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Food loss and waste in food supply chains. A systematic literature review and framework development approach

Chetna Chauhan [a, b], Amandeep Dhir [c, d, e, *], Manzoor Ul Akram [b], Jari Salo [f]

[a] FORE School of Management New Delhi, 110016, Delhi, India
[b] Indian Institute of Management Rohtak, India
[c] The Norwegian School of Hotel Management, Faculty of Social Sciences, Stavanger, Norway
[d] Department of Management, School of Business & Law, University of Agder, Kristiansand, Norway
[e] Optentia Research Focus Area, North-West University, Vanderbijlpark, South Africa
[f] Department of Economics and Management, Faculty of Agriculture and Forestry, University of Helsinki, Finland

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ABSTRACT

This study examines the state of the art of the literature in the domain of food loss and waste (FLW) in food supply chains (FSC). The authors used a systematic literature review (SLR) approach to examine and synthesise the findings of the existing literature to identify the key research themes, research gaps and avenues of future research on FLW in FSC. To this end, this SLR considered 152 articles relevant for the review. The authors uncovered the extant literature in the domain by presenting the research profile of the selected studies, along with thematic analysis. The authors identified eight key themes from the extant literature. The themes range from factors responsible for FLW generation to new, emerging areas of research such as digitalisation and food surplus redistribution. The study's findings will help clarify existing practices in FSC for waste mitigation and act as a foundation for strategic and policy initiatives in this area. The findings indicate that the major factors responsible for FLW include the poor management of perishable food items, stakeholder attitudes, buyer–supplier agreements and supply chain interruptions. Some of the important implications of the study include formal guidelines and policy-level interventions for assisting the accurate quantification of FLW along with an impetus on digitalisation to reduce FLW. The study concludes with the development of a research framework to assist future research in this domain.

1. Introduction

Food loss and waste (FLW) is an important topic due to its high socioeconomic costs and its relationship to waste management and climate change challenges. The FLW leads to huge losses concerning invaluable resources while contributing to environmental degradation (Beretta et al., 2013). FLW is also a moral issue because almost 12 per cent of the population in the world is suffering from hunger (Lohnes and Wilson, 2018). Despite this awareness and the efforts taken to minimise FLW, it remains excessively high. According to Gustavsson et al. (2011), nearly half of all root crops, vegetables and fruits across the globe get wasted. Owing to the magnitude of the situation, scholars have conducted several studies concerning FLW in the food supply chain (FSC). These studies examine the sources of waste and offer potential solutions.

Recently, much research has emerged regarding FLW in FSCs. The literature has mainly focused on FLW occurring across FSC stages—namely, farm, postharvest, processing, distribution, retail and consumers (Xue et al., 2017). Food wastage happens at every stage in the food FSC. To mitigate FLW, the first step is to recognise how much food gets wasted across the FSC (Porter et al., 2016). Consequently, scholars have presented different methods to quantify the food that gets wasted at various FSC stages and geographies, with disparate kinds of produce (e.g. Redlingshöfer et al., 2017). Globally, researchers estimate that, in FSCs, the percentages of food loss in production, postharvest and consumption stages are 24, 24 and 35 per cent, respectively (Xue et al., 2017). Therefore, more than 80 per cent of food gets wasted in these stages, which is quite alarming (Xue et al., 2017). Scholars have tried to assimilate

* Corresponding author. The Norwegian School of Hotel Management, Faculty of Social Sciences, Stavanger, Norway.
E-mail addresses: chetna.chauhan@fsm.ac.in (C. Chauhan), amandeep.dhir@uia.no (A. Dhir), fpm03.005@iimrohtak.ac.in (M.U. Akram), jari.salo@helsinki.fi (J. Salo).

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the factors causing losses across the entire FSC (Diaz−Ruiz et al., 2018; Krishna Bahadur et al., 2016). For instance, Diaz−Ruiz et al. (2018), through their qualitative analysis of stakeholders' perceptions, categorise the reasons that lead to FLW. These were (a) micro-level causes (e.g. packaging and transportation) (b) meso-level causes (e.g. infrastructure and FSC practices); and (c) macro-level causes (e.g. purchasing options).

A closer inspection of the literature reveals that the issue of wastage of food in FSCs is multifaceted (Cakar et al., 2020) and requires attention from varied stakeholders, such as farmers, policymakers, managers and society. However, the findings of the previous studies remain fragmented because of the complex nature of the topic. A systematic literature review (SLR) can help to assimilate and analyse the extant work in the discipline to build a research framework that guides scholars and practitioners (Denyer and Tranfield, 2009). The present study has adopted an SLR methodology and addresses the following research questions (**RQs**): **RQ1.** What is the research profile of the relevant prior literature on FLW in the FSCs (e.g. publication timeline, country of study, key contributors and so forth)? **RQ2.** What are the research themes related to the pressing issues examined in the prior extant literature concerning FLW in FSCs? **RQ3.** What are the research gaps and limitations of the prior literature? **RQ4.** How can researchers of FLW in the FSCs advance knowledge through the actionable avenues of future research and a research framework?

Our review of prior literature suggests that some noteworthy SLRs already exist in similar areas of research. Muriana (2017) reviews the application of mathematical models in FLW research and explicates how FLW generation depends on FSC strategies. In their literature review, Xue et al. (2017) summarise FLW patterns across countries and FSCs with a special focus on the method deployed for FLW quantification. Apart from these, there exist SLR studies that investigate a specific stage of FSC where FLW is generated, for example, FLW in the retail sector (de Moraes et al., 2020), FLW in the consumption stage (Reynolds et al., 2019; Schanes et al., 2018) and FLW in the distribution and consumption stage (Yetkin Özbük and Coşkun, 2020). In addition, de Moraes et al. (2020) identify the causes and reduction strategies of FLW in the retail sector and underscore their significance in the broad FSC context. Reynolds et al. (2019) present an account of FLW reduction strategies and their effectiveness in the consumption stage of FSC. Several other review studies consider issues related to FLW, such as a sustainable environment (Shafiee−Jood and Cai, 2016), strategies for FLW reduction by identifying the hotspots in FSC (Priefer et al., 2016) and industrial applications of FLW generated in the FSCs (Girotto et al., 2015).

Most of the existing literature reviews in the field had a narrow focus concerning geography, and their research focus or FSC stage. For example, most SLRs focus primarily on the FLW in the consumption stage of the FSC (Reynolds et al., 2019; Schanes et al., 2018; Yetkin Özbük and Coşkun, 2020). Alternatively, they had a specific research focus, such as the effect of FLW reduction on environmental sustainability (Shafiee−Jood and Cai, 2016). Therefore, the present study aims to provide a detailed analysis of prior studies by specifically focusing on the FLW across the FSC before the consumption stage.

The topic of FLW in FSC is interdependent and interdisciplinary. Moreover, related studies appear in journals with diverse scopes and audiences. Therefore, the topic remains highly fragmented. The findings and outcomes of the present study would be of great interest to a wide range of scholars, practitioners and policymakers, as it assimilates the literature, which is cross-disciplinary. Scholars can understand topics of interest that have still not received enough attention from the scholarly community. Practitioners can use the study's findings to understand the factors leading to FLW across FSCs and prioritise strategic fields of action. Similarly, policymakers can use the current study to undertake the necessary policy interventions concerning FLW in FSCs. Hence, the SLR makes a significant contribution to both practice and theory.

The organisation of the present study is as follows. Section 1 outlined the introduction. Section 2 presents the boundary of the review. Section 3 underscores the research methodology and research profiling. Section 4 highlights the thematic foci, whereas Section 5 showcases research gaps and avenues for future research. Section 6 targets the development of the framework. Section 7 outlines conclusions, implications, limitations and directions for future SLRs.

2. Scope and boundary of this review

The *food supply chain* is defined as the movement of products and services along the value-added chain of food commodities that aim at realising better value for the customer alongside cost minimisation (Folkerts and Koehorst, 1998, p. 11). FSC differs from any other type of supply chain since it deals with complex issues such as the perishable nature of a commodity, interaction with many stakeholders and inter-sectoral influence (Mithun Ali et al., 2019). The complexity associated with FSC connects to concerns over the safety, sustainability, quality and efficiency of the processes (Göbel et al., 2015). Scholars have illustrated FSC concerning globally relevant stages which include (i) farm production, (ii) handling and storage, (iii) processing, (iv) distribution and (v) consumption (Porter et al., 2016). Inefficiencies in the FSC, leading to FLW generation take place across all FSC stages (Hartikainen et al., 2018). It is also possible that the reason for FLW at a particular stage might be concealed in another stage (Raak et al., 2017). The globally acknowledged approach of FLW reduction, like the one the European Commission posited, encounters the inefficiencies of the entire FSC (Hartikainen et al., 2018).

The length of the FSC and significance of each stage largely depends on geography (Porter et al., 2016). Prior studies contend that the initial stages of FSC contribute maximum toward FLW generation (Gustavsson et al., 2011). The reasons for FLW in developing countries generally relate to poor techniques for harvesting, lack of storage, packing and transport infrastructure (Gustavsson et al., 2011). The fact that most developing countries perform poorly concerning the hunger index, with about 800 million people facing chronic hunger (FAO, 2013), underscores the need to focus on FLW generation in the initial stages of FSC, from the farm until the distribution stage, as undertaken by the present study.

The conventional understanding of FLW focuses mainly on food disposed of or left unused (Irani et al., 2018). However, understanding what constitutes FLW is rather complex, as it comprises several dimensions. Moreover, each dimension has numerous economic, social and environmental implications (Irani et al., 2018). Prior literature suggests that scholars have used various definitions for FLW. Extending the suggestion of Gustavsson et al. (2011), the present study typifies FLW definitions into five major categories, discussed below.

The first category of definitions focuses on the stage of the FSC (WRAP, 2011). In the first group of definitions, most scholars consider food loss a subset of food waste (Muriana, 2017) and vice versa (Harvey et al., 2019). However, simultaneously, some scholars actively acknowledge the demarcation between food loss and waste (Aragie et al., 2018; Gustavsson et al., 2011). Such definitions suggest that losses in the initial stage of FSCs that is from the farm until the processing stage are labelled *food loss*. In comparison, food waste occurs in the later stages of FSC and is often due to the food waste behaviour of the consumers (Gustavsson et al., 2011).

The second category of definitions is based on the dimensions of edibility and the intention of food production. For the second definition group, Beretta et al. (2013) and Redlingshöfer et al. (2017) consider that the food which was intended to be consumed by humans can only qualify as food waste. However, Griffin et al. (2009) define *food waste* as wastage along FSCs, regardless of whether it was intended for consumption. Secondi et al. (2015) refer to discarded edible food as avoidable and possibly avoidable waste. They would define *food waste* as 'unavoidable waste' if it was never fit for human consumption (e.g. eyes, skins, shells and bones) (Secondi et al., 2015).

The third category of definitions is based on the dimension of quality understood as nutrition, aesthetics and shelf life (Porter et al., 2018). From an FSC perspective, it is more important to understand and reflect on the first two categories of definitions, as they deal with issues such as the identification of FLW across the FSC and categorisation of FLW.

The fourth category of definitions is based on the nature of food use. While defining FLW, scholars assert that food subjected to unplanned use should be considered FLW (Parfitt et al., 2010). However, Bellemare et al. (2017) argue that food with productive uses such as manure or feed for animals should not be considered wasted.

The fifth category of definitions contends that the destination of surplus food plays a significant role in deciding whether it should be considered waste (Hartikainen et al., 2018). Rethink Food Waste (2016) defines *food waste* as all the food used as landfill scrap besides on-farm losses. However, some studies argue that farm losses that farmers tilled into the land or processed for other uses, such as fertilisers or feeding animals, can be eliminated while quantifying the waste (Dusoruth et al., 2018).

All these scholarly assertions indicate the inability to draw a consensus on a precise definition of FLW. To this end, the current study does not discriminate between food loss and waste; instead, it uses these terms interchangeably. As discussed above, the features of FLW waste definitions are based on five broad dimensions, which include the FSC stage, human edibility, quality of food, nature of use and destination of food, as depicted in Fig. 1.

3. Methodology

The study follows the SLR methodology, which is based on a well-defined and well-planned protocol. The SLR process covers the planning of the search strategy, identifying target journals, establishing inclusion and exclusion criteria, conducting the review and recording findings and insights (Tranfield et al., 2003). The execution of the present SLR is conducted in two phases. The first includes a selection of keywords, setting up inclusion and exclusion criteria and executing a document search in the databases, followed by a rigorous quality evaluation applying the predetermined criteria. The second phase discusses the results of the SLR.

3.1. Planning the review

This review attempts to analyse and understand the nuances of FLW across the stages of the FSC, except the consumption stage. The present SLR does not demarcate between food waste and food loss, which is in accordance with some of the extant studies in the domain of FLW (e.g. Porter et al., 2018). Therefore, the authors determined an initial set of keywords to search databases for relevant studies. The authors searched Google Scholar for the initial set of keywords. However, the keywords list was updated after assessing the first hundred results on Google Scholar. In the next step, a search was done on leading journals from the area of supply chains, food and sustainability to ensure the list of selected keywords is exhaustive. For assuring the rigour in the selection and profiling of publications, a review panel was established. It was extremely important to establish the review panel to set the conceptual boundaries of the review. Three experts (two professors and one researcher) in FLW in FSCs constituted the review panel. This panel provided consultation to reach a consensus over selecting keywords for the final list (Table 1). This study used the three main databases: Scopus, Web of Science (WoS) and Google Scholar, in line with Mariani et al. (2018).

3.2. Specification of the study

In this stage, the studies obtained in the database search were identified by specifying the inclusion criteria and exclusion criteria, as shown in Table 2.

3.3. Data extraction

The authors created the final list from the selected keywords

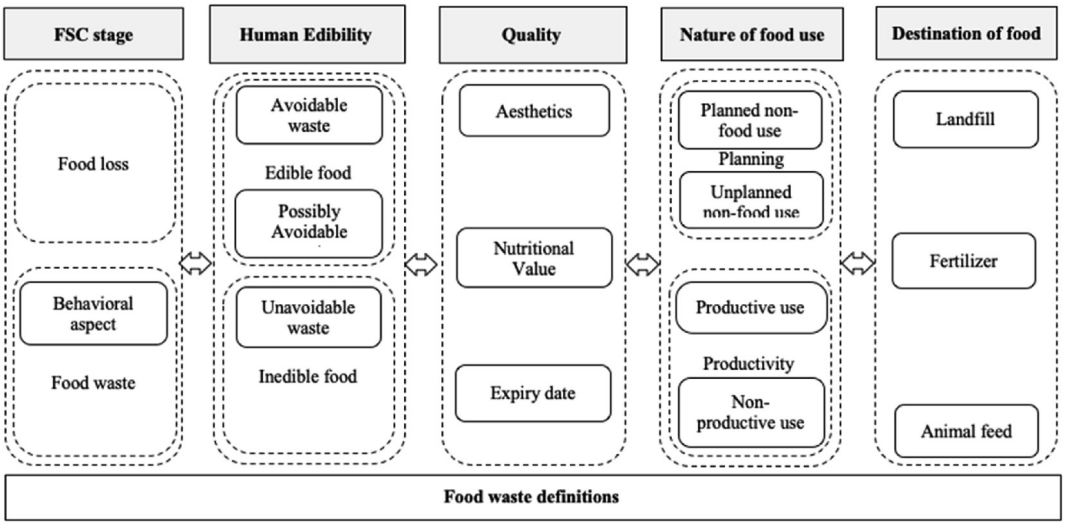

Fig. 1. Dimensions for defining food wastes and/or losses.

Table 1
Keywords for the literature search.

FLW-related Keywords	FSC-related Keywords	Search String
Food waste Food loss Waste of food	Supply chain Logistics Procurement Distribution Supplier Transportation Manufacturing Processing	("food wast*" OR "food loss*" OR "wast* of food") AND ("supply OR "logistics" OR "procur*" OR "distribut*" OR "transport*" OR "supplie*" OR "manufactur*" OR "process* of food")

Table 2
Study inclusion and exclusion criteria.

Inclusion Criteria	Exclusion Criteria
Articles focusing on FLW in SC	Studies on consumption patterns, perishable foods and sales forecasting but not dealing directly with FLW in SC.
Articles published in English until May 2020	Review articles, conceptual studies, editorials, data articles, errata, notes, book chapters, discussion articles and editorials
Peer-reviewed journal articles	Studies from digestion composting, valorisation, anaerobic treatment, chemical processes and FLW to energy-related studies
Articles that focus on FLW, specifically FSCs	Studies that focus primarily on packaging-related technologies
	The studies involving dietary patterns and nutrition.
	Studies focus on technical facets such as systems architecture and temperature control.

(Table 1) and transformed them into search strings by applying Boolean logic, using * along with 'OR' and 'AND' connectors. The authors searched for the title, abstract and author keywords in selected databases using a search string. The authors conducted the search for all the studies published in this domain until May 2020. The authors found 1299 publications on the Scopus database, while the WoS document search resulted in 501 articles. First, the authors removed duplicate articles across databases, leading to 417 articles. The authors further screened this pool by applying different inclusion and exclusion criteria, resulting in a dataset of 322 articles.

To carry out the next level of filtering of articles, the authors re-invited the review panel. The experts in the panel reviewed the articles (i.e. titles, abstracts and keywords) and assessed them based on the screening criteria and conceptual boundary of the review. To ensure the robustness of the screening protocol, each panel member conducted the task individually. In the next step, the authors shared the short-listed articles. Subsequently, the authors asked the panel members to resolve the differences in their short-listed pool of studies and arrive at a consensus. The authors excluded 121 studies at this stage because the authors found them discursive with respect to the scope and conceptual boundary of the present study. In the consequent step of filtering the articles, the authors analysed the full texts of the remaining 201 articles to verify their admissibility for inclusion in the present review. The authors reached a consensus to remove 45 articles. The focus of these articles was not pertinent to the present SLR and dealt with topics such as food donation and consumer behaviour. However, the conceptual boundary of the present study is FLW in FSCs before the consumption stage. To ensure the robustness of the search protocol, these researchers conducted forward and backward citation chaining for each article. This step was important to reduce the chances of missing relevant publications. The authors obtained 12 articles through citation chaining. The panel reviewed these studies, and nine out of 12 were added to the pool, as panel members agreed.

In the final stage of the study's screening process, the panel examined the 165 short-listed studies. Based on their observations, these researchers eliminated 13 studies to advance a final sample of 152 articles. The subsequent parts of the SLR discuss the results of research profiling and content analysis, which constitute the data execution process.

3.4. Data execution: research profiling

The research profiling of the studies suggests that literature on FLW in FSCs is relatively recent, as the number of publications has increased since 2013 (see Fig. 2). Fig. 3 depicts the most productive authors. The most important publishing outlets were those that have a focus on the environment and waste management (Fig. 4). Concerning the study design, most studies were quantitative (39%), accounting for nearly half of the studies (see Fig. 5). This is an obvious outcome since a major chunk of literature is fostered around FLW quantification and comprises of an analysis of primary as well as secondary data.

Fig. 6 illustrates the spread of literature according to the level of analysis. The level of analysis means the stakeholder or entity drawing the focus in the particular study (Derwik and Hellström, 2017). The authors discerned five levels of analysis in the selected publications: (i) individual level: considers FLW related to individuals; (ii) supply chain stage: considers FLW at or between the stages of the FSC; (iii) supply chain: considers FLW in the entire supply chain; (iv) product group level: considers FLW across categories of food products; and (v) geographic unit: relates to the geography where the FLW occurs.

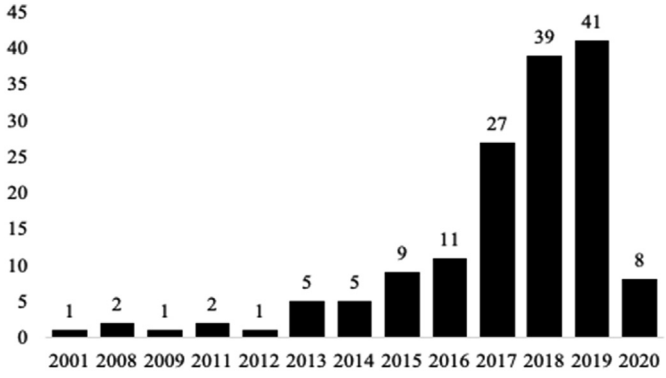

Fig. 2. Year-wise publications.

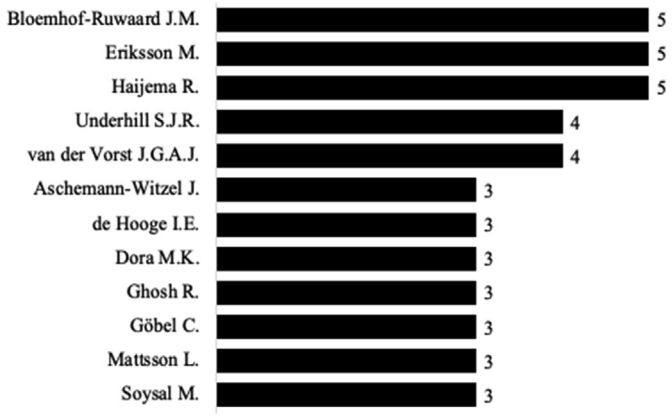

Fig. 3. Most productive authors.

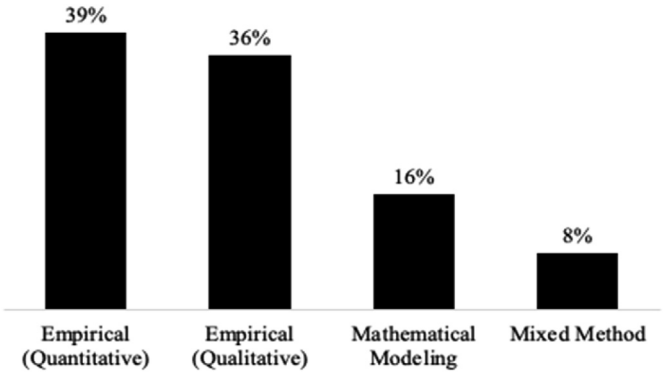

Fig. 5. Classification of articles.

4. Thematic foci

Deriving deep insights from the existing literature to advance our understanding of the FLW in FSCs was at the heart of this review. Therefore, two independent researchers developed themes independently, and after several rounds of discussions and taking insightful cues from two academics in this area, the researchers finally finalised seven broad themes. Other themes clustered under a separate category as the eighth theme, called 'other emerging themes.' To this end, the major research themes emerged from the literature (Fig. 7). The miscellaneous topics in the literature were clustered as with the other emerging themes mentioned earlier.

4.1. Factors responsible for FLW generation

Analysing factors that cause FLW is of topical interest in the extant studies. The extant literature that focuses on the factors responsible for FLW generation are divisible into two major streams. The first stream of literature emphasises a particular issue in the FSC, which is a cause of FLW. The factors highlighted in these studies include stakeholder attitude (Beausang et al., 2017; Janousek et al., 2018; Peira et al., 2018), poor management of spoilable foods (Rijpkema et al., 2014; Zhu, 2017), food aesthetics (de Hooge et al., 2018; Devin and Richards, 2018), buyer–supplier agreements (Eriksson et al., 2017; Ghosh and Eriksson, 2019), supply chain interruptions (Teller et al., 2018; Yang et al., 2017), improper or inadequate packaging (Goossens et al., 2019; Wohner et al., 2020) and stringent quality standards (Gillman et al., 2019; Hermsdorf et al., 2017; McKenzie et al., 2017).

Pullman and Wikoff (2017) and Peira et al. (2018) argue that the attitude of actors in FSC such as retailers and managers is an important factor in determining the generation of FLW. Beausang et al. (2017) and Garrone et al. (2016) study the stakeholder attitude toward surplus production and posit that most farmers consider FLW a 'necessary evil' and do not have standard solutions for mitigating FLW. Belavina et al. (2017) and Eriksson et al. (2017) point out that subscription-based orders and take-back contracts have a significant influence on FLW during supplier–buyer interaction. While subscriptions incentivise smaller orders and eliminate FLW, take-back contracts lead to higher FLW. Ghosh et al. (2017), Rijpkema et al. (2014), Teller et al. (2018) and Yang et al. (2017) attribute a large amount of FLW to erratic demand and improper replenishment policies. In developed countries, the improper design of food packaging is also one of the drivers of FLW (Wohner et al., 2020). Stringent quality standards across food manufacturing and processing units also lead to FLW (Kelepouris et al., 2007). Devin and Richards (2018) argue food supermarkets waste food that is suitable for consumption, owing to private quality standards. In cases where stringent quality standards and cosmetic specifications reduce FLW in retail, they tend to intensify the FLW problem in farms (de Hooge et al., 2018), as many stakeholders consider these high cosmetic standards a bare minimum benchmark for their offerings (i.e. food).

The second stream of literature deals with enlisting many

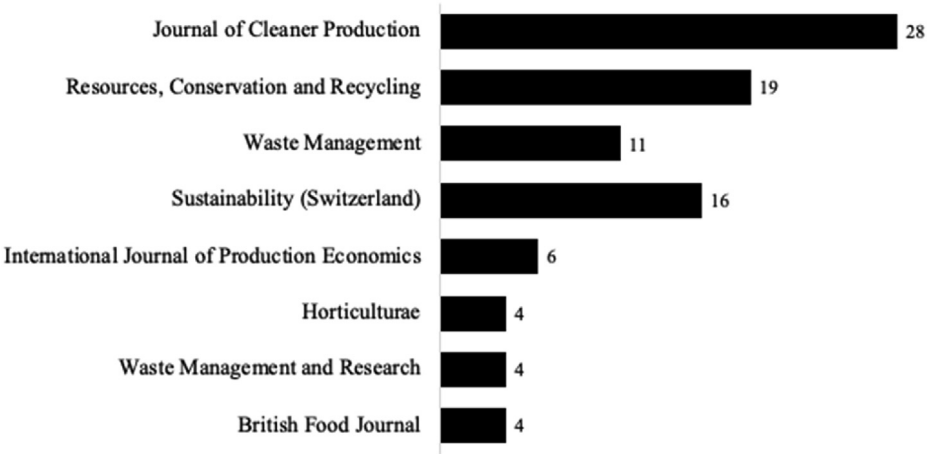

Fig. 4. List of studies across journals.

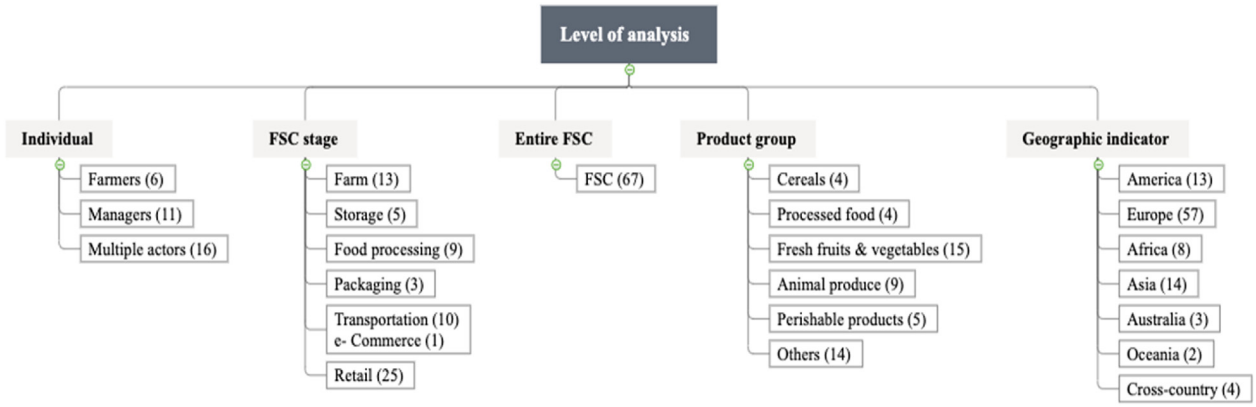

Fig. 6. Level of analysis in the study.

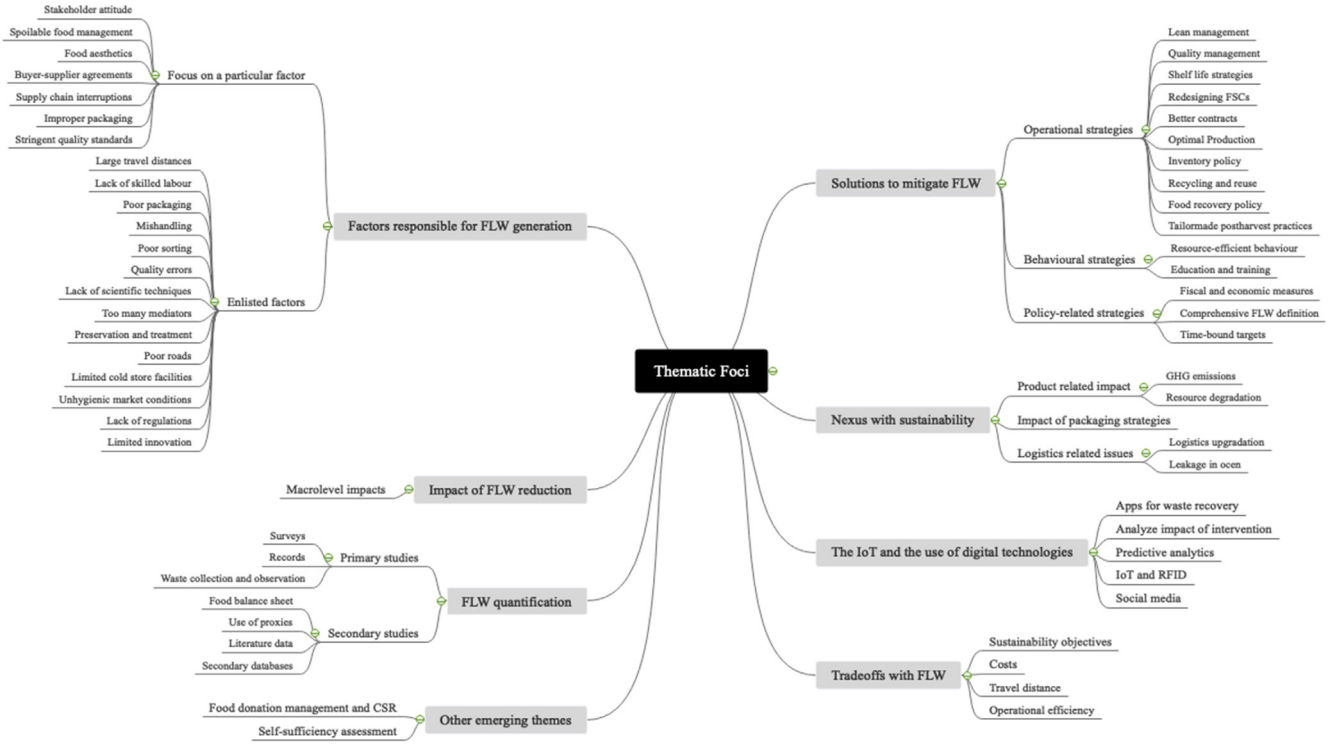

Fig. 7. Thematic foci of studies.

factors that lead to high FLW generation in FSCs (Mena et al., 2011; Arivazhagan et al., 2016; Balaji et al., 2016; Gokarn and Kuthambalayan, 2017; Diaz–Ruiz et al., 2018; Gogo et al., 2018; Sedlmeier et al., 2019; Simms et al., 2020; Wu and Huang, 2018). Some of the major sources of FLW, as these studies indicate, include large travel distances, the lack of skilled labour, poor packaging, damage caused by mishandling, poor sorting, errors in quality checks, the lack of scientific harvesting techniques, a high number of mediators, the lack of post-harvest preservation and treatment, poor roads, inadequate cold storage facilities, unhygienic market conditions, the lack of regulation, low technical expertise and limited innovations that can prevent FLW.

4.2. Solutions to mitigate FLW

Scholars have emphasised several solutions to prevent the FLW in FSCs in the extant literature (Arias Bustos and Moors, 2018; Caputo et al., 2014; Chalak et al., 2018; Derqui et al., 2016; Hermsdorf et al., 2017; Irani et al., 2018; Morris et al., 2019; Raut et al., 2019). Scholars contend solutions to mitigate FLW cannot be planned and implemented for a specific stage or aspect in isolation, as they require a participative approach (Strotmann et al., 2017b), need to be systematic (Tromp et al., 2016) and should cater to the social, economic and environmental aspects of FLW (Alamar et al., 2018). The solutions these studies highlight are broadly typifiable as operational, behavioural and policy-related strategies.

4.2.1. Operational strategies

Lean production and quality management are popular operational strategies to minimise FLW (Dome and Prusty, 2017; Strotmann et al., 2017b; Vlachos, 2015; Wesana et al., 2018). The other important solutions for FLW minimisation include better

shelf-life strategies (Buisman et al., 2019; Göransson et al., 2018; Muriana, 2015), redesigning FSCs (Giuseppe et al., 2014; Martins et al., 2019; Verghese et al., 2018), having better contracts (Despoudi et al., 2018; Göbel et al., 2015; Kaipia et al., 2013; Sel et al., 2017; Soysal et al., 2018), optimal production and inventory policies (Birisci and McGarvey, 2018; Wang et al., 2019), the impetus on FLW recycling and reuse in the food industry (Holweg et al., 2016), the food recovery policy for FSCs (Aiello et al., 2015; Krishnan et al., 2020) and tailor-made postharvest practices, depending on the scale of produce (Morris et al., 2019).

Recently, much research has targeted FSC digitalisation and circular economy strategies to eliminate FLW. The circular economy strategy helps to reduce FLW by redesigning the 'take−make−dispose' model of FSCs (DeLorenzo et al., 2019; Dora, 2019; Van Bemmel and Parizeau, 2020). Digital platforms can comprise a mechanism for organising the stakeholders that result in their active participation in the FLW reduction process (Cane and Parra, 2020; Ghinoi et al., 2020; Kamble et al., 2019; Mishra and Singh, 2018).

4.2.2. Behavioural strategies

From the review of the existing literature, a limited focus on the linkage between behavioural strategies and FLW reduction is observable. In a qualitative survey study on European retail FSCs, Beitzen−Heineke et al. (2017) argue that the resource-efficient behaviour of the retailers helps in the reduction of FLW. Mak et al. (2018) utilise the theory of planned behaviour to understand and emphasise the importance of FLW recycling behaviour among stakeholders. Peira et al. (2018) profile FSC actors based on behaviour and suggest specific actions such as educational programmes to improve their food waste behaviour.

4.2.3. Policy-related strategies

The extant literature emphasises the reduction of FLW through legally nonbinding governmental and non-governmental initiatives, fiscal and economic measures, policy implementation for raising stakeholders' awareness, time-framed waste reduction targets, and generating and monitoring strategies for FLW reduction (Chalak et al., 2018). However, Chalak et al. (2018) argue that FLW reduction strategies should be holistic in nature and not just focus on cosmetic fiscal measures. In a similar vein, narrowly defining the FLW concerning economic criteria (that is, minimising FLW only when it has an economic impact) is worrisome based on the far-reaching consequences of FLW. Therefore, the mitigation of FLW can be enhanced if companies are prompted to consider social and environmental factors (Derqui et al., 2016).

4.3. Impact of FLW reduction

Selective studies have assessed the consequences of FLW reduction, mostly at a macro level. The literature suggests mixed findings regarding the influences of FLW reduction; however, most studies report positive consequences of a reduction in FLW (Aragie et al., 2018; Campoy−Muñoz et al., 2017). On the national level, Campoy−Muñoz et al. (2017) examined how cutting down the FLW affects the nations with respect to their total output, employment and gross domestic product (GDP) and found noteworthy effects that can be attributed to the reduction in avoidable FLW. Similarly, the recovery of avoidable losses leads to a rise in farm income by 20 per cent with efforts to reduce the FLW across the subdivisions of the FSC (Aragie et al., 2018). Efforts at reducing FLW lead to the better sustainable performance of FSCs, as highlighted in the literature (e.g. Kaipia et al., 2013; Cánovas Creus et al., 2018).

4.4. Nexus with sustainability

The agri-food sector contributes to about a quarter of greenhouse gases (GHG) globally (Secondi et al., 2019). The negative effects of FSCs are because of the abuse of resources, soil erosion and the generation of FLW (Cellura et al., 2012). Due to these factors, scholars have focused on the interaction of FLW with the environment. The literature in this domain can be typified into three major categories, as discussed below.

4.4.1. Product-related impact

A vast stream of research underscores the negative impact of product-related FLW generation on the environment (Brancoli et al., 2017; Goossens et al., 2019; Porter et al., 2016, 2018; La Scalia et al., 2019; Scholz et al., 2015; Vandermeersch et al., 2014; Wakiyama et al., 2019; Caputo et al., 2014; Cakar et al., 2020; May and Guenther, 2020). For example, Porter et al. (2016) report that the increasing losses of fruits and vegetables have led to the largest increase in FLW-related GHG emissions. At the retail level, meat and bread contribute maximally to environmental degradation, despite the less-concerning mass (Brancoli et al., 2017; Scholz et al., 2015). An emerging focus area of interest in this field is the relationship between FLW and other resources such as land, water and energy. For example, Owen et al. (2018) and Pagani et al. (2020) apply environmental accounting tools to identify products in which energy, water and land impressions can be controlled by strategies such as FLW reduction or changes in dietary habits. Munesue and Masui (2019), Liu et al. (2013) and Kummu et al. (2012) evaluate the impacts of FLW on land, water and emissions for each stage of the FSC. Kummu et al. (2012) compare various FSCs based on the resource used per unit of generated FLW and suggest that food losses can be halved if the situation of best-performing geographies can be replicated globally. Farmers can minimise the environmental impact of crops through better planning crop production and distribution, cooperating with other farmers, identifying potential markets for nonstandard crops and investigating alternative destinations for surpluses (Wakiyama et al., 2019). Vandermeersch et al. (2014) and Caputo et al. (2014) developed a lifecycle assessment model to map the energy use of FLW. According to Vandermeersch et al. (2014), animal feed is a good option only for the FLW that is low in water content.

4.4.2. Impact of packaging strategies

Few studies have examined the environmental footprint caused by the packaging of food. However, they posit that better packaging strategies could contribute to FLW minimisation (Goossens et al., 2019; Pullman and Wikoff, 2017; Wikström et al., 2019).

4.4.3. Logistics-related issues

Little attention has focused on the role of logistics in environment-related issues with respect to FLW (Bottani et al., 2019; Mangla et al., 2019; Marsh et al., 2001). Lipińska et al. (2019), Mangla et al. (2019) and Marsh et al. (2001) explicate the improved sustainable performance of the FSC system by upgrading logistics systems. Marsh et al. (2001) argue that the occurrence of FLW during transportation has an adverse effect on the environment, especially during ocean transit, and requires organisational and technological improvements.

4.5. FLW quantification

Food waste quantification is a systematic approach for the accounting of FLW. Food waste quantification is necessary to prioritise interventions for the reduction in FLW and to assess the utility of such interventions (Hartikainen et al., 2018). Most studies

quantifying FLW across the FSCs focus on the United States and Europe (Dusoruth et al., 2018; Griffin et al., 2009; Johnson et al., 2018a; Principato et al., 2019). The European Union has been focusing on the sustainable development goals (SDGs) related to FLW, which has driven a high number of FLW quantification studies in Europe (UNEP, 2015). FLW quantification studies can be typified into two major categories.

4.5.1. Secondary studies

The first category of studies target quantification in a particular geography or across different countries and rely on secondary data (Hartikainen et al., 2018). Some studies also use simulations to quantify FLW (Buisman et al., 2019). The methods used in secondary studies to quantify FLW include food balance sheet methods (Aragie et al., 2018; Caldeira et al., 2019; Garcia−Herrero et al., 2018; Liu et al., 2016; Munesue and Masui, 2019; Porter et al., 2016), the use of proxies (Chalak et al., 2016; Porter et al., 2018), the use of data from the literature (Nahman and de Lange, 2013; Dusoruth et al., 2018; Hartikainen et al., 2018; D al' Magro and Talamini, 2019) and the use of secondary FLW databases (Redlingshöfer et al., 2017; Sun et al., 2018; Vázquez−Rowe et al., 2019).

4.5.2. Primary studies

The second category of studies target FLW quantification for a particular product or FSC and rely on primary data. The primary studies on FLW quantification incorporate methods such as surveys (Chaboud, 2017; Gustavsson et al., 2011; Gustavsson and Stage, 2011; Johnson et al., 2018b; Kumar and Underhill, 2019; Underhill et al., 2019), records (Ghosh and Eriksson, 2019), FLW collection and observation (Betz et al., 2015; Brancoli et al., 2017; Caputo et al., 2014; Johnson et al., 2018a; Principato et al., 2019; Santos et al., 2020; Strotmann et al., 2017a; Tostivint et al., 2017; Underhill et al., 2017; Wesana et al., 2019). The primary studies concern mainly the stage of the FSC. Scholars contend that, out of the techniques used for FLW quantification, material flow analysis (MFA) provides a more comprehensive and accurate overview of FLW concerning the percentage of FLW generated across stages of the FSC (e.g. Beretta et al., 2013). Among all food categories, cereals report the highest per-capita FLW, even more than perishable products such as vegetables and fruits (Xue et al., 2017). However, regarding postharvest losses, fruits, and vegetables face maximum loss (Gustavsson et al., 2013).

4.6. The Internet of Things and the use of digital technologies

Recently, digital tools (e.g. food sharing apps, data-driven farming) have become a viable solution for FLW recovery (Jagtap et al., 2019). However, limited prior literature has delved into understanding how these technologies can contribute to reducing FLW (Harvey et al., 2019; Mishra and Singh, 2018; Irani et al., 2018). Irani et al., 2018 argue that these technologies can determine the influence of interventions for reducing FLW within the broader food security landscape. Digital platforms can also facilitate the development of alternative food networks that have the potential to dissolve the traditional linear movement of food between FSC stakeholders (Harvey et al., 2019). The reduction in several FSC stages would mean less probability of food wastage across the FSC (Harvey et al., 2019).

For instance, Mishra and Singh (2018) explicate the use of Twitter data to develop FLW minimisation strategies by backtracking FSCs. The application of the Internet of Things (IoT; e.g. precision agriculture, smart farming) can help the actors in FSC control FLW by monitoring food quality, managing food about to surpass its shelf life and administering the right physical environment, especially concerning temperature and humidity (Kamble et al., 2019). Radio-frequency identification (RFID) technologies can help reduce FLW through efficient food category management, better store layout and improved management of inventory (Kamble et al., 2019).

4.7. Tradeoffs with FLW

Few articles highlight the major trade-offs in FSCs. The objective of such trade-offs is to balance the minimisation of FLW and other indicators of operational performance (e.g. cost, travel distance). The major themes that the literature reports are the trade-off between FLW and parameters such as environmental protection (Wikström et al., 2019); sustainability objectives (Martins et al., 2019; Owen et al., 2018; Pullman and Wikoff, 2017); shortages, inventory costs and shelf-life losses (Rijpkema et al., 2014); minimising travel distances (Fikar, 2018) and operational efficiency (Wen et al., 2015).

4.8. Other emerging themes

Two major themes related to FLW have emerged from the recent literature. These themes are (a) food donation management (Buisman et al., 2019; Muriana, 2015) and corporate social responsibility (CSR; Alexander and Smaje, 2008; Garrone et al., 2016; Lohnes and Wilson, 2018; Moggi et al., 2018; Sert et al., 2018) and (b) the assessment of food self-sufficiency based on FLW (Zasada et al., 2019).

Buisman et al. (2019) develop a mathematical model for food donation management that supports the acceptance of perishable food donations owing to food organisations' pressure to reduce FLW. Similarly, Moggi et al. (2018) develop a model for farmer markets to mitigate FLW through CSR activities that organisations support through real-time information flows, traceability and transparency. CSR also has active links with the operational performance of FSCs (Moggi et al., 2018; Sert et al., 2018). Based on a series of case studies in Italy, Sert et al. (2018) argue that operational efficiency reasons actively drive corporate CSR as companies perceive the donation channel as a method for managing surplus food.

Only one study (Zasada et al., 2019) assesses the self-sufficiency of geographical regions depending on spatial factors such as production systems, FLW and the origin of food.

5. Research gaps and potential research questions

The authors identified research gaps with the careful assessment of extant literature. The identified research gaps were mapped to the themes generated from the literature review. Table 3 presents the gaps in the literature and potential questions for future research.

6. Framework development

The present study proposes an FLW mitigation model-based, or M model-based, research framework. A combination of 5W1H (who, what, where, when, why, how) (Song, 1960) and the process control approach (input, process, output, feedback (Farrington, 1947) formed the basis for the development of this framework. This framework emphasises the role of actors (who), the actions they take (how), FSC (where), FLW indicators (what), time (when) and key drivers (why). The 5W1H approach is the choice to develop this framework because 5W1H is a simple, yet structured strategy that helps to understand the process and plan subsequent actions (Song, 1960). Scholars have argued that the 5W1H approach is

Table 3
Theme-based gaps and research questions.

Theme	Gaps	Potential Research Questions (RQs)
Factors responsible for FLW generation	1. The role of certain types of contracts for FLW generation remains relatively unexplored. 2. The drivers of FLW generation need to be comprehensively assessed, concerning relative importance and importance regarding a particular FSC stage. 3. There is very little information regarding the FLW caused by the internal quality standards of retailers and manufacturers. 4. There has been a limited focus on understanding FLW that occurs due to the poor packaging of food. 5. There is a general lack of theory-driven research in the domain of factors affecting FLW generation.	1. Which are the most important drivers of FLW? 2. How do disparate factors affect divergent stages of FSCs concerning FLW generation? 3. How can the effect of these factors be quantified? 4. What is the role of internal quality standards in the generation of FLW? 5. How does the nature of quality standards prevent/accelerate FLW across FSCs? 6. How do popular buyer–supplier contracts contribute to FLW generation at various stages of the FSC? 7. How do different types of packaging systems affect FLW generation? 8. What are the factors that shape the stakeholders' attitude toward FLW? How can these factors be understood from a theoretical standpoint?
Solutions to eliminate FLW	1. The extant literature has not explored in-depth the role of awareness campaigns for FLW mitigation. 2. The dearth of literature on improving logistics systems for the mitigation of FLW. 3. The assessment of FLW, which is based on inventory models, generally focuses on financial measures of performance. 4. A limited number of studies assess trade agreements concerning their potential to mitigate FLW. 5. Few studies focus on the comparative analysis of FLW mitigation measures concerning relative importance, product groups, FSC stage and geographies. 6. There is a limited understanding of the practical applicability of the solutions that various studies pose. 7. There is a general lack of theory-driven research in FLW. 8. There is a dearth of evidence-based policy research in the context of FLW mitigation measures.	1. How effective are awareness campaigns as a solution to FLW mitigation? 2. How do varied modes of transportation contribute to FLW? How can different modes of logistics systems be improved? 3. To what extent do inventory policy and production planning strategies contribute to FLW reduction? 4. What is the potential of trade agreements concerning FLW mitigation and cost-effectiveness? 5. Which are the most important FLW mitigation measures? 6. To what extent are the measures underscored in the literature for FLW mitigation practically applicable? 7. What is the effect of contextual variables on FLW reduction? Can the contingency theory perspective quantify this effect? 8. What is the effect of policy interventions at various FSC stages—farm, postharvest, processing, manufacturing and retailing?
Impact of FLW reduction	1. Very few studies focus on the micro-level impacts (e.g. operational performance, quality performance) of FLW mitigation. 2. There is limited research at the conjunction of quality management systems and FLW.	1. How does FLW reduction influence the operational aspects of the FSC, such as efficiency, speed, quality and responsiveness? 2. How do quality management systems interact with FLW mitigation practices?
Sustainability studies	1. A limited number of studies assess how circular business models can help to mitigate FLW, along with digitalisation technologies. 2. Existing studies permit the narrow discernment of circular business strategies useful for FLW mitigation. 3. A limited focus on packaging strategies for better environmental performance along with FLW mitigation.	1. How can digital platforms lead to the integration of stakeholders for participating in a take–make–dispose model of FSC in the circular economy? 2. Which circular business strategies are particularly useful for FLW reduction? 3. What type of packaging strategies contribute maximally to the environmental footprint, and how do they influence FLW generation?
FLW quantification	1. The overall cost estimation of FLW does not incorporate environmental and social costs. 2. Lack of uniformity in FLW quantification methods. 3. The aspect of seasonality has not figured into most studies on FLW quantification. 4. Very few studies seek to provide an in-depth understanding of differences in FLW in developed vs developing countries. 5. Despite the accuracy, the material flow analysis (MFA) method has not been used much for quantification. 6. FLW produced in the farm stage often get ploughed back into the land or used as animal feed. There is a need for more studies at the farm level. However, such studies are temporally demanding in nature.	1. Can existing research guide managers to carry out comprehensive studies on FLW quantification that incorporate the social, ethical and environmental cost of food FLW they generate? 2. What are the challenges to implementing a unified approach toward FLW quantification? 3. How does the amount of FLW generated in FSC's stages vary across developed vs developing countries? 4. What are the reasons for such variations, if any? 5. Apart from the enhanced accuracy, what are the other potential benefits of MFA? 6. How can society overcome challenges to FLW quantification at the farm level?
Internet of things (IoT) and use of digital technologies	1. The digitalisation-related studies do not shed much light on the extent of FLW-related improvements driven by digitalisation. 2. More researchers need to understand the type of technology use for a particular geography, FSC stage or product group. 3. Scholars need to delve deep into understanding which is the most effective and inexpensive digitalisation tool. 4. Few researchers have worked to understand the advantages and/or disadvantages of using Industry 4.0 technologies for FLW reduction.	1. What is the extent of improvements that can be affected by digitalisation technologies in agricultural production? 2. How do these improvements vary by geography, FSC stage and type of agricultural product? 3. Which are the most effective and inexpensive tools that actors can use within the FSC to mitigate FLW? 4. What are the advantages and disadvantages of using Industry 4.0 technologies for FLW reduction?
Tradeoff	1. Very little knowledge is obtainable in the context of the tradeoff between the FLW mitigation strategies (e.g. cold-storage facility) and the cost drivers.	1. What are the various cost drivers that should achieve a tradeoff with FLW management strategies? 2. What are the issues faced while obtaining such trade-offs?
Other emerging themes	1. There is a lack of research on penalty and incentive schemes in conjunction with a corporate food donation to reduce FLW.	1. What are the optimal incentive and penalty schemes that can motivate food donation behaviour among retailers to prevent FLW?

useful to identify and describe the problem under analysis (Nevstad et al., 2018). Researchers have applied this approach to a wide variety of domains (e.g. quality management, project management) to understand the objectives of business cases (Nevstad et al., 2018). The 5W1H approach provides basic information to develop plans and initiate action toward problem-solving. However, the problem of FLW mitigation is dynamic. That is, the resources (e.g. amount of available food, technologies, policy support) and the outcomes (e.g.

the quantity of FLW reduction, environmental footprint) keep changing. Considering the variability of the FLW mitigation process, it is important to have a feedback mechanism in place that can consider the actual performance of FSC concerning the FLW mitigation goal. The process control approach is a powerful conceptual tool that facilitates dynamic problem-solving in the settings where a set of activities and the availability of resources keeps changing (Ivanov and Sokolov, 2012). Therefore, this work utilised a hybrid approach comprising 5W1H and process control to develop its FLW mitigation model.

In the present study, the 5W1H approach utilises factors responsible for FLW generation and solutions to mitigate FLW, which are unravelled through the thematic analysis of the literature. The responses to the questions (what, who, why, where, how) relate to each other. These responses represent the steps of the control process and are helpful for the development of a detailed action plan to mitigate FLW.

'Who' refers to the actors that FLW generation affects who can take actions to mitigate FLW. 'How' refers to the FLW mitigation measures actors undertake. This study has captured the response to 'how' by enlisting the solutions to mitigate FLW. The response to the who and how questions act as the 'input' for the control process. The actors include farmers, manufacturers, retailers, government, NGOs and society. The actions that the actors take in this step would lead to a change in the quantity of FLW generated and its subsequent effects (e.g. social impact). These effects will be the output of the control process.

'Where' refers to the location of the FLW generation, which comprises the stages of the FSC. In the present study, the response to 'where' is the supply chain stages from the farm to the retail stage. 'When' refers to the point of time when FLW reduction efforts need to be undertaken.

FSC performance indicators answer the 'What' question. To reduce FLW, these performance indicators are captured and intervene' upon. 'Why' refers to the factors that act as a driving force for FLW mitigation. The responses to the 'What' and 'why' questions, that is indicators and drivers of FLW, act as the output for the control process. These indicators and drivers connect to the FSC, as they typically comprise the factors responsible for FLW generation, the quantity of FLW and sustainable performance indicators of FSC. The output for the control process is FLW mitigation, which is characterised by a change in these indicators. The change in these indicators provides 'feedback'. This feedback is used to reconsider decisions (actions) at the input of the control process. Fig. 8 represents the M model-based research framework developed in the present SLR.

7. Implications of the study

7.1. Theoretical implications

The present study has important theoretical implications. First, several review studies in the past have investigated FLW at a particular stage of the FSC. Most of these studies focus on the consumption stage. The present study takes its departure from the extant literature and investigates the important areas in FLW generation from the perspective of FSC.

Second, the authors conducted a thematic analysis of the extant literature to gather knowledge in a systematic manner and highlight areas with a deficit of scholarly attention. As the analysis showed, the extant literature on FLW skews toward outlining the factors responsible for FLW generation (Fig. 7). The thematic analysis of literature in this study serves as a foundation for scholars to extend the scope of their exploration and consider the upcoming approaches of digitalisation and circular economy for FLW mitigation.

Third, the research profiling and analysis of themes in the literature has reinvigorated the understanding of scholars concerning the problems associated with FLW. By highlighting themes such as FLW quantification, factors responsible for FLW generation and solutions to FLW mitigation, the study progresses and contributes to the global agenda of FLW mitigation. The research profiling conducted in the SLR points at the geographies, product groups and FSC stages that require further attention from scholars.

Fourth, the present study identifies important research gaps and points out several critical research questions to mitigate these gaps. Thus, this work has constructed a future research agenda in this domain. The present SLR reveals future studies should take a comprehensive outlook while assessing the cost of FLW. The cost should account for the social as well as the environmental outlay associated with the FLW. The present study emphasises the need to shift attention beyond the monetary value of wasted food. Furthermore, future work should examine the micro-level influences of FLW generation. The justification of the need for comprehensive costing and micro-level influences of FLW in the food industries derives from the fact that a fine-grained analysis of the effect of generated FLW is necessary. Such analyses would boost the in-depth understanding of the influences of FLW in the food industry and help develop targeted strategies for its mitigation.

Last, through the development of the M model, the study provides a systematic overview of the FLW mitigation process and constructs an actionable plan to mitigate FLW by utilising a combination of 5W1H and the process control approach. The M model enables scholars an aerial view of the key areas in the domain of FLW generation in FSCs.

7.2. Implications for practitioners

The present study has six important implications for practitioners associated with FSCs. Managers should understand the issue of FLW in detail because their attitude and behaviour play an important role in FLW reduction. The key implications for practitioners are summarised below.

The thematic foci presented in the study would help managers to have a bird's-eye view of the depth and scope of the issues associated with FLW and their causes. This is the first implication for managers. For example, it is evident from the literature that stringent internal quality standards led to FLW at different stages of the FSC; thus, there is a need for managers to curb the avoidable waste resulting from quality-related practices (Devin and Richards, 2018; Gillman et al., 2019).

Second, the methods for quantifying FLW need attention. As the literature indicates, FLW quantification relies on several methods of FLW data logging. The need to develop formal guidelines for assisting the supply chain actors with the accurate quantification of FLW is importunate, considering the magnitude of the problem. Therefore, at the policy level, interventions should ensure FLW data is compulsorily reported in a prescribed format, which can be compared against the benchmark (Eriksson et al., 2017). Additionally, the overemphasis on the monetary value of the FLW needs to be replaced with a strategy of FLW quantification that accounts for social and environmental costs.

The third implication for managers is to understand the importance of integrating digital technologies for the mitigation and management of FLW. Digitalisation principles can help to minimise FLW in the FSCs (Kamble et al., 2019). Furthermore, managers need to aid the development of infrastructure to implement new technologies, such as IoT, to decrease FLW in their FSCs. This is also important for businesses because, in the future, the food business driven by data might push those who do not use such

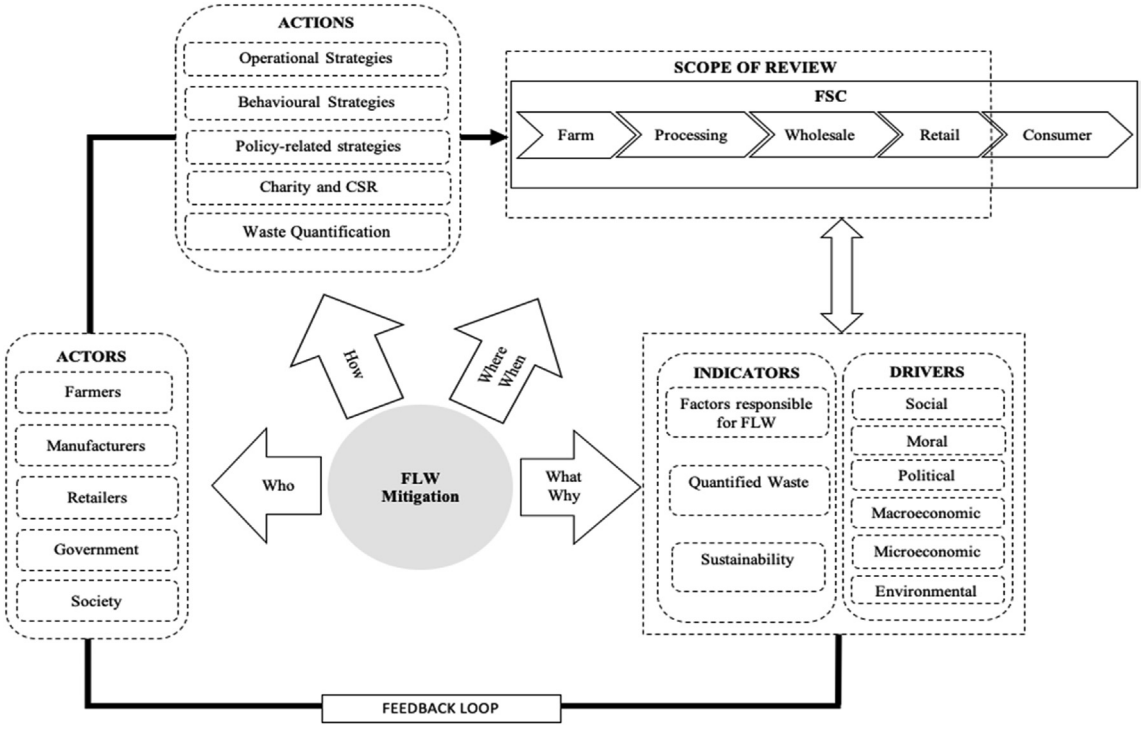

Fig. 8. FLW mitigation model (M model).

technologies out of business.

Fourth, most empirical studies in the FLW domain present a specific context concerning geographic location, product category or stage of the FSC. To generalise the findings of such a wide variety of studies, managers should substantiate these studies with their input. Such validation from managers would highlight the deficiencies, if any, with the theoretical findings that the extant literature propounds.

The fifth implication for managers is to understand the impacts associated with FLW generation. The studies on FLW's relationship with sustainability reveal the impact of FLW on natural resources (e.g. Caputo et al., 2014). Exploring the sustainability issues associated with FLW would guide managers in their efficient management and use of resources. The study would also guide managers toward understanding the value of missing food that can be avoided by adopting solutions to mitigate FLW.

Sixth, the present study also signals to policymakers that policy interventions must deal with the issue of FLW (e.g. Chalak et al., 2018). Policymakers play an important role in several cases. For example, many companies tend to dispose of edible food because surplus food management is expensive (Sert et al., 2018). As evident from the literature, policymakers must make it compulsory for managers to devise time-bound plans to effectively conduct and monitor FLW reduction targets (DeLorenzo et al., 2019). Policymakers should also pay attention to FLW research respecting geographical indicators, as the findings will allow them a reality check on ground-level conditions.

8. Conclusions

The current SLR critically examines the state of the research on the topic of FLW in FSCs. The study makes a multifaceted contribution to the existing literature. As for the first important contribution to theory, this SLR has embarked on disentangling the existing research by carefully organising it according to the publication timeline, country of origin, key contributors and so forth for 152 articles. The analysis reveals that the research in this area has largely remained fragmented. The literature on FLW is spread across a variety of journals and several overlapping domains of research, methodologies and levels of analyses. The earlier review studies in the domain had primarily concentrated upon the causes and reduction strategies of FLW. Most of these studies focused specifically on a particular FSC stage (e.g., de Moraes et., 2020) or specific issues related to FLW, such as a sustainable environment (e.g., Reynolds et al., 2019). However, the present study offered a detailed analysis of the FLW literature and tried to analyse the important themes in entirety. Therefore, the second important contribution of the present study is the segregation of literature based on the key themes, which has resulted in the identification of critical topics for FLW research. The key themes include the following: a) factors responsible for FLW generation; b) solutions to mitigate FLW; c) impact of FLW reduction; d) nexus with sustainability; e) FLW quantification; f) IoT and the use of digital technologies; g) trade-off with FLW and h) other emerging themes. Based on the analysis of literature, the major factors responsible for FLW in the FSCs include the poor management of perishable food items, stakeholder attitudes, buyer–supplier agreements and supply chain interruptions. The present SLR also highlights important solutions to FLW extracted from the literature. The review concluded by outlining the gaps and potential research questions for the future research and development of a research framework, which is the third major contribution of the present SLR.

8.1. Limitations of the study and areas for future SLRs

This review has illuminated the state of FLW in supply chain research. However, there are also limitations that future reviews or studies of this type can take up. First, the authors only included English-language journal articles available in the WoS and Scopus

databases in the review. Therefore, some relevant studies may be missing from the present study. Future SLRs can investigate the conference studies, book chapters and studies published in other languages, augmented with a search on other academic databases. Second, we selected the articles of this review based on the stringent criteria of inclusion and exclusion. For example, we excluded conceptual studies. These studies could have enriched the findings of the present review; however, we excluded them due to scope and space constraints. The future SLRs should assimilate the conceptual studies as well. Last, research on IoT and digitalisation in conjunction with FLW is still in a nascent stage. That is, there are still a few relevant studies. Nonetheless, authors have used these studies to guide future research on the topic. However, as research on digitalisation matures, some of the findings of this study may cease to be useful. Nevertheless, this study has provided a detailed discussion of the emerging themes in the FLW literature. In the future, it could be interesting to carry out a bibliometric study that can also provide a detailed understanding about recurring networks such as that of researchers as well as countries, that have been at the forefront for analysing the issue of FLW. The authors hope the present study will act as a foundation for future scholarly explorations in this area.

CRediT authorship contribution statement

Chetna Chauhan: participated in, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Amandeep Dhir:** participated in, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Manzoor Ul Akram:** participated in, Investigation, Methodology, Writing – review & editing, Supervision, Validation. **Jari Salo:** participated in, Investigation, Methodology, Writing – review & editing, Supervision, Validation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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