

Addressing Food Loss and Waste through Collaborative Digital Transformation: Emerging Themes and Trends

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Abstract

This developmental paper examines how collaborative digital transformation can mitigate food loss and waste in agri-food supply chains. Adopting a systematic science mapping approach, we analyse 152 peer-reviewed articles from 2014 to 2024 to reveal multiple thematic clusters that illustrate the interplay between technological innovations, stakeholder collaboration, and sustainability-focused practices. The research seeks feedback on cluster validity, methodological rigour, and potential future research directions, particularly regarding SME-centric solutions and integrated digital platforms that can strengthen collaboration and scalability in food loss and waste mitigation.

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Introduction

Food insecurity remains a persistent global challenge, exacerbated by vulnerabilities in food supply chains due to health crises, climate change, and conflicts (Paudel et al., 2023; Barakat et al., 2023; Shemyakina, 2022). Simultaneously, a significant proportion of food is lost or wasted throughout agri-food supply chains (AFSCs), contributing to economic inefficiencies, environmental degradation, and missed opportunities for achieving food security (FAO, 2021; O'Connor et al., 2021).

Digital transformation initiatives, incorporating technologies such as the Internet of Things (IoT), blockchain, and artificial intelligence (AI), are increasingly recognised as promising tools to enhance supply chain efficiency and foster stakeholder collaboration (Ahmadzadeh et al., 2023; Hassoun et al., 2023b). While many studies have demonstrated how these digital solutions can improve traceability and real-time monitoring (Liegeard and Manning, 2020; Nath et al., 2024), significant gaps remain. The literature often adopts a fragmented perspective, focusing on isolated digital applications rather than providing a holistic view of collaborative digital transformation (CDT) in reducing food loss and waste (FLW) (Annosi et al., 2021; Zhao et al., 2023). Moreover, barriers such as fragmented communication, trust deficits, and limited SME engagement continue to challenge the effective integration of these technologies (Khan et al., 2022; Benyam et al., 2021).

To address these issues, this paper seeks to answer the following overarching question:

How can we systematically classify the literature on CDT for mitigating FLW in AFSCs, and what key thematic clusters, evolutionary patterns, and research gaps emerge from this analysis?

This overarching question is addressed through two specific sub-questions:

Sub-question 1: How do these CDT characteristics relate to supply chain stakeholder engagement and measurable FLW reduction outcomes?

Sub-question 2: Where are the critical knowledge gaps and emerging research clusters that require future investigation for effective implementation and policy guidance?

By integrating systematic literature review (SLR), bibliometric analysis, natural language processing (NLP), and systematic science mapping (SSM), this study develops a comprehensive taxonomy that synthesises current digital and collaborative practices and identifies critical research gaps through three key approaches: (1) semantic similarity analysis to identify hidden connections between disparate studies, (2) network visualisation to reveal thematic clusters invisible in traditional reviews, and (3) temporal analysis to trace evolutionary patterns across the literature landscape, providing actionable insights for both academic inquiry and practical applications in reducing FLW.

Literature Review and Theoretical Background

This section will serve two purposes. First, it will define the key concepts of FLW, Digital Transformation (DT), and CDT within the context of AFSCs. Second, it will introduce and critically assess the currently available literature reviews in these domains. We will build on this foundation by presenting a systematic mapping of the literature, which will highlight areas that require further research and development.

Definitions and Context

FLW in AFSCs encompasses two interrelated dimensions: food loss (FL), which occurs from production to retail, and food waste (FW), which primarily occurs at the retail and consumer levels. Globally, approximately one-third of food produced is lost or wasted each year, contributing significantly to greenhouse gas emissions and resource inefficiencies (Yadav et al., 2022; O'Connor et al., 2021). In developing regions, losses are largely attributable to inadequate storage and infrastructure, whereas in developed countries, consumer behaviour and retail inefficiencies are the primary drivers (Kozek and Wasilewska-Wojtan, 2022). In the UK alone, 10.7–12.8 million tonnes of food are wasted annually (WRAP, 2023; WWF, 2022).

DT in AFSCs refers to the integration of Industry 4.0 technologies—such as IoT, blockchain, AI, and big data—to optimise operations, enhance traceability, and reduce FLW (Hassoun et al., 2023a; Corallo et al., 2023). CDT extends DT by promoting multi-stakeholder collaboration among farmers, processors, retailers, and consumers. This collaborative approach is crucial for aligning incentives, sharing data, and co-designing innovative solutions that address the root causes of FLW (Bhattacharya and Fayezi, 2021; Octavia et al., 2022).

Review of Existing Literature Reviews

Table 1 summarises key literature reviews on CDT and FLW in AFSCs, detailing their principal contributions and identifying research gaps that our study will seek to address. This table will guide our systematic mapping process by providing clear benchmarks for the strengths and limitations of existing literature reviews.

Table 1: Summary of Literature Reviews on CDT and FLW in AFSCs

Authors	Review Title	Findings	Research Gaps
(Agarwal et al., 2024)	<i>Food wastage and consumerism in circular economy: a review and research directions</i>	Examines consumer behaviours affecting food wastage. Highlights issues in planning and purchasing. Emphasises convenience handling as a key factor.	Calls for alignment of circular economy (CE) principles with food waste interventions. Suggests integration of sustainability with consumer practices. Proposes further consumer behaviour studies.
(Hong et al., 2024)	<i>Mobile applications to reduce food waste in supply chains: a systematic literature review</i>	Identifies mobile applications' impact on consumer behaviour. Discusses their role in waste reduction. Highlights user engagement for effective outcomes.	Emphasises need for long-term studies on global impact. Calls for scalability research in different regions. Notes limitations in digital access affecting adoption.
(Areche et al., 2022)	<i>Innovative trends in reducing food waste and ensuring a more sustainable food system and environment</i>	Analyses digital tools' role in waste reduction. Focuses on mobile applications in food safety. Highlights potential in food monitoring.	Calls for cost-effectiveness studies for widespread adoption. Suggests studies on technology feasibility in low-resource settings. Emphasises need for integration in traditional food systems.
(Liegeard and Manning, 2020)	<i>Use of intelligent applications to reduce household food waste</i>	Investigates effectiveness of intelligent apps. Highlights consumer awareness on food waste. Focuses on in-home waste reduction efforts.	Calls for further research on privacy concerns. Emphasises app effectiveness for sustained impact. Notes potential consumer privacy issues limiting use.
(Babbitt et al., 2022)	<i>Transforming wasted food will require systemic and sustainable infrastructure innovations</i>	Discusses systemic changes for food waste reduction. Focuses on interventions in the U.S. Explores scaling of controlled systems.	Recommends research on scalability of controlled environments. Suggests studying diverse food environments. Emphasises role of policy in supporting change.

(Hassoun et al., 2024)	<i>Leveraging the potential of fourth industrial revolution technologies to reduce and valorize waste and by-products in the dairy sector</i>	Examines Industry 4.0's potential in reducing waste. Highlights IoT and AI's contributions. Analyses real-time data use in waste management.	Addresses implementation challenges in supply chains. Suggests focus on cost-benefit analyses for Small Medium Enterprises (SMEs). Recommends additional infrastructure for tech integration.
(Octavia et al., 2022)	<i>A Conceptual Framework for Food Sharing as Collaborative Consumption</i>	Explores food-sharing platform roles in reducing waste. Emphasises collaboration in waste mitigation. Analyses platform accessibility and use cases.	Recommends studies on feasibility of collaborative models. Calls for exploration of platform scalability. Suggests further analysis of cost-effectiveness.
(Zhao et al., 2023)	<i>Reducing food waste from social innovation perspective: a review of measures, research gaps and future directions</i>	Discusses the impact of social innovation on FLW. Highlights food-sharing platforms for redistribution. Focuses on consumer-level reduction efforts.	Calls for research on scalability and effectiveness. Emphasises integration with existing supply chains. Suggests more studies on regulatory frameworks.
(Benyam et al., 2021)	<i>Digital agricultural technologies for food loss and waste prevention and reduction: Global trends, adoption opportunities and barriers</i>	Reviews digital tools for preventing food loss. Emphasises technologies in monitoring and efficiency. Analyses value in early production stages.	Suggests studies on adoption feasibility. Calls for examination of cost structures for SMEs. Emphasises technology's role in resource management.
(Jenkins et al., 2022)	<i>Exploring the application of social media in food waste campaigns and interventions: A systematic scoping review of the academic and grey literature</i>	Explores social media's role in raising FLW awareness. Highlights consumer engagement through online campaigns. Examines reach of awareness efforts.	Emphasises need for studying long-term effectiveness. Recommends more targeted social media studies. Suggests integration with behavioural change initiatives.

(Facchini et al., 2018)	<i>Food flows in the</i>	Examines food redistribution initiatives	Recommends integration with digital tools for impact.
	<i>United Kingdom: The potential of surplus food redistribution to reduce waste</i>	in the UK. Highlights their role in reducing food waste. Analyses integration with traditional food systems.	Suggests studies on scalability of redistribution platforms. Calls for further research on infrastructure needs.
(Ahmadzadeh et al., 2023)	<i>A Comprehensive Review on Food Waste Reduction Based on IoT and Big Data Technologies</i>	Focuses on IoT's role in FLW management. Highlights potential for data-driven insights. Discusses applications across AFSCs.	Recommends integration with existing supply chain systems. Suggests additional studies on IoT's scalability. Calls for policies to support IoT adoption.

Building on these findings, we identify under-researched areas and propose a unified taxonomy integrating technological and collaborative practices across AFSCs. Unlike recent reviews focusing on specific technologies or single supply chain stages, this study uniquely combines collaborative and technological dimensions across entire AFSCs. Our approach differs from existing systematic reviews by using advanced semantic mapping to reveal previously unidentified thematic connections and by explicitly focusing on collaborative rather than purely technological solutions.

Methodology

An SLR-inspired approach, guided by the PRISMA framework (Page et al., 2021), will be employed to systematically identify and select relevant literature. The search will be conducted in Scopus and WoS, known for their extensive coverage of peer-reviewed sources (Harzing and Alakangas, 2016; Brzezinski, 2015).

A refined keyword strategy (*Table 2*) will be developed through brainstorming, existing literature analysis, and snowball sampling to ensure comprehensive coverage of CDT, FLW, and AFSCs. The initial search is expected to yield approximately 3,169 results from Scopus and 12,845 from WoS. Filters will be applied to limit results to English-language journal articles published between 2014 and September 2024, reflecting the growing focus on digital transformation in supply chains, particularly post-COVID-19 (Queiroz et al., 2022; Singh et al., 2021; Choi, 2021; Golan et al., 2020; Kumari et al., 2023; Sharma et al., 2022, 2021; Joshi and Sharma, 2022).

After removing duplicates and refining the dataset based on JCR SJR indexing, approximately 2,776 articles will be subjected to title and abstract screening. Applying predefined inclusion and exclusion criteria (*Table 3*), approximately 152 articles will be selected for detailed analysis.

The selected articles will undergo SSM following the framework of Núñez-Merino et al. (2022) and Garcia-Buendia et al. (2024) to map the literature on CDT strategies for mitigating FLW in AFSCs. As illustrated in Figure 1, selected articles will undergo text preprocessing using

Python and the Natural Language Toolkit (NLTK), and key terms will be extracted through a rule-based Named Entity Recognition (NER) model. We will then use sentence-BERT embeddings to calculate semantic similarities among documents. These similarities will be visualised through force-directed network graphs (e.g., ForceAtlas2) on Graphext (Núñez-Merino et al., 2022), which will help cluster the literature into thematic groups.

This SSM method will enable us to identify and refine key thematic clusters and emerging trends. The study adopts an organizing theoretical approach, developing a comprehensive taxonomy of CDT practices in FLW reduction. The contribution remains primarily classificatory, providing conceptual clarity for future theory development. Conference feedback will further refine this taxonomical framework before study completion.

Table 2: Keywords and Search Strings

Collaborative Digital Transformation AND	Food Loss and Waste AND	Agri-Food Supply Chain OR	Digital Transformation & Agri-Food Supply Chain
"Collaborative digital*"	"Food loss*"	"Agri-food supply chain*"	"Digital agricultur*"
"collaborat* digital transformation*"	"Food waste*"	"Agricultural supply chain*"	"Smart farm*"
"Digital collaboration*"	"FLW"	"Food supply chain*"	"Precision agricultur*"
"Digital integration*"	"Food loss and waste*"	"Farm supply chain*"	"IoT agricultur*"
"Digital ecosystem*"	"FLW reduction*"	"Rural supply chain*"	"Blockchain agricultur*"
"digit*"	"Food waste management*"	"Circular agricultur* supply chain*"	"Circular econom* agricultur*"
	"post-harvest loss*"	"Circular food supply chain*"	"Circular supply chain digital agricultur*"

Table 3: Inclusion/Exclusion Criteria

Inclusion	Exclusion
Studies covering digital transformation within AFSC/FSC for FLW mitigation. (e.g., blockchain, AI in mitigating FLW in AFSC/FSC.)	Papers outside of AFSC/FSC (e.g., unrelated supply chains, industries).
Research specifically addressing FLW reduction strategies within AFSC/FSC using CDT. (Mitigating FLW using digital platforms connecting farmers and end users or food sharing platforms)	AFSC/FSC papers without focus on digital transformation, stakeholders' collaboration, or aimed at reducing FLW.

Research on collaborative business models/strategies within AFSC/FSC to mitigate FLW. (E.g. CE Business Models, Sustainability Business Models, Stakeholders Collaboration)

Papers addressing FLW without focus on collaboration or digital transformations' roles.

Studies covering digital transformation within AFSC/FSC for collaborative practices. (e.g., technology for CE in AFSC)

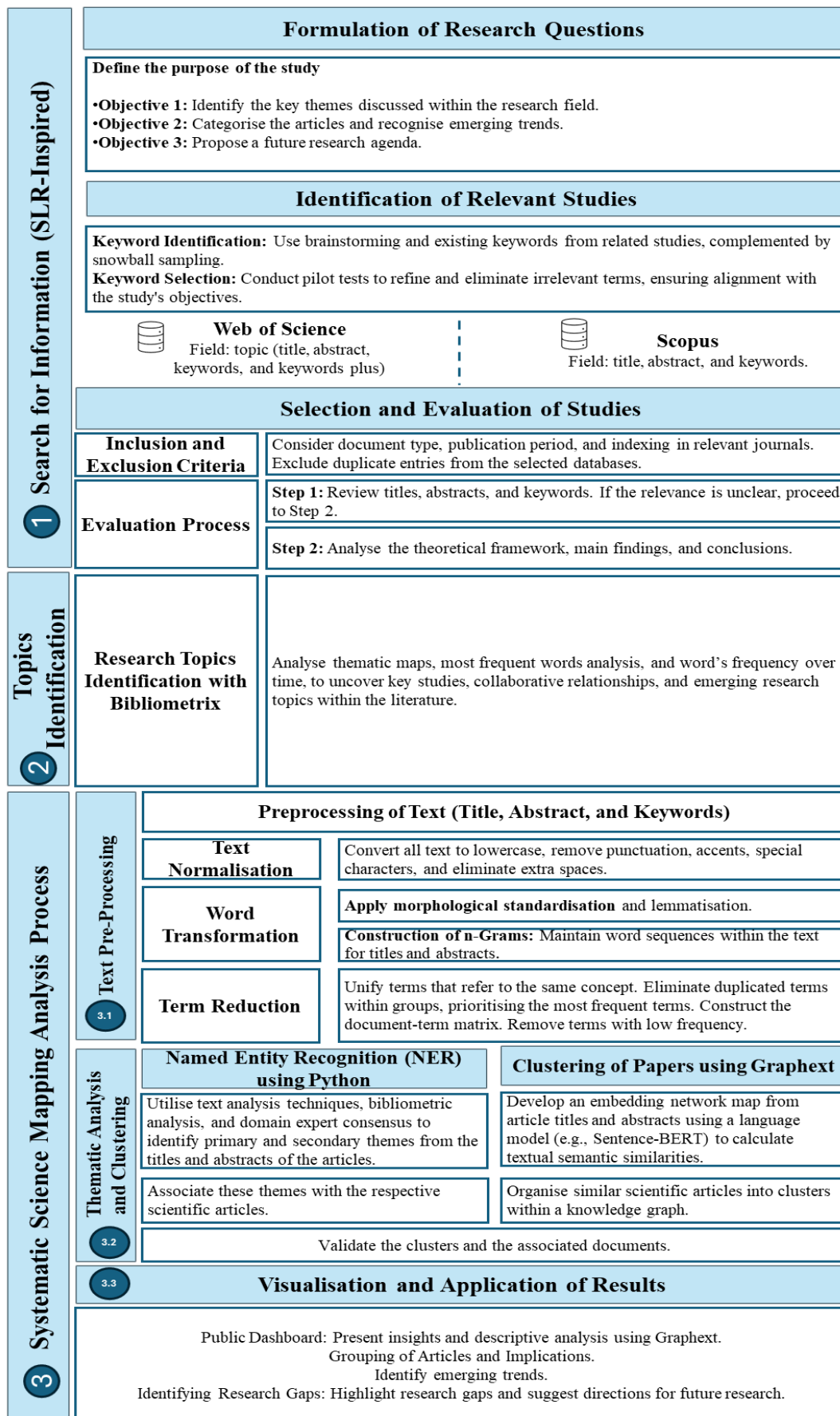


Figure 1: SSM Analysis Method Adapted from Núñez-Merino et al., (2022) and Garcia-Buendia et al. (2024)

Anticipated Results and Thematic Clusters

Preliminary semantic and bibliometric indicators suggest that our final analysis will likely yield several distinct thematic groupings, each highlighting a specific dimension of how CDT can mitigate FLW within AFSCs. We anticipate discovering a cluster focused on operational efficiency, underlining the role of advanced digital agricultural technologies (DATs) to streamline harvesting, cold chain management, and other postharvest operations (Kusumowardani et al., 2022; Nath et al., 2024). Another grouping is expected to emphasise proactive, tech-enabled solutions, featuring AI-driven algorithms and sensor-integrated packaging that identify early spoilage triggers (Ahmadzadeh et al., 2023; Liegeard and Manning, 2020).

Additionally, the analysis may reveal a community- and consumer-centric cluster centred on digital platforms (e.g., OLIO, Too Good to Go) that mobilise surplus-sharing or facilitate behaviour shifts in consumers (Zhao et al., 2023). A separate cluster will address collaborative barriers, examining how mistrust, fragmented data-sharing, and limited SME engagement affect digital solution uptake (Annosi et al., 2021; Freitas et al., 2024). Furthermore, there could be a group of studies exploring infrastructural frameworks for converting unavoidable food waste into valuable resources, leveraging CE models through processes such as anaerobic digestion or biochar production (Escudero-Curiel et al., 2023). Finally, an additional cluster may emerge around social media insights, focusing on how sentiment analysis, public discourse, and AI-based tools support real-time FLW mitigation strategies (Jenkins et al., 2022).

Each of these prospective clusters stands to reflect both bibliometric patterns and qualitative insights, aligning frequency-driven observations (e.g., rapid keyword growth) with interpretive analyses of existing case studies or theoretical frameworks (Khan et al., 2022; Babbitt et al., 2022). Feedback gained during the conference will guide further refinement, ultimately shaping a more cohesive understanding of CDT's capacity to reduce FLW at multiple stages of the agri-food supply chain.

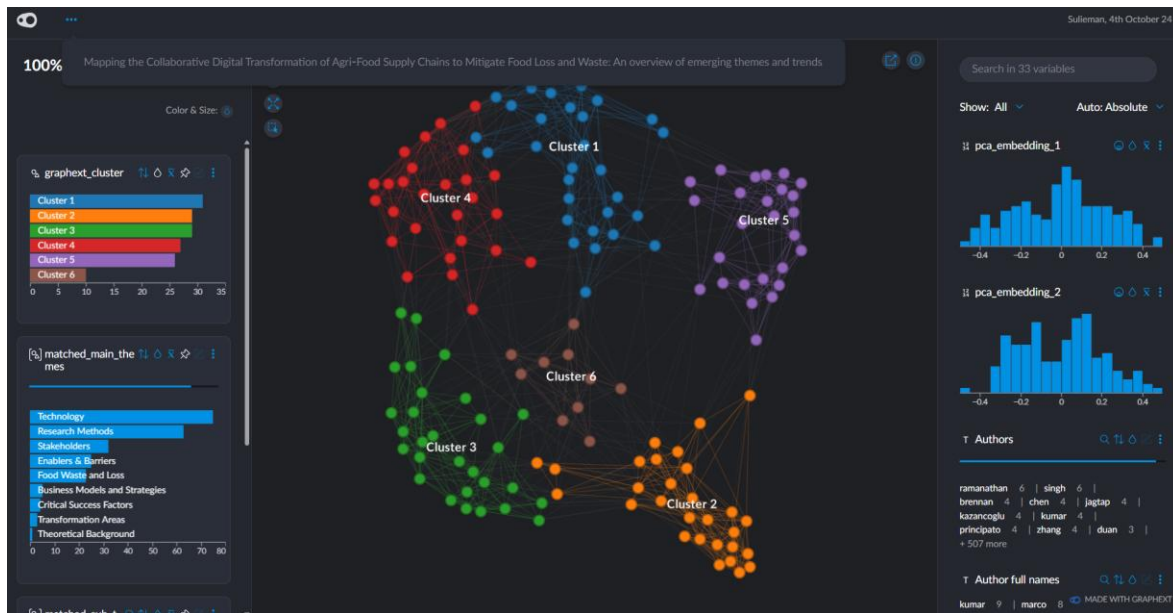


Figure 2: CDT in AFSC for FLW field. Available at:

https://public.graphext.com/13d2de5e6b86b869/index.html?section=graph&colorMap=graphext_cluster&areaMap=n

Discussion

Each anticipated cluster offers distinct managerial implications bridging academic insights with practical applications. Operational efficiency clusters guide strategic investment priorities in digital agricultural technologies, while proactive solution clusters provide frameworks for predictive analytics adoption. Consumer-centric clusters shape digital platform design decisions, collaborative barrier clusters highlight critical change management needs, infrastructural framework clusters direct circular economy investments, and social media insight clusters enable real-time response capabilities for supply chain disruptions.

The study's results are likely to show that the transformation of AFSCs will persist and gain momentum with more emphasis on new technologies and better engagement with various stakeholders. It is possible to expect that the use of IoT, blockchain, and AI-based data analytics will enhance supply chain transparency and efficiency and thus FLW reduction. However, the preliminary review of the literature reveals that there will still be major challenges, especially in the context of the fragmentation of the digital environment and the low participation of SMEs in the adoption of these technologies. In addition, given the digital platforms' potential to draw people in and shift their behaviour toward more sustainable consumption patterns, it is probable that we will find out that there are gaps in the integration of the platforms across all the stages of the supply chain. Our analysis will be to determine how more thorough digital solutions can provide for the easy exchange of information and real-time decision making. In the current study, from a theoretical perspective, we seek to extend the literature by creating a systematic framework that integrates various research findings into meaningful thematic clusters. In practice, we seek to offer specific recommendations for policy makers and practitioners who are interested in creating and implementing digital solutions that can improve the performance and sustainability of AFSCs.

Conclusion and Future Directions

This developmental paper establishes a foundation for CDT strategies in mitigating FLW through four key research directions:

Future Work Priorities:

- **Empirical Validation:** Collecting primary stakeholder data to validate thematic clusters and quantify digital intervention impacts on FLW reduction
- **Digital Platform Integration:** Exploring seamless collaboration mechanisms among producers, retailers, and consumers through case studies and pilot projects
- **SME-Focused Solutions:** Developing cost-effective, scalable digital solutions to enhance SME participation in collaborative initiatives
- **Policy Frameworks:** Examining regulatory roles in supporting digital transformation and sustainability adoption

Expected Contributions:

By integrating bibliometric, NLP, and clustering techniques, this study will identify six thematic clusters capturing digital transformation's current state in agri-food sectors. Anticipated findings will highlight digital technologies' potential for improving supply chain efficiency, enhancing stakeholder collaboration, and converting food waste into valuable resources. However, analysis is expected to reveal persistent barriers, particularly concerning SME adoption and digital platform integration.

Ongoing Development:

Future work will address these challenges while refining our comprehensive taxonomical framework for CDT in AFSCs. Conference feedback will prove instrumental in this iterative process, sharpening both taxonomy development and practical recommendations. This continuous refinement will contribute to ongoing discourse in eBusiness and Information Systems Management, ensuring our final paper delivers both academic insights and actionable solutions.

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