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Review

Food loss and waste management in the retail food supply chain: Methods and framework to achieve environmental sustainability

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ABSTRACT

Food loss and waste (FLW) represents critical challenge to environmentally sustainable development, impacting food security, waste management, and climate change. One-third of the world's food is disposed of, with 13 % lost between harvest and the supply chain and 17 % wasted domestically and in food services. Food loss and waste (FLW) in retail supply chains is a critical issue demanding new frameworks due to its significant economic, social, and environmental impacts, including pollution, resource depletion, and climate change contributions. Effective operational and inventory management practices to reduce FLW can yield significant cost savings and increased economic and environmental performance of the retail supply chain. A new framework is needed to combine all aspects related to logistics, packaging, and management practices to comprehensively address the FLW issue in the retail chain. This study critically analyses empirical research from 2009 to 2025 to identify key research gaps and to propose strategies for FLW reduction.

The research identifies three primary gaps: limited focus on FLW due to inefficient packaging strategies, insufficient information on logistical inefficiencies that cause FLW, and scarce literature on how management practices affect perishable food chain. By addressing these gaps, the study aims to enhance understanding of FLW reduction strategies, emphasizing the need for integrated approaches and cooperation across the supply chain. By examining the impact of packaging, logistics, and management practices, this research provides insights into improving operational performance through the reduction of FLW and development of sustainable waste management systems. The findings underscore importance of proactive actions and innovation from both public authorities and private sector in reducing FLW. Effective strategies for FLW reduction can lead to significant environmental, social, and economic benefits, contributing to a more sustainable and efficient food supply chain.

1. Introduction

Food loss and waste (FLW) generally refers to food not consumed, and become a waste. FAO (2019) defines FLW as the decrease in food quantity or quality along the supply chain, distinguishing between food loss and waste based on Food supply chain (FSC) stages. Food loss occurs at the upper part of FSC from post-harvest to retail, including storage, transportation, processing, and importing. Food waste arises at the lower part of FSC from retail to consumption

Overall, about one-third of the world's food is disposed of. Globally, about 13 percent of food produced is lost between harvest and the supply chain and about 17 percent of food produced worldwide is wasted domestically, in the food service and the supply chain. (UNEP, 2022). It is also important to note that approximately 30 % of food produced globally is lost or wasted along the retail food supply chain. These steps include production, handling, processing, distribution, and food consumption (Varese et al., 2023). The causes of FLW are many and occurs throughout the supply chain. Packaging, logistics and management practices are central to FLW as they directly impact the efficiency, cost-effectiveness and customer satisfaction of the entire food supply chain, from production to customer delivery (Garcia-Arca et al., 2022). As the food materials move from farm to consumer, the effective packaging practices keeps food safe, logistics moves it safely and quickly, and supportive management practices make sure the whole system runs smartly. Without effective packaging, more food gets damaged, spoils faster, and is wasted. Inefficient logistics and warehousing practices create more spoilage during distribution, generating huge food losses. Inappropriate management practices not aligning with reducing spoilage and wastes in food supply chain further contributes to degrading the environment.

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Reducing FLW is an opportunity for both the Public Authority and Private sector to be proactive in actions and adopt innovation towards reducing FLW.

Globally, FLW challenge sustainable development, impacting food security, waste management, and climate change. FLW incurs high socioeconomic costs and leads to environmental degradation (Carter, et al., 2020). The moral implications are profound, with 12 % of the global population suffering from hunger (Lohnes and Wilson, 2018). Despite efforts to minimize FLW, it remains high, with nearly half of all root crops, vegetables, and fruits wasted worldwide (Gustavsson et al., 2011). Addressing FLW is crucial for a sustainable future, necessitating further research on the food supply chain.

Food safety, crucial for public health, is directly linked to food freshness, which dictates quality (Kucha and Ngadi, 2020; Baba and Esfandiari, 2023). Expired food fosters harmful germs, increasing food poisoning risks. Accurate, continuous freshness monitoring is therefore crucial for consumer health(Zhang et al., 2024). Traditional subjective methods are unreliable, and lab testing is expensive and slow. Efficient, rapid, non-destructive techniques are key for meeting demand for safe, high-quality food (Zhao and Manning, 2019). Chemometrics created a model linking food quality to spectral data for precise assessment, enabling real-time data acquisition and cloud-based visualization for enhanced monitoring and traceability helping to achieve accurate and continuous food freshness monitoring (Zhang et al., 2024).

Reducing food waste is crucial for environmental sustainability and better nutrition. The Waste and Resources Action Program (WRAP) indicates that investing in food loss reduction can improve food security and sustainability. The COVID-19 pandemic highlighted the fragility of global food supply chains, resulting in the disposal of unsold goods. Food waste contributes to pollution, resource depletion, and undermines food security (Kummu et al., 2021). Implementing food loss and waste (FLW) reduction offers significant economic benefits for food retailers and stakeholders. Research indicates that every dollar invested can yield up to $14 in operational savings through reduced procurement, handling, and disposal costs (Aramyan et al., 2021). Minimizing FLW streamlines operations, providing a high return on investment, with many companies recovering their initial costs within one to two years (Dou et al., 2018). Adopting FLW reduction practices also substantially enhances a food retail firm's brand reputation and customer loyalty by demonstrating a commitment to sustainability and ethical responsibility (Garcia-Garcia et al., 2019).

Food retailers such as supermarkets contribute significantly to food waste due to purchasing problems and inventory miscalculations (Filimonau and Gherbin, 2017; Teller et al., 2018).

While prior literature reviews provide a crucial foundation, three research limitations are evident. First, there has been an imbalanced focus on customer responsibility for food waste, neglecting the significant roles of other supply chain stakeholders. Second, many studies narrowly concentrate on specific points within the supply chain, offering a limited perspective on this complex issue, which cannot be attributed to a single factor. A singular viewpoint is insufficient for understanding FLW reduction strategies. Finally, some studies lack transparency and thoroughness, potentially introducing researcher bias in interpreting existing literature (Transfield et al., 2003). Consequently, more comprehensive research is necessary to adequately address food loss and waste across the entire supply chain (Chaboud and Daviron, 2017). This review addresses waste reduction throughout the supply chain, emphasizing technologies, innovative solutions, and good management practices. Reducing waste offers environmental, social, and economic benefits. This study examines FLW sources, including perishables management, stakeholder attitudes, disruptions (Biuki et al., 2020), and packaging impacts on waste generation (Carter et al., 2020; Centobelli et al., 2020).

This research focuses on empirical studies conducted from 2009 to 2025 on FWL and its management strategies within the FSC. The findings of this study contribute to the existing literature by critically analysing previous sustainable food chain cases to identify the essential common aspects that drive companies to achieve environmental sustainability in the FSC (Giannetti et al., 2020).

Specifically, four research gaps are emerged in the literature.

1. There is limited focus on understanding FLW that occurs due to the packaging strategy of food products (Lindh et al., 2016).
2. There is limited information regarding the FLW caused by logistical efficiency such as, technology, material handling, stacking of food products and expected targets (Pietzsch et al., 2017).
3. There are limited literatures on how management practices such as facility layout, inventory strategy, and back-order rate affect the perishable FLW (Bhatia and Gangwani, 2021).
4. There is limited understanding on how FLW reduction strategies could impact the operational performance (Koberg and Longoni, 2019).

The overarching aim of the Systematic Literature Review (SLR) in this paper is to critically analyse existing literature to understand strategies to reduce FLW in FSC. This research bridges the Gap identified by addressing the following research questions.

1. How do different types of packaging strategies of Food products affect FLW generation?
2. What is the impact of logistical efficiency such as, material handling, Stacking of Food Products and Expected Targets in the supply chain on FLW?
3. To what extent could the Management Strategies/Practices solve or adversely affect the problem of FLW?
4. How does FLW reduction strategies influence the operational aspects of the FSC, such as efficiency, speed, quality, responsiveness, and inventory policy?

The research question was addressed through a systematic literature review of papers published between 2009 and 2025 in leading journals.

This study aims to deepen our understanding of food waste by examining the causes of food loss and waste throughout the supply chain. Previous research suggests that initial supply chain stages significantly contribute to food loss and waste (FLW) (Gustavsson et al., 2011), but there is a growing need for a more holistic approach to identifying reduction strategies. Traditionally, FLW has focused on discarded or uneaten food (Huang et al., 2021), with earlier studies not differentiating between "food loss" and "food waste." This study will focus on FLW within the supply chain, considering five dimensions: the supply chain stage, edibility, quality, use, and destination. Recently, research has shifted from assessing loss to implementing environmentally focused recommendations, aiming to improve FLW management at every stage and establish benchmarks for the food industry (Beausang et al., 2017; Salim et al., 2021). This study contributes to that effort by providing a nuanced understanding of FLW causes to inform reduction strategies.

The paper is organized into six sections. Section 1 introduces the research topic. Section 2 details the methodology, focusing on the Systematic Literature Review (SLR) process, following Transfield et al. (2003) framework. This includes planning the search strategy, identifying target journals, setting inclusion and exclusion criteria, conducting the review, and documenting findings. Section 3 categorizes the selected research papers for analysis. Section 4 discusses the analysis, findings and their interpretation. Section 5 explores potential avenues for future research. Finally, Section 6 concludes the study, summarizing the key insights and outcomes.

2. Methodology

A systematic review (SR) was conducted to address the research aims, utilizing a search strategy to identify relevant literature (Denyer and Transfield, 2009). Managing perishable FLW faces two main challenges: the high cost of sustainability limits facilities development for small businesses, and inadequate follow-up on employee training effectiveness impacts waste volumes despite increased training efforts (Jaji et al., 2014).

This review utilized SCOPUS and Web of Science (WoS), two of the largest repositories of peer-reviewed journals (Centobelli et al., 2020). These databases are ideal for comprehensive literature reviews in Operational Management and supply chains (Shashi et al., 2018). Integrating both databases enhances the likelihood of finding all relevant contributions and ensures objectivity in selecting journals or articles for analysis. Fig. 1 illustrates the steps involved in the literature selection process.

The search fields in Scopus included "Title, Author, Keywords, Abstract, Document Type, and Source Type," while in WoS, they included "Title, Author Keywords, Keyword Plus, and Abstract." Scopus returned 3628 papers, and WoS returned 837 on 'Food loss' or 'food waste.' For 'Food loss' or 'food waste' and ('Sustainable supply chain' or 'Circular supply chain' or 'Logistics'), Scopus returned 343 papers and WoS 286. After applying inclusion and exclusion criteria, the number was reduced to 194 articles, excluding 43 duplicates found in both databases.

The SLR is implemented in two stages. In the first stage, keywords were selected, inclusion and exclusion criteria were set, a database search was implemented, and documents were evaluated for quality. In the second stage, SLR results were reviewed (see Table A2 in the appendix). After removing duplicates, the full texts were read to eliminate unrelated papers, reducing the count to 87. Researchers reviewed titles, abstracts, and keywords, assessing them using screening criteria and conceptual boundaries.

2.1. Data extraction

The final list was made from the selected keywords (Refer Table A1 in the appendix) and transformed them into a search base by applying Boolean logic, using * along with 'OR' and 'AND' connectors. The researcher searched for title, abstract, and author keywords in the selected databases using a search base. The researcher conducted a search for all studies published in this domain until March 2025. The researcher initially found 343 Articles on the Scopus database, while the WoS document search resulted in 286 articles. First, 43 duplicate articles were removed from the databases, leading to 586 articles. We further screened this pool by applying different inclusion and exclusion criteria, as explained below.

2.2. Inclusion and exclusion criteria

It is pertinent to note that only journal papers published in English are added, which is consistent with Fahimnia et al. (2015). Conference papers, commercial magazine papers, and books are not included in the search to ensure strict adherence to research interest, (as shown in Table A3 in the appendix); only journal papers, reviews, and articles are included. The final shortlisted papers were published in the period 2009–2025.

In Fig. 1 above, the first analysis, which includes the selection stage for articles, the inclusion or exclusion decision is made after reading the study title, abstract, and keywords (Wong and Hernandez, 2012). Of the 629 papers found, 392 were rejected, 43 were duplicated, and 194 met the criteria established in the protocol.

In the second stage, all previously shortlisted articles were read in full and included in the article extraction process. Studies that were not relevant to the research theme were excluded (Wong and Hernandez, 2012). This analysis ensured that the articles considered for the research

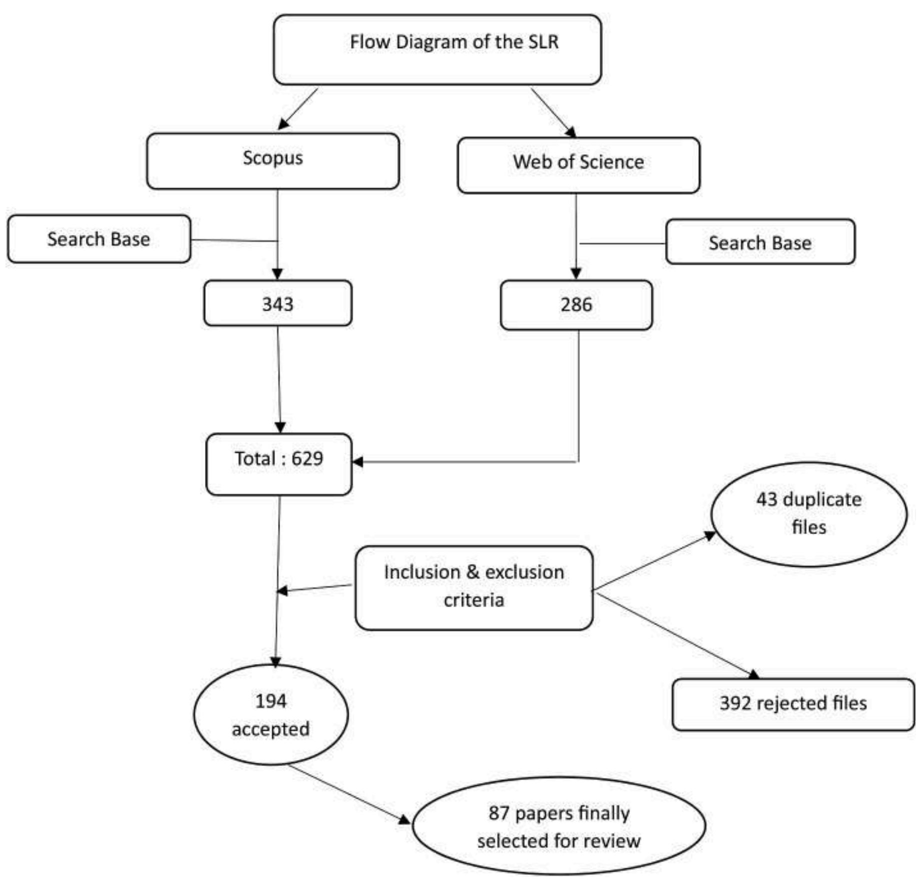

Fig. 1. Steps taken to shortlist the papers for SLR.

fit the objectives of the study. Therefore, we read and evaluated 194 articles, accepted 87 articles, and rejected 107 articles for final review.

The final sample of 87 articles accepted in the extraction stage was analysed considering the publication year of each article in the scientific journal, geographical context, location of the country where each study was developed, and type of study.

2.3. Data performance: research outlining

Preliminary assessment seeks to observe the historical progress, the journals commonly targeted for publications, and the geographical distribution of the journals in the research topic. Prior to 2015, studies in this area were limited. Few papers were published between 2009 and 2013.

The research outlining the studies indicates that papers on FLW in FSCs are quite recent, as the number of journals has risen since 2015 (Refer Fig. A1 in the appendix).

2.4. Distribution of articles per year of publication

Fig. A1 (Refer the appendix) shows the distribution of 343 recognized articles by year of publication. It could be observed that publications on this research interest are growing. The first publication was in 2002, with one article published, and no article was published until 2008, which has one Article. The same applies to 2009 and 2010. It increased marginally to three articles in 2011 and dropped again in 2012. Furthermore, there were six publications in 2014, which showed more interest in this area of research. The number of publications, however, started increasing sharply from 2017 with 18 articles, followed by 2018 with 22 papers, 2019 with 25 papers. It reached its peak in 2021 when 58 papers were published, and it dropped in 2022 to 40 publications but picked up in the year 2023 and 2024 with 52 papers and 60 papers respectively. In the year 2025, only 10 papers were published till March. Fig. A2 (Refer the appendix) indicates that 83 % of the papers used for this research were articles, while 17 % of Literature review papers were used.

2.5. Geographic background

This geographical background shows the countries in which the designated papers were published. We made this decision because some journals do not specify the country where the study was conducted, or alternatively, they might refer to a broader geographical area, such as the EU, instead of identifying a specific country. Table A6 (Refer the appendix) describes the geographical background of the published articles and shows that Italy, the United Kingdom, and Germany constitute the combined greatest number of publications, all countries in the EU. India, China, and the USA are the only three countries outside Europe among the top ten countries with the highest number of affiliations. This shows European Countries' commitment to research on Food Loss and Waste Management in the Retail Food Supply Chain, targeting FLW among the priorities.

It should be noted that 271 papers were published in the top nine countries (Refer Fig. A3 in the appendix), and 70 % of these studies were carried out in the EU, especially in Italy and the UK. Twenty% of the studies were conducted in developing countries. The recognition of publications in the EU and the USA indicates a position with heightened interest from companies and policymakers in these countries.

It is also observed that out of 343 papers published, 52 papers were from countries other than European countries, representing interest from other parts of the world. However, there is worldwide interest in FLW researchers in the retail food supply chain. It is also worth noting that publications on the subject are being published, including in developing countries such as Brazil and India.

2.6. Type of study

Nearly all the published papers are mainly Literature Reviews and case studies, and most of the case studies are new and published between 2021 and 2024. Literature Reviews were focused on 2020 and 2024. Furthermore, there has been an increase in literature reviews in recent years, and the number of case studies has also increased.

From the year of publication, geographical distribution, and type of study mentioned above, it is ideal to emphasize some important aspects. The first reveals academic interest represented by the surge in publications from 2020 to 2024. This meets the sustainable development goals and objectives of the United Nations (UN). These objectives reduce food loss and waste, as well as the generation of waste through prevention, reduction, recycling, and reuse (Oliveira et al., 2021).

Fig. A4 (Refer the appendix) shows that Business Management and Accounting Journals are extensively used by approximately 16 % of the research papers. In addition, energy (17 %), engineering (12 %), environmental science (21 %) decision science and computers (3.6 %), economics (3.6 %), and other topics are also applied frequently. Fig. A5 (Refer the appendix) shows the most productive authors. The most important publishing outlets were those focused on waste management and environmental issues.

Table A8 (Refer the appendix) shows the authors of the most published papers. Ten authors published at least three studies. This is a long way to indicate how this research has generated interest in recent years. In Table A9 (Refer the appendix), the Journal of Cleaner Production attracted the greatest number of publications, followed by Sustainability Switzerland, Foods, Food Policy, and the Journal of Enterprise Information Management. These journals jointly numbered over 30 % of the total publications in the review sample. Even though the FLW in the FSC could relate to multiple research areas, the field of review papers is appropriate within the scope of these journals, which exemplifies FSC management practices and the sustainability concept.

3. Articles categorization and review

In the 87 selected articles, information was extracted and organized into five categories explained in this study as, 1, The concept of FLW to achieve sustainability, 2, Food Packaging strategies, 3, supply chain management process, 4, Firms Practices along the FSC and, 5, Network design of Food redistribution.

3.1. The concept of FLW to achieve sustainability

Among the 87 selected articles, 18 defined FLW along the FSC, with eight using the FAO definition (Gustavsson et al., 2011). The FAO states that food loss occurs at the initial stages (production to processing), while food waste happens at the final, retail, and consumption stages.

Based on the report from FAO regional conference for Europe in the year 2020, FLW denotes the reduction in the volume of food intended for human consumption at all stages of the food chain, from yield to consumption (Jocelyn et al., 2023). Food loss refers to a decrease in the quantity or quality of food during production, post-harvest, and processing stages before retail. Food waste occurs when food is discarded in the FSC due to unsuitability for human consumption, damage, or expiry. These issues arise from consumers' financial capabilities, poor inventory management, and carelessness in food services and at home (Kayikci, 2019). Porter et al. (2018) use "loss" for upstream FSC stages and "waste" for downstream stages. FLW is a general term used when the distinction between loss and waste is unnecessary, as seen in (Jocelyn et al., 2023) who consider "food losses" to cover both loss and waste at all FSC stages and also propose "food loss" for food not counted as surplus, specifically referring to edible parts suitable for human consumption.

Food loss and waste (FLW) occur throughout the food supply chain (FSC), impacting quality from production to consumption (Koberg and Longoni, 2019). The FSC's complexity involves logistics, manufacturing, processing, distribution, and consumption, with a focus on quality, safety, sustainability, and efficiency (Baba and Esfandiari, 2023). Key challenges include security, waste, farming, public health, climate change, oil dependency, fair trade, and localism (Li et al., 2014). Each FSC stage contributes to total waste, and reducing FLW and its environmental impact is essential for sustainability and long-term profitability (Wikstrom et al., 2019). Waste at one stage can raise prices downstream, so improving sustainability benefits the entire supply chain.

Food companies should enhance sustainability throughout the chain for environmental and commercial benefits. Key steps include identifying areas for change, investing in modern technology, and improving management (Heard et al., 2019). Failure to invest in new technology and strategies leads to environmental harm as food waste in landfills releases methane, affecting climate (Heard et al., 2019). Irresponsible food wastage, especially meat, impacts land use significantly, with approximately 950 million hectares dedicated to meat production worldwide, adding urgency to addressing this issue globally (Li et al., 2014).

3.1.1. Collaboration between private and public sectors to reduce FLW

Effective food loss and waste (FLW) reduction requires collaboration between public and private sectors, from production to retail. This includes FLW reduction policies and mandatory targets. Collaboration involves developing technologies and infrastructure for better food storage, data sharing, and research to identify FLW hotspots in the supply chain. The EU Platform on FLW, established in 2016, unites key public and private stakeholders, ensuring representation from all supply chain actors, including international organizations like FAO and UN Environment, and EU agencies like the Economic and Social Committee. The platform guides the implementation of EU regulations and policies on FLW reduction along the supply chain. This multi-stakeholder approach facilitates coordinated efforts and knowledge exchange, incentivizing retailers towards sustainable practices (EU, 2021).

In Asia, countries like China address FLW through public-private partnerships, with initiatives like the 2021 Anti-Food Waste Law aimed at prevention and food security, moving towards green food production and processing laws. However, implementation challenges, particularly due to cost, exist for small food retail enterprises (Zhang and Huo, 2023).

3.2. Food packaging strategies

Twenty of the selected articles emphasize that food packaging functions are crucial for reducing FLW (Lindh et al., 2016). Packaging plays a vital role in mitigating food loss and waste by safeguarding food products from damage and spoilage, extending shelf life, and ensuring food safety, thus minimizing waste throughout the retail and consumer supply chain stages (Zhang and Zhao, 2012). Packaging serves in handling food products throughout the supply chain and communicating information in different parts of the system. Retail packaging must be durable to prevent damage and loss hence, optimizing sales. Consumer-friendly features like easy opening, resealing, and efficient use minimize spills and waste. Acknowledging and valuing diverse packaging functions can effectively mitigate FLW across various stages of the food supply chain.

Fig. 2 shows the movement of Food Products along the FSC and how FLW is normally recouped back into the system. It also shows that FLW is generated along the supply chain mainly due to poor packaging. Poor packaging of Food Products amounts to 45 % of the waste generated by the FSC (see Fig. 3).

Chaffee et al. (2022) found that older adults frequently spill food when opening packages. Proper portioning can prevent overconsumption and waste. WRAP (Wikstrom et al., 2019) reported significant household food waste in original or partially used packaging. Packaging should cater to diverse needs with clear freshness and safety information, using standardized date labelling (eFED, 2016).

FLW in retail can increase due to slower turnover with multiple packaging sizes. There are trade-offs between FLW in retail, households, and packaging volume. For high-impact food products, smaller packaging sizes may reduce waste despite using more material. Packaging's communication functions, like RFID tags and temperature recording during distribution, also impact food waste (Aschemann-Witzel et al., 2019).

Muangmala (2016) noted that food packaging contributes 0.3 % of GHG emissions for resource-intensive foods like red meat but up to 20 % for low-resource foods like blueberries. Heller et al. (2018) reviewed GHG ratios across products, ranging from 0.06 to 700. Optimized packaging can reduce FLW, and NGOs, governments, and companies should integrate this into sustainability initiatives. Balancing product protection with minimal material use conserves resources and lowers environmental impact.

Prior studies have explored various packaging technologies impacting food loss and waste (FLW), from traditional materials like plastics, glass, and cardboard to innovations such as active and intelligent packaging. Results indicate a significant correlation between plastic and cardboard packaging and increased fresh food waste, alongside environmental impacts (Zhang and Zhao, 2012). Consequently, with the

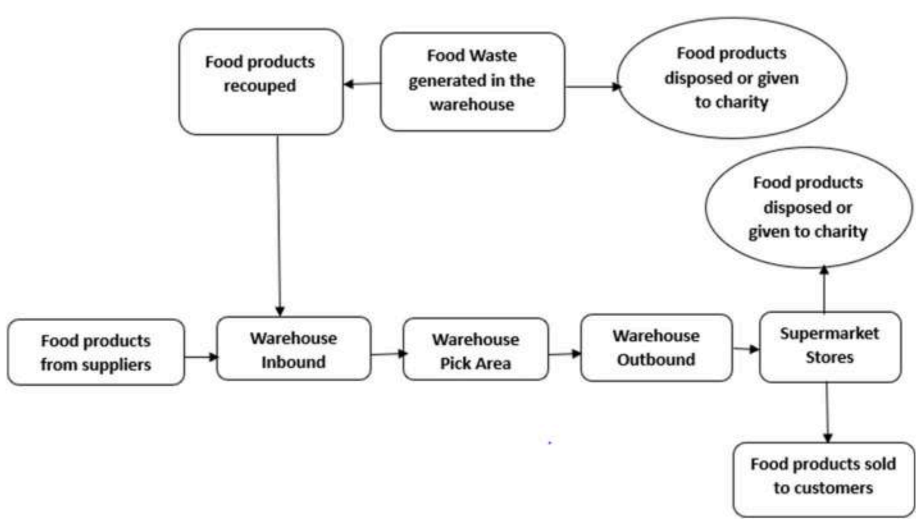

Fig. 2. Simplified flow sheet of food supply chain.

Fig. 3. Principles of environmentally sustainable practices in FSC.

need to track and monitor food products, firms are recognizing the limitations of some packaging raw materials in significantly reducing FLW and are seeking greener alternatives. The adoption of flexible and intelligent packaging, which provides information and modifies the internal environment to extend shelf life, has increased. These include smart packaging which uses technology like RFID or QR codes for tracking and monitoring food product throughout the FSC and the active and sustainable packaging which uses biodegradable materials like the combined use of plastics, cardboard, and foil, offering space-saving, customer-friendly, and environmentally conscious advantages (Huang, 2017). Food retail firms implementing these packaging innovations are gaining a competitive edge over others (Dora et al., 2021).

3.2.1. Barriers of implementing effective FLW reduction strategies

Implementing effective food loss and waste (FLW) reduction faces financial constraints, regulatory hurdles hindering innovation, and technological gaps affecting management practices. High facility upgrade costs and complex government policies are significant barriers. Investing in storage, transport, and processing machinery is costly, disproportionately impacting smaller firms and developing nations (Montoli et al., 2023). Modern technologies like cold chain systems are expensive and indirect costs like staff training add up. (Sundin et al., 2023),

Despite their benefits in reducing FLW, smart and sustainable packaging face cost implications such as higher upfront cost of eco-friendly materials and cost of disposal. While flexible packaging's compactness is advantageous, justifying smart packaging for low-value food is often economically challenging, hindering wider adoption due to customer cost concerns. However, as smart packaging becomes more common, its cost has begun to decline. Selecting the appropriate type of smart and sustainable packaging is crucial but also challenging. While plastic packaging has offered a global, cheap, and safe solution, its current use is unsustainable due to environmental impacts. Food retail companies are increasingly adopting flexible and smart packaging strategies that are not only suitable for the food product but also economical and environmentally friendly (Brennan et al., 2021; Sasaki et al., 2022).

Furthermore, Government food packaging regulations aim for safety and environmental protection through sustainable practices (FSA, 2022). However, partial policy implementation hinders sustainable adoption by retailers, many prioritizing cost-cutting over full compliance.

Logistical management is a key competitive advantage for many firms in the food supply chain (Defra, 2022). However, managers struggle to devise strategies that simultaneously reduce logistical costs and enhance efficiency while minimizing food loss and waste (Muth et al., 2019). The process improvement involves optimizing each supply chain stage using IoT and AI technologies, alongside investments in infrastructure and sustainable practices like effective inventory, storage, and transportation (Ciccullo et al., 2021; Mandal et al., 2021). Technological gap hinders FLW reduction in some regions of the world, with efforts to bridge it through investment and government intervention (Spring and Biddulph, 2020).

3.3. Supply chain management process

Several analysed articles have explored the management process of delivering food products from farms to consumers. This process involves planning operations across the supply chain and product planning. As part of the management philosophy aimed at reducing Food Loss and Waste (FLW), operations planning plays a crucial role. According to Parfitt et al. (2010), waste is one of the major barriers to the sustainability of the Food Supply Chain (FSC). An efficient FSC aims to supply, distribute, and consume food in a more sustainable manner without compromising costs. This involves setting standards and leveraging technology to enhance sustainable development, reduce operating costs, and minimize food waste (Li et al., 2014). Companies are motivated to explore this area due to the incentives of using resources efficiently, reducing FLW, and saving money (Richter and Bokelmann, 2016).

3.3.1. The effect of logistical efficiency

Efficient logistics are crucial for minimizing food loss and waste (FLW) through optimized handling, inventory, and transportation, reducing spoilage and ensuring optimal food delivery (Bhatia and Gangwani, 2021). For example, resource optimization enhances sustainability and minimizes environmental impact. Real-time inventory tracking allows precise stock level monitoring, enabling retailers to balance orders and avoid overstocking or stockouts.

Logistical inefficiencies from farm to supermarket significantly contribute to FLW, including inadequate storage, transportation delays, and ineffective inventory management. For example, at the farm production and harvesting stages, Poor harvesting and lack of cold storage cause farm-level spoilage. Post-harvest, inconsistent grading and insufficient infrastructure exacerbate the problem (Biuki et al., 2020). High transportation costs, lack of cold storage in warehousing, and absent on-site processing increase waste. Addressing these cumulative inefficiencies across the supply chain is vital for minimizing FLW and enhancing sustainability.

Further, it is evident that temperature control is crucial in food logistics, especially for delicate items like fresh fruits and cucumbers requiring immediate cold storage transfer. Precise temperature-controlled transportation is essential. Smart sensors track and log critical environmental parameters (humidity, temperature, stock, light, air pressure) for each shipment, providing real-time data. This empowers retail managers to monitor each product's journey, enabling proactive spoilage prevention, ensuring optimal condition upon arrival, minimizing waste, and maintaining quality (Filimonau and Gherbin, 2017; Teller et al., 2018). This data also supports traceability and accountability.

Maintaining temperature control is vital in the cold chain logistics of fruits like table grapes to minimize spoilage, prolong storage, and preserve economic value (Kim et al., 2015). Implementing Wireless Sensor Networks (WSN) is a highly effective solution for real-time monitoring in food cold chains (Aung and Chang, 2014), and agriculture (Correa et al., 2014). This measurement enhances the traceability, sustainable performance, and transparency of the fruit products, ultimately ensuring their quality and safety (Xiao et al., 2013).

3.3.2. Environmentally sustainable practices

Retail firms' environmentally sustainability practices in the management Planning of food waste reduction are business strategies within the Food Supply Chain (FSC) successfully implemented in countries like China, South Korea, and Japan. Its core values focus on continually reducing Food Loss and Waste (FLW) to enhance customer service and achieve sustainability, helping these countries reduce food waste by about 30 %. Everyone in the FSC, from top management to workers and suppliers, participates in reducing food waste across all operations (Krishnan et al., 2020).

However, current supply chain practices often accelerate food waste due to reliance on overproduction and surplus-creating processes. Without altering these fundamental characteristics, systemic overproduction will continue, posing a significant challenge (Messner et al., 2021). Thapa-Karki et al. (2021) outline five key principles for organizations to achieve continuous order fulfilment and reduce food waste.

1. **Food Waste Reduction at First Contact:** Integrates waste reduction into operational processes with ongoing improvements. Training pickers enhances their skills in achieving these goals.
2. **Strategic Improvement of Picking Processes:** Focuses on improving the picking of food products and minimizing spills during dispatch. Strategic plans should integrate food waste reduction, ensuring suppliers provide quality products with functional packaging. Monitoring by SKU helps identify poorly packaged items, fostering continuous improvement through supplier communication (Brennan et al., 2021).
3. **Continuous Improvement Throughout the FSC:** Involves evaluating and implementing more effective methods across the supply chain. Qualified and trained employees facilitate information flow between suppliers, retail stores, customers, and distribution centers, optimizing data management and resolving operational obstacles (Abbasi and Nilsson, 2012).
4. **Teamwork and Mutual Respect:** Promotes a culture of waste reduction and cost savings. This principle is embraced by many organizations in the UK and France, encouraging workforce feedback and recognizing significant achievements (Albizzati et al., 2019).
5. **Customer-Focused Approach:** Ensures food products meet and exceed customer needs, emphasizing quality and packaging on store shelves. Warehouses require a systematic approach involving the entire FSC workforce.

While these principles address key FSC challenges, they often overlook outsourcing, integration, and strategic alignment. Further research should develop principles incorporating management operations, external suppliers, and retail stores.

3.3.3. Conflicts between efficiency improvements and environmental sustainability goals

The conflict between efficiency and sustainability emerges when aiming for greater supply chain output unintentionally causes resource depletion and increased food loss and waste (FLW), leading to environmental degradation and hindering long-term sustainability (Baumgartner and Quass, 2010). Efficiency-driven increases in food product volume, if poorly managed, can exacerbate FLW. Sustainability, in terms of consistency, fundamentally differs from efficiency (Huber, 2000). Performance targets for retail workers significantly contribute to food waste, causing pollution and undermining environmental sustainability.

Technological advancements, while boosting output efficiency, can inadvertently increase waste generation, posing environmental challenges. For instance, highly automated supply chains in major UK supermarkets, despite operational efficiency gains, lead to substantial waste. UK supermarkets waste approximately 270,000 tonnes of food annually, with 100,000 tonnes being edible (BWA, 2024), raising concerns for retail management and the government. In November 2021, the UK's five largest supermarkets pledged to halve the environmental impact of weekly food shopping by the end of the decade (COP 26 Summit).

3.3.4. The impact of research and development

Research and Development (R&D) support is a crucial innovation model in the food supply chain, fostering new product development and jointly reducing supply disruption risks, thereby enhancing environmental performance (Yang et al., 2024). A supply chain is an intricate network of interconnected supply and demand relationships, encompassing various processes delivering value to consumers (Jahani et al., 2024).

Given the food industry's rapid expansion and consumers' growing focus on material safety and environmental sustainability, proactive innovation is vital for firms to remain competitive. R&D collaboration within the supply chain occurs as horizontal cooperation among similar-level firms and vertical cooperation between upstream and downstream entities (Solaimani and van der Veen, 2022).

These collaborations offer significant benefits, including lower production costs and fostered joint innovation with suppliers. Identifying suitable R&D partners within the complex supply chain network, based on their specific technical strengths, is critical for target firms. Determining the most appropriate partners is essential (Wu et al., 2023). Thus, enhancing R&D cooperation and innovation in the food supply chain is increasingly vital for firms seeking sustained growth and competitive success in a dynamic market.

3.4. Evaluating performance

Sixteen analysed articles examined firms' practices along the Food Supply Chain (FSC). One important practice involves evaluating performance categories within the FSC to identify areas for corrective action. This approach assesses strengths, weaknesses, and critical variables influencing the chain's efficiency. While external metrics like stock turnover, fill rate, and back-order rate are commonly emphasized to enhance customer satisfaction and reduce food waste, internal variables are critical for determining FSC success and food loss and waste (FLW) reduction (Guo et al., 2019). Effective management practices are critical to the reduction of food loss and waste as they enable the tracking, and monitoring of food product with optimization of the food supply chain which leads to increase efficiency, resource conservation and reduced environmental impact. By analysing data on food handling by pickers, inventory, backorder, and transportation, food retail firms can identify inefficiencies and implement strategies to minimize food loss and waste (Filimonau and Gherbin, 2017).

Handfield et al. (2020) highlights the importance of broadening performance measures in the FSC to meet diverse objectives across industries. A key internal variable is the control system within food retail firms, particularly in the UK. This system plays a significant role in managing the FSC by maintaining data reliability, managing paperwork, meeting store requests promptly, and using computer systems effectively (Carter et al., 2020). Real-time online order-entry systems allow for batch orders and provide timely instructions, enhancing operational trust and efficiency. However, data reliability remains a challenge due to unpredictable purchase trends and economic uncertainty, which impacts consumer behaviour and contributes to FLW (Munson and Rosenblatt, 1998). As such, robust control systems and accurate data management are crucial to reducing FLW and optimizing supply chain operations.

Inventory accuracy is another vital factor in preventing FLW. Effective inventory management and lot sizing strategies help reduce FLW by extending planning horizons, while individual portion sizes in hospitality can mitigate waste (Alvarez et al., 2020). Accurate inventory management is essential for smooth supply chain operations, impacting vendor supplies, labour efficiency, and customer service. Inadequate forecasting can lead to excess or shortages in inventory, thus affecting customer satisfaction and operational efficiency. Proactive inventory management systems enhance accuracy, reliability, and overall performance, reducing FLW risks.

Another significant practice is fulfilling the Outbound Warehouse Request (OWR), a key workload-planning tool for warehouse managers (Lebersorger and Schneider, 2014). This helps streamline transportation planning by offering insights into completed orders, package carriers, and other indicators. Conducted quarterly, OWR supports effective outbound request management in food supply chains.

The design and use of facility layouts also impact supply chain efficiency. Effective facility layouts optimize space usage, material handling, and product storage, minimizing damage to food products and reducing FLW (Carter et al., 2020). Similarly, prioritizing health and safety, including fire safety and hazardous materials handling, is crucial for minimizing accidents that lead to food loss.

Large EU retail firms focus on key performance indicators (KPIs) such as order-picking accuracy to minimize food waste (Priefer et al., 2016). Inaccurate orders increase returns, transport time, and error rates. KPIs like orders per hour and order cycle times help streamline these processes.

Finally, supportive leadership plays a key role in motivating employees to reduce FLW and promote sustainable food management (Akkaş and Gaur, 2022). Leadership fosters a culture of collaboration and flexibility, enhancing information sharing and driving sustainability across the supply chain (Belavina, 2021).

3.4.1. *The impact of data-driven strategy and Artificial Intelligence (AI) on inventory management*

EU food retailers are increasingly using AI-driven inventory control and predictive analytics to enhance decision-making and optimize operations. Both methodologies use data and algorithms to forecast future outcomes by identifying patterns in historical data (Gayam et al., 2021). While both aim to optimize inventory, AI-driven systems autonomously learn and adapt, offering an advantage over traditional predictive analytics that rely on manual processes (Eyo-Udo, 2024). AI-driven systems use sophisticated algorithms to analyse patterns, predict demand fluctuations, monitor inventory in real-time, and dynamically optimize stock levels (Nimmagadda, 2021).

These systems integrate data points like sales trends, supplier performance, customer behaviour, and external factors, providing a holistic supply chain view. For instance, AI can proactively predict demand spikes, ensuring sufficient inventory and improving customer satisfaction, contrasting with reactive stockout responses. Firms use AI to gain data-driven insights, maintaining optimal inventory levels instead of overstocking (Muthukalyani, 2023).

Implementing AI-driven inventory control offers benefits like reduced operational costs, increased profitability by minimizing food loss and waste, improved customer experiences through timely availability and automated replenishment, reduced manual errors, and enhanced environmental sustainability by reducing unnecessary inventory and waste. This dynamic solution empowers firms to navigate modern retail complexities and achieve sustainable growth.

Adopting AI inventory management poses challenges for small businesses with legacy systems. Incompatibility with modern AI requires costly modifications. Aligning manual processes with predictive analytics is very difficult. Synchronizing data between AI and outdated systems present hurdles. Outdated inventory records undermine AI accuracy and effectiveness (Eyo-Udo, 2024).

3.4.2. *Greenhouse facilities management and digital transformation in agriculture*

Digital transformation is revolutionizing agriculture, enhancing efficiency and environmental performance through data-driven insights that improve decision-making and reduce waste (Abedrabboh et al., 2022). Effective financial management, considering upfront costs, operating expenditures, revenues, financing, and government support (Durmanov et al., 2024), is crucial for adoption, particularly in greenhouse operations.

While the EU and Asia invest in digital agriculture, a lack of supply chain coordination hinders small to mid-sized operations (Choi and Kang, 2022). This review reveals that integrating digital platforms with supply chain coordination significantly boosts productivity and financial sustainability. Participation in digital platforms notably increases profitability, reduces expenses, enhances yields and technical efficiency, and improves environmental performance (Durmanov et al., 2024). This provides quantifiable evidence of synergistic gains from combining infrastructure upgrades with enhanced data visibility and supply network integration, effectively addressing challenges for smallholder agriculture.

3.4.3. *Ecosystem dynamics and environmental impact*

Food chains are environmentally crucial, involving management, ecology, mathematics, engineering, and economics. A food chain model shows a single path of organism, energy, and resource flow. Interconnected food chains form complex food webs. Food chains exhibit various trophic levels. Organisms in different stages, including producers, consumers, and decomposers, are categorized within these levels. The movement of organisms, energy, and resources in a food chain model is found to bilinear and these impact the environment (Arif et al., 2024). A food web's formation uses a framework. Mathematical analysis and modelling can represent food chains as (Naji, 2012). Ecologically, food chains are species sequences where each serve as food for the next. Interconnected food chains form complex food webs (Nath and Das, 2018). Various methods integrate cannibalism and harvesting to understand ecosystem dynamics and environmental impacts. Methods include connecting ANNs to computational proficiency for model behaviour insights over time. Findings demonstrate that system boundedness, computed fixed points, and stability characteristics exists among the organisms (Arif et al., 2024).

3.4.4. *Circular economy influence on operational efficiency and sustainability*

Implementing circular economy frameworks in the food supply chain provides significant environmental, economic, and social benefits, such as reduced waste, improved resource efficiency, and new business models, despite challenges like high initial investment. For example, implementing reuseable packaging by opting for reusable or returnable containers of food products and also finding alternative use for food that are not perfect but are still edible (Vegter et al., 2020). Focusing on minimizing waste and maximizing resource use from production to consumption can lead to substantial cost savings for businesses and consumers. By adopting circular economy principles, food retailers can achieve greater operational efficiency and more sustainable economic development, gaining strategic advantages by reducing environmental impacts and enhancing economic performance (Yang et al., 2024). For example, this framework helps prioritize waste reduction, resource efficiency, and closed-loop systems, including optimized inventory management (Bocken et al., 2016). However, substantial initial investments, uncertain long-term financial returns, and the difficulty of changing consumer behaviour toward sustainable practices can hinder widespread adoption (Todeschini et al., 2017).

3.5. Network design of food redistribution

Eleven of the reviewed papers considered the Food redistribution practices of Food retail firms and highlighted the multifaceted causes of FLW in food retail firms. External factors like weather, natural variability, and regulatory constraints impact FLW (Kummu et al., 2021). Strategic-level causes include inadequate infrastructure, logistical challenges, and limited market access (FAO, 2019). Interfaces within the food value chain are significant contributors (Gobel et al., 2015). In the fruit and vegetable industry, high trading standards and retail regulations drive FLW (Richter and Bokelmann, 2016). Donating unsold products is a viable solution, offering social and ecological benefits, enhancing corporate image, reducing costs, and providing tax deductions (Whelan, 2014). However, economic, infrastructural, and legal barriers persist (Priefer et al., 2016). Legal concerns also pose barriers to food redistribution; UK retailers fear litigation and administrative burdens (Gruber et al., 2016). Conversely, legal protections like Italy's "Good Samaritan Act" and similar US legislation mitigate donor liability (Priefer et al., 2016). Vlaholias et al. (2015) highlight the importance of awareness in charitable contributions, advocating for better communication between distributors and retailers regarding recipient needs. Addressing barriers like legal concerns, logistical challenges, and societal stigma is crucial. Enhancing awareness and fostering collaboration among stakeholders are essential steps toward reducing FLW through effective food donation practices in the retail sector. Preventing donated food waste requires retailers to maximize distribution via charities, ensure food quality, and implement surplus management strategies like repurposing or donating to local food banks. Utilizing a first-in-first-out system and clear date labelling of “best before”, and "use by” is crucial for food quality and safety. Retailers should promptly remove damaged or expired items and communicate with food aid organizations about low-quality donations (Bajzeli et al., 2020). Partnering with local food banks and charities is vital for effective distribution, including repackaging surplus food and simplifying donation pickups. Exploring alternative uses like animal feed or shelter donations is also important. Cultivating a waste reduction culture necessitates trained staff collaborating with charities and food banks. Regular communication, clear donation quality guidelines, and efficient logistics are key to successful, waste-minimizing food donation programs supporting local communities (Kummu et al., 2021).

Food redistribution addresses food insecurity and reduces waste but has environmental and social trade-offs. Potential impacts on food quality and nutritional value exist, along with logistical demands for infrastructure, transport, and storage. Increased consumption could offset environmental gains (Midgley, 2019), and transportation can increase emissions. Food quality concerns, especially near expiry, may lead to spoilage and health issues. Extra packaging can add to landfill waste, and recipients might have limited food choice. Redistribution can also shift waste management burdens to charities and food banks (Schanes et al., 2018). Careful consideration of these trade-offs is vital for optimizing the effectiveness and sustainability of food redistribution. Determining the most appropriate partners is essential (Wu et al., 2023).

4. Discussion

This research proposes that achieving a sustainable food supply chain requires boost in management techniques focusing on logistical efficiency and effective packaging strategies. Organizational readiness for change is crucial for sustainability, supported by proactive management practices addressing detrimental factors in the food supply chain (FSC). Integrating environmental and social sustainability into the corporate model guides FSC decision-making. Embedding sustainability effectively demands that all employees engage in practices aligned with business targets, fostering sustainability as a routine discourse. This inclusive approach necessitates widespread communication and engagement on the non-economic aspects of sustainability throughout the organization, transcending individual roles.

Proposition 1. A Food Supply Chain that recognizes that the type of food product must be considered in the packaging designs.

Insufficient attention has been given to diverse packaging functions influencing food loss and waste (FLW), critical for sustainable product and package design. Each product, like yogurt, dry pasta, and bread, faces unique waste challenges (Humbert, 2009; Lindh et al., 2016; Verghese et al., 2015). Understanding and integrating these specific packaging purposes into design and development processes are essential to mitigate FLW across the food supply chain (FSC).

Proposition 1 (*i*): *Identifying and obtaining specific data on packaging design impact food waste for different products*. (Morashti et al., 2022; Ada et al., 2023).

Proposition 1 (*ii*): *Developing reusable design methods improve packaging with regards to FLW*. (Wikstrom et al., 2019; Beitzen-Heineke et al., 2017; Verghese et al., 2015).

Proposition 2. A clear management focus toward the logistics efficiency of the Food Supply Chain is necessary to reduce food losses and waste (Derqui et al., 2018).

Evidence has shown that financial considerations influence firms' decisions regarding investments in facilities for food product stacking, potentially affecting FLW generation (Beausang et al., 2017). Additionally, integrating health and safety strategies into logistics training enhances management practices that impact FLW. Worker productivity and meeting of targets also influence FLW in the food supply chain, necessitating further study on their environmental implications.

Proposition 2 (*i*): *Logistics efficiency is supported by product display and stacking* (Pietzsch et al., 2017).

Proposition 2 (*ii*): *The management focus on Health and Safety Strategies demonstrated by the sustainable training of workers, as part of logistics efficiency, impacts FLW* (Silvestri et al., 2021).

Proposition 2 (*iii*): *Product handling is an important issue in logistics efficiency, which deserves firms' attention* (Bates and Phillips, 1999).

Management focus is supported by Company's values which drives corporate decisions.

Proposition 2 (*iv*): *Workers' productivity and expected targets impact the FLW generated along the FSC* (Gokarn and Kuthambalayan, 2019).

Proposition 3. Management Practices along the Food Supply Chain impact the generation of FLW (Janousek et al., 2018).

Proposition 3 (*i*): *Management Practices such as Inventory strategies, back-order rate, facility layout, and outbound warehouse request could impact FLW* (Silvestri et al., 2021).

Proposition 4. Operations planning along the supply chain and product planning affect FLW along the Food Supply Chain.

Evidence has shown that operational planning along the supply chain and food product planning affect FLW along the Food Supply Chain (Pietzsch et al., 2017). Employee involvement in operational planning has a major impact on the generation of FLW along the FSC. In addition, the management's strategic operational style has a tremendous impact on FLW.

Proposition 4 (*i*): *Employee involvement in operational planning impacts the generation of FLW along the FSC*(Krishnan et al., 2020).

Proposition 4 (*ii*): *Dynamic Teamwork Approaches and Tactics affect FLW generation along the FSC* (Kharola et al., 2022).

Proposition 4 (iii): Management's focus on customer orientation has a long-term impact on FLW (Colicchia et al., 2022).

Proposition 4 (*iv*): *Management Operational style has tremendous impact on FLW* (Luo et al., 2022).

Proposition 5. A Food Redistribution policy that aims to donate unsold products to needy people is a possible solution to reduce FLW (Varese et al., 2023).

Evidence suggests that food redistribution which has been put into practice by many firms in the Western world that aim to donate unsold products to needy people is a possible solution to reduce FLW (Gerstberger and Yaneva, 2013).

Proposition 5 (*i*): *Infrastructure and legal issues impact Food Redistribution, and hence, the generation of FLW along the Supply Chain* (Abbade, 2020; Kumar et al., 2020).

Proposition 5 (*ii*): *The Administrative and Logistical structure of firms could impact their Food Redistribution policy and, hence, impact FLW*. (Belavina 2021).

Proposition 5 (iii): There is impact of 'in store donation' on the costs and quantities of FLW. (Varese et al., 2023; Thapa Karki et al., 2021).

The proposed framework emerged from the SLR *is shown in* Fig. 4. This reveals different elements that contributes to the generation of FLW along the FSC. Evidence has shown that financial considerations significantly influence firms' decisions on investing in facilities to optimize food stacking, potentially reducing FLW (Beausang et al., 2017). Integrating health and safety strategies through sustainable worker training enhances logistics efficiency, impacting FLW (Derqui et al., 2018). Workers' productivity and meeting targets also influence FLW in the FSC, posing environmental concerns (Pietzsch et al., 2017). The buyer-supplier contract's impact on food overproduction affects inventory levels, back-order rates, and facility layouts, contributing to potential waste (Jamani, 2018). Balancing food production with consumption needs careful consideration, often overshadowed by financial incentives.

Also, packaging strategies influencing FLW have received insufficient attention but are crucial for sustainable product/package design and development. Gathering product-specific data on packaging's influence on food waste (e.g., yogurt, dry pasta, bread) is essential (Lindh et al., 2016). Exploring the impact of packaging design strategies on FLW across the FSC is necessary. In addition, operational planning and food product management significantly influence FLW (Pietzsch et al., 2017). Employee engagement in operational planning and strategic management styles profoundly affect FLW generation in the FSC.

Food redistribution, implemented widely in the Western world to donate unsold products to those in need, offers a potential solution for reducing FLW. Infrastructure and legal considerations significantly affect its effectiveness along the supply chain. Analysing the concept of "awareness of the need" in redistribution and the impact of in-store donation on FW costs, quantities, and store image is crucial.

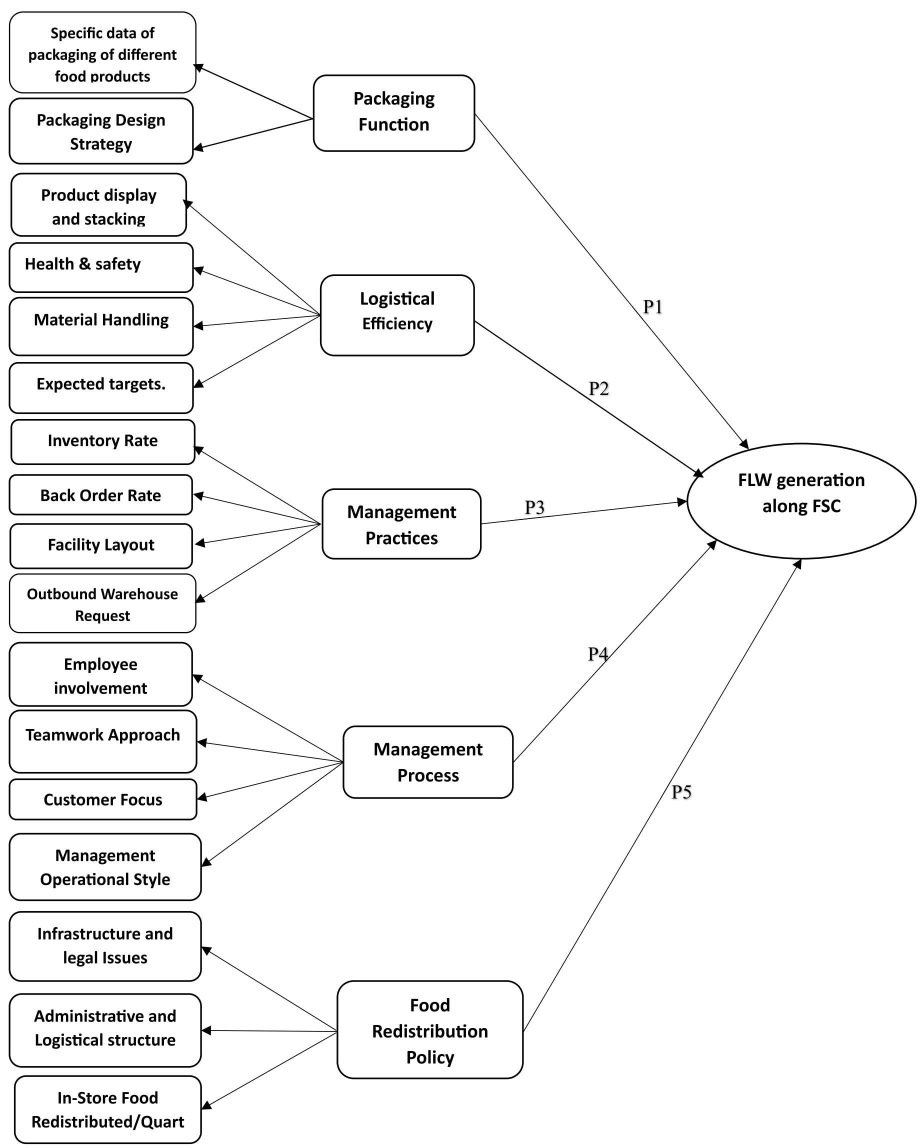

Fig. 4. *Proposed Framework.*

Additionally, understanding who benefits—needy individuals or regular clients—impacts ecological and social outcomes. The administrative and logistical structure of firms plays a critical role in shaping their food redistribution policies and influencing FLW.

4.1. The coherence of propositions with papers reviewed

There are 87 papers reviewed and there are strong correlations between those papers reviewed and the proposals identified in the conceptual framework.

It should be noted that eighteen (18) of the eighty-seven (87) papers discussed Logistical Efficiency with about 80 % of the identified papers which consists of the following variables, (i) stacking of food products, (ii) Material Handling and (iii) Expected Targets as indices of Logistical Efficiency and close to 20 % identified also, Health and Safety as one of the indices.

Sixteen (16) of the eighty-seven (87) papers considered Management Practices with mostly all these papers indicated that all the variables listed are linked to Management Practices.

Twenty (20) of the eighty-seven (87) papers examined Packaging Functions and all the papers identified, highlighting packaging design strategy and specific data of packaging of different food products as indices of Packaging function.

Fourteen (14) of the eighty-seven (87) papers discussed Management Processes and all the papers indicated that all the variables listed are associated with Management Processes.

Eleven (11) of the eighty-seven (87) papers examined Food Redistribution Policies as a factor affecting FLW. All the papers assessed the variable listed in the conceptual framework as being associated with Food Redistribution Process. Table 1 presents the key literature supporting the propositions.

5. Scope of future research

These research findings have implications for future studies and practice. First, the agri-food industry supply chain is the area where work should be conducted to effectively reduce FLW. Therefore, future research should identify company practices that impact FLW. This includes poor management of perishable food items along the FSC, stakeholder attitudes, buyer-supplier agreements, and supply chain interruptions. Further research should also focus on how to identify and overcome weaknesses in communication structures between company leadership and employees, as it affects food waste in FSC (Kharola et al., 2022).

Further research is required to address the need for a comprehensive approach to the packaging of food supply chains. This includes whether better packaging strategies could contribute to FLW minimization in logistics (Wikstrom et al., 2019). Therefore, future research needs to understand and collect data on how various packaging purposes affect food wastes along the FSC for different food products. In addition, it is important to develop purposeful design methods to improve packaging with regards to FLW.

Furthermore, it is vital that future research examines how supply chain operational processes affect FLW. We propose that future research should apply the findings of this study to real-world trials to measure the actual improvement caused by changes in supply chain operations.

Studying the "awareness of need" concept in redistribution and the impact of in-store donations on FW costs, quantities, and store image is crucial. This approach could simplify food products redistribution network design. Additionally, examining whether FW benefits needy people or regular clients reveals different ecological and social impacts. Finally, infrastructure and legal issues significantly influence food redistribution and FLW generation along the supply chain.

The study provides a critical analysis of the existing literature to provide the propositions. This study can be used by the practitioners and researchers to understand the role of strategies on FLW.

Table 1
Key literature supporting the propositions.

FLW generation along FSC	Key elements	Key references
Logistical Efficiency	*Stacking of Food Products*	Quynh et al. (2021), Sánchez-Teba et al. (2021)
	Material Handling	Bates and Phillips (1999), Kaipia et al. (2013)
	Health & safety	Mithun Ali et al. (2019). Amicarelli et al. (2021) .
	Expected targets.	Gokarn and Kuthambalayan. (2019), Manzini et al. (2014)
Management Practices	*Back Order Rate*	Somlai (2022), Silvestri et al. (2021), Janousek et al. (2018)
	Inventory Rate	Wang et al. (2019), Luo et al. (2021)
	Facility Layout	Akkaş and Gaur (2022), Pakseresht et al. (2021),Azadivar and Wang (2000) *and* Cancellara. (2019)
	Outbound Warehouse Request	*Voldrich* et al. *(2017),* Genovese et al. (2017)
Packaging Function	*Specific data of packaging of different food products*	Morashti et al. (2022), Ada et al. (2023), Dora et al. (2021), Brennan et al. (2021)
	Packaging Design Strategy	Wikstrom et al. (2019), Beitzen-Heineke et al. (2017),. Verghese et al. (2015),. Sasaki et al. (2022)
Management Process	*Strategic Style*	Luo et al. (2022), Pullman and Wikoff (2017), Aschemann-Witzel et al. (2019), Da Silva et al. (2025)
	Teamwork Approach	Kharola et al. (2022), Lemaire and Limbourg (2019)
	Employee involvement	Jones et al. (2008), Krishnan et al. (2020),Strotmann et al. (2017)
	Customer Focus	Colicchia et al. (2022),. Gokarn and Kuthambalayan (2017)
Food Redistribution Policy	*In-Store Food Redistributed Per Quarter*	Varese et al. (2023),. Thapa Karki et al. (2021),. Lemaire and Limbourg (2019)
	Environmental, Infrastructure and legal Issues	Jones et al. (2008), Carter et al. (2020), Abbade (2020), Kummu et al. (2021)
	Administrative and Logistical structure	Belavina, E. (2021), Salim et al. (2021),. Amicarelli et al. (2021)

6. Conclusion

This literature review critically analyses existing literature to examine environmentally friendly strategies in Food Loss and Waste (FLW) Management within the Retail Food Supply Chain (FSC). It aims to assess how different packaging strategies for food products affect FLW generation, evaluate the influence of logistical efficiency factors like material handling, stacking, and target expectations on FLW, determine the management strategies and practices' role in FLW issues, and investigate how FLW reduction strategies impact operational aspects of the FSC, including efficiency, speed, quality, responsiveness, and inventory policy.

The main findings indicate that FLW occurs at all stages of the supply chain and faces several stage-dependent variables, identified as food packaging strategies, supply chain management processes, firm practices along the FSC, and network design of food redistribution.

Evidence shows that packaging systems play a critical role in reducing FLW. NGOs, governments, and firms must ensure improved packaging practices are part of their circular economies and sustainability agendas.

Small changes in food packaging can significantly affect sustainable development. Balancing product protection and packaging material use can lead to resource savings, reduced environmental impact, and increased overall system efficiency.

This research proposes that environmental sustainability supply chains are best achieved with pragmatic management techniques involving logistical efficiency and good packaging strategies. The capacity for change and transformation is directly related to sustainability.

The articles suggest firms need to address management practices adversely affecting the FSC. Proactivity and dedication can be effective if the corporate model and sustainability elements are closely integrated.

Company involvement in charity impacts FW costs, quantities, and store image, potentially addressing FLW along the FSC. One could study whether FW benefits needy people or regular clients, as this has different ecological and social impacts.

Mixed outcomes in some studies create opportunities for further research. The UK government's collaboration with major supermarkets highlights the importance of research in Sustainable Chain Management Practices and focusing on FLW along the FSC.

Recent organizational interest in the environmental impact of supply chain activities provides evidence to examine how these activities impact the environment and how FSC management could significantly reduce FLW.

However, there are limitations, including the inability of some organizations to release essential data and the research's restriction to specific subjects, impacting the number of papers reviewed.

Researchers can overcome challenges in obtaining primary data from food retailers through strategic planning, ethical communication, and technology. Utilizing secondary data and ensuring robust data quality and security are also key. Formulating clear research questions, establishing protocols, and building strong relationships with managers are crucial. Transparency about research goals, methods, benefits, and risks is paramount. Researchers must also be aware of any limitations imposed by the food retail firms.

CRediT authorship contribution statement

Oluwole Olabode: Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Niraj Kumar:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Conceptualization, Investigation. **Debashree De:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Investigation.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: No other relationship or activity. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Table A1
Keywords used for searching literature.

Search Terms	Scopus	WoS
Food loss' and 'food waste'	594	72
Food loss' or 'food waste'	3628	837
Food loss' and 'food waste' and 'supply chain'	231	73
Food loss' and 'food waste' or 'supply chain'	180	712
('Food loss' or 'food waste') and 'supply chain'	350	25
('Food loss' or 'food waste') and 'sustainable supply chain'	172	7
('Food loss' or 'food waste') and 'sustainability'	485	29
('Food loss' or 'food waste') and 'circular supply chain'	141	77
('Food loss' or 'food waste') and 'circular economy'	575	107
('Food loss' or 'food waste') and 'operational performance'	24	16
('Food loss' or 'food waste') and 'logistics'	114	76
('Food loss' or 'food waste') and ('sustainable supply chain' or 'circular supply chain' or 'logistics')	343	286
('Food loss' or 'food waste') and ('sustainable supply chain' or 'circular supply chain' or 'logistics' or 'operational performance')	43	178
Year of Restriction:	2009–2025.	

Table A2
Literature Search Keywords.

FLW-Linked Keywords	FSC Linked Keywords	Search Documents
Food Loss	Supply Chains, Food Supply Chain	("Food loss or "food waste") and ("sustainable supply chain" or "circular supply chain" or "logistics")
Food Waste	Food Shortage	
Food Security	Management,	
Food Wastage	Food Chain, Sustainable Supply Chain.	
Food Reduction	Logistics, Supplier, Procurement, Food Production, Distribution, Transportation.	

Table A3
Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Journals, Articles & Reviews. Papers published from 2009 to March 2025 were finally shortlisted. Studies focusing on Business Management and Accounting, and Social Science. All Source Title considered. Initial source not restricted.	Conference papers, Discussions Articles & Editorials, Conceptual Studies, Data Articles, Notes, Papers in commerce Magazines and book chapters

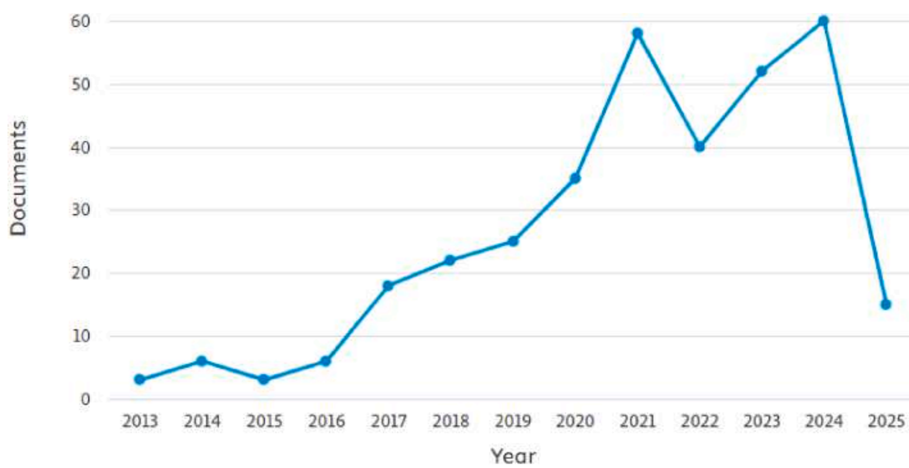

Fig. A1. Trend of publications over the year

Table A4
Trend of Publication of Documents

Year of Publication	Number of Documents
2013	3
2014	6
2015	3
2016	6
2017	18
2018	22
2019	25
2020	35
2021	58
2022	40
2023	52
2024	60
2025	15

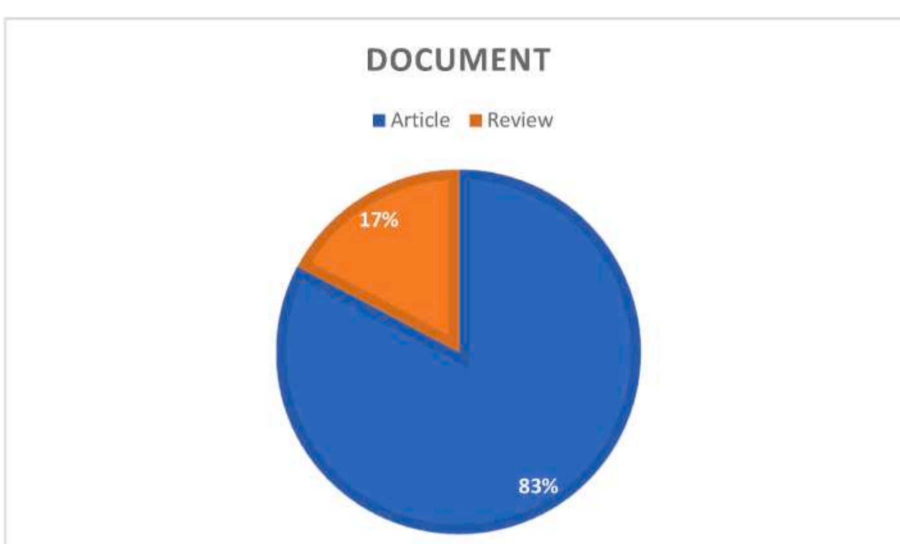

Fig. A2. Types of Documents (Number of Papers: 343)

Table A5
Types of Documents

Document Type	Document
Article	284
Review	59

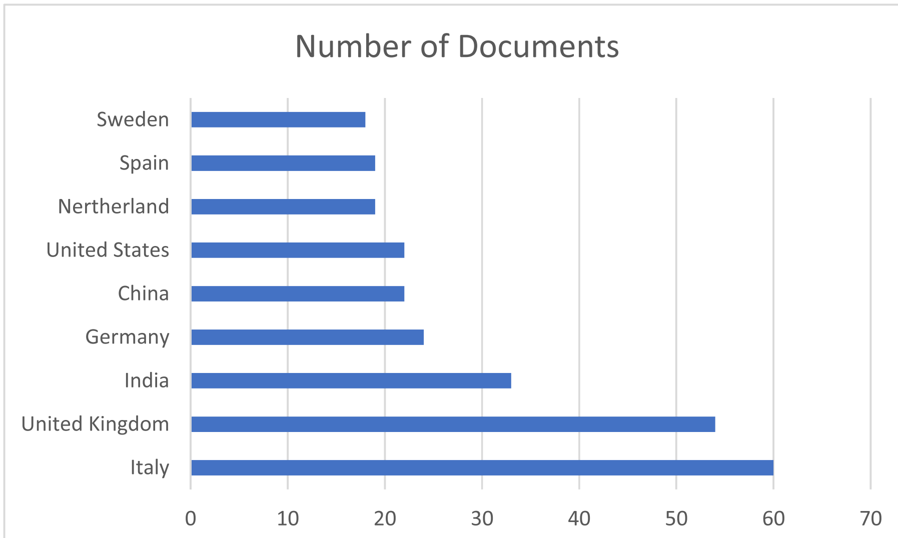

Fig. A3. Documents by Country or Territory

Table A6
Documents by Country or Territory

Country/Territory	Number of Documents
Italy	60
United Kingdom	54
India	33
Germany	24
China	22
United State	22
Netherland	19
Spain	19
Sweden	18

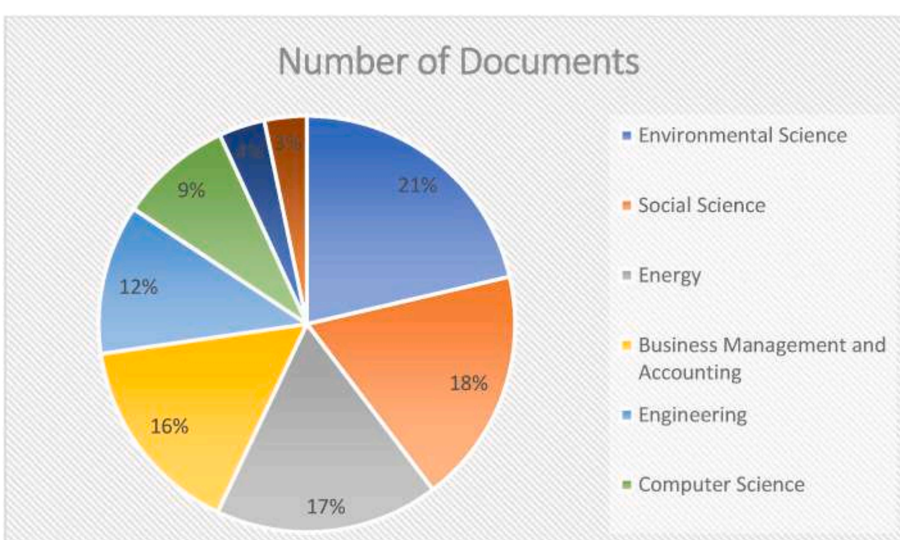

Fig. A4. Documents by Subject Area

Table A7
Publication by Subject Area

Subject Area	Number of Documents
Environmental Science	233
Social Science	200
Energy	190
Business Management and Accounting	171
Engineering	127
Computer Science	96
Economics, Econometrics and Finance	39
Agriculture and Biological Science	36

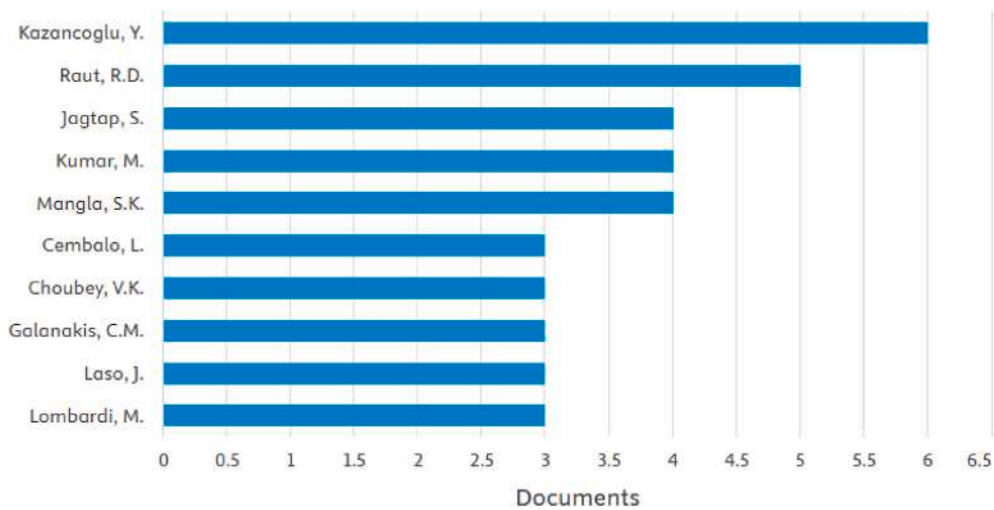

Fig. A5. Documents by Author.

Table A8
Documents by Top Ten Authors.

Author Name	Number
Kazancoglu, Y	6
Raut, R. D.	5
Jagtap, S	4
Kumar, M.	4
Mangla, S.K.	4
Cembalo, L.	3
Choubey, V.T.	3
Galanakis, C. M.	3
Laso, J	3
Lomberdi, M.	3

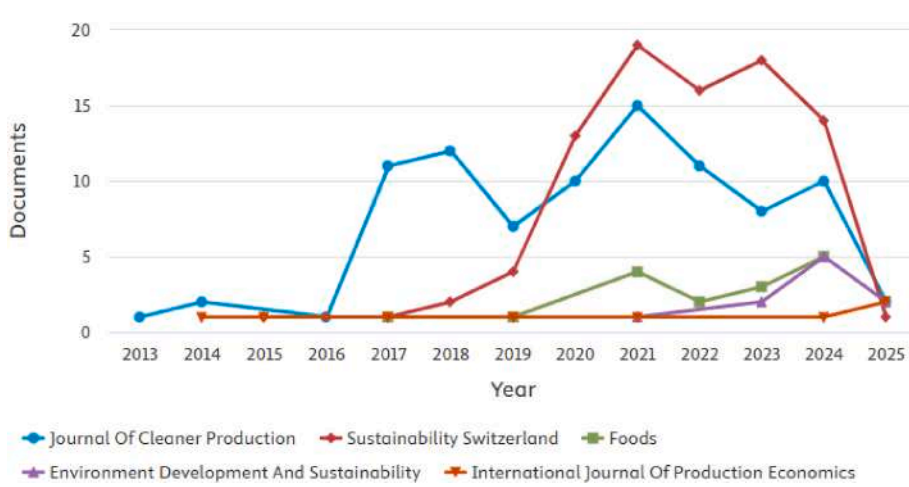

Fig. A6. Documents per Year by Source.

Table A9
Number of Publications from Top Nine Journals

Source Title	Number
Journal of cleaner Production	90
Sustainability Switzerland	90
Food	16
Environmental Development and Sustainability	6
International Journal of production economics	6
Journal of Industrial Ecology	6
Business Strategy & the Environment	6
International Journal of Production Economics	5
Production Planning and Control	5

Data availability

Data will be made available on request.

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Glossary

FL:: Food Loss
FLW: Food Loss and Waste
FSC: Food Supply Chain
FW: Food Waste
SC: Supply Chain
SLR: Systematic Literature Review
SKU: Stock Keeping Units