

Comprehensive mapping of food loss and food waste: Insights from a systematic literature review

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Abstract. This research aims to comprehensively map the stages at which food materials are discarded as food loss and food waste, drawing insights from existing literature. This study employs a systematic literature review methodology-the works of literature collected from reputable international journal databases. The findings of this investigation reveal a diverse array of research endeavors within the realm of food waste management. Researchers have undertaken endeavors to categorize different types of food waste, while others have delved into examining food resilience and waste generation in agricultural phases or amongst farmers. Distinct studies have concentrated on food resilience and waste issues encompassing traditional market traders. The academic community has also directed attention towards food waste in harvest, retail sales, followed by the hospitality industry, restaurant management, and household settings. The outcomes of this systematic literature review offer a foundational framework for delineating food waste patterns across agricultural, traditional market, retail, restaurant, hotel, and household contexts. Subsequent empirical research is poised to focus on categorizing food waste by type, identifying root causes, exploring mitigation efforts, and elucidating waste management strategies enacted by farmers, traditional market traders, retail stores, restaurants, hotels, and households.

1 Introduction

The background of this research is rooted in the alarming fact that millions of tons of food are wasted each year across agricultural, retail, and consumer levels [1]. Globally, one-third of the food, equivalent to 1.3 million tons per year, is discarded throughout the food supply chain [2]. The Food Sustainability Index (FSI) assesses three primary challenges facing the current global food system: sustainable agriculture, nutrition, and food waste. France ranks first in the world according to the FSI due to its holistic policies related to food waste [1]. In

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contrast, the United States ranks third worst in the FSI, followed by Indonesia in the second position and Saudi Arabia at the top globally. Saudi Arabia generates 427kg of food loss and waste per capita per year, and the United States produces 277kg per capita per year.

In comparison, Indonesia contributes 300kg per capita per year to this issue [1]. These figures are deeply concerning, and food waste remains a significant problem that Indonesia must address to ensure food security and environmental sustainability, as food waste also contributes to emissions. On the other hand, the issue of food waste is crucial concerning efforts to combat hunger, boost income, and enhance food security [3].

Based on the abovementioned problem, the research question is “What are the key factors contributing to food loss and food waste across different stages of the food supply chain, and how can comprehensive research inform strategies to minimize waste and promote sustainability?”

This research aims to systematically investigate and analyze food loss and food waste at various stages of the food supply chain, including production, distribution, consumption, and food processing. The primary objectives are to:

1. Identify the causes, actors involved, and geographical variations in food loss and food waste.
2. Examine the economic and environmental implications of food waste at each stage of the supply chain.
3. Explore potential solutions and interventions to reduce food waste and enhance food resilience.
4. Address the research gaps in the existing literature by conducting comprehensive research that spans the entire food supply chain.
5. Foster interdisciplinary collaboration to develop holistic strategies for minimizing food waste and promoting sustainability in the food system.

The significance of this research stems from Indonesia's second-ranking position in the world in terms of food waste production, according to the FSI. It is essential to map food waste by type, identify the causes of food wastage, and explore efforts to reduce and manage food waste throughout the supply chain. The findings of this research may lead to the discovery of solutions to the national food waste problem.

2 Methods

2.1 Data collection and search strategy

A systematic literature review was employed to gather relevant research articles, reports, and publications in a comprehensive mapping of food loss and food waste [4]. The search process was conducted in several critical academic databases, including but not limited to PubMed, Web of Science, Scopus, and Google Scholar. The search was conducted using a combination of controlled vocabulary terms (e.g., "food loss," "food waste," "supply chain," "households") and relevant keywords (e.g., "farmers," "retail," "restaurants," "economic impact," "environmental impact").

2.2 Inclusion and exclusion criteria

Articles considered for inclusion in the review must meet specific criteria to ensure relevance and quality [5]. The inclusion criteria encompassed publications that focused on food loss and food waste, including their causes, actors involved, economic implications, environmental consequences, and potential solutions. The research articles must also be

published in peer-reviewed journals or recognized publications. Non-English articles were excluded from the review.

2.3 Data extraction

Data extraction involved systematically reviewing and recording pertinent information from the selected articles. This process encompassed details such as the publication year, study objectives, methodology, key findings, and the specific focus of each study within the food supply chain [6]. Additionally, data related to the geographical scope of the research and the types of actors studied (e.g., farmers, traders, households) were documented.

2.4 Synthesis and mapping

The collected data were synthesized and categorized to create a comprehensive map of food loss and food waste [5]. Studies were grouped according to the stages of the food supply chain they addressed (e.g., production, distribution, consumption) and the specific actors studied within each stage. This systematic categorization facilitated the identification of common patterns, trends, and research gaps.

2.5 Analysis and insights

The synthesized data were then analyzed to extract valuable insights into the dynamics of food loss and food waste across the entire supply chain [5]. This analysis included examining each stage's causes, consequences, and potential interventions. Key findings and trends were summarized to provide a clear overview of the current research on food loss and food waste.

3 Results

Food loss and food waste represent distinct concepts within food supply chains. Food loss refers to the deterioration in food quality along the supply chain, rendering it unsuitable for human consumption [3]. This can occur during the distribution and production stages. On the other hand, food waste occurs at the end of the supply chain, specifically at the retail and final consumption levels, linked to the behaviors of retailers and consumers. This is why it is said that 1.3 million tons of food are wasted annually, spanning from farmers to household consumption [2].

Conducting a literature review in reputable international journals is a crucial foundation for the forthcoming research. First, it involves mapping out the prior research undertaken by international scholars. Second, it entails identifying research gaps that have not received sufficient attention or limitations from previous studies. These limitations are often associated with partial research, forming the basis for conducting more comprehensive investigations from upstream to downstream.

Studies related to food waste by food type have been carried out by Buzby and Hyman [7]. They found that the top three sources of food waste in the United States were meat and fish (41%), vegetables (17%), and dairy products (14%). Similarly, Alcorn et al. [8] and Umunnakwe et al. [9] have researched this domain. These studies can serve as a foundation for this research to delve deeper into the primary types of food waste generated from the practices of farmers and households.

3.1 Food waste at the farmer phase

In the context of food waste generation, it is essential to examine farmers' behaviors, as they are one of the primary contributors to this issue. Several studies have explored various aspects of food security and food resilience related to farmers' practices. For instance, Yu et al. [10], Bovay [11], Zhang et al. [12], Corsi et al. [13], and Hulbrock et al. [14] have conducted research involving farmers as a central theme, shedding light on their roles in food production and waste generation.

The literature emphasizes that farmers play a crucial role in food waste generation. By conducting research involving farmers as a central theme, the studies (Yu et al., [10]; Bovay [11]; Zhang et al. [12]; Corsi et al. [13]; and Hulbrock et al. [14]) shed light on the behaviors and practices of farmers that contribute to food waste within the agricultural sector.

The cited studies acknowledge the importance of considering farmers within the broader context of food waste generation and food resilience. They recognize that farmers are not isolated actors but are integrated into complex supply chains and food systems. Understanding their roles and challenges within this context is critical for effective waste reduction and resource management.

The research findings offer valuable insights into areas for improvement and sustainable food resource management. By studying farmers' practices and behaviors, these studies provide a foundation for identifying opportunities to minimize food waste, enhance food security, and increase profitability within the agricultural sector.

The literature underscores that addressing food waste is an environmental concern and vital for enhancing food resilience. By understanding farmers' roles in food production and waste generation, these studies contribute to developing strategies that promote resilience in food systems, particularly in the face of challenges such as food scarcity and economic fluctuations.

The reviewed literature highlights the central role of farmers in food waste generation, emphasizing the need to consider their behaviors and practices within broader food systems. This understanding contributes to waste reduction and fosters food resilience and sustainability within the agricultural sector.

3.2 Food waste at the retail phase

Furthermore, some studies focusing on food resilience have also engaged traditional street food traders, such as the research conducted by Cheng et al. [15]. This suggests that food resilience research extends beyond the agricultural sector to encompass the activities of street food vendors, who play a significant role in urban food systems.

It is worth noting that Alfiero et al. [16] have emphasized the interconnectedness of food resilience research and food waste issues. They argue that effective handling of unsold food not only reduces food waste but also enhances profitability. Alfiero et al.'s study highlights that farmers exhibit greater efficiency in managing unsold food products than traditional street food traders.

Food waste typically reemerges during this phase when food transitions from farmers to traditional market vendors or retail stores in supermarkets. Research focused on food waste during the retail phase has been conducted to shed light on this phenomenon. Lebersorger and Schneider [17] conducted a study involving 612 retail outlets throughout Austria, finding that fruit and vegetables were the most significant source of food waste in this context.

Additionally, Eriksson et al. [18] conducted research concerning fruit and vegetable waste in six retail stores in Sweden. These studies collectively highlight the presence of food waste during the retail phase of the food supply chain, with a particular emphasis on fruit and vegetable waste.

The findings underscore the need to address food waste at the retail level and suggest that fruit and vegetable waste are prominent contributors to this issue. Such insights are essential for developing strategies to minimize food waste in the retail sector, promoting sustainability, and mitigating environmental impacts associated with discarded food items.

3.3 Food waste at the food processing industry

Food waste is generated at markets or retail establishments and occurs within the food processing industry, including restaurants, hotels, and other accommodation services. Alcorn et al. [8] researched to examine the various types of discarded food originating from restaurant kitchens. Other researchers who have explored food waste in the restaurant industry include Christ and Burritt [19] and Charlebois et al. [20]. Additionally, Luu [21] investigated behaviors aimed at reducing food waste in the hospitality industry in Vietnam, while Wan et al. [22] delved into food waste issues within the hospitality industry in Macau.

This body of research collectively highlights that food waste is not limited to traditional markets or retail settings but extends into various food processing sectors, particularly restaurants and hotels. Researchers have explored different facets of food waste generation within these contexts, shedding light on the types of discarded food and strategies for waste reduction, contributing to a more comprehensive understanding of the issue.

The literature showcases research conducted in various settings within the food processing industry, such as restaurants and hotels, and across different geographical locations, including Vietnam and Macau. This diversity reflects the global nature of food waste and the need for localized strategies.

Alcorn et al.'s [8] research stands out as it delves into the specific types of discarded food originating from restaurant kitchens. This focus allows for a granular understanding of the nature of food waste in these establishments, providing insights into potential areas for improvement and reduction.

Researchers within this field have explored different facets of food waste generation, including identifying strategies for waste reduction. Luu [21] and Wan et al. [22] have examined behaviors and practices to reduce food waste in the hospitality industry. These studies provide actionable insights for businesses and establishments seeking to minimize waste and improve sustainability.

The reviewed literature highlights the multifaceted nature of food waste within the food processing industry, including restaurants and hotels. It underscores the importance of considering different types of discarded food, waste reduction strategies, and the issue's global relevance. This body of research contributes to a more holistic understanding of food waste generation and management within these sectors.

3.4 Food waste at the household

Households play a significant role in contributing to food waste generation, and several studies have been conducted worldwide to investigate this issue. Researchers have explored various aspects of household food waste, including its economic implications, the sheer volume produced, and potential strategies for reducing waste at the household level. These studies collectively provide valuable insights into the substantial impact of households on the global food waste problem and offer potential solutions for mitigating it.

Household food waste has been investigated in different regions, including Africa and other parts of the world. The economic perspective of household food waste, as highlighted in Nahman et al.'s [23] research in South Africa, reveals the substantial financial losses associated with wasted food and the costs incurred in managing this waste. Similarly, Umunnakwe's study (2019) in Nigeria emphasizes that a considerable portion of food waste,

amounting to 44 percent and 269,870 tons, originates from households, underlining the significance of this issue in the context of waste management and food security.

Furthermore, additional research conducted by Ng et al. [24], Ayob et al. [25], Farr-Wharton et al. [26], Silvennoinen et al. [27], Liu and Nguyen [28], Williams et al. [29], and Principato et al. [2] has further explored various dimensions of household food waste. These studies have contributed to a more comprehensive understanding of the factors influencing food waste at the household level and have proposed strategies and interventions to address this pressing issue.

Research on household food waste has been conducted across different countries, highlighting its global significance. These studies collectively provide insights into the economic, environmental, and social dimensions of food waste, facilitating the development of targeted solutions to reduce food waste at the household level and its associated negative impacts.

3.5 Research gaps and future research directions

Narrow scopes have constrained many previous studies. They often focused exclusively on specific actors within the food supply chain, such as farmers, traders, restaurants, hotels, or households. This limited focus can hinder a comprehensive understanding of the food waste ecosystem, as food waste generation occurs across the entire supply chain, from farmers to household consumption.

A significant research gap lies in the absence of comprehensive studies encompassing the entire food supply chain. Such research could provide a holistic view of food waste generation, allowing for the identification of interrelated factors and potential interventions at various stages of the supply chain.

Future research should map food waste generation throughout the supply chain extensively. This would involve studying the behaviors and practices of farmers, traders, restaurants, hotels, and households. Such comprehensive research can provide valuable insights into the interconnectedness of food waste across different sectors and help identify critical intervention points.

The findings from comprehensive research efforts can serve as the basis for developing national-level solutions for food waste management. By understanding the root causes and patterns of food waste generation at each stage of the supply chain, researchers can contribute to formulating effective strategies to minimize waste, reduce economic losses, and promote sustainability.

Future research could benefit from interdisciplinary approaches involving experts from various fields, such as agriculture, economics, environmental science, and social sciences. Collaborative efforts can yield more holistic insights into the multifaceted issue of food waste and lead to innovative solutions that address both the economic and environmental aspects of the problem.

Future research should bridge the existing gaps by conducting comprehensive studies encompassing the entire food supply chain. This approach can contribute to a deeper understanding of food waste dynamics and develop effective national-level solutions to address this critical issue.

4 Conclusion

This systematic literature review offers a comprehensive overview of food loss and food waste across various supply chain stages, including agriculture, traditional markets, retail, restaurants, hotels, and households. The findings highlight the multidimensional nature of the food waste problem, emphasizing the critical role of each sector in its generation. Key

insights from this review can guide future research, policy development, and practical interventions to mitigate food waste and enhance sustainability.

Future research should focus on mapping food waste generation across the entire supply chain, from farm to consumer. Such comprehensive studies can provide a holistic view of the interconnected factors contributing to food waste and enable the identification of intervention points at different stages.

Collaborative research efforts involving experts from diverse fields, including agriculture, economics, environmental science, and social sciences, should be encouraged. Interdisciplinary approaches can yield innovative insights and solutions addressing food waste's economic, environmental, and social dimensions.

Investigating the behaviors and practices of critical actors, including farmers, traditional market traders, retailers, restaurants, hotels, and households, is essential. Future research should delve deeper into understanding the motivations and barriers to food waste reduction within these sectors.

Future studies should explore mitigation efforts undertaken by various actors within the supply chain. Identifying successful strategies for waste reduction can inform best practices and policy recommendations.

Assessing the environmental and economic impacts of food waste at different stages of the supply chain is crucial. This can help quantify the consequences of waste generation and inform decision-making processes.

Research should contribute to the development of national-level solutions for food waste management. Understanding the root causes and patterns of food waste generation can guide the formulation of effective strategies to minimize waste, reduce economic losses, and promote sustainability.

In conclusion, addressing the global challenge of food waste requires a comprehensive and interdisciplinary approach that considers the entire supply chain. Future research endeavors should fill existing gaps, foster collaboration among experts, and contribute to sustainable solutions for this critical issue.

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