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A Systematic Review of Factors Affecting Food Loss and Waste and Sustainable Mitigation Strategies: A Logistics Service Providers' Perspective

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Abstract: This study investigates the causes of food loss and waste (FLW) from the perspective of logistics service providers (LSPs) and provides sustainable options for the Chinese market. To this end, this study reviews the literature on FLW and cold chain logistics published from 2008–2021. Until recently, little attention has been paid to understanding FLW drivers from the LSP perspective. This critical systematic literature review (SLR) aims to identify the potential drivers of FLW and provide a coherent and integrated knowledge base regarding these factors. A configurative SLR was performed, and after a filtering process, 43 articles were analyzed. Potential factors were identified and categorized into four groups: (i) poor management, (ii) inappropriate operational practices, (iii) high cost, and (iv) restrictions. The results reveal that technical inefficiency and facility costs are the most serious risks, and the lack of legislation and standards constitutes the second most serious risk for FLW. Sustainable solutions are recommended to address these risks. Finally, the study findings provide guidance for LSPs to achieve sustainability in social, economic, and ecological dimensions.

Keywords: agricultural (Agri) products; food loss and waste (FLW); logistics service providers (LSPs); cold chain logistics (CCL); systematic literature review (SLR); sustainable mitigation strategy

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1. Introduction

China is regarded as an agricultural country and is a leading fruit and vegetable producer in the world [1,2]. With the expansion of trade, a major challenge is to maintain and protect food quality, and many factors affect food quality [3] and result in food loss and waste (FLW). FLW is a vital topic because of its expensive socioeconomic costs, which further affect three bottom lines of sustainability. FLW contributes to huge losses of precious resources while causing environmental deterioration [4]. In summary, FLW occurs at each stage of the food supply chain (FSC) and impacts the three dimensions of sustainability: economic, social, and environmental (Table 1) [1].

Table 1. Impacts of FLW on the three dimensions of sustainability.

Economic	Social	Environmental
Reduced profit Decreased financial resources for investment in other sectors [1] Decreased customer value and repurchase intention	Harm to LSP reputation [5] Reduced labor productivity and wages [1]	Increased emissions of greenhouse gas methane [6] Waste of non-renewable energy

Various studies investigating the causes of FLW revealed that inappropriate logistics is a significant reason for FLW in China. There is a huge gap between China and developed countries in terms of cold chain logistics (CCL). The loss rate is approximately

25–30% [7], and the value of products is nearly CNY 280 billion (about USD 40.55 billion) in transportation every year [8]. The seriousness of broken CCL is especially evident in the distribution process [7], which arises from problems concerning management and regulation mechanisms [9]. Logistics-related FLW drivers are worth identifying but still have not been thoroughly studied [10].

Most studies identified causes of FLW from various streams; the first stream deals with enlisted drivers that result in high FLW emerging in FSCs [11–14]. The main causes of FLW, following these studies' findings, include poor forecasting, overproduction, lack of training/worse processing ability, poor packaging, logistic constraints mismanagement of cold chain (CC), inadequate cold storage facility, errors in quality checks, inappropriate precooling, a large number of participants, the lack of post-harvest precooling and handle, the lack of regulation, technology inefficiency, and loss of innovations that lead to FLW. The second stream relates to special issues in FSCs, such as CCL brokenness [9,15], stochastic demand and supply [11], poor temperature control [16] and management, and policy and industry standards. Third stream compares developing and developed countries in FLW, occurring in stages with regard to developing countries and FLW mainly emerging in the upstream of food supply chain. However, in developed countries, consumption stage is the significant driver of FLW [17]. Even though extant findings provide various drivers of FLW, it is hard for LSPs to review their errors and challenges directly.

As for the field of causes of FLW in CCL, scholars make an effort on academic studies, especially through quantitative research. One study measures risk assessment using a catastrophe progression method and choosing two cold chain logistics companies to conduct a case study. Even though the result mentions technology application in cold chain logistics, this method limits the control within four variables related to only one state variable [18]. The other study evaluates reliability of CC distribution system by Bayesian network [8], and the limited data may affect the accuracy of research findings.

Although there are many authors show interest in the topic of causes of FLW, most of them mention food supply chain stages and debate which stage significantly affects FLW. There are few scholars that study the drivers of FLW from the perspective of LSPs. On the other hand, each method that seeks to explore causes of FLW has its own features and advantages, but most of them lead to subjective bias in the process of decision making and the final results [18].

This study identifies causes of FLW and ranks these causes based on extant findings and provides a comprehensive explanation using a systematic literature review (SLR) from the LSPs perspective. The method of SLR is selected because it helps to understand the breadth and depth of the extant findings and identify gaps to explore in order to push knowledge advancement [19]. Causes and sustainable mitigation options were identified by systematically analyzing the research published from 2008–2021. Our results reveal that LSPs face critical challenges of technical and technology inefficiency, high facility cost, and lack of legislation and standards. Findings provide valuable insights for both practitioners and policy makers on how to optimize CCL operations and management in order to improve efficiency and sustainability.

The traditional understanding of FLW refers to food that is disposed of or left unused. Currently, the understanding of what causes and constitutes FLW is fairly complex. Five dimensions make up the definition of FLW: FSC stages, human edibility, food quality, nature of use, and food destination, which are also the features of FLW [4]. In a wider definition adopted by the authors, according to the stages of FSC, food loss occurs upstream of the FSC, that is, from farm to processing. In comparison, food waste emerges downstream of the FSC [14,15]. However, there is still no single agreed-upon definition of food loss and waste [16,17], and the terms food loss (FL) and food waste (FW) are used interchangeably [4,18]. We adopted the definition proposed by FAO (HLPE, 2014) that refers to FLW as reduced quality of food originally intended for human consumption at all stages of the food chain, no matter the cause [19]. In this study, LSPs act as intermediaries connecting different stages in the total cold chain, actively working from the origin to end

customers, and FLW is the preferred term to use. This study focuses on identifying causes of FLW and ranks the drivers without considering the interrelationships of these factors.

The remainder of the paper is organized as follows: Section 2 provides the related literature review and value of this study. Section 3 discusses the systematic literature review approach. Section 4 presents our results. Section 5 discusses the results. Section 6 presents the conclusion, contributions, and limitations.

2. Literature Review

This paper is related to risk factors that affect the deterioration of agricultural products. We first review related articles and then compare our study to others to highlight differences and describe our contributions to the literature.

The analysis of FLW in supply chains must be region-specific because the relative significance of causes that restrain CC efficiency differs by region [1]. China's agricultural products are developed at the expense of the logistics industry. Actually, many logistics operations are inefficient in China. Even though the study findings hinted at some causes of FLW from a different point of view, LSPs as intermediaries were not fully explored. Researchers evaluated FLW through food cold chain logistics from different perspectives. More details are provided as follows:

(1) From the CCL perspective: Han et al. (2021) compared the current status of cold chain logistics regarding special issues of infrastructure, digital development level, and national policies and legislation between China and developed countries. The findings revealed a huge gap in these three areas [14].
(2) From the logistics companies' point of view: Tian et al. (2007) evaluated the performance of Chinese agri-food cold chain logistics companies, and the results showed the strengths and weaknesses of these operations. Specifically, the authors found that cold chain logistics companies were effective at customer service, especially in service processes and delivery. Conversely, companies performed poorly in learning and development, especially with regard to the lack of storage and technical innovation [20]. The performance of finance and internal processes was satisfactory, which was inconsistent with currently official reports, such as CCL suffering high logistics costs and having difficulty earning profits. However, factors excluding infrastructure and facilities and research time in 2007 studies could not represent the current status.
(3) Based on food characteristics: Liu et al. (2019) assessed meat safety by collecting 135 samples from 45 online stores in China and recording the shipment conditions, such as delivery time, distance, endpoint temperature, and package model. The results showed that endpoint temperature control was the most important factor to ensure the safety of meat products sold online in China [12].
(4) According to different geographic units: Lan et al. (2020) evaluated the inefficiency rate and total factor productivity (TFP) of logistics in 36 Chinese cities from 2006–2015. The findings revealed that the inefficiency rate of logistics systems in the eastern region was the highest, followed by the western and central regions [11].
(5) Focusing on the cold chain stage: Liu (2014) reported that the main loss happened during the storage and transportation stages in China, and the main reason was the incomplete infrastructure of the cold chain. However, Wu and Hsiao (2021) emphasized that the top five food quality and safety problems occur in the product-receiving step [3].

The authors identify different causes of FLW from various points of views. There are still some shortcomings among the extant findings, such as the stage that significantly leads to FLW, which is inconclusive and inconsistent in the measurement of logistics companies' performance with recent CCL yearbook; currently, LSPs are not performing well in agricultural product protection and financial aspects. The reason why this condition occurs has to be excavated. This study identifies the critical causes of FLW and driver categories capable of being used to develop strategies for delivering more efficient and effective CCL solutions in China.

While a number of studies concentrate on mitigation strategies, studies have attempted to improve supply chain efficiency through different methods, such as enhanced supply chain management [21,22], optimized distribution networks [23,24], enhanced monitoring [24], increased traceability [23,25], reduced logistics costs [26,27], waste management [26], and sustainability [28]. Even though previous research provides suggestions on how to mitigate the risk of FLW and shows an increasing trend in concentrating on sustainability and sustainable solutions as a good way to release FLW [29], practically, LSPs face specific FLW risks that are not easily addressed. After analyzing the risks and challenges faced by LSPs, this study provides solutions while deeply considering their sustainable development. The findings of this study can help managers solve practical problems as well as improve their sustainability and core competence.

Value of This Study

From the research point of view, Figure 1 shows that numerous studies have focused on the topics of food supply chains (FSCs), cold chain logistics (CCL), logistics service providers (LSPs), management, and third-party logistics. According to a cluster analysis of terms by CiteSpace, most studies on CCL and FLW show indirect relationships between CCL, LSPs, and FLW; there are relatively few studies on FLW in LSPs; and FSC plays a mediating role.

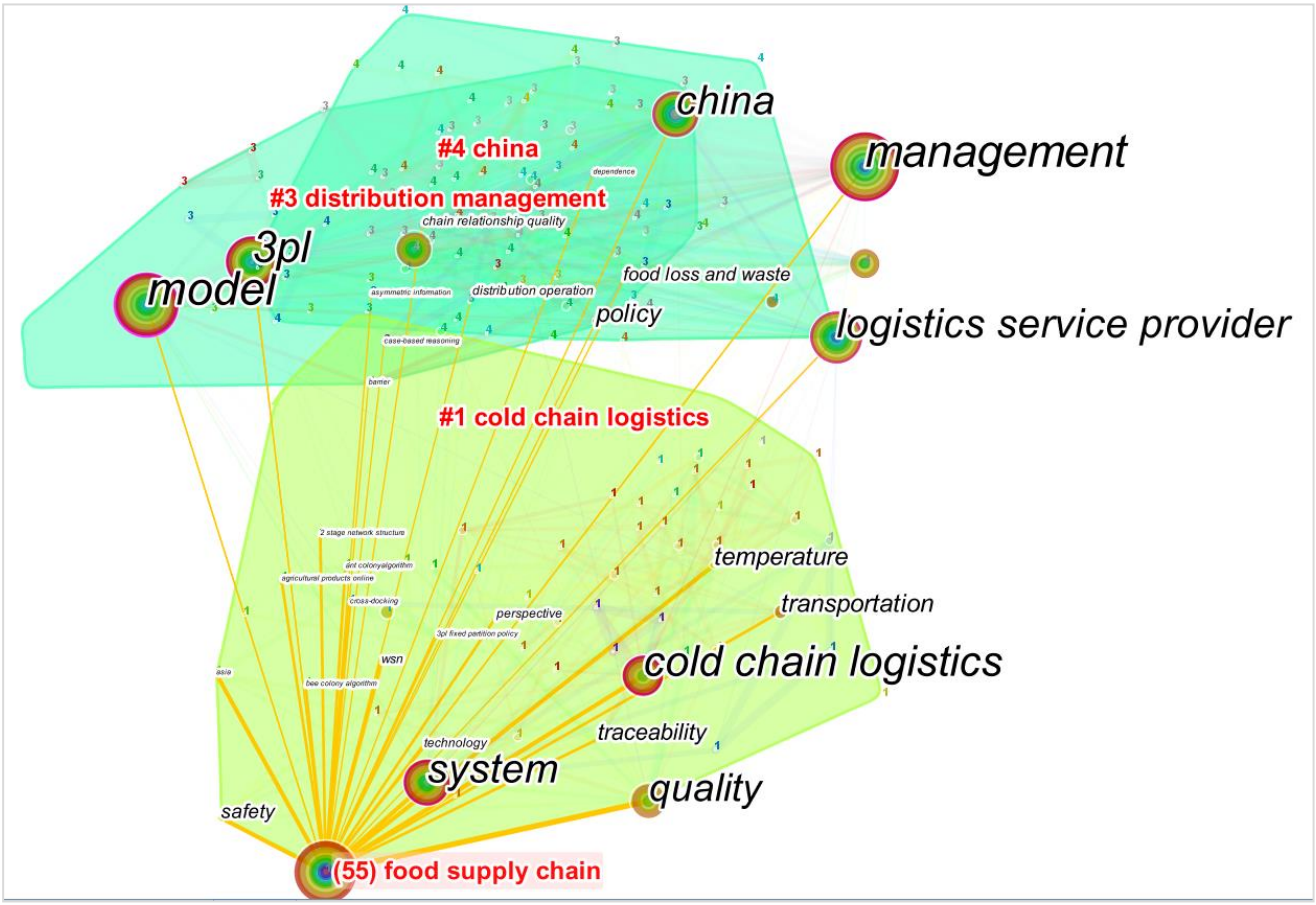

Figure 1. Cluster analysis of terms based on CiteSpace.

The main contributions that differentiate our study from other works are as follows:

(1) This study provides a comprehensive understand of FLW in LSPs, identifies 18 causes related to FLW by SLR, and shows a detailed summary of the current situation for LSPs. It establishes a direct connection between FLW and LSPs.

(2) The stated causes of FLW broaden the current research scope, including operation, management, cost, and policy.
(3) Solutions are provided that consider the three bottom lines of sustainability and mitigate the most challenging problems that LSPs frequently face.
(4) Managerial insights and policy contributions are provided, which should help LSPs involved in designing and managing CCL and explain policy gaps in the CCL industry.

3. Methodology

3.1. Systematic Literature Review (SLR)

The SLR process is "a systematic, explicit, and reproducible design for identifying, evaluating, and interpreting the existing body of completed and recorded work produced by researchers, scholars, and practitioners" [30]. This helps researchers to precisely analyze the current status of their topic of interest. In addition, the SLR follows a search strategy to pick out relevant literature that relates to the research question [31] and enables a strict, fair, and full assessment of findings, quality, and design. However, previous findings lack a connection between FLW and LSPs because of the complex feature of the topic. SLR is beneficial for absorbing and analyzing current outcomes within the discipline or across disciplines in order to establish a comprehensive research framework that can be instructive for both academia and industry [4]. Excavating deep insights from current findings to promote our comprehension of FLW at the level of LSPs is the highlight of our work.

The SLR process places some delimiting criteria to provide a comprehensive review, and the information is organized and provides meaningful insights. For this purpose, our steps were as follows [31]: (1) definition of the study: defining the issue topic, database selection, and filters to be applied for the research; (2) data collection and treatment: selecting, collecting, merging, and duplicating data after the first step filter; (3) data analysis: using CiteSpace 5.7.R5W for bibliometric and science mapping; and (4) interpretation: interpreting and disseminating results. Figure 2 shows the SLR method used in this study.

CiteSpace is open-source software that provides an alternative method to analyze an ever-changing knowledge domain based on our own datasets. It has three characteristics: first, it provides comprehensive, systematic reviews of topic history, thematic foci of research questions, landmark studies, established methods and techniques, and remaining problems. Second, it helps to continuously match the scientific literature with the knowledge domain and identifies emerging field of studies. Third, it is based on a wide spectrum of disciplines and publications [32].

3.2. Planning the Review

This review analyzes the causes of FLW from the perspective of LSPs. This study does not demarcate between FL and FW, which is in accordance with the existing studies in the domain of FLW [4]. The Web of Science databases were chosen for data collection. The following criteria were used: (i) inclusion: research articles or review articles, studies related to cold chain logistics and logistics service providers, studies on cold chain logistics management and practice, studies focused on food cold chains, studies that present causes of FLW, studies that connect upper criteria, and studies written in English; (ii) exclusion: studies not associated with the research objective, studies that do not present a research method, and studies that do not show results in the paper abstract.

The authors determined an initial set of keywords to use in searching the databases. Our keywords list led to 446 results in the Web of Science. In the next step, a search was performed by country. In order to assure rigor in the selection and profiling of publications, a review panel was established. It was extremely important to establish the review panel in order to set the conceptual boundaries of the review. Three experts in FLW causes (one professor and two researchers) constituted the review panel. This panel consulted to reach a consensus over the selection of keywords for the final list (Figure 3).

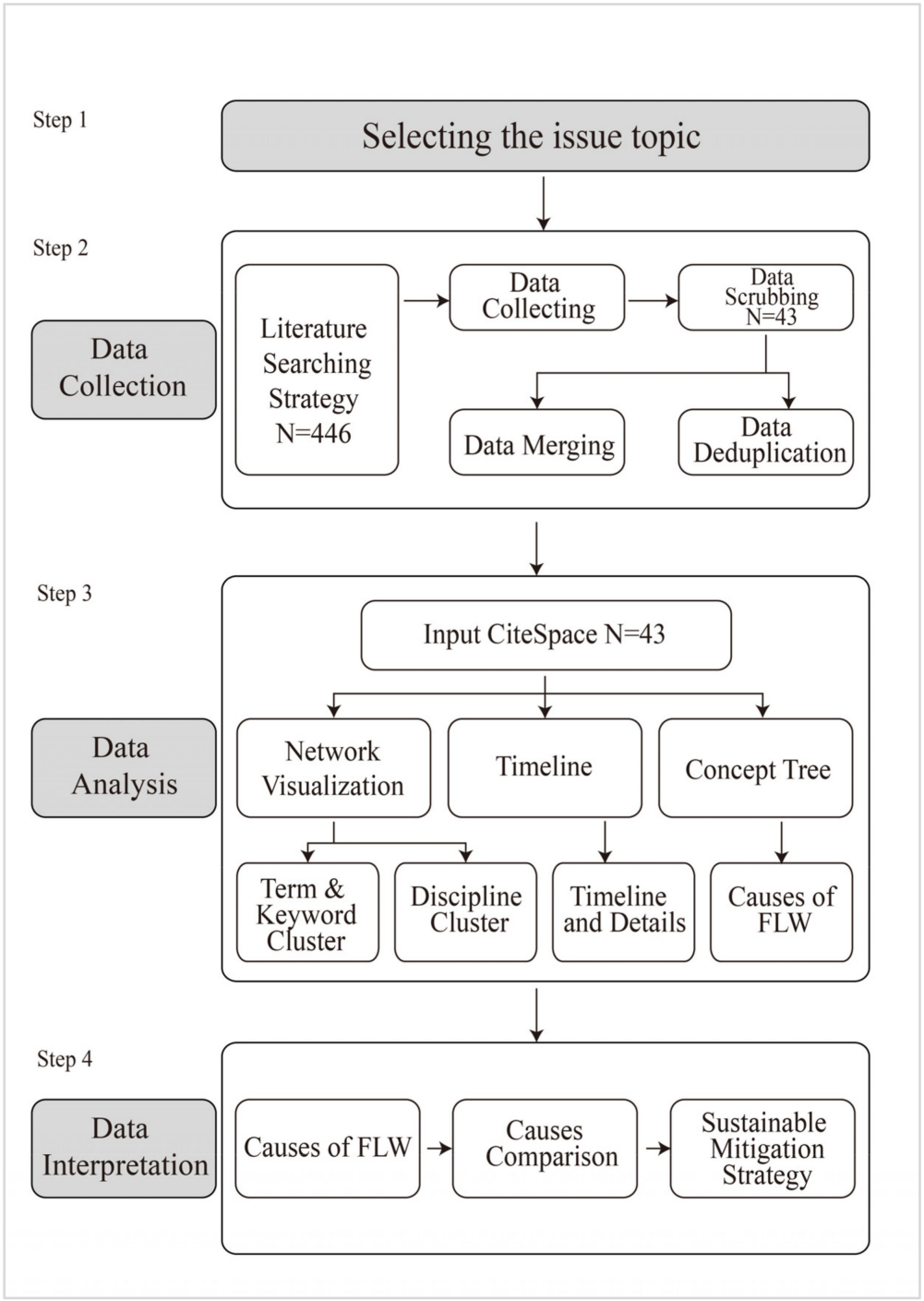

Figure 2. Process of SLR.

The time period used in this study was 2008 to 2021, mainly due to the policy and practice background. First, in 2008, the Ministry of Commerce of the People's Republic of China launched a policy aimed at developing third-party logistics (3PL). Second, from the practice perspective, in 2008, the scale of the logistics industry grew rapidly, and logistics infrastructure was enhanced (Logistics industry adjustment and revitalization plan, 2009). Third, from the academic point of view, growing interest in the topic of the environmental sustainability LSPs arose in 2008 [20].

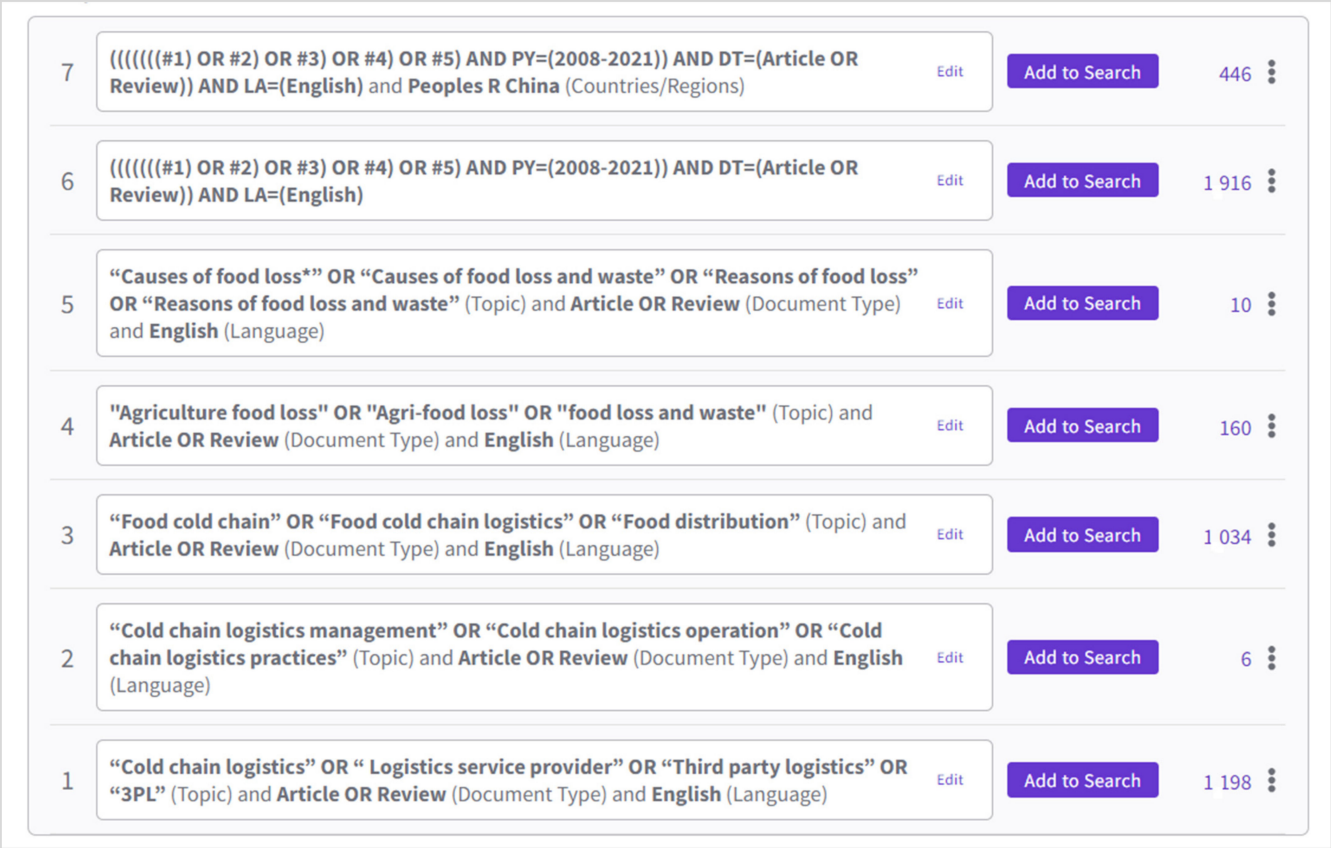

Figure 3. Topic search queries used for data collection.

3.3. Data Collection

First, an initial SLR was performed manually, using the main terms related to cold chain logistics and food loss and waste, resulting in a total of 446 files. All keywords resulting from this review were systematized and analyzed. The keywords with the highest occurrence in previous studies were identified and used to perform the SLR on the WOS database. All keywords were used as a search string, and 446 documents were found on the Web of Science platform.

3.4. Data Extraction

The final sample of 43 articles in the period 2008–2021 was used in the extraction stage because they had a close relationship with the main topic, they connected FLW and LSP management and operations, and the target country was China. Data analysis using CiteSpace software was conducted, relying on three functions: cluster analysis of terms and keywords of studies, display of timeline of terms of studies, and the discipline. The publication year of each article, list of FLW causes, and important risk factors were also provided.

3.5. Factors

Figure 4 depicts the 18 factors identified by the systematic literature review, which were divided into four groups for better understanding. These groups are displayed in Figure 4.

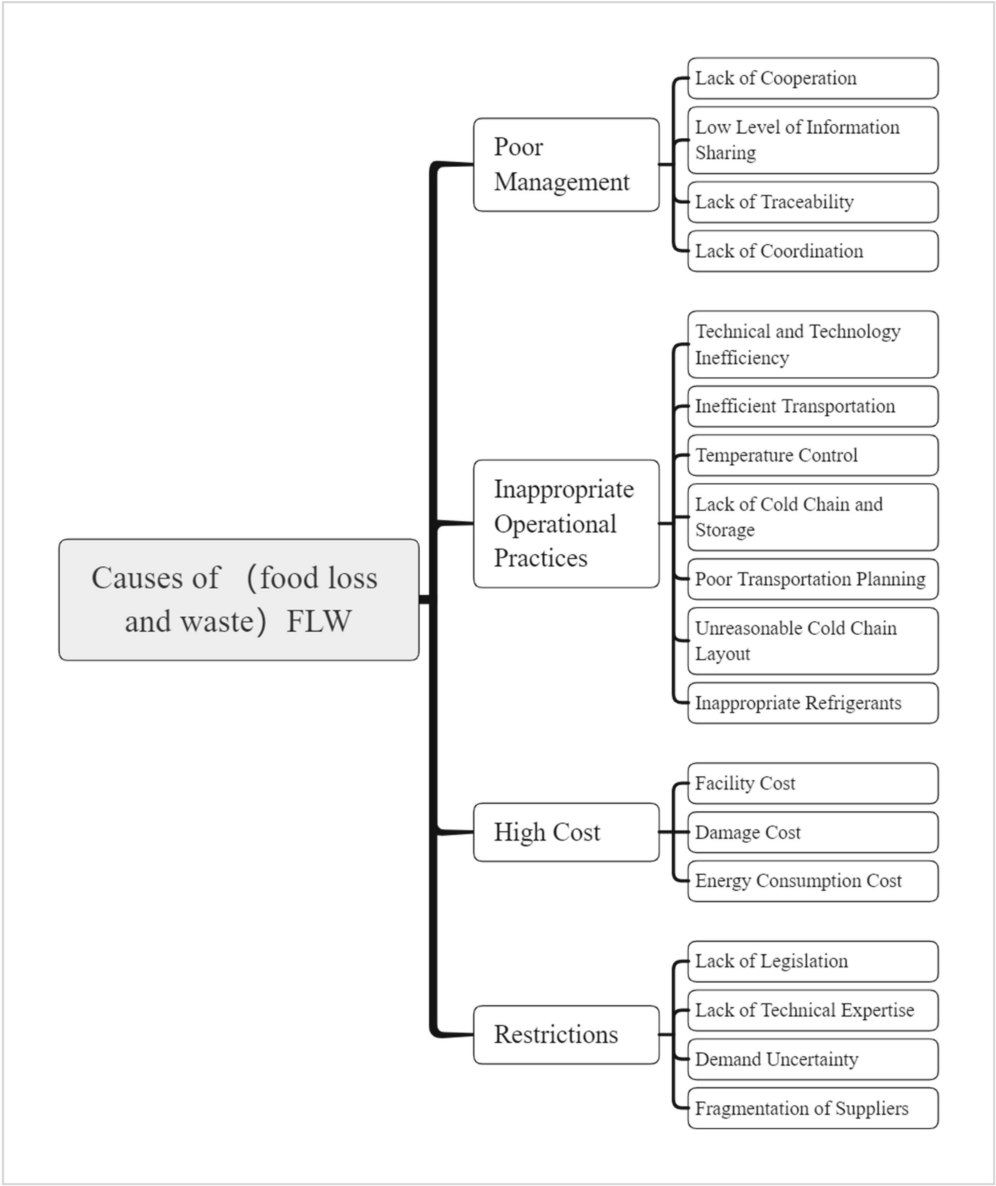

Figure 4. Groups of factors.

4. Result

4.1. Data Execution: Research Profiling

In Figure 5, the main features of the 43 articles are displayed by CiteSpace. According to the cluster analysis of term and keyword in 43 articles, the parallel research topics were classified into seven clusters. The most frequent keywords are labelled as the cluster. Moreover, the connection, development, and evolution of topics are illustrated by timeline visualization, showing some details of the term and keyword cluster analysis (Figure 6). Year of publishing distribution and discipline distribution and connection are also explained (Figures 7 and 8).

The distribution of term and keyword clusters illustrate the seven main clusters and their labels from the 43 articles, and the result is shown in Figure 5. The topic of food waste received the most attention from authors, followed by food safety and waste prevention. Logistics service capability and customer satisfaction occupy the fifth and sixth clusters, respectively. Cluster 6 focuses on outsourcing. Even though previous studies showed different interests, these topics lack a connection. This study fills this gap and builds connections between clusters.

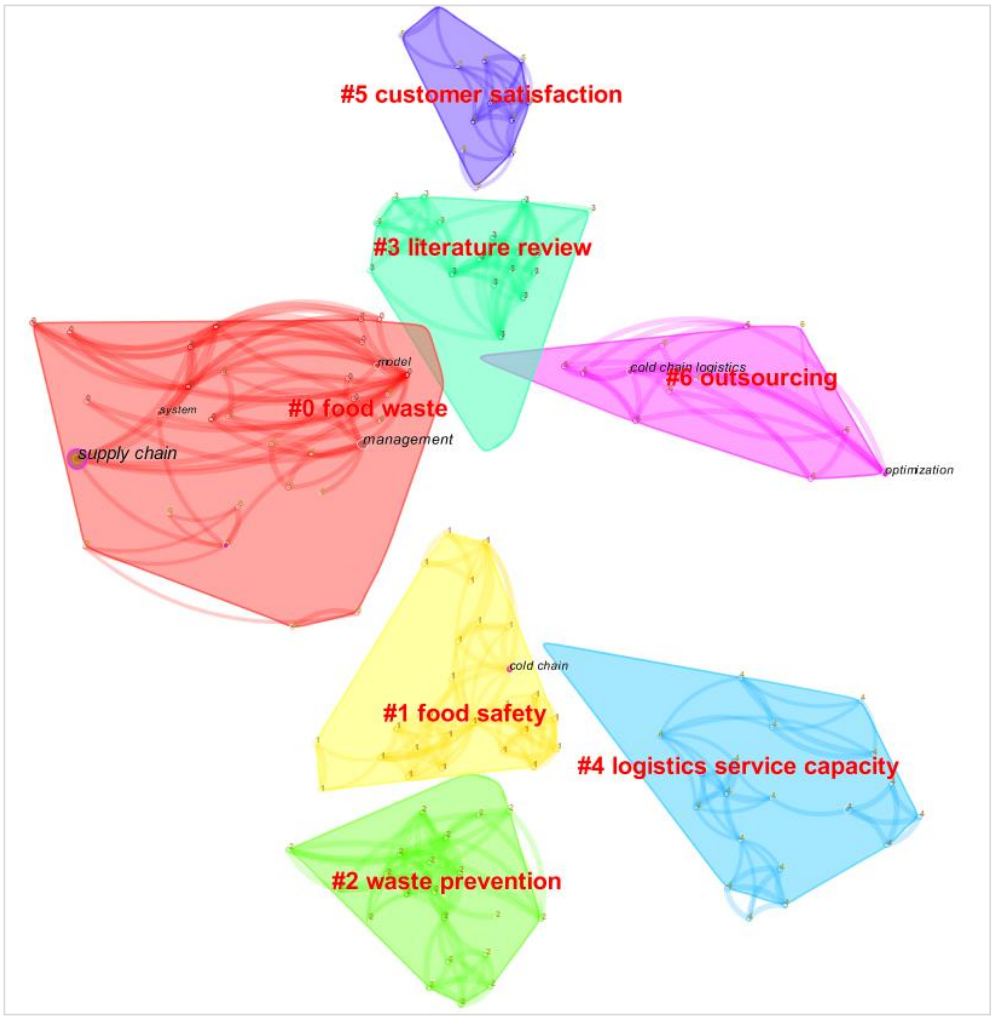

Figure 5. Landscape view of term and keyword network generated as 50 per slice between 2012 and 2021 (LRF = 3.0, LBY = 5, e = 1.0).

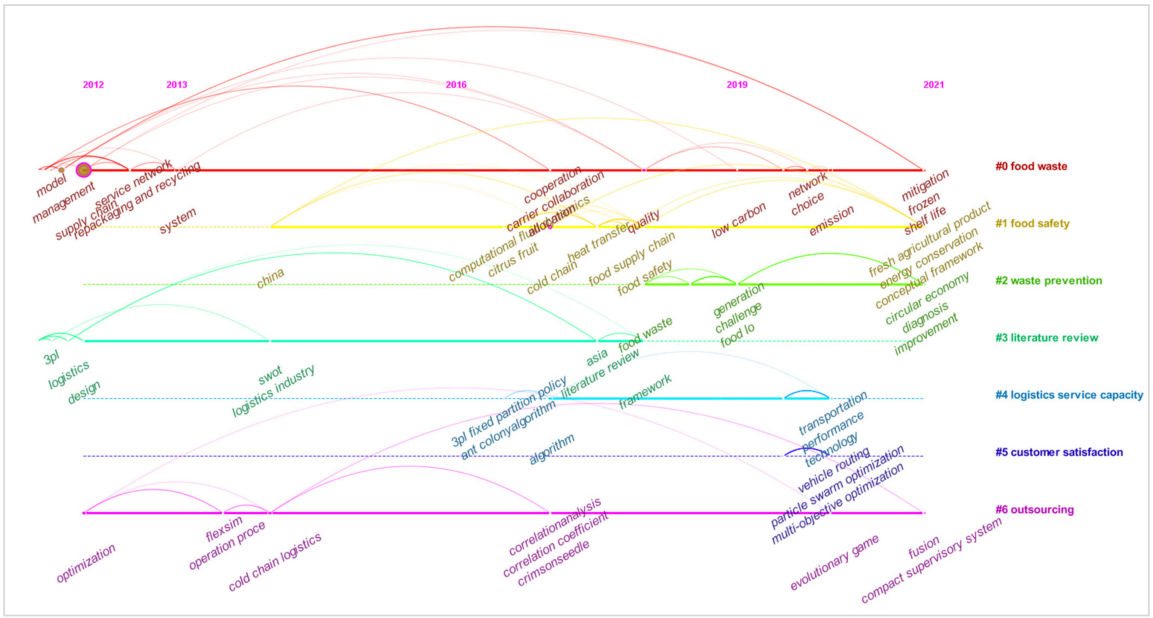

Figure 6. Timeline visualization of clusters.

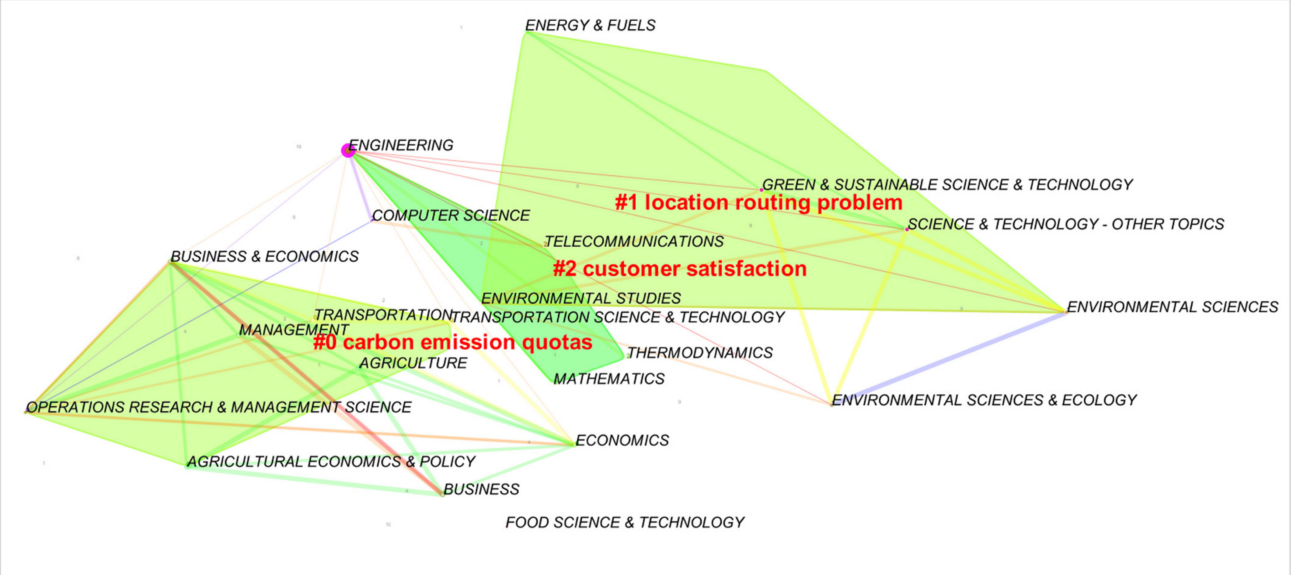

Figure 7. List of studies across disciplines.

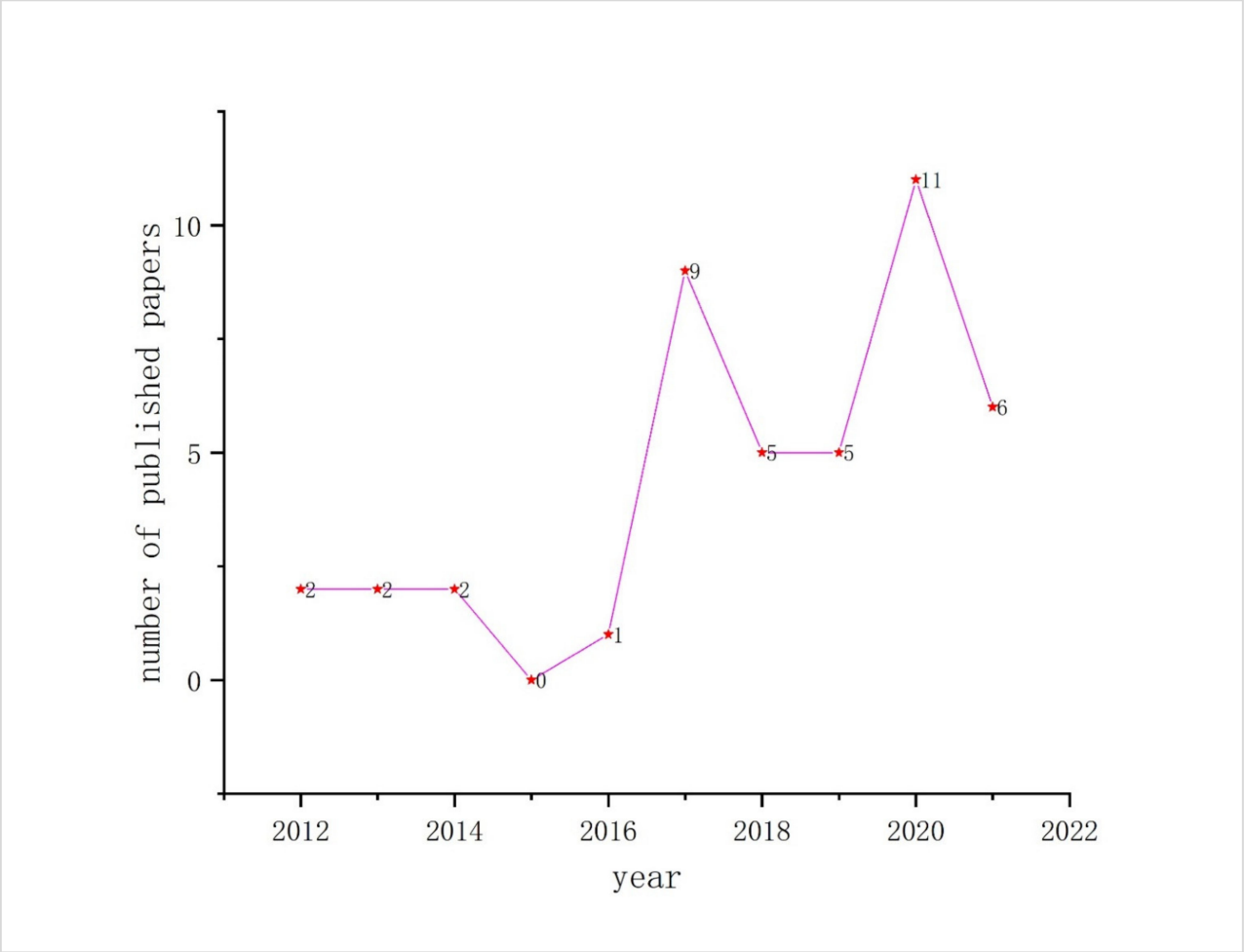

Figure 8. Distribution of selected papers by year of publication.

A timeline visualization in CiteSpace explains the details of term clusters in Figure 5 (see Figure 6). The clusters are displayed from left to right. The publication years are shown at the top of the figure in different colors. The clusters are distributed vertically

depending on their size. Large nodes are particularly important, as they represent either high frequency or bursts or both. Under each timeline, the three most frequent terms and keywords in a particular year are displayed. The label for the highest frequency is placed at the lowest position. Terms and keywords that occurred in the same year are arranged so that the less frequent ones are shown on the left.

Cluster labels were numbered starting with 0, representing the largest one that included the most studies from the timeline overview, varying by active time period and existing published topics of studies. Some clusters, such as 0 and 6, cover a total time period and keep active, whereas others cover relatively short periods, such as 1, in which studies started in 2014 and continue until now. Clusters 1 and 4 cover the same period; however, 1 is still active. Some clusters include emerging topics until 2021, the most recent year of publication for a cited reference in this study.

Figure 7 shows the disciplines of 43 articles and their connections. The most important publishing outlets were those with a focus on environmental concerns and on food waste and food safety. There were 19 articles published in engineering and accounting, making up the largest portion (see Figure 7). Studies related to food science and technology had the second highest rank, and the authors showed an increasing interest in green and sustainability topics.

Regarding the distribution of year of publication (see Figure 8), the first article was published in 2012, when two articles were published, and the number remained stable until 2014. The number of publications grew from one article in 2016 to nine articles in 2017. In December 2017, China established the world's largest national carbon emissions trading market [33]. Moreover, in this period, China's cold chain logistics entered a stage of rapid growth, and foreign cold chain LSPs developed in the country. The second boom occurred between 2019 and 2020, and publication peaked at 11 articles. Authors concentrated on reducing the externalities of cold chain logistics activities, such as low carbon processes [34], and optimizing cold chain logistics systems with environmental concerns [33].

4.2. Causes of FLW from LSPs

The main group factors, sub-risk factors, sub-risk factor evidence, sources, and importance are listed from findings in the Appendix A (Tables A1–A4). Importance is divided into high, medium, and low based on frequency of previously published studies. Table 2 explains the main risk sub-factors associated with poor management of LSPs, with the evidence and sources listed and counted to show their importance. The table also lists inappropriate operational practices of LSPs and sub-factors with more details about their wrong activities and includes the main high cost of LSPs suffered and which cost is the highest. The table also considers obstacles for LSPs when operating CCL and shows more details and importance.

Based on our findings (Table 2), technical and technological inefficiency, facilities cost, and lack of legislation and standards are the top three challenges for LSPs in protecting agri-product quality; most importantly, technical inefficiency and high facility cost lead to food loss and waste (FLW).

Technology in CCL is mainly adopted in traceability, temperature control, and information systems, which is supported by the results of timeline visualization (Figure 6). The current research in 2020–2021 mainly focuses on the topics of vehicle routing problems, FLW mitigation, energy conservation, and circular economy, which are high-technology-related research directions. In addition, the discipline with the most publication is engineering, which also reflects the importance of technology. Technical and technology inefficiency significantly leads to FLW from few perspectives. First, inefficient IT compatibility occurs in forecasting, order purchasing, inventory replenishment, and life-cycle management [27,35,36]. Moreover, a new technology can have uncertain reliability when newly adopted by LSPs, with similar outcomes for current technology transferred to serve in a new condition without familiarizing users with its failure rate [16,35]. Third, agricultural products need to have real-time monitoring, tracking, and temperature measuring;

current tools, such as Radio Frequency Identification (RFID) tags and Wireless Sensor Networks, provide accurate and convenient service, but these tools have some drawbacks, such as sensor signals always being attenuated by a humid environment in delivering agri-food [35]. Last, lack of specialization and interdisciplinary talent also contribute to technical and technology inefficiency [14]. Technical inefficiency includes poor capabilities, security, and reliability. Therefore, this result is supported by previous studies reporting in which IT-related challenges are critical for third-party logistics providers [37]. This also illustrates the cause of high FLW in China.

Table 2. Comparison of factors.

Major Factors	Related Sub-Factors	Article Studied	Value		
			High	Moderate	Low
Poor management	Lack of cooperation	5	3	1	1
	Low level of information sharing	3	2	0	1
	Lack of traceability	2	2	0	0
	Lack of coordination	1	1	0	0
Total		11	8	1	2
Inappropriate operational practices	Technical and technological inefficiency	10	9	0	1
	Inefficient transportation	8	5	2	1
	Temperature control	6	6	0	0
	Lack of cold chain and storage	6	6	0	0
	Poor transportation planning	5	2	3	0
	Unreasonable cold chain layout	4	2	2	0
	Inappropriate refrigerants	2	1	1	0
Total		41	31	8	2
High cost	Facility cost	10	9	1	0
	Damage cost	2	2	0	0
	Energy consumption cost	2	1	1	0
Total		14	12	2	0
Restrictions	Lack of legislation and standards	9	6	1	2
	Lack of technical expertise	5	4	0	1
	Demand uncertainty	3	1	2	0
	Fragmentation of suppliers	2	2	0	0
Total		19	13	3	

Fierce competition and high facilities costs account for the second-largest risk. Ten studies mention that Chinese cold chain LSPs encounter high costs, such as for purchasing refrigerated vehicles [2,38] and building cooling warehouses [24], refrigeration facilities [39], special equipment, and IT facilities [40]. Many small- and medium-sized cold chain LSPs have gone bankrupt, and 82.76% of logistics companies have suffered low profits [41,42]. Changes in consumer habits and economic growth have resulted in the growth of the cold chain logistics market since 2016. Thus, additional investment has been made in CCL facilities and equipment in China; the number of refrigerated vehicles reached 164,000, with 24,000 new ones added annually. This represents a year-on-year increase of 33% [35].

The lack of legislation and standards has been frequently analyzed by researchers and practitioners, such as the shortage of laws [38] and the lack of industry standards, especially in mandatory standards [2]. Current standards have low enforcement operability and inadequate regulatory oversight [14]. Actually, existing laws mainly focus on food safety requirements and ignore the role of the cold chain in China [20]. There are still some problems regarding cold chain standards in China compared with developed countries:

(1) There are 13 different authorities, and many local governments are currently working independently in the process of drafting, organizing, approving, and issuing stan-

dards regarding cold chains rather than collaborating with stakeholders. This causes inefficiency in implementing policies and regulations [2,32,43].
(2) Existing standards do not cover the total cold chain.
(3) Most standards are at the local or industrial level and are recommended standards rather than mandatory laws.
(4) It is difficult to implement standards.

5. Discussion of Findings and Sustainable Mitigation Solutions

5.1. Findings

Through the analysis in the previous section, the first three drivers of FLW in LSPs with high importance are technical and technology inefficiency, high facility cost, and lack of legislation and standards. The results build direct connection between FLW and LSPs. In general, the above conclusions are consistent with reality. Thereby, SLR can be well applied in the field of drivers of FLW.

The first three factors affecting customer satisfaction further influence customers' re-buy decision because customers seek high quality of service and timely delivery, especially for perishable food, and technological inefficiency means that temperature, time, and traceability cannot be well managed. LSPs that are cost-oriented and unwilling to invest in infrastructure and technology, within lack of legislation and standards, limit the development of LSPs capability and business.

The findings of this study suggest both managerial and policy implications. Regarding the former, it concludes various challenges that limit LSPs efficiency and capabilities to protect agricultural product quality and safety. LSPs have to improve the technical and technology efficiency by decreasing the cost and familiarizing the function, advantage, and disadvantage of each tool, making full use of its advantages and escaping its disadvantages. Regarding the governments and policy makers, it is better to redistribute the responsibilities of 13 different authorities and combine current issues of LSPs for drafting international, easy to implement, full cold chain and mandatory regulations.

5.2. Sustainable Mitigation Solutions

Sustainability emphasizes a balance between the economy, the environment, and society. Based on a resource-based view (RBV), resources and capabilities affect firm performance. According to RBV theory, internal integration (operational ability) and external integration (cooperation and information technology abilities) are treated as resources that benefit distribution performance and encourage LSPs to increase their sustainability.

5.2.1. Mitigating Risk of Technical and Technology Inefficiency

There are two methods for solving problems of technical and technology inefficiency. First, traditional CCL has been transformed and upgraded to automatic, visible, digital, and intelligent supply chains by the new generation of information technology (e.g., the IoT, cloud computing, big data, blockchain, AI, WSN) and communication technology (e.g., WIFI, 5G, RFID), ensuring that CCL operations are safer, more efficient, and sustainable. However, there is no cold chain technology that fits everything [44]. The key success metric is strategic technological complementarity.

The second method involves employee training within logistics companies, making sure practitioners are familiar with current tools' features and drawbacks in order to reduce human error, such as WSN lacking robustness and RFID lacking reading range and having limited sensing systems. However, IoT provides a platform of information exchange between items that makes RF technologies and WSN better interconnect the data and items and helps them utilize databases relating hardware and software [44]. The right use of technology can effectively reduce FLW, improve operational efficiency, and simplify processes of CCL.

5.2.2. Mitigating Risk of Facility Costs

Facility costs include investment in cold storage, refrigerated transportation, and cooling infrastructure. It was claimed in [44] that less developed countries have to invest more to modify facilities in order to reduce FLW, while focusing on reducing facility costs, collaborating with peers, supply chain players, and stakeholders is the best appropriate solution. In [39], the authors studied collaboration with peers and found that resource sharing with peers can reduce the operation costs of cold chain logistics and also that collaboration with supply chain players can cut down delivery time by eliminating unnecessary links within the logistics process. Collaborating with stakeholders and developing collaboration among the facilities of cold chain logistics systems to reach agreement between stakeholders on transport equipment purchases, maintenance, use, and other aspects could improve the equipment utilization rate. Third, collaborating with the government, the government, as the leader, arranges and guides the diversified input investment mechanism and needs to encourage increased capital investment by multiple participants, such as logistics companies and wholesale and distribution centers [45].

Freight villages (FVs) create benefits of sustainability and are defined as areas "within which all activities relating to transport, logistics, and distribution of goods both at the domestic and international level are carried out by various operators" [27]. According to the three principles of sustainability, the functions of FVs include: (1) economic benefits, e.g., reduced transport cost and promotion of regional economic development; (2) environmental impacts, e.g., reduced freight emissions by consolidated transport; and (3) social effects, e.g., job creation, public transport connectivity, and improved urban planning. A freight village breaks the logistics bottleneck by sharing access to logistics infrastructure, facilities, and equipment [27].

The reduction in total logistics cost offsets facility costs. Optimizing vehicle routing problems can reduce total costs and energy costs [37], using a hierarchical hub network can reduce transportation costs [21], and solving the vehicle-routing problem involves a trade-off between total cost reduction and increased customer satisfaction by an improved artificial fish swarm (IAFS) algorithm [46]. A variable neighborhood search (VNS) approach is proposed to solve the multi-compartment vehicle-routing problem with time window and, considering carbon emissions, can reduce total travel costs and fixed, refrigeration, and carbon emission costs and further achieve a higher level of logistics services [47].

Qian et al. (2019) explored the relationship between LSPs' low-carbon supply chain integration (SCI) and firm performance in China. The findings proved that LSPs' low-carbon SCI significantly promotes their environmental and financial performance. Moreover, their environmental performance is positively related to their financial performance [43].

5.2.3. Mitigating Lack of Legislation and Standards

Government policies should make sure they cover the total cold chain and do not have duplicate and broken issues. Government also lead LSPs to control carbon emissions by introducing caps and fines. In this regard, policies by regulatory authorities should be framed in a manner that encourages LSPs to voluntarily reduce their carbon footprint. Policies should also impose standards that ensure environmental protection [48].

From the macro-environmental perspective, for a policy to be effective, it needs to be comprehensive and flexible to motivate LSPs and should reference international standards. Policymakers should have to clearly inform the public that (1) emission standards, (2) vehicle types, and (3) selected refrigerants (R717 or in combination with R744) have proven to be safe, environmentally friendly, and efficient [36], and (4) modified-atmosphere storage (MAS) for refrigeration is used to adjust the composition of the storage atmosphere (e.g., high carbon dioxide and low oxygen) to prolong the shelf life of food [14].

From the internal perspective, firms' eco-friendly norms enable them to enhance their brand image and increase sales as well as gain a competitive advantage [48]. LSPs have to formulate standards inside their company, establish regulatory systems to monitor, and supervise the behavior of employees, measure the performance of sustainable prac-

tices, and publish official reports that enhance both managers' and employees' awareness of sustainability.

6. Conclusions

This study evaluates the causes of FLW from the LSP perspective because LSPs act as intermediaries between CCL and food safety, and agri-food quality relies on their conduct. The contributions of this study fill a gap between academia and practice. LSPs have important responsibilities and face risks while delivering agri-food; they urgently need to identify and explore the causes of FLW to prevent economic, social, and environmental losses by concentrating on internal management and practices, high costs, and restrictions. Surprisingly, technology, transportation inefficiency, and facility costs account for the highest risk factors, and the lack of legislation and standards is the most serious constraint. Other causes include incomplete logistics infrastructure and maldistribution, unreasonable resource allocation, non-normalized logistics operation, and lack of supervision. According to these factors, cold chain logistics are regarded as a bottleneck for agri-food delivery in China. However, reducing FLW can solve the difficulties encountered by LSPs. This study considers capacity and sustainability issues and provides sustainable solutions from multiple dimensions.

6.1. Theoretical Contribution

The findings of this study fill a gap in previous research from the following perspectives. First, the risks of FLW, especially in developing markets, were examined. This study presents the most urgent risks in FLW in China from the LSP perspective and reveals representative problems of LSPs activities in developing countries, especially with regard to the biggest agricultural producers. Second, sustainable solutions based on a natural resource-based view, focusing on integrating resources and capabilities with the internal and external side and improving competitive advantage and sustainability [49,50], were discovered.

6.2. Practical Contribution

This study identifies serious risks for practitioners as a reminder of upcoming challenges and opportunities and gives them sustainable suggestions to mitigate their risks. Challenges include technical and technology inefficiency, lack of legislation and standards, and high facility cost. Methods mainly involve becoming a member of a freight village [27], encouraging peer cooperation [39], and reducing total logistics costs [37] in order to escape a huge investment in facilities and promote individual service and customize service that is hard to imitate and build up competitive barriers.

For internal operations, as a first step, LSPs should familiarize themselves with the competitive challenge by analyzing their firm's internal and external conditions. After diagnosing the competitive challenges, LSPs have to formulate effective policies, such as making investments and implementing changes to the organization's incentive and reward system. As a last step, the policies need to be implemented with a set of coherent actions that support further steps.

6.3. Political Contribution

The cold chain industry lacks supervision, and rigorous and normative standards need to be introduced. Due to the demand for international trade in fresh food, international standards are worthy of consideration. There are two main suggestions for legislation. First, encourage LSPs to be involved voluntarily in reducing their carbon footprint. While identifying drivers of green practice adoption, one study showed some evidence that mandatory norms were the main driver [51], and green supply chain practices can improve company performance, more specifically, actions such as developing distribution and transportation strategies, reverse logistics, and eco-design and packaging, which will benefit the company's environmental, economic, and social performance [52]. The second

method of implementing mandatory industry standards and regulations, which can be ensured through the promotion of environment-oriented efforts, is detailed below [48].

Previous studies proved that government pressure prompts LSPs to change their operation [53], and LSPs are always cost-oriented. Whatever government subsidies or punishments can heighten LSPs' awareness of reducing FLW, the government can issue relevant policies or regulations according to their pain points and urge them to make reasonable changes. More details are listed as follows:

(1) Revise the role and responsibility of 13 authorities and many local governments in the drafting, organization, approval, and issuing of standards so as to avoid policy duplication and cross-phenomena [2].
(2) Formulate a specific and effective procedure or requirement that provides good guidance for implementation.
(3) Revise and combine current cold chain logistics standards to meet the demand for complete, networked, traceable, informative, newly patterned, highly efficient, and strict standards (State Council, 2017).

6.4. Limitation and Future Directions of This Study

While this study promotes the development of research in both developing and developed countries and identifies causes of FLW from the LSP perspective, it still has some limitations. First, the causes of FLW are regionally based, and the findings of this study may not apply to other countries. Second, the causes of FLW may be correlated with each other. However, this study does not investigate the interaction of factors. Future research could utilize the ISM method and construct a hierarchy of risk factors. Third, the exact quantity of FLW in China is unknown, which could open a new area for future research.

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Appendix A

Table A1. Factors in the literature relate to poor management.

Sub-Factor	Evidence	Source	Importance
Lack of cooperation	Brokenness	[14]	High
		[6]	High
	Cooperation difficulties	[37]	High
	Lack of reasonable cooperation mechanism	[22]	Moderate
	Lack of overall planning and coordination	[14]	Low
Low level of information sharing	Lack of information sharing from origin to end	[54]	High
	Lack of intelligent management, information integration, and information sharing	[54]	High
	Inadequate agriculture information systems	[55]	Low
Lack of traceability	Hard to trace agricultural products during delivery	[56]	High
	Inadequate tracking and tracing of agri-food products from farm to folk	[55]	High
Lack of coordination	Weak coordination of government organizations	[57]	High

Table A2. Factors in the literature related to inappropriate practices.

Sub-Factors	Evidence	Source	Importance
Technical and technology inefficiency	Experience-based operation	[58]	High
	Current tools have drawbacks; attenuation of signal	[35]	High
	Poor information technology	[8]	High
	Poor or low-tech approaches; lack of available cooling technology	[26]	High
	Many technologies have not been thoroughly implemented in agri-food logistics processes	[55]	High
	Inefficient temperature sensors	[24]	High
	Cold-chain infrastructure limits the application of related information technology	[14]	High
	Input congestion	[59]	Low
Inefficient transportation	Different transportation requirements of perishable food-product categories	[60]	High
	Ordinary mechanical refrigerated trucks	[56]	High
	Inefficient transportation network	[8]	High
	Poor delivery strategy; inappropriate traveling speed	[61]	High
	Derailment of intermediate links and untimely delivery	[54]	Moderate
	Limited transport mode	[14]	Moderate
	Low cold chain circulation and transport rate	[14]	Low
Temperature control	Temperature abuses	[60]	High
		[35]	High
		[62]	High
	Inability to control/monitor temperature	[44]	High
	Shortened cooling periods	[24]	High
	Temperature fluctuations	[22]	High
Lack of cold chain and storage	Serious shortage of transport fresh product	[42]	High
	85% of meat, 77% of aquatic products, and 95% of vegetables and fruits are still transported by regular trucks without refrigeration	[2]	High
	28% of LSPs can provide cold chain transportation, warehousing within 111 e-commerce firms; low CCL service under self-operation mode	[56]	High
	Only 15% of all perishable products are transported in refrigerated vehicles	[55]	High
	China has 0.132 m^3 of cold storage capacity per urban resident, which is far below the level of developed countries	[14]	High
Poor transportation planning	Low efficiency of equipment	[63]	High
	Numerous allocation mesh points	[42]	High
	Poor design of CCL facilities and uneven temperature distribution	[35]	Moderate
	Long-distance transportation	[26]	Moderate
		[64]	Moderate
Unreasonable cold chain layout	Inappropriate postharvest handling; uneven distribution of refrigerated warehouses and vehicles	[14]	High
	Lack of integrated CCL system	[55]	Moderate
	Incomplete cold chain facilities	[2]	Moderate
Inappropriate refrigerants	Less use of natural refrigerant R744 and R290	[54]	High
	Low level of refrigeration applied	[60]	Moderate

Table A3. Factors in the literature related to high cost.

Sub-Factors	Evidence	Source	Importance
Facility cost	Facilities cost	[39]	High
	Cost of trucks, drivers, and machine maintenance	[42]	High
		[65]	High
	Investment in specific equipment, IT facilities, and management systems	[40]	High
	High technology facility cost based on sophisticated technical requirements	[55]	High
	Investment in employees training	[40]	High
	Deployment cost; depot cost	[24]	High
	Investment in information transformation of cold chain infrastructure	[14]	High
	Higher refrigeration facility costs	[65]	Moderate
Damage cost	70% of sold price needs to make up for FLW	[2]	High
	Huge resource waste when packaging and transporting of goods deviates from the superiority that saved the cost from e-commerce and manpower	[2]	
Energy consumption cost	Energy costs account for a significant portion of storage costs	[66]	High
	Cooling costs	[55]	Moderate

Table A4. Factors in the literature related to restrictions.

Sub-Factors	Evidence	Source	Importance
Lack of legislation and standards	Low adoption of international standards; of 185 cold chain standards in China, only 7 are mandatory	[2]	High
	No regulation or no enforcement of regulation	[26]	High
	Despite reforming and perfecting of statutes, there is still a huge issue about agriculture safety in China compared with developed countries	[35]	High
	Government regulations	[67]	High
	Current standards have overlapping national, local, and industry standards and low enforcement operability	[14]	High
	Shortage of laws	[42]	Moderate
	Current regulations have inconsistent standards	[14]	Low
	China's national policies and legislation and regulatory oversight are inadequate	[14]	Low
Lack of technical expertise	Poor perception of multi-source online information, poor stability, high error rate, and, in particular, lack of a dynamic perception of product quality	[14]	High
	Lack of appropriate logistics infrastructure and knowledge	[14]	High
	Lack of interdisciplinary talent	[42]	High
		[14]	High
	Low digital development level	[14]	Low
Demand uncertainty	Massive demands and limited transportation resources	[65]	High
	Too much transportation	[63]	Moderate
	Rapidly changing consumer demand	[55]	Moderate
Fragmentation of suppliers	Fragmented and small scale of farm structure	[28]	High
	Numerous small-scale suppliers	[55]	High

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