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Bridging Human-Centered Design and Digital Innovation in Agri-Food Supply Chain: A Bibliometric and Thematic Review

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Abstract

Purpose: This review explores the integration of human-centered design (HCD) and digital innovation within the agri-food supply chain (AFSC). It aims to clarify how technologies such as blockchain, AI, and the combination of Supply Chain 5.0 contribute to fostering a human-centric, sustainable, and adaptive AFSC.

Materials and Methods: A two-step bibliometric and thematic synthesis was applied. Drawing on over 600 articles retrieved from the Dimensions database and analyzed using Vosviewer, this map visualizes and illustrates keyword co-occurrence trends between 2013 and 2025. 31 articles were then selected based on their relevance to the study's propositions.

Findings: The review finds that while digital tools are crucial in addressing issues in agri-food systems and climate challenges, their success is dependent on how they effectively work with local capabilities, user-centered values, and within cultural contexts. The review identifies three major thematic domains: enabling digital technologies for HCD evolution, ethical and accessible-driven technological transformation, and bridging the operational gap in HCD within AFSC innovation.

Unique Contribution to Theory, Practice and Policy: The approach and application in this study present a novel perspective within the human-centered scope of the agri-food supply chain, suggesting a transition from technology-led innovation to socially responsive and regenerative practices.

Keywords: *Supply chain 5.0, Human-centric, Digital Innovation, Agri-food supply chain*

Subject Classification: *Supply Chain Management; Sustainability and Resilience; Human-Centered Design; Digital Innovation and Technology Integration; Agri-Food Systems.*

INTRODUCTION

Over the last decade, the supply chain has undergone a change, such as digital technologies, with the broader paradigm of supply chain 5.0 (SC 5.0) continuously redefining the operational and strategic scope of the agri-food supply chains (AFSC). Organizations operate within a fast-evolving technological context, where continual innovation challenges the long-standing operational and strategic models (Malacina & Teplov, 2022). Thus, like other areas of business, supply chain management has undergone transformations due to digital technologies. The emergence of digital innovation in the supply chain is driven by tools like artificial intelligence (AI), blockchain (BC), data analytics, robotic automation, and many more, which have considerably reshaped the traditional supply chain operations (Benatiya Andaloussi, 2024). These innovations have promising prospects such as efficiency, real-time responsiveness, and data-driven decision making across the agri-food supply chain functions (Das et al., 2023). However, as these technologies evolve, so too must the ways in which they engage with the actors that drive and sustain agri-food supply chain operations (Ghobakhloo et al., 2023; Silva et al., 2023; Malacina & Teplov, 2022).

The rise in digital technologies has made room for agri-food manufacturers and organizations to modernize their supply chain processes, which brings about better operational efficiency, improved efficiency, and better responsiveness to customers' needs (Benatiya Andaloussi, 2024). The agri-food supply chain is a sector that continually needs improvement, from the processors down to the end customers (Vasanthraj et al., 2023). Therefore, the supply chain influences a range of stakeholders, which includes the workers, communities, and the broader society. Within the context of digital transformation, the integration of human-centered design (HCD) helps ensure that technologies improve user experience, support worker engagement, and foster more adaptive systems across the supply chain (Pagell & Wilhelm, 2025). Within the agri-food sector, there is growing pressure for agri-food manufacturers to not only produce nutritious and safe food but also minimize the environmental impacts of the agri-food supply chain activity. Challenges such as water stress, soil degradation, and climate fluctuations strain the food systems globally. For example, plant diseases can reduce crop yields and threaten food security, especially in regions that are dependent on agricultural exports (Yap & Al-Mutairi, 2024). Addressing these issues requires innovative methods and technologies that can improve productivity while promoting long-term resilience in the agri-food supply chains (Yap & Al-Mutairi, 2024).

The AFSC is a complex chain that operates within a dynamic global environment shaped by various factors, including resource scarcity, climate change, and population growth (Vasanthraj et al., 2025; Singh et al., 2023). To mitigate these problems, digital technologies such as smart sensors, cobots, AI, blockchain, and automation have been developed to improve efficiency, sustainability, transparency, and collaboration in the AFSC. While technological advancements are currently being explored, there remains a significant gap in understanding how supply chain innovation integrates human-centred design (HCD) principles, such as system usability, personalization, and worker satisfaction, into its tools and frameworks. Most studies focus on technological capabilities, but only a few examine how such technologies align with HCD in digitally innovative agri-food supply chains. Thus, this review aims to examine how the synergy of human-centered design and technological innovation has continuously changed in the agri-food supply chain management literature. By conducting a combined bibliometric and thematic analysis, this research identifies key themes, conceptual trends, and influential works that define where this emerging area meets. The review not only maps the academic contribution but also offers theoretical insights and future research directions.

To support this study, the research draws on various frameworks that integrate technology and human-centered design. Specifically, the socio-technical systems theory (Trist & Bamforth, 1951; Bostrom & Heinen, 1977) and the human-centred design framework (Norman & Draper, 1986; Krippendorff, 2006) state that the integration of human and technology must continue to evolve to meet sustainable innovation. Within the AFSC, parties involved need to understand that digital transformation is not solely the advancement in technology but a socio-technical one, where usability, worker engagement, and specific adaptation determine the success of HCD integration (Ghobakhloo et al., 2023; Pagell & Wilhelm, 2025). With the use of the frameworks, the reviews position HCD as an important part of digital innovation, indicating a theoretical pathway for examining how human interaction, design, and technology shape the transformation of the AFSC.

The review not only maps the academic contribution but also offers theoretical insights and future research directions.

This review is structured around the following key propositions:

Proposition 1

The integration of human-centered design principles in the agri-food supply chain has evolved in response to the advancement of digital technologies such as AI, blockchain, and Supply Chain 5.0.

Proposition 2

The integration of human-centered design and digital innovation has led to the emergence of distinct thematic domains in the agri-food supply chain literature, such as worker-centric automation, inclusive digital transformation, and ethical technology use.

Proposition 3

There are conceptual and practical gaps in the current literature regarding the operationalization of human-centered innovation in digital and agri-food supply chains, particularly in relation to accessibility, agency, and long-term system usability.

Together, these propositions establish the conceptual ideas of this review and establish its focus on the growing role of technology and design in the AFSC. The next section details the methodological approach used to carry out both bibliometric and thematic analysis.

MATERAILS AND METHODS

This review employs a two-step approach, comprising a bibliometric analysis and a thematic synthesis. We used the SPAR-4-SLR protocol of Paul & Bresciani (2021). The protocol consists of four steps: Search, Evaluation, Synthesis, and Report, which guide the systematic organization of review studies to capture both the structural and conceptual evolution of research, integrating human-centered design and digital innovation in technology in the AFSC. In this review, a bibliometric analysis is conducted first to identify strong publications, author collaborations, and keyword patterns that have been used over time. Second, we conducted a thematic synthesis to extract and interpret conceptual themes from the literature. The two-step method provides both quantitative insights and qualitative depth into emerging thematic trends, enabling a more comprehensive understanding of how human-centered design and digital innovation are advancing in the AFSC.

To ensure continuity between the two approaches, the findings from the bibliometric method were not treated as a separate result but rather as a guideline for the thematic synthesis. The findings from the bibliometric analysis provided a foundation for the thematic synthesis.

Research domains and frequently used keywords were generated through VOSviewer as displayed in the cluster visualizations and co-occurrence maps. These maps and clusters highlighted research areas such as technology, digitalization, food security, industry, transition, blockchain, advanced technology, and more, which informed the thematic synthesis and coding categories in the next phase. We selected 31 papers in the synthesis to ensure we covered the identified clusters. This method allowed the thematic synthesis to build upon the bibliometric findings, ensuring accurate interpretations.

The papers were identified and selected using the SPAR-4-SLR screening process and selected according to their relevance to the study's focus on digital innovation and HCD in the AFSC. We applied a deductive coding approach using predefined thematic categories that align with the study's propositions, and ensured coding consistency through repeated review and cross-validation. While this review provides a comprehensive synthesis of how digital innovation and HCD connect in the AFSC, there are certain limitations to be acknowledged. The search process was limited to only peer-reviewed journal articles retrieved via the Dimensions database, which may not capture all relevant studies available in other databases. To minimize selection bias, the review adhered to the SPAR-4-SLR protocol, which included clear inclusion and exclusion criteria to guide each stage of the review. The thematic synthesis employed transparent coding procedures with detailed coding criteria, as outlined in Table 2. The findings were cross-checked to minimize subjective interpretation. Nevertheless, future research can expand the database sources to SCOPUS, Web of Science, and many others. Apply another method of coding techniques and examine new perspectives on AFSC research.

Bibliometric Analysis

To meet the required structure and academic scholarly development of research bridging human-centered design and digital innovation in the AFSC, a bibliometric analysis was carried out. This approach allows for identifying top journals that contributed to the field and collaborative works through a quantitative examination of academic papers and conceptual trends (Donthu et al., 2021; Aria & Cuccurullo, 2017). The dataset was retrieved using Dimensions, an open-access academic database compatible with VOSviewer. A combination of keywords such as "agri-food supply chain", "human-centered design", "digital innovation", "artificial intelligence", "blockchain", and "supply chain 5.0" was applied in the search, which was limited to peer-reviewed journal articles published between 2013 and 2025.

Approximately 620 relevant articles were identified for the bibliometric analysis. The bibliographic data was exported in .csv format, and analysis was conducted using the VOSviewer (Van Eck & Waltman, 2010), which facilitated the visualization of keyword pairings, citation differences, and author collaborations. A threshold was used to filter frequently occurring keywords and highly cited documents, highlighting the dominant research clusters and emerging themes in the field (D'Angelo & Belvedere, 2023). Figure 1 illustrates the flowchart for the bibliometric and thematic synthesis analysis. The analysis also pinpointed the overlaps between digital and green supply chain innovation (Lam et al., 2023) and further identified how bibliometric tools have been employed to structure research in evolving domains, such as sustainability and digital twin integration. This review phase sets the groundwork for a deeper thematic synthesis by revealing knowledge patterns and gaps in the current literature (Donthu et al., 2021; Aria & Cuccurullo, 2017).

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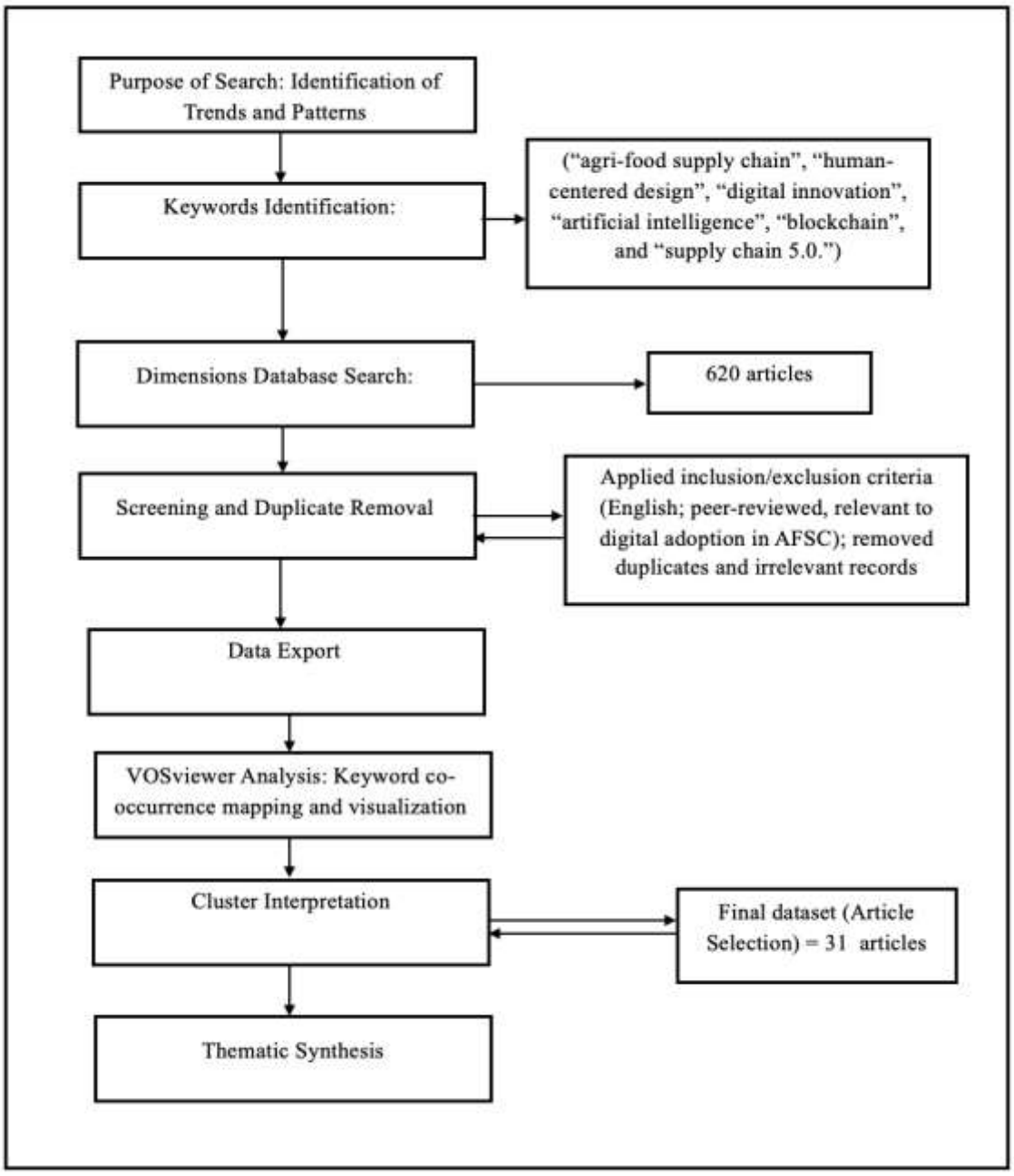

Figure 1: SPAR-4-SLR flowchart of the review process

Source: Authors own work

To understand the research aim, a bibliometric analysis was conducted using data from Dimensions, which is an open-access research database that works well with VOSviewer. We retrieved a total of 620 articles based on the research string we provided: "agri-food supply chain", "human-centered design", "digital innovation", "artificial intelligence", "blockchain", and "supply chain 5.0." The publication period was set from 2013 to 2025 to ensure the data captured past, recent advancements, and trends. The dataset was exported in .csv format, which is suitable for bibliometric mapping, and imported into the VOSviewer (version 1.6.20). We first performed a co-occurrence analysis to examine the frequency and relationship of the keywords within the dataset. This method helps visualize the field's structure by identifying collaborative networks, dominant themes, and recent trends among

authors (Donthu et al., 2021; Verma & Gustafsson, 2020). We applied the full counting, which had 14,082 terms; however, with a minimum occurrence threshold of 10, a total of 409 keywords met the criteria, from which 60% of the most relevant terms (245) were selected for the final map.

VOSviewer then generated a visual network of keyword relationships, representing grouping into clusters based on term co-occurrence. Each cluster then represents a thematic area across the research field. Figure 2 presents the keyword co-occurrence network, showing the connections between key themes such as technology (AI, blockchain), Industry (supply chain 5.0), food, year, region, digitalization, and many more. To complement this, Figure 3 shows an overlay visualization pinpointing how interest in different terms is recent, on the other hand, Figure 4 displays a density map presenting the area with the highest term concentration and researchers' activity. These maps enable researchers to identify well-established emerging areas of interest.

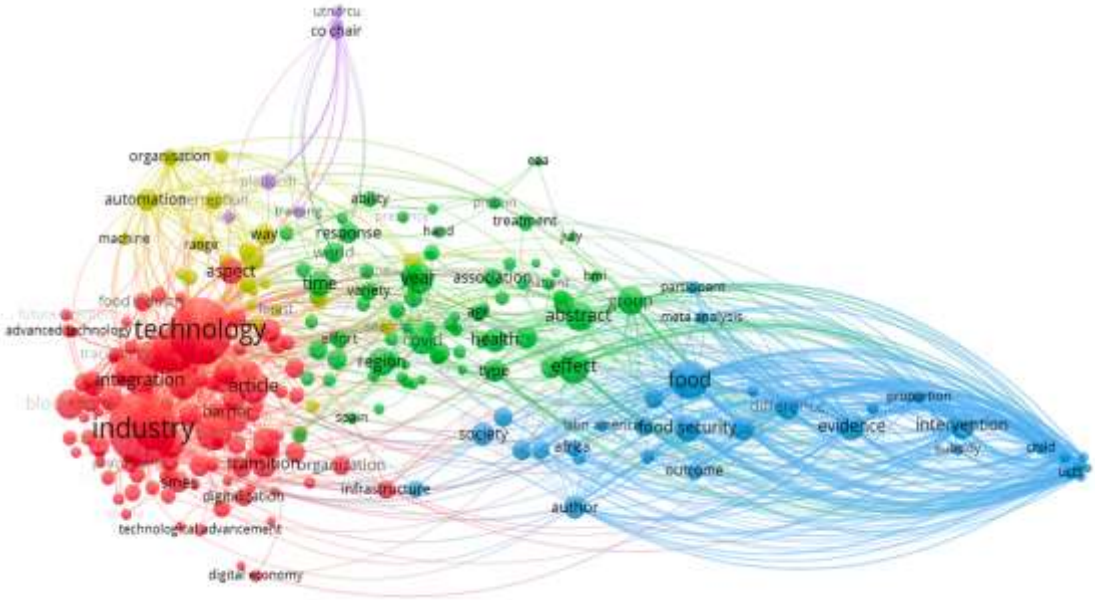

Figure 2: Keyword co-occurrence map

Source: Authors own work

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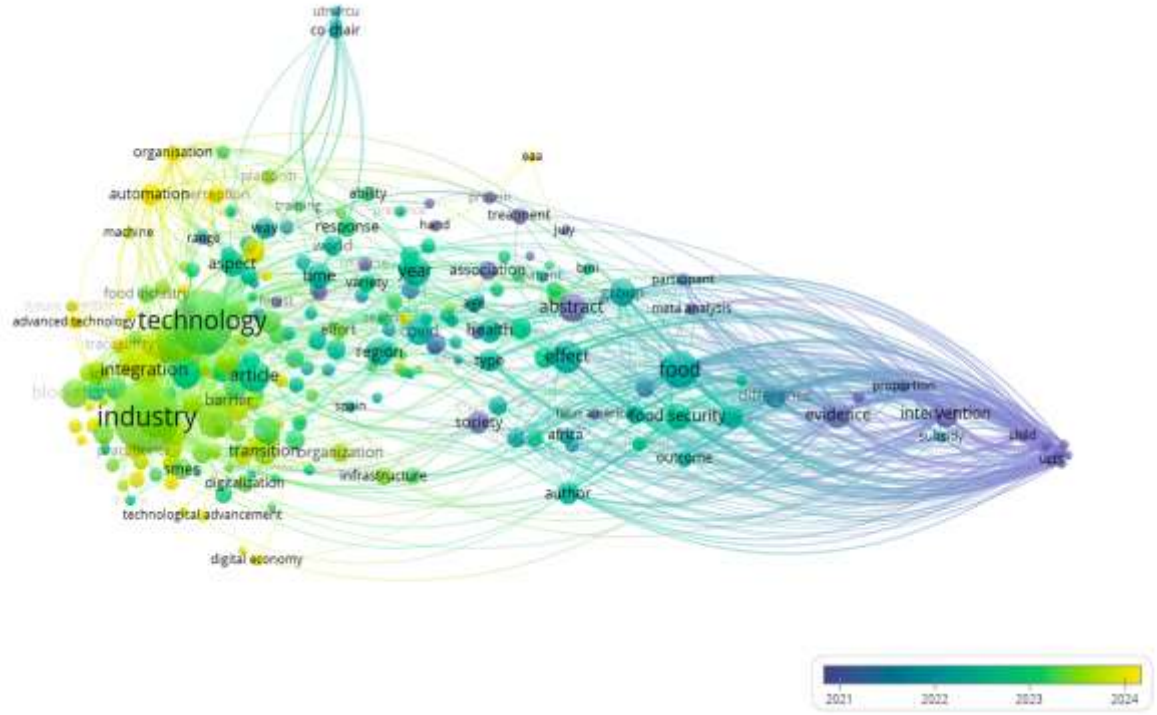

Figure 3: Overlay visualization of keyword trends

Source: Authors own work.

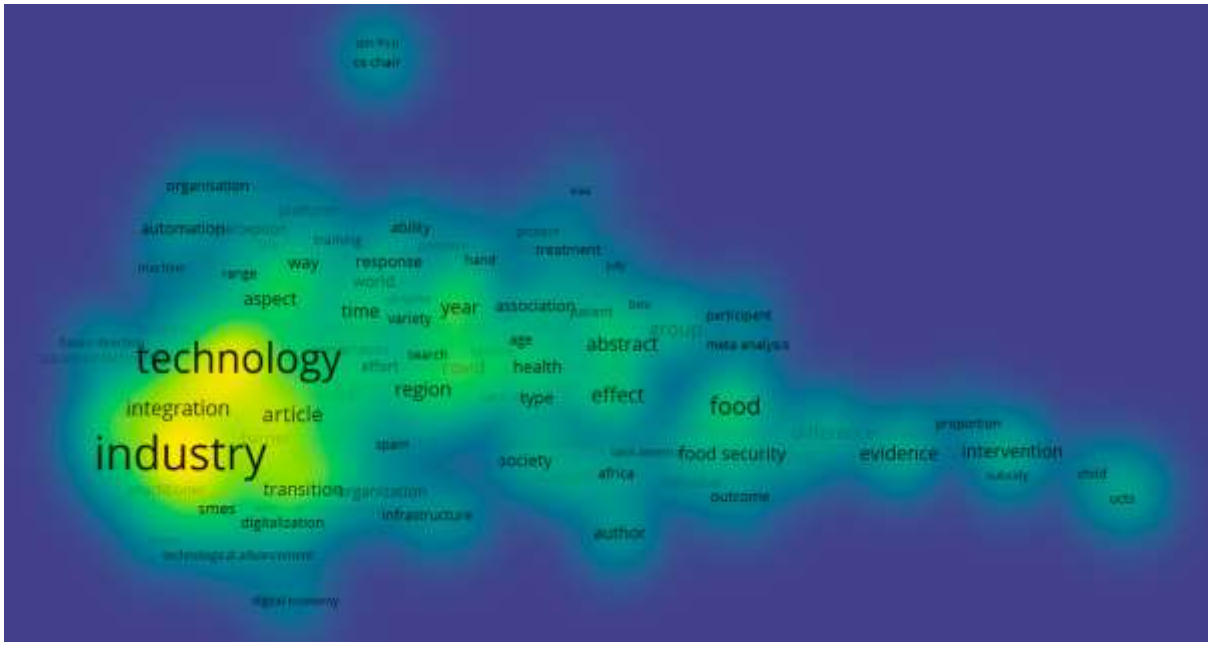

Figure 4: Density visualization of keyword frequency

Source: Authors own work.

As shown in the visualization, keywords that are related to human-centered design and regenerative practices are peaking in interest recently, as shown in the overlay visualization. The clustered patterns also highlight the recent interest and academic work around technological innovation in the agri-food supply chain, and they are interrelated with traceability, sustainability, and supply chain 5.0 (de Carvalho et al., 2022; Pandey et al., 2024;

Yadav et al., 2024). The analysis generated 5 clusters, each representing a unique yet linked research domain.

Cluster 1: Technological Integration and Digitalization (Red 113 items)

This dominant cluster captures the frequent terms such as industry, technology, integration, digitalization, practitioner, technological advancement, digital economy, and more. As shown visibly in the density visualization (Figure 3), this cluster shows to have the highest term concentration, meaning that the digital transformation of industry, especially through AI, blockchain, and many other interesting technologies, has been of central focus. The overlay map further suggests that this trend gained interest and speed between 2022 and 2023.

Cluster 2: Health and Regional Development (Green 71 items)

This cluster links keywords such as health, region, year, COVID, time, variety, response, effort, ability, and more, as seen in Figure 3. Indicating studies that address public health issues, often in connection with demographic, regional, or pandemic-related variables. The overlay visualization shows a minimal recent interest, with research activity making waves around 2021 and 2022. This possibly means that the interest in pandemic-related research has slowed down.

Cluster 3: Food Security and Sustainability (Blue 32 items)

Terms such as food, food security, outcome, individual, support, Latin America, and Africa are frequent here in Figure 4. This area highlights the growing academic attention towards sustainable food systems and socio-political interventions, especially in the global south. The overlay map shows a recent research activity (2023 to 2024), highlighting it as an emerging research interest.

Cluster 4: Organizational Learning and Perception (Yellow 23 items)

A small yet distinct cluster that includes terms like organization, way, range, machine, automation, perception, and more, indicating a focus on the human-centric aspects of the adoption of technology, especially in organizations, as shown in Figures 2 and 3. This research activity was moderately distributed over time, with a visible connection between clusters 1 and 2.

Cluster 5: Research Methodology and Meta-analysis (Purple 6 items)

Represented by nodes such as co-chair, number, interaction, sample, and meta-analysis, this cluster pinpoints the methodological papers and systematic reviews. Though smaller in size and impact, its presence highlights the methods used in the field and can be found in Figures 2 through 4 (Fattahi & Govindan, 2022; Zhao et al., 2024; Kazancoglu et al., 2023).

Beyond identifying the clusters, the co-occurrence analysis provided an in-depth insight into the research stream and structure. It revealed how frequently certain keywords form linkages, indicating not only growing research interests, such as sustainability and technology adoption, but also emerging and less connected topics, including human-centered and inclusive design, and digital ethics. The co-occurrence maps provided more than visual summaries, but served as a guide to determine emerging themes, conceptual gaps, and the growing research areas in the AFSC literature.

Thematic synthesis

This section presents a thematic synthesis of 31 scholarly papers, based on which three specific themes emerged that align with the study's propositions. These themes highlight core aspects of digital innovation, human-centered transformation, and transition within the agri-

food supply chain. Table 1 provides a summary of the thematic synthesis, presenting the theme and relevance to the propositions, and how often it appeared across the coded literature. An overlap between propositions 1 and 2 appeared in two studies, which adds an interesting pattern and depth to the thematic synthesis.

Table 1: Theme Mapping Summary

Theme Code	Relevance to Propsitions	Counts
Enabling digital technologies for HCD evolution.	Proposition 1	10
Ethical and accessible-driven technological transformation.	Proposition 2	7
Enabling digital technologies for HCD evolution/ Ethical and accessible-driven technological transformation.	Proposition 1 and 2	2
Bridging the operational gap in HCD within AFSC innovation.	Proposition 3	12

Source: Author's own work

The following subsections present the identified themes. These thematic domains are interpreted in relation to each corresponding proposition to pinpoint how HCD, digital innovation, and ethical technological transformation connect across the AFSC.

Theme 1: Enabling Digital Technologies for HCD Evolution

This theme addresses the enabling of digital technologies such as AI, blockchain, IoT, cobots, robotics, and digital twins that are actively reshaping the AFSC by supporting and creating awareness of the necessity for HCD. Ten papers coded under this theme laid emphasis on the strategic implementation and operational adoption of such technologies to improve operational performance while considering the interests of human-centricity, usability, access, and interaction. For example, (Hassoun et al., 2024; Charles et al., 2023), these authors highlighted the importance of accessible, integrative, and adaptive systems that boost user autonomy and system reliability, which aligns with Proposition 1 on enabling HCD evolution through digital integration. Another example, Arif et al. (2024), explored how blockchain, big data, AI, IoT, and cloud computing can reduce carbon footprints in the agricultural supply chains, emphasizing the need to address global challenges such as food demand and climate change. The authors studied food safety, decision-making, traceability, food waste reduction, information, and security systems. Similarly, Haloui et al. (2024) highlighted digital transformation in agriculture, such as AI, IoT, robotics, which ties industry 5.0, advocating for solutions that prioritize smart and sustainable agriculture, which are part of the key factors of HCD. Together, these works underline the integration of digital innovation and the HCD principles, setting the foundation for a better, responsive, human-centered, and scalable technological future for the AFSCs.

Theme 2: Ethical and Accessible-Driven Technological Transformation

Theme 2 emphasizes the ethical, accessible, and socially responsive dimensions of the technological transformation in the AFSC. This theme supports proposition 2, which focuses on a vision that is accessible and socially acceptable innovation. The seven papers that are grouped under this theme highlight how emerging technologies must be shaped and serve values such as access, trust, fairness, and user protection to make sure these technologies

truly aid the needs of the community rather than just advance operational capability. From the identified papers, a recurring focus across these is the importance of people-oriented digitalization and stakeholder involvement. For example, Adel (2022) examined the transition from Industry 4.0 to 5.0, pinpointing how the industrial paradigm shifts focus from mainly technological advances to human-machine collaboration. In a different context, Liu et al. (2024) addressed the transformation of the intelligent manufacturing framework and its implications for sustainable development for enabling improved social benefits and public services.

Samuels (2025) explored the use of AI and how it transforms the supply chains during the shift from Industry 4.0 to 6.0 as AI supports resilience and operational efficiency, while promoting sustainability through the optimum utilization of resources. The author also emphasized the skills gap and issues of cybersecurity. Moreover, the EU-funded SESTOSENSO project (Pietrantoni et al., 2024) offered a mixed methods approach on how collaborative cobots, vehicle assembly, and agriculture, warehouse logistics should be designed to align with user-friendly design, workforce training for effective human-centered cobot adoption, as well as tailored safety standards. Notably, the 2021 paper by Mondejar et al., though a bit outside the primary date range of 2022 to 2025, was retained due to its key contribution. The paper highlights digitalization as a comprehensive approach to addressing climate change challenges while advocating for social and environmental well-being, justifying its inclusion under this theme. In summary, the theme reflects a shift from technological focus to accessibility, user protection, human-centricity, and the goals that shape the success and sustainability of digital innovations in the AFSC.

Theme 3: Bridging the Operational Gap in HCD within AFSC Innovation

This theme aligns with proposition 3, which focuses on bridging the operational gap in HCD in AFSC digital innovation by overcoming structural and operational barriers. A total of 12 papers were coded under this theme to highlight the skills gaps, limited infrastructure, especially in emerging economies, accessible innovation frameworks, institutional limitations, consumer perceptions and usability, and many more to become applicable in real-world AFSC contexts. Several studies emphasized design issues at the system level. For example, Ahmad et al. (2024) examined the importance of AI in improving food security, especially in emerging and underdeveloped countries. The authors highlighted the increasing use of AI in the AFSC, such as monitoring the crops, disease detection, and supply chain optimization. Although AI has shown promising support in the UN's Goal 2 of zero hunger, there are still challenges faced by developing and underdeveloped countries like limited infrastructure, economic disparities, dynamic global policy, data access, and more are thus hindering the widespread adoption of AI in the AFSC (Ahmad et al., 2024). Similarly, Mahroof et al. (2023) reported the need to create awareness either through campaigns or training, which will transfer knowledge to improve the adoption of wider benefits of sustainability. The authors further extended a sustainability model to show how the use of drone technology can support system-level clean production in emerging countries. Costa et al. (2023) also emphasized the barriers faced by emerging countries in terms of technology utilization within the AFSC, such as economic, governmental, and technological, and cultural barriers, where limited government aid and the dynamic restricted market access are the key factors.

Importantly, operational readiness, not just having the technology available, has been identified as a concern. Papers such as Ahmed et al. (2025) and Dibbern et al. (2025) highlighted the issues faced by digital agriculture, like data compatibility, costs, energy use, and the literature gap concerning objective indicators to measure the adoption of digital use

without producer bias. These findings thus suggest HCD relevance and adaptive co-design, where designs should be realistic and not just innovations made out of centralized decision-making. This theme also identified studies that addressed the transition from theory to implementation. For example, Velasco-Muñoz et al. (2022) find that the circular economy in agriculture is new but slowly getting attention. However, most studies focus on environmental factors, leaving a major gap in understanding other aspects, such as the economic and social dimensions, especially financially, availability, and stakeholder perceptions, while Yaqub et al. (2023) identified the challenges when it comes to adopting the digital transformation brought about by Industry 4.0 for effective implementation, empahsizing how digital transformation can reshape processes, business models and governance.

This theme highlights the need to bridge operational gaps through stakeholder involvement, and human-centric design practices are important to improving HCD principles into a meaningful digital innovation transformation in the AFSC. Table 2 provides a detailed summary of the selected papers applied in the thematic synthesis. Together, the three thematic domains offer broader insights into how digital innovation and human-centered design overlap within the AFSC. The findings indicate that HCD in digital agri-food supply chains is transitioning from a complete technical process to a socially inclusive innovation style. This transition underscores the importance of implementing human-technology collaboration, as the success of human-centered design hinges on integrating human values. The findings thus strengthen HCD theory by revealing how inclusivity, worker welfare, participation, and usability shape adaptive innovation and sustainability in the AFSC.

Table 2: Thematic Synthesis of Selected Papers on HCD and Digital Innovation in the AFSC

Author	Techonology	Theme Code	Propositions	HCD Relevance	Findings
(Hassoun et al., 2024)	AI, IoE, 4D printing, cobots and digital twins, blockchain, advanced drones, edge computing, metaverse.	Enabling Digital Technologies for HCD Evolution/ Ethical and Accessible-Driven Technological Transformation.	1 and 2	Holistic approach (Industry 5.0), technology enablers, and potential future applications.	The authors find that the technological shift is a step by step process, rather than a sudden transition, however the AFSC just recently started adopting these innovations.
(Charles et al., 2023)	AI, blockchain.	Enabling Digital Technologies for HCD Evolution.	1	_	The findings revealed that the integration of AI and blockchain contributes both practically and emprically to suppy chain innovations.
(Hassoun et al., 2024)	AI, blockchain, IoT, big data analytics, robotics.	Enabling Digital Technologies for HCD Evolution.	1	Climate, waste, pandemics.	The findings indicate that these I4.0 innovations have reshaped food prouction and consumption, setting the path for transition to I5.0
(Arif et al., 2024)	AI, blockchain, IoT, big data analytics.	Enabling Digital Technologies for HCD Evolution.	1	_	The findings grouped ICT applications into five areas: food safety and monitoring, waste reduction, security and information systems, traceability, and decision-making in the agribusiness.
(Adel, 2022)	data analytics, IoT, collaborative robots, blockchain, digital twins and future 6G systems.	Ethical and Accessible-Driven Technological Transformation.	2	Improve customer satisfcation, personalization.	The findings indicate that The industrial revolution is boosting customer satisfaction by personalization. I5.0 is necessary for gaining competitive advantage and also economic growth for factories.
(Ahmad et al., 2024)	AI.	Bridging the operational gap in HCD in AFSC	3	Empowerment in AI adoption for agri-food.	The paper proposes the need to bridge digital limitation

		innovation.			and AI solutions to improve agricultural productivity and sustainbility especially in emerging economies.
(Liu et al., 2024)	Intelligent manufacturing.	Ethical and Accessible-Driven Technological Transformation.	2	Societal impacts, stakeholder inovelvement, public service improvement.	The paper discusses the need for decision-makers to improve social, economic, and environmental sustainability through intelligent manufacturing.
(Samuels, 2025)	AI.	Ethical and Accessible-Driven Technological Transformation.	2	Balanced technology ethic, Human-AI collaboration.	The authors highlighted the importance of AI such as resilience, operational efficiency, while advocating for sustainbility. Howver there are still skill gaps and cybersecurity challenges.
(Brennan, 2024)	_	Bridging the operational gap in HCD in AFSC innovation.	3	Consumer perception and usability.	The paper positioned innovation as an important tool for acheieving global health and sustainbility goals through better food production systems.
(Pietrantoni et al., 2024)	Collaborative robots (cobots).	Ethical and Accessible-Driven Technological Transformation.	2	Safe human-robot interaction.	The study emphasizes the importance of user-friendly design, saftey measures and effective traning of workfoce in agriculture.
(Mansilla-Obando et al., 2023)	_	Bridging the operational gap in HCD in AFSC innovation.	3	User engagement, perception.	The study empahsizes the role of consumer perception and behvior towards the promotion of eco-innovation in the food industry within emerging markets.
(Mondejar et al., 2021).	IoT, big data, smart systems.	Ethical and Accessible-Driven	2	Health equity, environemtal well-being with	The authors presents digitalization as a

		Technological Transformation.		people in mind.	solution to solving climate change crisi while improving social and enviromental situation.
(Singh et al., 2025)	AI, IoT, big data, robotics, blockchain, digital twins.	Ethical and Accessible-Driven Technological Transformation.	2	Personalized solutions, consumer engagement, Human-machine collaboration.	The findings indicate that industry 5.0 holds a promising solution to advancing resilient, eco-friendly, personalized food systems.
(Panigrahi et al., 2025)	_	Bridging the operational gap in HCD in AFSC innovation.	3	_	The review paper found several key factors such as digitalization in food supply chain, circular economy, sustainability, food waste with SCM, food security with climate change are opportunities for the adoption of digitalization and sustainbility in the AFSC.
(Tombe & Smuts, 2023)	_	Bridging the operational gap in HCD in AFSC innovation.	3	Inclusive digital economy, sustainable social agriculture.	The paper offers a framework for agri-food stakeholders, policy makers an undertsanding of the technological capabilities to sustain communities through digitalized agricultural value chains.
(Apeh & Nwulu, 2025)	Blockchain	Enabling Digital Technologies for HCD Evolution.	1	Traceability, transparency, trust.	The paper offers a comprehensive understanding of how to strengthen blockchain's integration for a better sustainable agri-food sector.
(Villar et al., 2023)	_	Enabling Digital Technologies for HCD Evolution.	1	Supply chain 5.0, optimization and resilience through human-machine collaboration.	The study emphasizes how Industry 5.0 supports a human-centric supply chain, resilience and optimization that promotes improves

					disruptions and competitvness.
(Rogers & Dora, 2024)	AI, IoT, blockchain, drones, and digital platforms.	Ethical and Accessible-Driven Technological Transformation.	2	Ethical values, Social inclusion, Workers training.	The paper addressed the need for urgent transofrmations in global food systems which arises from food waste, obesity, undernourishment.
(Trabelsi et al., 2023).	AI	Enabling Digital Technologies for HCD Evolution.	1	Huamn-centred design principles	The paper provides a dual role of AI and offers a foundation for the practical innovation in the AFSC.
(Garrido et al., 2024)	IoT and big data	Bridging the operational gap in HCD in AFSC innovation.	3	Human-centred research as underexplored.	The paper identifies that Industry 4.0 is heavily studied with a limited work on Industry 5.0.
(Mahroof et al., 2024)	I5.0 drones	Bridging the operational gap in HCD in AFSC innovation.	3	Perceptions, worker health and safety, stakeholder intentions.	The study advocates for a need for knowledge transfer and awareness to advance drone adoption for sustainablity benefits and how the drone technology can support clean production in emerging economies.
(Haloui et al., 2024)	AI, robotics, IoT	Enabling Digital Technologies for HCD Evolution.	1	Automation designed with long-term human use and adapatbility.	The authors comapred the impact of Industry 4.0 and 5.0 in agriculture and global smart startegies.
(Holzinger et al., 2024)	AI	Enabling Digital Technologies for HCD Evolution.	1	Human invovlement, adaptability, accessibility.	The authors provides a framework that intergrates human capabilities with AI to ensure the systems are accessible and adatable to real farming needs.
(Rejeb et al., 2025)	_	Enabling Digital Technologies for HCD Evolution.	1	Human-centric systems.	The authors proposed that research should align technology with socio-economic goals

					which can open a pathway for an inclusive sustainable industrial practices.
(Yaqub & Alsabban, 2023)	_	Bridging the operational gap in HCD in AFSC innovation.	3	_	The review emphasizes how Industry 4.0 serves as an important driver and enabler for digitali transformation in businesses.
(Costa et al., 2023)	Drones, IoT sensors, cloud computing, and big data analytics.	Bridging the operational gap in HCD in AFSC innovation.	3	Social impact, tailored technology.	The authors discussed the barriers hindering the adoption of Industry 4.0 technologies in agriculture in an emerging economy such as cultural barriers, limitd governmental support, and resticted market.
(Yadav et al., 2023)	Blockchain and 6G.	Enabling Digital Technologies for HCD Evolution.	1	Safer and truthworthy systems.	The aunthors points that the integration of blockchain and 6G technology as solution to security and reliability in industruial automation.
(Fraga-Lamas et al., 2024)	Blockchain.	Enabling Digital Technologies for HCD Evolution/ Ethical and Accessible-Driven Technological Transformation.	1 and 2	Human-centricity, worker-well-being and resilience.	The review paper profers a guide to the use of blockchain in building human-centered resilient and sustainable industrial solutions.
(Ahmed & Shakoor, 2025)	IoT, Big Data, and AI.	Bridging the operational gap in HCD in AFSC innovation.	3	User-oriented systems, environrmental sustainability.	The reviews empahsizes how AI, IoT, big data can can be integrated to reduce and monitor carbon emissions, sustainable farming in the AFSC.
(Dibbern et al., 2024)	_	Bridging the operational gap in HCD in AFSC innovation.	3	Technology access, user skill.	The findings provides a guide for policymakers in creating a targeted strategy to boost the adoption of digital agriculture.
(Velasco-	_	Bridging the	3	Stakeholder	The paper finds that

Muñoz et al., 2022)	operational gap in HCD in AFSC innovation.	perception, social factors in CE adoption.	the research on CE in agriculture is rapidly gaining research interest.

Source(s): Authors own work

Discussion and Implications

The aim of this review is to synthesize how human-centered design principles can work with emerging or already existing technological transformations in the agri-food supply chain, guided by three propositions. We started by conducting a bibliometric analysis, applying vital keywords to access target papers, which resulted in 620 papers, exceeding our target goal of 300 to 500 papers, making the review robust. For the thematic synthesis, we carefully selected and coded 31 peer-reviewed studies spanning from 2021 to 2025. The analysis offers a comprehensive understanding of the continuously growing role of digital technologies and human values in defining a resilient, sustainable, and efficient agri-food system.

Theoretical Implications

This review contributes to the theory by advancing the ongoing discussion on human-centred innovation in the AFSC contexts through the perspective of HCD, digital transformation, and sustainability frameworks. Across all three thematic domains, our findings align with the synergetic role of HCD in bridging the gap between stakeholder involvement, needs, and technological capabilities, especially in a resource-constrained environment and emerging economies (Charles et al., 2023; Hassoun et al., 2023; Brennan, 2024; Mansilla-Obando et al., 2023). First, the review supports the notion that digital technologies, such as AI, IoT, blockchain, and robotics, are viewed as enablers of HCD evolution, rather than replacements for human inputs. This aligns with proposition 1 and is supported by various studies (Pietrantoni et al., 2024; Villar et al., 2023; Trabelsi et al., 2023; Holzinger et al., 2024), which show that these technologies are currently being designed to meet ethical use and user accessibility. This transition marks an important progression from Industry 4.0's efficiency-oriented paradigm to Industry 5.0's human-centric mission (Zekhnini et al., 2024; Singh & Cohen, 2025).

Second, the review pinpoints how ethically and socially responsive technology adoption supports not only operational efficiency and production goals but also well-being, stakeholder trust, supplier relationships and partnerships, accessibility, and inclusivity (Rogers & Dora, 2024; Singh et al., 2025). The emerging research stream highlights a growing interest and commitment to designing systems and processes that respond to local values and visions, reduce exclusion, and emphasize social impact. Finally, the review contributes to the circular economy and supply chain resilience by indicating how HCD can address the long-standing operational challenges and constraints in the AFSC. Several studies (Garrido et al., 2024; Mahroof et al., 2024) highlight that integrating digital technologies supports an adaptive, transparent AFSC.

Practical Implications

From a practical lens, this review provides actionable pathways for stakeholders in agri-food supply chain innovation. First, the development of technology should implement a process that allows for usability, co-design, and an affordable platform, especially in the context of emerging economies where resources are constrained and the digital divide is still a barrier (Costa et al., 2023; Dibbern et al., 2024). Second, there should be a policy in place to bridge the adoption of technology and inclusive governance structures that will create awareness

among the local communities and improve stakeholder collaborations (Khan et al., 2023). Finally, agri-food manufacturers and SMEs can leverage the use of HCD models to monitor and improve knowledge, enabling a responsive and socially integrated system.

CONCLUSION AND RECOMMENDATIONS

Conclusion

While this review drew from over 600 articles for its bibliography and key findings across 31 studies, several limitations are acknowledged. Some articles were drawn from abstracts due to access limitations, which may not have given the depth of their methodology insights. Additionally, while the thematic synthesis was done manually and rigorously, there are overlaps between propositions 1 and 2, which may open up a discussion on how the synthesis is viewed. Future research can build on this study by carrying out a cross-case comparison, validating the identified themes through empirical studies, and exploring the challenges, barriers of implementing HCD in a resource-limited environment, as well as resilience and userability in the digital AFSC transition. Expanding the study to underrepresented regions to understand the role and behavioral responses of local farmers would enhance the generalizability of the topic.

This review provides a comprehensive bibliography and thematic synthesis examining how digital innovation and human-centered design applications shape the current and future state of agri-food supply chains. The findings reveal how enabling technologies such as AI, IoT, blockchain, cobots, robotics, digital twins, and many more are reshaping food systems not only in the operational aspects but also in establishing values like social responsiveness, collaboration, and sustainability. Importantly, the review highlights that while digital tools are essential in addressing issues in agri-food systems and climate challenges, their success is dependent on how they properly work with local capabilities, user-centered values, and within cultural contexts. This suggests a transition from technology-led innovation to socially and regenerative practices. More importantly, this review contributes to emerging research on building a better, resilient, yet digitally advanced agri-food supply chain system that is focused on the realities of the agri-food personnel.

REFERENCES

Adel, A., 2022. Future of industry 5.0 in society: human-centric solutions, challenges and prospective research areas. *Journal of Cloud Computing*, *11*(1), p.40.

Ahmad, A., Liew, A.X., Venturini, F., Kalogeras, A., Candiani, A., Di Benedetto, G., Ajibola, S., Cartujo, P., Romero, P., Lykoudi, A. and De Grandis, M.M., 2024. AI can empower agriculture for global food security: challenges and prospects in developing nations. *Frontiers in artificial intelligence*, *7*, p.1328530.

Ahmed, N. and Shakoor, N., 2025. Advancing agriculture through IoT, Big Data, and AI: a review of smart technologies enabling sustainability. *Smart Agricultural Technology*, p.100848.

Apeh, O.O. and Nwulu, N.I., 2025. Improving traceability and sustainability in the agri-food industry through blockchain technology: A bibliometric approach, benefits and challenges. *Energy Nexus*, *17*, p.100388.

Aria, M. and Cuccurullo, C., 2017. bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of informetrics*, *11*(4), pp.959-975.

Arif, J., Samadhiya, A., Naz, F. and Kumar, A., 2024. Exploring the application of ICTs in decarbonizing the agriculture supply chain: A literature review and research agenda. *Heliyon*, *10*(8).

Benatiya Andaloussi, M., 2024. A bibliometric literature review of digital supply chain: Trends, insights, and future directions. *Sage Open*, *14*(2), p.21582440241240340.

Bostrom, R., & Heinen, J. (1976). *MIS problems and failures: A Socio-technical Perspective*.

Brennan, C.S., 2024. Regenerative food innovation: the role of agro-food chain by-products and plant origin food to obtain high-value-added foods. *Foods*, *13*(3), p.427.

Charles, V., Emrouznejad, A. and Gherman, T., 2023. A critical analysis of the integration of blockchain and artificial intelligence for supply chain. *Annals of Operations Research*, *327*(1), pp.7-47.

Costa, F., Frecassetti, S., Rossini, M. and Portioli-Staudacher, A., 2023. Industry 4.0 digital technologies enhancing sustainability: Applications and barriers from the agricultural industry in an emerging economy. *Journal of Cleaner Production*, *408*, p.137208.

D'Angelo, V. and Belvedere, V., 2023. Green supply chains and digital supply chains: Identifying overlapping areas. *Sustainability*, *15*(12), p.9828.

Das, S., Barve, A., Sahu, N.C. and Muduli, K., 2023. Enabling artificial intelligence for sustainable food grain supply chains: an agri 5.0 and circular economy perspective. *Operations Management Research*, *16*(4), pp.2104-2124.

de Carvalho, M.I., Relvas, S. and Barbosa-Póvoa, A.P., 2022. A roadmap for sustainability performance assessment in the context of Agri-Food Supply Chain. *Sustainable Production and Consumption*, *34*, pp.565-585.

Dibbern, T., Romani, L.A.S. and Massruhá, S.M.F.S., 2024. Main drivers and barriers to the adoption of Digital Agriculture technologies. *Smart Agricultural Technology*, *8*, p.100459.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N. and Lim, W.M., 2021. How to conduct a bibliometric analysis: An overview and guidelines. *Journal of business research*, *133*, pp.285-296.

Fattahi, M. and Govindan, K., 2022. Data-driven rolling horizon approach for dynamic design of supply chain distribution networks under disruption and demand uncertainty. *Decision Sciences*, *53*(1), pp.150-180.

Fraga-Lamas, P., Fernández-Caramés, T.M., da Cruz, A.M.R. and Lopes, S.I., 2024. An overview of blockchain for Industry 5.0: towards human-centric, sustainable and resilient applications. *IEEE Access*.

Garrido, S., Muniz Jr, J. and Ribeiro, V.B., 2024. Operations management, sustainability & industry 5.0: A critical analysis and future agenda. *Cleaner Logistics and Supply Chain*, *10*, p.100141.

Ghobakhloo, M., Iranmanesh, M., Morales, M.E., Nilashi, M. and Amran, A., 2023. Actions and approaches for enabling Industry 5.0-driven sustainable industrial transformation: A strategy roadmap. *Corporate social responsibility and environmental management*, *30*(3), pp.1473-1494.

Haloui, D., Oufaska, K., Oudani, M. and El Yassini, K., 2024. Bridging industry 5.0 and agriculture 5.0: Historical perspectives, opportunities, and future perspectives. *Sustainability*, *16*(9), p.3507.

Hassoun, A., Aït-Kaddour, A., Abu-Mahfouz, A.M., Rathod, N.B., Bader, F., Barba, F.J., Biancolillo, A., Cropotova, J., Galanakis, C.M., Jambrak, A.R. and Lorenzo, J.M., 2023. The fourth industrial revolution in the food industry Part I: Industry 4.0 technologies. *Critical reviews in food science and nutrition*, *63*(23), pp.6547-6563.

Hassoun, A., Jagtap, S., Trollman, H., Garcia-Garcia, G., Duong, L.N., Saxena, P., Bouzembrak, Y., Treiblmaier, H., Para-López, C., Carmona-Torres, C. and Dev, K., 2024. From Food Industry 4.0 to Food Industry 5.0: Identifying technological enablers and potential future applications in the food sector. *Comprehensive reviews in food science and food safety*, *23*(6), p.e370040.

Holzinger, A., Fister, I., Kaul, H.P. and Asseng, S., 2024. Human-centered AI in smart farming: Toward agriculture 5.0. *IEEe Access*, *12*, pp.62199-62214.

Kazancoglu, I., Ozbiltekin-Pala, M., Mangla, S.K., Kumar, A. and Kazancoglu, Y., 2023. Using emerging technologies to improve the sustainability and resilience of supply chains in a fuzzy environment in the context of COVID-19. *Annals of Operations Research*, *322*(1), pp.217-240.

Khan, S., Kaushik, M.K., Kumar, R. and Khan, W., 2023. Investigating the barriers of blockchain technology integrated food supply chain: a BWM approach. *Benchmarking: An International Journal*, *30*(3), pp.713-735.

Krippendorff, K. (2005). *The semantic turn: A new foundation for design*. crc Press.

Lam, W.S., Lam, W.H. and Lee, P.F., 2023. A bibliometric analysis of digital twin in the supply chain. *Mathematics*, *11*(15), p.3350.

Liu, S., Li, P., Wang, J. and Liu, P., 2024. Toward industry 5.0: Challenges and enablers of intelligent manufacturing technology implementation under the perspective of sustainability. *Heliyon*, *10*(15).

Mahroof, K., Omar, A., Vann Yaroson, E., Tenebe, S.A., Rana, N.P., Sivarajah, U. and Weerakkody, V., 2024. Evaluating the intention to use Industry 5.0 (I5. 0) drones for cleaner production in Sustainable Food Supply Chains: an emerging economy context. *Supply Chain Management: An International Journal*, *29*(3), pp.468-496.

Malacina, I. and Teplov, R., 2022. Supply chain innovation research: A bibliometric network analysis and literature review. *International Journal of Production Economics*, *251*, p.108540.

Mansilla-Obando, K., Llanos, G., Gómez-Sotta, E., Buchuk, P., Ortiz, F., Aguirre, M. and Ahumada, F., 2023. Eco-innovation in the food industry: exploring consumer motivations in an emerging market. *Foods*, *13*(1), p.4.

Mondejar, M.E., Avtar, R., Diaz, H.L.B., Dubey, R.K., Esteban, J., Gómez-Morales, A., Hallam, B., Mbungu, N.T., Okolo, C.C., Prasad, K.A. and She, Q., 2021. Digitalization to achieve sustainable development goals: Steps towards a Smart Green Planet. *Science of The Total Environment*, *794*, p.148539.

Norman, D. A., & Draper, S. W. (1986). *User centered system design; new perspectives on human-computer interaction*. L. Erlbaum Associates Inc...

Pagell, M. and Wilhelm, M., 2025. Putting the S in sustainable supply chain management: A people-centric research agenda. *Journal of Supply Chain Management*, *61*(1), pp.83-95.

Pandey, A.K., Daultani, Y. and Pratap, S., 2024. Blockchain technology enabled critical success factors for supply chain resilience and sustainability. *Business Strategy and the Environment*, *33*(2), pp.1533-1554.

Panigrahi, R.R., Singh, N. and Muduli, K., 2025. Digital technologies and food supply chain: a scoping view from 2010 to 2024. *International Journal of Industrial Engineering and Operations Management*, *7*(2), pp.150-174.

Paul, J., Lim, W.M., O'Cass, A., Hao, A.W. and Bresciani, S., 2021. Scientific procedures and rationales for systematic literature reviews (SPAR-4-SLR). *International Journal of Consumer Studies*, *45*(4), pp.O1-O16.

Pietrantoni, L., Favilla, M., Fraboni, F., Mazzoni, E., Morandini, S., Benvenuti, M. and De Angelis, M., 2024. Integrating collaborative robots in manufacturing, logistics, and agriculture: Expert perspectives on technical, safety, and human factors. *Frontiers in Robotics and AI*, *11*, p.1342130.

Rejeb, A., Rejeb, K., Zrelli, I. and Süle, E., 2025. Industry 5.0 as seen through its academic literature: an investigation using co-word analysis. *Discover Sustainability*, *6*(1), p.307.

Rogers, H. and Dora, M., 2024. Guest editorial: The interplay between new innovations, sustainability and food supply chains. *Supply Chain Management: an International Journal*, *29*(3), pp.409-413.

Samuels, A., 2025. Examining the integration of artificial intelligence in supply chain management from Industry 4.0 to 6.0: a systematic literature review. *Frontiers in artificial intelligence*, *7*, p.1477044.

Silva, M.E., Fritz, M.M., Seuring, S. and Matos, S., 2023. Guest editorial: The social sustainability of global supply chains–a critical perspective on current practices and its transformative potential. *International journal of physical distribution & logistics management*, *53*(1), pp.1-12.

Singh, D. and Cohen, V., 2025. Socio-economic dimensions and human centricity in Industry 5.0: a study on manufacturing sectors in central and Eastern European economies. *Journal of Economic Studies*, *52*(2), pp.254-275.

Singh, K.A., Patra, F., Ghosh, T., Mahnot, N.K., Dutta, H. and Duary, R.K., 2025. Advancing food systems with industry 5.0: A systematic review of smart technologies, sustainability, and resource optimization. *Sustainable Futures*, p.100694.

Tombe, R. and Smuts, H., 2023. Agricultural social networks: An agricultural value chain-based digitalization framework for an inclusive digital economy. *Applied Sciences*, *13*(11), p.6382.

Trabelsi, M., Casprini, E., Fiorini, N. and Zanni, L., 2023. Unleashing the value of artificial intelligence in the agri-food sector: where are we? *British Food Journal*, *125*(13), pp.482-515.

Trist, E. L., & Bamforth, K. W. (2000). Some social and psychological consequences of the longwall method of coal-getting¹. *Technology, Organizations and Innovation: The early debates*, *1*, 79.

Van Eck, N. and Waltman, L., 2010. Software survey: VOSviewer, a computer program for bibliometric mapping. *scientometrics*, *84*(2), pp.523-538.

Vasanthraj, V., Potdar, V., Agrawal, H., & Kaur, A. (2025). Transforming milk supply chains with blockchain: Enhancing visibility and cost reduction. *Benchmarking: An International Journal*, *32*(5), 1686-1719.

Velasco-Muñoz, J.F., Aznar-Sánchez, J.A., López-Felices, B. and Román-Sánchez, I.M., 2022. Circular economy in agriculture. An analysis of the state of research based on the life cycle. *Sustainable Production and Consumption*, *34*, pp.257-270.

Verma, S. and Gustafsson, A., 2020. Investigating the emerging COVID-19 research trends in the field of business and management: A bibliometric analysis approach. *Journal of business research*, *118*, pp.253-261.

Villar, A., Paladini, S. and Buckley, O., 2023, July. Towards supply chain 5.0: redesigning supply chains as resilient, sustainable, and human-centric systems in a post-pandemic world. In *Operations Research Forum* (Vol. 4, No. 3, p. 60). Cham: Springer International Publishing.

Yadav, M., Agarwal, U., Rishiwal, V., Tanwar, S., Kumar, S., Alqahtani, F. and Tolba, A., 2023. Exploring synergy of blockchain and 6G network for industrial automation. *IEEE access*, *11*, pp.137163-137187.

Yadav, N., Luthra, S. and Garg, D., 2023. Blockchain technology for sustainable supply chains: a network cluster analysis and future research propositions. *Environmental Science and Pollution Research*, *30*(24), pp.64779-64799.

Yadav, S., Samadhiya, A., Kumar, A., Luthra, S., Kumar, V., Garza-Reyes, J.A. and Upadhyay, A., 2024. The interplay effects of digital technologies, green integration, and green innovation on food supply chain sustainable performance: An organizational information processing theory perspective. *Technology in Society*, *77*, p.102585.

Yap, C.K. and Al-Mutairi, K.A., 2024. A conceptual model relationship between Industry 4.0—Food-agriculture nexus and agroecosystem: A literature review and knowledge gaps. *Foods*, *13*(1), p.150.

Yaqub, M.Z. and Alsabban, A., 2023. Industry-4.0-enabled digital transformation: Prospects, instruments, challenges, and implications for business strategies. *Sustainability*, *15*(11), p.8553.

Zekhnini, K., Chaouni Benabdellah, A., Bag, S. and Gupta, S., 2024. Supply chain 5.0 digitalization: an integrated approach for risk assessment. *Management Decision*.

Zhao, G., Xie, X., Wang, Y., Liu, S., Jones, P. and Lopez, C., 2024. Barrier analysis to improve big data analytics capability of the maritime industry: A mixed-method approach. *Technological Forecasting and Social Change*, *203*, p.123345.

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