different novel strategies	Ehrler, Schöder, and Seidel 2021	22	13
	Analysis of the role of stakeholders in the sustainable last mile	de Kervenoael, Schwob, and Chandra 2020	3	2
	Determination of how the sustainable last mile should be structured	Mkansi and Nsakanda 2021	1	1

With regard to each pillar of sustainability, the extent of coverage (% of relationships between topics covered by at least one article) for the economic pillar is the highest (60%), followed by the environmental pillar (57%) and the social pillar (51%). For stakeholders, the total extent of coverage comes to 74% (retailer: 91%, transport companies: 98%, customers: 89%, institutions: 85%, citizens: 62% and drivers: 17%). Finally, in the study of logistics factors, last-mile transport has a coverage of 59%, compared to 52% for last-mile delivery.

Based on these two figures, a detailed analysis of the extent of the coverage of the literature published to date on the subject is presented below, highlighting the areas of most significant interest for the research, as well as the most relevant gaps.

5.1. Last mile logistics factors

- The most analysed logistics factors are vehicle type and size, reception point, order origin, vehicle ownership, routing, and speed. They predominate because they are more important when designing last-mile strategies (e.g. Halldorsson and Wehner 2020) and significantly impact sustainability.
- Factors of less interest in current research are order characteristics, fleet, green choice options, information, returns, delivery area, dispatch time slots, reverse logistics and reliability. This more limited interest is related to their novelty in last-mile implementation (e.g. green choice options) or because these factors have a lower impact on the sustainability of last-mile strategies.
- Factors for which interest has begun to increase in recent times, although their analysis is not yet in-depth, are order consolidation, time slots, crowd logistics and price.

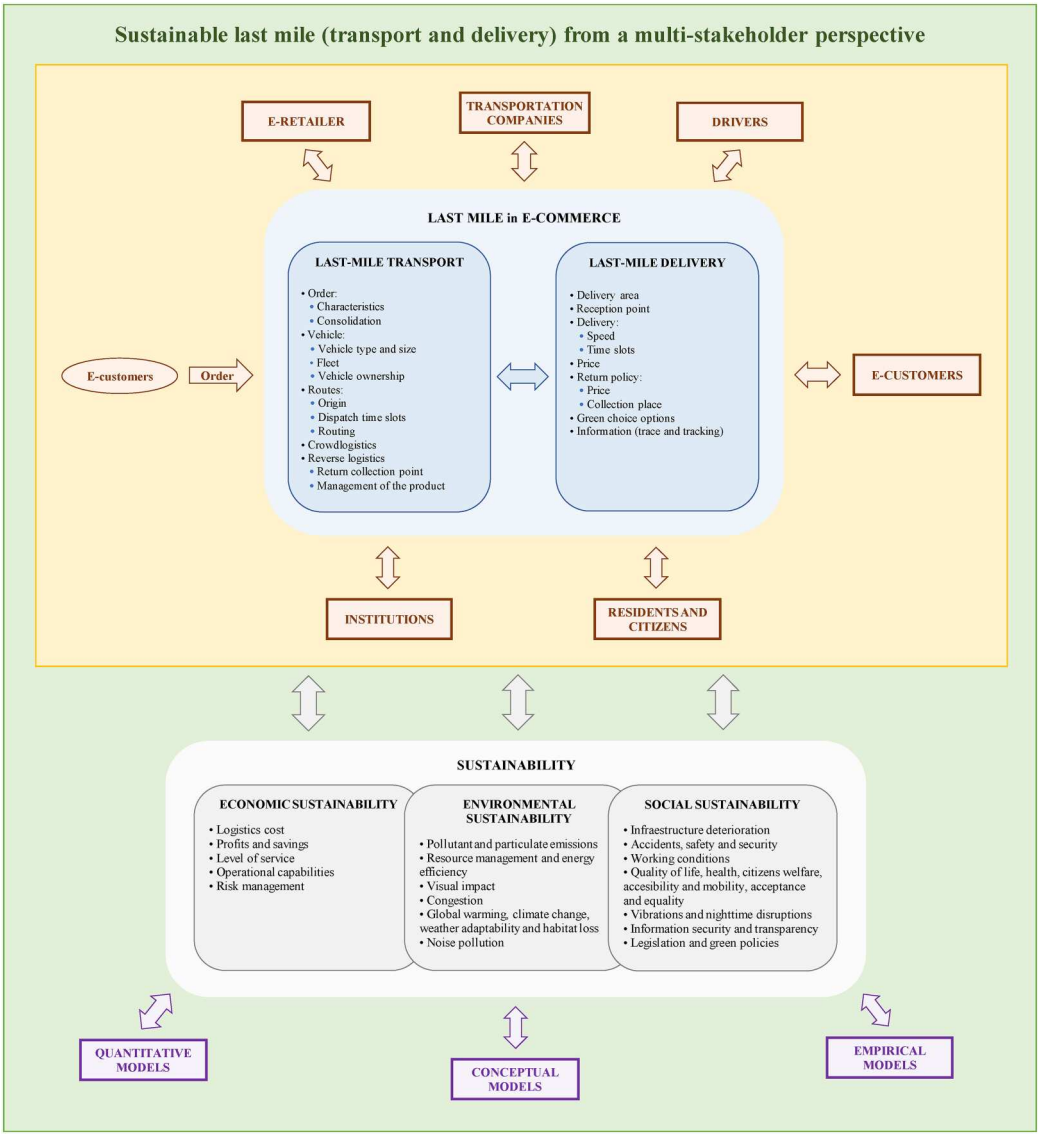

Figure 2. Conceptual framework linking sustainability, logistics factors and stakeholders.

5.2. Sustainability

- It can be noted that the economic and environmental pillars of sustainability are the most analysed, with 123 papers in the first group and 114 in the second, compared to the 41 articles that concerned the social pillar.
- Most of the articles concerning the economic pillar have focused on cost analyses, as they are of great concern to specific stakeholders (mainly retailers and transport companies), followed by the service level on offer (from the perspective of consumers and transport companies). It is noteworthy that these studies have not focused on logistical factors such as reverse logistics and returns, green choice options or delivery area.
- Elements that have limited coverage in the economic pillar are operational capabilities and risk management.

		Last-mile Transport										Last-mile Delivery								
		Order characteristics	Order consolidation	Vehicle type and size	Fleet	Vehicle ownership	Order origin	Dispatch time slots	Routing	Crowdlogistics	Reverse logistics	Delivery area	Reception point	Speed	Time slots	Reliability	Returns	Green choice options	Price	Information
Economic Pillar	Cost	3	20	54	2	39	42	6	40	22	5	8	52	25	21	7	4	2	14	3
	Benefits and savings	0	0	2	0	2	2	1	0	1	0	0	1	3	0	1	0	0	0	0
	Level of service	2	9	25	0	15	18	4	17	9	3	3	29	22	15	7	5	2	9	7
	Operational capabilities	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1
	Risk management	0	0	1	0	0	1	0	0	0	0	0	1	1	0	0	0	1	0	1
Environmental Pillar	Pollutants emissions	0	23	58	4	34	41	8	34	16	5	6	46	31	11	8	4	2	11	6
	Particulate emissions	0	3	9	0	5	7	1	7	1	2	0	7	5	1	2	0	0	0	1
	Resource management	0	8	22	0	16	15	5	16	4	4	3	20	9	5	2	1	0	0	0
	Congestion	1	11	23	1	14	16	3	16	1	4	2	21	10	4	2	2	0	2	0
	Visual impact	0	1	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0
	Weather adaptability	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	Climate change	0	1	2	0	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0
	Global warming	1	1	2	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	Habitat loss	0	1	2	0	2	0	0	1	0	1	0	1	2	0	1	1	0	1	0
	Noise pollution	0	11	19	1	10	15	1	12	3	2	3	14	8	5	2	0	0	0	1
Social Pillar	Accidents	0	6	12	0	7	9	2	9	1	2	0	9	6	3	0	1	0	2	1
	Safety and security	0	5	10	0	5	5	1	8	1	0	2	8	6	4	2	0	1	1	2
	Quality of life	0	1	3	0	1	2	0	3	0	0	0	1	1	1	0	0	0	0	0
	Infraestructure deterioration	0	7	12	1	8	7	2	8	1	1	1	9	7	5	0	0	0	1	1
	Vibrations	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	Nighttime disruptions	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Accesibility and mobility	0	1	4	0	2	0	0	1	2	0	1	4	1	1	1	0	0	0	1
	Working coditions	0	1	5	1	2	2	1	2	1	0	0	3	2	1	0	0	0	1	0
	Health (public and workers)	0	0	3	0	2	0	0	0	0	1	0	0	2	0	0	1	0	1	0
	Information security and transp	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	Acceptance	0	1	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0
	Equality	0	0	1	0	2	1	0	0	1	0	0	1	2	0	0	0	0	1	0
	Legislation and green policies	0	0	3	0	0	1	0	1	0	0	0	2	2	1	0	0	1	0	1
Stakeholders	Retailers	4	23	58	3	32	42	7	43	11	9	5	58	27	20	11	6	3	11	2
	Transportation companies	3	27	74	3	45	47	5	50	24	10	10	62	30	20	11	7	4	13	4
	Customers	1	13	29	1	20	18	2	17	13	6	1	42	29	11	8	8	3	20	6
	Government and Institutions	0	13	22	1	14	15	1	10	5	4	1	13	8	9	3	4	1	4	1
	Residents and Citizens	0	3	6	0	6	2	0	2	1	1	0	4	1	0	0	1	0	1	0
	Drivers	0	1	2	0	2	1	0	0	1	0	0	1	0	0	0	0	0	0	0

Legend: +15 | 11-15 | 6-10 | 1-5 | 0

Figure 3. The number of mentions of each pair of elements in the identified articles (sustainable elements and stakeholders related to last-mile logistics factors).

		Retailers	Transportation companies	Customers	Government and Institutions	Residents and Citizens	Drivers
Economic Pillar	Cost	73	94	36	23	5	3
	Benefits and savings	3	3	2	2	1	0
	Level of service	27	36	28	7	2	2
	Operational capabilities	0	1	0	0	0	0
	Risk management	1	2	0	0	0	0
Environmental Pillar	Pollutants emissions	63	79	39	25	6	1
	Particulate emissions	14	13	3	2	1	0
	Resource management	27	36	11	9	4	0
	Congestion	26	28	12	9	4	0
	Visual impact	0	0	1	0	0	0
	Weather adaptability	1	1	0	0	0	0
	Climate change	1	2	0	2	0	0
	Global warming	2	2	0	0	0	0
	Habitat loss	1	1	2	1	0	0
	Noise pollution	21	25	11	10	2	0
Social Pillar	Accidents	12	12	7	7	2	0
	Safety and security	10	13	7	6	3	0
	Quality of life	4	4	3	2	1	0
	Infraestructure deterioration	13	12	6	6	3	0
	Vibrations	0	1	1	1	1	0
	Nighttime disruptions	1	1	1	0	0	0
	Accesibility and mobility	3	5	2	2	2	0
	Working coditions	5	5	3	1	1	0
	Health (public and workers)	1	3	2	1	1	0
	Information security and transpare	0	1	1	1	1	0
	Acceptance	2	2	1	2	1	0
	Equality	2	3	2	1	0	0
	Legislation and green policies	3	4	1	1	0	0
Last-mile Transport	Order characteristics	4	3	1	0	0	0
	Order consolidation	23	27	13	13	3	1
	Vehicle type and size	58	74	29	22	6	2
	Fleet	1	3	3	1	0	0
	Vehicle ownership	32	45	20	14	6	2
	Order origin	42	47	18	15	2	1
	Dispatch time slots	7	5	2	1	0	0
	Routing	43	50	17	10	2	0
	Crowdlogistics	13	21	12	4	1	0
	Reverse logistics	9	10	6	4	1	0
Last-mile Delivery	Delivery area	5	10	1	1	0	0
	Reception point	58	62	42	13	4	1
	Speed	27	30	29	8	1	0
	Time slots	20	20	11	9	0	0
	Reliability	11	11	8	3	0	0
	Returns	6	7	8	4	1	0
	Green choice options	3	4	3	1	0	0
	Price	11	13	20	4	1	0
	Information	2	4	6	1	0	0

+15
11-15
6-10
1-5
0

Figure 4. The number of mentions of each pair of elements in the identified articles (sustainable elements and last-mile logistics factors related to stakeholders).

- Regarding the environmental pillar, researchers have mainly focused on gas and particulate emissions exclusively focused on the vehicle and the point of reception; and resource management mainly regarding the type and size of the vehicle used or the reception point. To a lesser extent, the research focuses on city congestion or noise at collection points.
- More general elements on the environmental pillar such as weather adaptability, climate change or global warming, where the effect of the last mile is more complex to calculate, are the least analysed and only addressed by a small number of papers (seven out of the total).
- Concerning the social pillar, the most investigated elements are infrastructure deterioration, accidents, and safety. To a lesser extent, research also analysed elements such as worker benefits and working conditions, accessibility and mobility or the quality of life and health of consumers and citizens. However, night-time disruptions and information security have barely been addressed.

- The concern shown by institutions regarding last-mile deliveries has been increasing, triggering research on legislation and green policies (e.g. Simić, Lazarević, and Dobrodolac 2021). However, such research is still limited.

5.3. Stakeholders

- The most analysed stakeholders are, according to the number of mentions, transport companies, e-retailers and consumers as the stakeholders with the most significant involvement in the chain. Conversely, the perspectives of institutions, citizens and drivers are much less prevalent in the research.
- E-retailers are the most studied group of stakeholders, and research covered, to a large extent, all the logistics factors identified within the last mile. However, factors such as the order characteristics, dispatch time slots or delivery area have not yet been analysed in depth.
- Research concerning transportation companies concerned almost all of the logistics factors identified. However, it highlights the lack of research on order characteristics, dispatch time slots, green choice options and information.
- Despite the importance of drivers within the last mile, only two articles expressly analysed their role (e.g. Paddeu and Parkhurst 2020; Xiao and Ke 2019). In these works, the authors pointed out the role of drivers as a key factor for implementation success.
- Research provides a deep examination of the role of e-customers.
- The concern of institutions about the adverse societal effects of the last mile has led to an increase in research. However, research remains limited.
- Research centring on citizens is minimal and has focused on how last-mile deliveries affect their quality of life and on their role as actors in crowd logistics strategies.

5.4. The conceptual framework as a tool

The conceptual framework presents a complex picture of the sustainable last mile, identifying up to three dimensions, 11 axes and 53 elements. Consequently, multiple interactions emerge when analysing the framework, the importance of which and impact are case sensitive (depending on the last-mile strategy analysed in each case). However, given this complexity, the level of detail offered by this conceptual framework allows it to be used as a tool in two different ways.

Firstly, the framework can be employed by academics and managers as a tool for reflection and strategic design of the sustainable last mile. The framework has detailed the elements to be considered when designing these strategies. Therefore, it can guide a sustainable design in which attention is paid to each element and its interrelationship. Consequently, in order for the framework to be used in this context, it must be applied in a conscious manner in terms of the decisions made regarding the design of each element highlighted in the framework. Furthermore, it is also important to consider the impact of these decisions on the other elements.

Secondly, the framework can also be employed as a diagnostic tool (as a checklist). Its utilisation provides insight into the present status of a specific last-mile strategy with respect to sustainability. Consequently, it permits the identification of the current status of a specific strategy with respect to each identified element, thereby enabling the understanding of how these elements interact and how the current level of sustainability can be diagnosed.

6. Discussion, research gaps and future agenda

While research on sustainable last mile in e-commerce has grown significantly in recent years (Ha, Akbari, and Au 2022), the analysis has revealed a varying level of scrutiny and extent of coverage for

different topics. Our research has shown that coverage is still limited. Regarding the least-analysed elements, only two papers concern drivers and last-mile deliveries. However, these studies do reflect the importance of their role in the success of sustainable last-mile strategies, so further research is needed. This should focus on identifying the role of drivers on the implementation of sustainable strategies, as well as how their acceptance plays a major role in implementation success. To that, an empirical and quantitative approach should be considered.

Institutions and citizens have also rarely been studied, focusing their analysis on the perception of retailers and transport companies on their role in the sustainable last mile (e.g. Ranieri et al. 2018). However, its predominant role in the design of new sustainable alternatives is becoming increasingly evident (e.g. De Marco, Mangano, and Zenezini 2018). Thus, institutions are paying more attention to the creation of regulations that ensure the sustainability of their cities and the adequate level of living of their citizens. More empirical research is needed on how institutions should deal with the increase in sustainable last-mile regulation, as well as the impact of such regulations on the actual sustainability of the delivery process.

Furthermore, the novelty of their implementation, the difficulty of quantifying their impact on sustainability or the complexity for retailers to modify their design has meant that logistics factors such as order characteristics, dispatch time slots, reverse logistics and green choice options were the least studied (e.g. Harrington et al. 2016). However, these difficulties, and the studies already carried out, have not demonstrated their lesser impact on the sustainability of the last mile. Therefore, greater involvement of researchers is needed to precisely determine the impact of these logistics factors on sustainability and their most appropriate design in line with last-mile sustainability. Thus, quantitative methodologies should be employed to this end.

In addition, the social perspective of sustainability, along with certain elements of the environmental pillar (particulates, visual impact, climate change) have been little studied due to a lack of quantitative indicators to assess the impact of last mile strategies and the complexity of calculating this impact (e.g. Oliveira et al. 2019). However, the few studies focusing on these elements have demonstrated their importance and implications on the sustainability of the last mile (e.g. Oliveira et al. 2019). Thus, it is necessary that researchers focus on designing quantitative indicators, through conceptual and empirical methodologies, and applying them through quantitative studies.

In addition to the individual study of each sustainability pillar, the literature has also begun to pay attention to the concept of sustainability in general, integrating all three pillars (25 articles out of a total of 169). Thus, specific papers have considered the three pillars of sustainability when compiling innovations and opportunities in the field (e.g. Kiba-Janiak et al. 2021), assessing the level of sustainability of some last-mile strategies (e.g. Melkonyan et al. 2020) or studying the possible implementation of innovations such as drones or electric vehicles (e.g. Borghetti et al. 2022). However, these studies demonstrated the complexity of designing and analysing last-mile strategies that are sustainable without compromising any of the three pillars. More conceptual and empirical studies are therefore needed that analyse the interaction between all the elements that integrate the sustainable last mile. Furthermore, more empirical, and quantitative research is also needed to analyse last-mile strategies from a sustainable perspective, using a wider range of sustainable indicators and clearly assessing the impact of solutions on all three pillars. Particularly, as most research has focused on the perspective of developed countries (e.g. UK, Belgium, Germany, China) and urban areas, there is still a need to establish and expand the global vision of the three sustainability pillars. Thus, this vision should be applied to all studies in this area, integrating the perspective of different geographical contexts (developing countries, and suburban and rural areas).

Another dimension that requires a higher level of research attention is stakeholders, both at the individual level and at a collective level. Twenty papers have integrated a vision of four or more stakeholders (one article analysed all stakeholders, four papers analysed five and fifteen articles analysed four). These papers have highlighted the positive impact of establishing collaborative relationships between different stakeholders on the sustainability of the last mile. Given this situation, there

Table 9. Summary of research gaps.

Research gap	Further research	Methodology to approach this research
The role of drivers in the last mile	To analyse the role and involvement of drivers in the sustainability of the last mile, detailing how their implication and acceptance play a major role in the success of sustainable last-mile strategies	Empirical and quantitative research
Research on institutions and citizens	To research the design and content of regulations on sustainability, analysing how institutions should deal with the increase in sustainable last-mile regulation and the impact of such regulations	Empirical research
Logistics factors such as order characteristics, dispatch time slots, reverse logistics and green choice options	To determine the impact of these logistics factors on sustainability. To define their most appropriate design in line with last-mile sustainability	Quantitative research
A lack of quantitative indicators has led to a limited societal analysis, along with certain elements of the environmental pillar.	To define and design new indicators for the quantification of these elements. To implement these indicators and analyse in a more formal way the impact of these societal and environmental elements	Conceptual (definition of these indicators) and quantitative (application of these indicators) research
The intersection of the three pillars	To analyse the interaction between all the elements that integrate the sustainable last mile. To establish and expand the global vision of the three pillars of sustainability in the last-mile research, integrating the perspective of different geographical contexts	Conceptual, empirical and quantitative research
Collaborative relationships between stakeholders	To analyse the challenges and benefits of establishing collaborative relationships between all stakeholders, paying special attention to the specificities of partnerships in rural settings	Conceptual and empirical research
Sustainable alternatives	To focus on the implementation of sustainable alternatives in e-retailing, considering large-scale analysis and paying attention to the specificities of different circumstances (developed and developing countries; urban, suburban and rural areas)	Empirical and quantitative research
Geographical characteristics	To focus on developing research that includes different geographical contexts (developed and developing countries, and urban, suburban and rural areas) in its analysis	Conceptual, empirical and quantitative research
Theory-based papers or abstracted existing knowledge on sustainable last mile in e-commerce	To place more emphasis on the development and application of theory, as well as the development of frameworks for structuring the existing contributions	Conceptual research

needs to be more conceptual and empirical research on the challenges and benefits of establishing these collaborative relationships amongst all stakeholders, paying particular attention to the specificities of partnerships in rural settings.

Increased concern about the high impact of the last mile on sustainability has prompted studies on possible sustainable alternatives (e.g. Rosenberg et al. 2021). However, most of this research is based on geographically limited case studies as most of the papers focus on analysing the difficulties and benefits of applying a new sustainable alternative in a limited and specific case study (e.g. deliveries of a specific online retailer in New York, Madrid, Rome, Paris or London), leaving aside the possible expansion of this alternative to different retailers or geographic areas. Furthermore, these studies are limited to the analysis of the circumstances of developed countries (e.g. Europe, North

America) and urban areas. Thus, the characteristics of developing countries, as well as suburban and rural areas, are neglected. Thus, the lack of analysis on the possibility of large-scale implementation (different geographical circumstances and characteristics) of some of these alternatives and their implications for security and legislation is preventing their mass implementation in last-mile strategies. Therefore, to facilitate the implementation of these sustainable alternatives in e-retailing, further empirical and quantitative research with a focus on large-scale analysis in different circumstances is indicated.

Furthermore, the dominant vision in the study of the sustainable last mile has been limited to the analysis of the circumstances of developed countries and urban areas. In this sense, most quantitative and empirical analysis have been based on case studies or samples located in developed countries and urban areas. Only a few studies have made an effort to include the perspective of less developed areas (e.g. de Mello Bandeira) or to compare the differences between urban, suburban or rural areas (e.g. Mommens et al. 2021). However, these studies have identified key differences in the context and needs of each of these areas. For example, Mommens et al. (2021) highlighted how the impact of reception point selection on sustainability changes depending on the typology of the delivery area (urban, urbanised/suburban and rural area). In this sense, home delivery is the most sustainable alternative in rural and urbanised areas. However, the use of collection points becomes the best option in urban areas. In this context, these significant differences mean that current research developed based on certain geographical characteristics cannot be applied to multiple circumstances and contexts. As a result, the potential extension of the sustainable last mile to different geographical areas is significantly limited. In this sense, in order to facilitate the expansion and adaptation of the sustainable last mile to different geographical contexts (developed and developing countries, and urban, suburban and rural areas), further research (conceptual, empirical and quantitative) should focus on including these different contexts in its analysis.

Finally, there is a need to highlight the importance of theory as a tool for developing research in all fields (Ha, Akbari, and Au 2022). While researchers must place more emphasis on the application of theory as suggested by Olsson, Hellström, and Pålsson (2019) and Ha, Akbari, and Au (2022), the latter has pointed out the low number of theory-based papers that still exist (although the trend is positive). In the same vein, research has yet to focus on structuring and abstracting existing knowledge on sustainable last mile. Some papers have tried to create frameworks to structure this operation (e.g. Olsson, Hellström, and Pålsson 2019). However, these are not fully completed or do not consider all relevant elements. Thus, it is recommended that researchers place more emphasis on the development and application of theory, as well as the development of frameworks that can structure the existing contribution in this area. This effort of abstraction and theorisation will serve as a basis for future research on sustainable last mile in e-commerce.

Table 9 summarises the main research gaps identified in the literature.

7. Conclusions, limitations, and future direction

This research has produced a novel framework for understanding sustainable last-mile transport and delivery, focusing on the three pillars of sustainability (economic, environmental, and social), the logistics factors and the main stakeholders (e-retailers, e-customers, transport companies, drivers, citizens, and institutions). The framework is based on a comprehensive review of the literature on sustainable last mile, the study of which has been the subject of much interest by researchers in recent years. The review analysed publications in which a partial or complete relation is established among the last mile in e-commerce, the three pillars of sustainability, logistics factors, and the stakeholders involved. Then, a content, methodological and coverage analysis of the 169 selected papers was undertaken.

The literature review and the conceptual framework (Section 5) have the potential to play a role in the future of the sustainable last mile, assisting researchers in planning their future research and

managers in designing their sustainable strategies. The review has thoroughly examined the literature, facilitating the understanding of the role of sustainability in the last mile. It revealed that the interest shown by the academic community in this field increased significantly from 2020 onwards. This literature can be framed in three dimensions (11 axes and 53 elements) that structure the sustainable last mile in e-commerce: the last-mile logistics factors (integrated into last-mile transport and last-mile delivery), sustainability (formed by the economic, environmental, and social pillars) and the main stakeholders (e-retailer, transport companies, drivers, e-customers, citizens, and institutions).

In addition, we have structured these dimensions by creating a conceptual framework composed of the three dimensions and the 11 previously identified axes. This framework integrated all topics, establishing the relationship between the last mile (and its logistics factors), stakeholders and sustainability and encompassing the research on the sustainable last mile in e-commerce. The framework's core was formed by the last mile itself, structured into last-mile transport (10 factors) and last-mile delivery (9 factors). From this core, the factors were related to the six stakeholders and the three pillars of sustainability (and 28 elements), creating different pathways and approaches to the design of last mile strategies.

However, the results of this review indicate that further research is needed (mainly through conceptual and empirical methodologies). First, there is a need for balanced attention to be paid to the three dimensions and their axes since, in general, the extent of coverage is still low and partial. Thus, future research should focus on developing less-studied areas such as the social pillar of sustainability, the driver's perspective and the role of logistics factors such as order characteristics, dispatch time slots, or reverse logistics. Second, these studies should endeavour to integrate the three pillars of sustainability in a holistic rather than partial manner. Third, the stakeholder perspective should also be studied as a whole, paying special attention to the role of stakeholder collaboration in sustainability. Fourth, there is a need to start conducting large-scale analyses to facilitate the use of new sustainable alternatives in the last-mile strategies of retailers and transport companies. Finally, the next steps in sustainable last-mile research need to focus on bringing more structure and abstraction to the existing literature, paying more attention to applying relevant theory to this area of research.

7.1. Implications for research

Implications for research can be drawn from this study. First, the framework encompasses the research on the sustainable last mile in e-commerce, setting the precedents for a deeper understanding of the subject that will form the basis for future research. The framework articulates how the previously mentioned dimensions, axes and factors are integrated with each other and, consequently, how these elements should be studied. Thus, the framework pointed out how the 19 interrelated logistics factors are influenced by or influence the stakeholders' perspective. Therefore, it highlighted the role of all stakeholders in influencing the sustainable last-mile strategy and the influence of this strategy on the perspectives of consumers and citizens. Furthermore, based on these influences, the design of the last mile impacted 28 sustainable elements. These impacts were different depending on the strategy.

Second, from the coverage analysis, mainly, researchers should use the findings when designing and developing their future studies on sustainable last mile in e-commerce. The findings ensure that all areas of this field of research will be similarly developed. Thus, future research should focus on analysing elements such as order characteristics, dispatch time slots, reverse logistics, or green choice options, studying the social pillar perspective or examining the role of drivers.

7.2. Implications for managers

Managerial implications can also be drawn from this study. These implications are oriented to both the information collected, analysed, and discussed and the structure with which it is provided.

Almost 80% of the reviewed research articles have taken an experimental research approach and have, thus, undergone some type of empirical validation. Therefore, although the step from the academic to the business sphere is a challenge, the comprehensive review and analysis of the literature conducted in this article (and, mainly, the framework) may contribute to ensuring that this step is carried out in the relatively near future. Furthermore, managerial implications can be drawn from the framework. This contribution is based on the ability of the framework to be used as a tool for the design and evaluation of sustainable last-mile strategies. Thus, managers can employ the paper as a reference when designing, evaluating and redesigning their last-mile strategies, focusing on more sustainable solutions.

7.3. Future directions and limitations

First, in order to investigate any effect on sustainability and take the necessary measures, it is essential to include an integrated view of the three pillars of sustainability. In addition, it is important to have a multi-stakeholder view in future research. Based on the findings, it is also considered necessary, through the creation of a metrics system, to evaluate the current level of sustainability of retailers' last-mile strategies, taking into account the three pillars of sustainability. Future studies should focus on establishing which sustainable last-mile design is the most appropriate, considering the characteristics of each e-retailer, the preferences of their customers, and the relationship with their stakeholders. The authors also encourage further theoretical validations of the work. Furthermore, the applicability of the conceptual framework as a design and evaluation tool should be analysed and empirically validated. It would also be beneficial to ascertain the interrelationships between the various elements identified within the framework, with a view to determining their importance and impact. Finally, it should be noted that this article may have some limitations. In this regard, only Scopus and Web of Science have been used as databases, and there may be articles indexed in other reference sources that have been excluded.

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Data availability statement

The authors confirm that the data supporting the findings of this study are available upon request.

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References

R. Al-dal'ain, and D. Celebi. 2021. "Planning a Mixed Fleet of Electric and Conventional Vehicles for Urban Freight with Routing and Replacement Considerations." *Sustainable Cities and Society* 73:103105. https://doi.org/10.1016/j.scs.2021.103105.

Allen, J., M. Piecyk, M. Piotrowska, F. McLeod, T. Cherrett, K. Ghali, T. Nguyen, et al. 2018. "Understanding the Impact of E-commerce on Last-mile Light Goods Vehicle Activity in Urban Areas: The Case of London." *Transportation Research Part D: Transport and Environment* 61:325–338. https://doi.org/10.1016/j.trd.2017.07.020.

Alves, R., R. da Silva Lima, D. Custódio de Sena, A. Ferreira de Pinho, and J. Holguín-Veras. 2019. "Agent-based Simulation Model for Evaluating Urban Freight Policy to e-Commerce." *Sustainability* 11 (15): 4020. https://doi.org/10.3390/su11154020.

Arrieta-Prieto, M., A. Ismael, C. Rivera-Gonzalez, and J. E. Mitchell. 2022. "Location of Urban Micro-consolidation Centers to Reduce the Social Cost of Last-mile Deliveries of Cargo: A Heuristic Approach." *Networks* 79 (3): 292–313. https://doi.org/10.1002/net.22076.

Baldi, M. M., D. Manerba, G. Perboli, and R. Tadei. 2019. "A Generalized Bin Packing Problem for Parcel Delivery in Last-mile Logistics." *European Journal of Operational Research* 274 (3): 990–999. https://doi.org/10.1016/j.ejor.2018.10.056.

Borghetti, F., C. Caballini, A. Carboni, G. Grossato, R. Maja, and B. Barabino. 2022. "The Use of Drones for Last-Mile Delivery: A Numerical Case Study in Milan, Italy." *Sustainability* 14 (3): 1766. https://doi.org/10.3390/su14031766.

Brown, J. R., and A. L. Guiffrida. 2014. "Carbon Emissions Comparison of Last Mile Delivery Versus Customer Pickup." *International Journal of Logistics Research and Applications* 17 (6): 503–521. https://doi.org/10.1080/13675567.2014.907397.

Buldeo Rai, H., S. Verlinde, J. Merckx, and C. Macharis. 2017. "Crowd Logistics: An Opportunity for More Sustainable Urban Freight Transport?" *European Transport Research Review* 9 (3): 1–13. https://doi.org/10.1007/s12544-017-0256-6.

Cárdenas, I., J. Beckers, and T. Vanelslander. 2017. "E-commerce Last-mile in Belgium: Developing an External Cost Delivery Index." *Research in Transportation Business & Management* 24:123–129. https://doi.org/10.1016/j.rtbm.2017.07.006.

Caspersen, E., and S. Navrud. 2021. "The Sharing Economy and Consumer Preferences for Environmentally Sustainable Last Mile Deliveries." *Transportation Research Part D: Transport and Environment* 95:102863. https://doi.org/10.1016/j.trd.2021.102863.

Chen, J. S., H. T. Tsou, C. Y. Chou, and C. H. Ciou. 2019. "Effect of Multichannel Service Delivery Quality on Customers' Continued Engagement Intention: A Customer Experience Perspective." *Asia Pacific Journal of Marketing and Logistics* 32 (2): 473–494. https://doi.org/10.1108/APJML-12-2018-0508.

Comi, A., and L. Savchenko. 2021. "Last-mile Delivering: Analysis of Environment-friendly Transport." *Sustainable Cities and Society* 74:103213. https://doi.org/10.1016/j.scs.2021.103213.

de Kervenoael, R., A. Schwob, and C. Chandra. 2020. "E-retailers and the Engagement of Delivery Workers in Urban Last-mile Delivery for Sustainable Logistics Value Creation: Leveraging Legitimate Concerns under Time-based Marketing Promise." *Journal of Retailing and Consumer Services* 54:102016. https://doi.org/10.1016/j.jretconser.2019.102016.

De Marco, A., G. Mangano, and G. Zenezini. 2018. "Classification and Benchmark of City Logistics Measures: An Empirical Analysis." *International Journal of Logistics Research and Applications* 21 (1): 1–19. https://doi.org/10.1080/13675567.2017.1353068.

De Mello Bandeira, R. A., G. V. Goes, D. N. S. Gonçalves, D. A. Márcio de Almeida, and C. M. de Oliveira. 2019. "Electric Vehicles in the Last Mile of Urban Freight Transportation: A Sustainability Assessment of Postal Deliveries in Rio de Janeiro-Brazil." *Transportation Research Part D: Transport and Environment* 67:491–502. https://doi.org/10.1016/j.trd.2018.12.017.

de Oliveira, L. K., E. Morganti, L. Dablanc, and R. L. M. de Oliveira. 2017. "Analysis of the Potential Demand of Automated Delivery Stations for E-commerce Deliveries in Belo Horizonte, Brazil." *Research in Transportation Economics* 65:34–43. https://doi.org/10.1016/j.retrec.2017.09.003.

Edwards, J. B., A. C. McKinnon, and S. L. Cullinane. 2010. "Comparative Analysis of the Carbon Footprints of Conventional and Online Retailing: A 'Last Mile' Perspective." *International Journal of Physical Distribution & Logistics Management* 40 (1/2): 103–123. https://doi.org/10.1108/09600031011018055.

Ehrler, V. C., D. Schöder, and S. Seidel. 2021. "Challenges and Perspectives for the Use of Electric Vehicles for Last Mile Logistics of Grocery E-commerce–findings from Case Studies in Germany." *Research in Transportation Economics* 87:100757. https://doi.org/10.1016/j.retrec.2019.100757.

Figliozzi, M. A. 2020. "Carbon Emissions Reductions in Last Mile and Grocery Deliveries Utilizing Air and Ground Autonomous Vehicles." *Transportation Research Part D: Transport and Environment* 85:102443. https://doi.org/10.1016/j.trd.2020.102443.

Florio, A. M., D. Feillet, and R. F. Hartl. 2018. "The Delivery Problem: Optimizing Hit Rates in E-commerce Deliveries." *Transportation Research Part B: Methodological* 117:455–472. https://doi.org/10.1016/j.trb.2018.09.011.

Frehe, V., J. Mehmann, and F. Teuteberg. 2017. "Understanding and Assessing Crowd Logistics Business Models–Using Everyday People for Last Mile Delivery." *Journal of Business & Industrial Marketing* 32 (1): 75–97. https://doi.org/10.1108/JBIM-10-2015-0182.

Garus, A., B. Alonso, M. A. Raposo, M. Grosso, J. Krause, A. Mourtzouchou, and B. Ciuffo. 2022. "Last-mile Delivery by Automated Droids. Sustainability Assessment on a Real-world Case Study." *Sustainable Cities and Society* 79:103728. https://doi.org/10.1016/j.scs.2022.103728.

Gatta, V., E. Marcucci, M. Nigro, S. M. Patella, and S. Serafini. 2019. "Public Transport-based Crowdshipping for Sustainable City Logistics: Assessing Economic and Environmental Impacts." *Sustainability* 11 (1): 145. https://doi.org/10.3390/su11010145.

Ghaderi, H., P. W. Tsai, L. Zhang, and A. Moayedikia. 2022. "An Integrated Crowdshipping Framework for Green Last Mile Delivery." *Sustainable Cities and Society* 78:103552. https://doi.org/10.1016/j.scs.2021.103552.

Guo, X., Y. J. L. Jaramillo, J. Bloemhof-Ruwaard, and G. D. H. Claassen. 2019. "On Integrating Crowdsourced Delivery in Last-mile Logistics: A Simulation Study to Quantify its Feasibility." *Journal of Cleaner Production* 241:118365. https://doi.org/10.1016/j.jclepro.2019.118365.

Ha, N. T., M. Akbari, and B. Au. 2022. "Last Mile Delivery in Logistics and Supply Chain Management: A Bibliometric Analysis and Future Directions." *Benchmarking: An International Journal* 30 (4): 1137–1170.

Halldorsson, A., and J. Wehner. 2020. "Last-mile Logistics Fulfilment: A Framework for Energy Efficiency." *Research in Transportation Business & Management* 37:100481. https://doi.org/10.1016/j.rtbm.2020.100481.

Harrington, T. S., J. Singh Srai, M. Kumar, and J. Wohlrab. 2016. "Identifying Design Criteria for Urban System 'Last-mile' Solutions–A Multi-stakeholder Perspective." *Production Planning & Control* 27 (6): 456–476. https://doi.org/10.1080/09537287.2016.1147099.

Ignat, B., and S. Chankov. 2020. "Do E-commerce Customers Change their Preferred Last-mile Delivery Based on its Sustainability Impact?" *The International Journal of Logistics Management* 31 (3): 521–548. https://doi.org/10.1108/IJLM-11-2019-0305.

Iwan, S., M. Nürnberg, M. Jedliński, and K. Kijewska. 2021. "Efficiency of Light Electric Vehicles in Last Mile Deliveries–Szczecin Case Study." *Sustainable Cities and Society* 74:103167. https://doi.org/10.1016/j.scs.2021.103167.

Janjevic, M., and M. Winkenbach. 2020. "Characterizing Urban Last-mile Distribution Strategies in Mature and Emerging E-commerce Markets." *Transportation Research Part A: Policy and Practice* 133:164–196. https://doi.org/10.1016/j.tra.2020.01.003.

Janjevic, M., M. Winkenbach, and D. Merchán. 2019. "Integrating Collection-and-delivery Points in the Strategic Design of Urban Last-mile E-commerce Distribution Networks." *Transportation Research Part E: Logistics and Transportation Review* 131:37–67. https://doi.org/10.1016/j.tre.2019.09.001.

Jiang, L., H. Chang, S. Zhao, J. Dong, and W. Lu. 2019a. "A Travelling Salesman Problem with Carbon Emission Reduction in the Last Mile Delivery." *IEEE Access* 7:61620–61627. https://doi.org/10.1109/ACCESS.2019.2915634.

Jiang, X., H. Wang, X. Guo, and X. Gong. 2019b. "Usbing the FAHP, ISM, and MICMAC Approaches to Study the Sustainability Influencing Factors of the Last Mile Delivery of Rural E-ommerce Logistics." *Sustainability* 11 (14): 3937. https://doi.org/10.3390/su11143937.

Kancharla, S. R., and G. Ramadurai. 2018. "Incorporating Driving Cycle Based Fuel Consumption Estimation in Green Vehicle Routing Problems." *Sustainable Cities and Society* 40:214–221. https://doi.org/10.1016/j.scs.2018.04.016.

Kiba-Janiak, M., J. Marcinkowski, A. Jagoda, and A. Skowrońska. 2021. "Sustainable Last Mile Delivery on E-commerce Market in Cities from the Perspective of Various Stakeholders. Literature Review." *Sustainable Cities and Society* 71: 102984. https://doi.org/10.1016/j.scs.2021.102984.

Klein, R., J. Mackert, M. Neugebauer, and C. Steinhardt. 2018. "A Model-based Approximation of Opportunity Cost for Dynamic Pricing in Attended Home Delivery." *OR Spectrum* 40 (4): 969–996. https://doi.org/10.1007/s00291-017-0501-3.

Lai, P. L., H. Jang, M. Fang, and K. Peng. 2022. "Determinants of Customer Satisfaction with Parcel Locker Services in Last-mile Logistics." *The Asian Journal of Shipping and Logistics* 38 (1): 25–30. https://doi.org/10.1016/j.ajsl.2021.11.002.

Leyerer, M., M. O. Sonneberg, M. Heumann, and M. H. Breitner. 2020. "Shortening the Last Mile in Urban Areas: Optimizing a Smart Logistics Concept for E-grocery Operations." *Smart Cities* 3 (3): 585–603. https://doi.org/10.3390/smartcities3030031.

Li, L., X. Wang, Y. Lin, F. Zhou, and S. Chen. 2019. "Cooperative Game-based Profit Allocation for Joint Distribution Alliance under Online Shopping Environment: A Case in Southwest China." *Asia Pacific Journal of Marketing and Logistics* 31 (2): 302–326. https://doi.org/10.1108/APJML-02-2018-0050.

Mangiaracina, R., A. Perego, A. Seghezzi, and A. Tumino. 2019. "Innovative Solutions to Increase Last-mile Delivery Efficiency in B2C E-commerce: A Literature Review." *International Journal of Physical Distribution & Logistics Management* 49 (9): 901–920. https://doi.org/10.1108/IJPDLM-02-2019-0048.

Mangiaracina, R., G. Song, and A. Perego. 2015. "Distribution Network Design: A Literature Review and a Research Agenda." *International Journal of Physical Distribution & Logistics Management* 45 (5): 506–531. https://doi.org/10.1108/IJPDLM-02-2014-0035.

Marujo, L. G., G. V. Goes, M. A. D'Agosto, A. F. Ferreira, M. Winkenbach, and R. A. Bandeira. 2018. "Assessing the Sustainability of Mobile Depots: The Case of Urban Freight Distribution in Rio de Janeiro." *Transportation Research Part D: Transport and Environment* 62:256–267. https://doi.org/10.1016/j.trd.2018.02.022.

Melkonyan, A., T. Gruchmann, F. Lohmar, V. Kamath, and S. Spinler. 2020. "Sustainability Assessment of Last-mile Logistics and Distribution Strategies: The Case of Local Food Networks." *International Journal of Production Economics* 228:107746. https://doi.org/10.1016/j.ijpe.2020.107746.

Mkansi, M., and A. L. Nsakanda. 2021. "Leveraging the Physical Network of Stores in E-grocery Order Fulfilment for Sustainable Competitive Advantage." *Research in Transportation Economics* 87:100786. https://doi.org/10.1016/j.retrec.2019.100786.

Mommens, K., H. B. Rai, T. Van Lier, and C. Macharis. 2021. "Delivery to Homes or Collection Points? A Sustainability Analysis for Urban, Urbanised and Rural Areas in Belgium." *Journal of Transport Geography* 94:103095. https://doi.org/10.1016/j.jtrangeo.2021.103095.

Moncef, B., and M. M. Dupuy. 2021. "Last-mile Logistics in the Sharing Economy: Sustainability Paradoxes." *International Journal of Physical Distribution & Logistics Management* 51 (5): 508–527. https://doi.org/10.1108/IJPDLM-10-2019-0328.

Mucowska, M. 2021. "Trends of Environmentally Sustainable Solutions of Urban Last-mile Deliveries on the e-Commerce Market—A Literature Review." *Sustainability* 13 (11): 5894. https://doi.org/10.3390/su13115894.

Na, H. S., S. J. Kweon, and K. Park. 2021. "Characterization and Design for Last Mile Logistics: A Review of the State of the Art and Future Directions." *Applied Sciences* 12 (1): 118. https://doi.org/10.3390/app12010118.

Nenni, M. E., A. Sforza, and C. Sterle. 2019. "Sustainability-based Review of Urban Freight Models." *Soft Computing* 23 (9): 2899–2909. https://doi.org/10.1007/s00500-019-03786-x.

Nogueira, G. P. M., J. J. de Assis Rangel, and E. Shimoda. 2021. "Sustainable Last-mile Distribution in B2C E-commerce: Do Consumers Really Care?" *Cleaner and Responsible Consumption* 3:100021. https://doi.org/10.1016/j.clrc.2021.100021.

Oliveira, L. K. D., R. L. M. D. Oliveira, L. T. M. D. Sousa, I. D. P. Caliari, and C. D. O. L. Nascimento. 2019. "Analysis of Accessibility from Collection and Delivery Points: Towards the Sustainability of the e-Commerce Delivery." *urbe. Revista Brasileira de Gestão Urbana* 11: 1–17.

Olsson, J., D. Hellström, and H. Pålsson. 2019. "Framework of Last Mile Logistics Research: A Systematic Review of the Literature." *Sustainability* 11 (24): 7131. https://doi.org/10.3390/su11247131.

Otter, C., C. Watzl, D. Schwarz, and P. Priess. 2017. "Towards Sustainable Logistics: Study of Alternative Delivery Facets." *Entrepreneurship and Sustainability Issues* 4 (4): 460–476. https://doi.org/10.9770/jesi.2017.4.4(5).

Paddeu, D., and G. Parkhurst. 2020. "The Potential for Automation to Transform Urban Deliveries: Drivers, Barriers and Policy Priorities." *Advances in Transport Policy and Planning* 5:291–314. https://doi.org/10.1016/bs.atpp.2020.01.003.

Peppel, M., J. Ringbeck, and S. Spinler. 2022. "How Will Last-mile Delivery be Shaped in 2040? A Delphi-based Scenario Study." *Technological Forecasting and Social Change* 177:121493. https://doi.org/10.1016/j.techfore.2022.121493.

Perboli, G., and M. Rosano. 2019. "Parcel Delivery in Urban Areas: Opportunities and Threats for the Mix of Traditional and Green Business Models." *Transportation Research Part C: Emerging Technologies* 99:19–36. https://doi.org/10.1016/j.trc.2019.01.006.

Perego, A., S. Perotti, and R. Mangiaracina. 2011. "ICT for Logistics and Freight Transportation: A Literature Review and Research Agenda." *International Journal of Physical Distribution & Logistics Management* 41 (5): 457–483. https://doi.org/10.1108/09600031111138826.

Phillips, R. 2003. *Stakeholder Theory, State of the Art*. Oakland, CA: Berrett-Koehler Publishers.

Rai, H. B. 2019. "Environmental Sustainability of the Last Mile in Omnichannel Retail." Ph.D. Thesis, Vrije Universiteit Brussel.

Rai, H. B., S. Verlinde, and C. Macharis. 2018. "The 'Next day, Free Delivery' Myth Unravelled: Possibilities for Sustainable Last Mile Transport in an Omnichannel Environment." *International Journal of Retail & Distribution Management* 47 (1): 39–54.

Rai, H. B., S. Verlinde, and C. Macharis. 2019. "City Logistics in an Omnichannel Environment. The Case of Brussels." *Case Studies on Transport Policy* 7 (2): 310–317. https://doi.org/10.1016/j.cstp.2019.02.002.

Rai, H. B., S. Verlinde, and C. Macharis. 2021. "Who is Interested in a Crowdsourced Last Mile? A Segmentation of Attitudinal Profiles." *Travel Behaviour and Society* 22:22–31. https://doi.org/10.1016/j.tbs.2020.08.004.

Ramirez-Villamil, A., A. Jaegler, and J. R. Montoya-Torres. 2021. "Sustainable Local Pickup and Delivery: The Case of Paris." *Research in Transportation Business & Management* 45 (A): 100692.

Ranieri, L., S. Digiesi, B. Silvestri, and M. Roccotelli. 2018. "A Review of Last Mile Logistics Innovations in an Externalities Cost Reduction Vision." *Sustainability* 10 (3): 782. https://doi.org/10.3390/su10030782.

Resat, H. G. 2020. "Design and Analysis of Novel Hybrid Multi-objective Optimization Approach for Data-driven Sustainable Delivery Systems." *IEEE Access* 8:90280–90293. https://doi.org/10.1109/ACCESS.2020.2994186.

Rosenberg, L. N., N. Balouka, Y. T. Herer, E. Dani, P. Gasparin, K. Dobers, D. Rüdiger, P. Pättiniemi, P. Portheine, and S. van Uden. 2021. "Introducing the Shared Micro-depot Network for Last-mile Logistics." *Sustainability* 13 (4): 2067. https://doi.org/10.3390/su13042067.

Sallnäs, U., and M. Björklund. 2020. "Consumers' Influence on the Greening of Distribution–Exploring the Communication between Logistics Service Providers, E-tailers and Consumers." *International Journal of Retail & Distribution Management* 48 (11): 1177–1193. https://doi.org/10.1108/IJRDM-07-2019-0213.

Seghezzi, A., and R. Mangiaracina. 2021. "On-demand Food Delivery: Investigating the Economic Performances." *International Journal of Retail & Distribution Management* 49 (4): 531–549. https://doi.org/10.1108/IJRDM-02-2020-0043.

Seghezzi, A., R. Mangiaracina, A. Tumino, and A. Perego. 2021. "Pony Express' Crowdsourcing Logistics for Last-mile Delivery in B2C E-commerce: An Economic Analysis." *International Journal of Logistics Research and Applications* 24 (5): 456–472. https://doi.org/10.1080/13675567.2020.1766428.

Serrano-Hernandez, A., A. Ballano, and J. Faulin. 2021. "Selecting Freight Transportation Modes in Last-mile Urban Distribution in Pamplona (Spain): An Option for Drone Delivery in Smart Cities." *Energies* 14 (16): 4748. https://doi.org/10.3390/en14164748

Settey, T., J. Gnap, D. Beňová, M. Pavličko, and O. Blažeková. 2021. "The Growth of E-commerce due to COVID-19 and the Need for Urban Logistics Centers Using Electric Vehicles: Bratislava Case Study." *Sustainability* 13 (10): 5357. https://doi.org/10.3390/su13105357.

Simić, V., D. Lazarević, and M. Dobrodolac. 2021. "Picture Fuzzy WASPAS Method for Selecting Last-mile Delivery Mode: A Case Study of Belgrade." *European Transport Research Review* 13 (1): 1–22. https://doi.org/10.1186/s12544-021-00501-6.

Simoni, M. D., E. Marcucci, V. Gatta, and C. G. Claudel. 2020. "Potential Last-mile Impacts of Crowdshipping Services: A Simulation-based Evaluation." *Transportation* 47 (4): 1933–1954. https://doi.org/10.1007/s11116-019-10028-4.

Siragusa, C., A. Tumino, R. Mangiaracina, and A. Perego. 2022. "Electric Vehicles Performing Last-mile Delivery in B2C E-commerce: An Economic and Environmental Assessment." *International Journal of Sustainable Transportation* 16 (1): 22–33. https://doi.org/10.1080/15568318.2020.1847367.

Sivaraman, D., S. Pacca, K. Mueller, and J. Lin. 2007. "Comparative Energy, Environmental, and Economic Analysis of Traditional and E-commerce DVD Rental Networks." *Journal of Industrial Ecology* 11 (3): 77–91. https://doi.org/10.1162/jiec.2007.1240.

Skiver, R. L., and M. Godfrey. 2017. "Crowdserving: A Last Mile Delivery Method for Brick-and-mortar Retailers." *Global Journal of Business Research* 11 (2): 67–77.

Švadlenka, L., V. Simić, M. Dobrodolac, D. Lazarević, and G. Todorović. 2020. "Picture Fuzzy Decision-making Approach for Sustainable Last-mile Delivery." *IEEE Access* 8:209393–209414. https://doi.org/10.1109/ACCESS.2020.3039010.

Szmelter-Jarosz, A., and J. Rześny-Cieplińska. 2019. "Priorities of Urban Transport System Stakeholders According to Crowd Logistics Solutions in City Areas. A Sustainability Perspective." *Sustainability* 12 (1): 317. https://doi.org/10.3390/su12010317.

Tranfield, D., D. Denyer, and P. Smart. 2003. "Towards a Methodology for Developing Evidence-informed Management Knowledge by Means of Systematic Review." *British Journal of Management* 14 (3): 207–222. https://doi.org/10.1111/1467-8551.00375.

Vincent, F. Y., P. Jodiawan, and A. P. Redi. 2022. "Crowd-shipping Problem with Time Windows, Transhipment Nodes, and Delivery Options." *Transportation Research Part E: Logistics and Transportation Review* 157:102545. https://doi.org/10.1016/j.tre.2021.102545.

Viu-Roig, M., and E. J. Alvarez-Palau. 2020. "The Impact of E-commerce-Related Last-mile Logistics on Cities: A Systematic Literature Review." *Sustainability* 12 (16): 6492. https://doi.org/10.3390/su12166492.

Wang, C. N., N. A. T. Nguyen, T. T. Dang, and H. P. Hsu. 2021. "Evaluating Sustainable Last-mile Delivery (LMD) in B2C E-commerce Using Two-stage Fuzzy MCDM Approach: A Case Study from Vietnam." *IEEE Access* 9:146050–146067. https://doi.org/10.1109/ACCESS.2021.3121607.

Xiao, L., and T. Ke. 2019. "The Influence of Platform Incentives on Actual Carriers' Continuous Participation Intention of Non-vehicle Operating Carrier Platform: A Study in China." *Asia Pacific Journal of Marketing and Logistics* 31 (5): 1269–1286. https://doi.org/10.1108/APJML-06-2018-0227.

Zhang, Y., L. Sun, X. Hu, and C. Zhao. 2019. "Order Consolidation for the Last-mile Split Delivery in Online Retailing." *Transportation Research Part E: Logistics and Transportation Review* 122:309–327. https://doi.org/10.1016/j.tre.2018.12.011.