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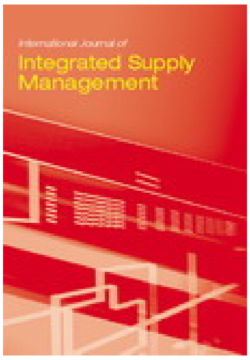

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Socio-technical transformations in citrus supply chains: a literature review based on bibliometric analysis

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Abstract: This study examines best practices for transforming agricultural supply chains (ASCs) into sustainable systems, with a particular focus on citrus supply chains. A bibliometric analysis of 871 papers from 2010 to 2023 was conducted using BiblioShiny, from which 111 papers were selected based on sustainability criteria. The analysis revealed six major thematic clusters: sustainability assessment, circular economy and byproducts, supply chain optimisation, nutrition values, citrus growth, and citrus diseases. A notable trend is the increasing adoption of technology, especially the utilisation of citrus waste as a bio-adsorbent for wastewater treatment. However, significant gaps remain, particularly in addressing social dimensions, socio-cultural influences, transparency, and the integration of holistic sustainability transformation approaches. To address these gaps the study proposes a socio-technical framework to guide future research and promote sustainable practices within ASCs.

Keywords: agriculture; citrus; supply chain; socio-technical transformations; sustainability practices; sustainability transformation; bibliometric analysis; literature review.

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1 Introduction

Food supply networks involve food production, processing, distribution, and consumption (Sala et al., 2017). Food loss and waste (FLW) is a global challenge with approximately one-third of the global food production being lost or wasted annually, as reported by the Food and Agriculture Organization (FAO, 2022, 2011). This issue has significant economic and environmental implications, particularly with regard to addressing world hunger. The causes of FLW vary across different stages of the supply chain (SC) and are directly linked to specific practices and activities within each stage, directly affecting all sustainability dimensions of agricultural supply chains (ASC) (Alzubi and Akkerman, 2022). Fruits and vegetables are particularly vulnerable, contributing 45–55% of the total FLW due to their perishability (Porat et al., 2018). Moreover, ASCs are the second-largest source of CO_2 emissions and remains a highly resource-intensive industry accounting for approximately 70% of water consumption (FAO, 2017; Peña et al., 2022; Pye-Smith et al., 2022), 32% of the energy usage, and 20% of the land use (Spang et al., 2019). Conversely, FLW reached an estimated 17% in 2021 (Deprá et al., 2022), contributing to negative impacts on natural resources without generating any returns.

Transformation practices enhance the socio-economic performance within ASCs, such as adopting compensation strategies that depend on working hours instead of cultivated quantities for farm workers (Ray et al., 2023), which leads to a higher motivation of the workers to work during the harvesting process accurately. Specifically, production planning strategies support farmers' decision to hire a sufficient number of workers to avoid citrus loss and waste (CLW) and cut the associated costs (Leon Pena-Orozco et al., 2022), and consequently, enhance the self-sufficiency index of a particular region (Alzubi et al., 2023). Although extensive multidiscipline research on practices on farm and food processing stages is found, yet no analysis of strategic practices covering all stages of ASC and aiming to transform the entire SC for holistic sustainability in citrus SCs is proposed in the literature. Therefore, this paper aims to provide a detailed analysis of sustainable practices in ASC, focusing on sustainability transformations within citrus SCs.

Citrus products are gaining significant prominence in the literature concerning fruits and vegetables due to their status as extensively produced fruit and their extensive cultivation area involved (Alzubi and Noche, 2022). At the farm level, citrus is a primary source of environmental impacts (Heller, 2019). Zacarias et al. (2020) and Zheng et al. (2022) conducted analyses on various factors within the citrus SC, focusing on fresh products, and put forth recommendations to mitigate CLW. Ferreira et al. (2016) and Dusch et al. (2018) researched the utilisation of citrus in various industrial applications, such as juice products, concentrated frozen juice, and jam. Citrus products, in general, possess a significant amount of pectin, cellulose, and hemicellulose, particularly in their peels. This characteristic highlights the potential of utilising citrus peel in fermentation processes, as suggested by Mamma et al. (2008). As of yet, the potential for a sustainable transformation in fruits and vegetables often remains untouched. We accordingly ask the following research question: Which practices support the sustainable transformation of citrus SC?

To answer the research question, the paper conducted a bibliometric analysis to determine sustainability transformation criteria within citrus SCs. Papers published in WoS from 2010 to 2023 were retrieved and analysed using BiblioShiny. Hundreds of studies tackled citrus SCs with multidisciplinary scopes, which were clustered into six groups: sustainability assessment, circular economy and byproducts, SC optimisation, nutrition values, citrus growth, and citrus diseases. Here, a tendency toward modelling has been observed within the papers focused on sustainability and any of its dimensions, especially regarding the environmental dimension, which could be modelled using life cycle assessment and SC optimisation. The present study contributes to the literature by providing an up-to-date review of practices transforming ASCs into more sustainable systems. On the one hand, the paper provides direction for future studies to determine existing research gaps, research trends in terms of keywords and terms used, authors analysis, citation analysis, most contributing institutions, publishing journals, and the co-occurrence network analysis. On the other hand, it presents a socio-technical transformation strategy in citrus SCs, supporting the decision-making for adopting sustainable transformation practices in ASCs.

The remainder of the paper begins with a theoretical background in Section 2. Section 3 introduces the research design, steps, and the software used, while Section 4 details the general results of bibliometric analysis, including descriptive statistics about the paper used in this review, citation analysis, institutional analysis, keywords analysis, co-occurrence network, and sustainability practices within citrus SCs. Section 5 introduces the strategic practices to promote socio-technical shifts for sustainability transformation within citrus SCs. Finally, Section 6 provides general conclusions and limitations of the study.

2 Literature background

Transformation practices are essential to enhance innovation potential for sustainable SCs (Kindström et al., 2013). However, organisations often face challenges associated with disturbing entrenched routines and replacing them with new ones (Fallon-Byrne and Harney, 2017). While practices describe "imitable activities […], often in the public domain, amenable to transfer across firms" (Bromiley and Rau, 2014), also roles, norms, and shared values have to be coordinated through strategies, objectives, plans, schedules, rules, and regulations (Katz and Kahn, 1978). To facilitate change for sustainability, companies accordingly must develop strategic plans to make their organisations sustainably competitive (Moore and Manring, 2009) that integrate environmental, social, and economic goals into internal operations and external stakeholder relationships and customer value propositions (Seuring and Müller, 2008). Thus, a multilevel or multi-system perspective is necessary to address the individual, organisational, political-economic, socio-cultural, and ecological dimensions (Melkonyan et al., 2019; Starik and Rands, 1995). Several studies, however, have argued that such a shift in resources, practices, and values of an organisation toward sustainability in complex systems remains difficult (Christensen and Overdorf, 2000; Hörisch, 2018).

Adopting transformation practices in citrus SCs while setting an ASC transformation strategy can enhance all dimensions of sustainability. These include innovation practices for sustainability, advanced technology use (Takhar and Liyanage, 2020), decision-making practices, knowledge management (Adamashvili et al., 2020; Ajayi, 2023), eco-design (Skalkos, 2023), tracking and tracing practices combined with transparency (Rainforest Alliance, 2020), and value creation practices (Rudloff and Wieck, 2020). One promising approach to achieve sustainability is to shift toward circular or closed-loop citrus SCs (Goodarzian et al., 2023; Liao et al., 2020; Phothisuwan et al., 2021; Roghanian and Cheraghalipour, 2019). However, sustainability practices vary enormously across different stages of ASCs and by various stakeholders. For instance, many agricultural practices for sustainability at the farmer level focus on selecting the input material, such as fertiliser or pesticide (Zhao et al., 2023), as well as selecting proper packaging material to reduce the generated FLW (Alzubi et al., 2022; Casas Cardoso et al., 2022). Often, the literature on ASCs focuses on agricultural practices in farms or sustainability assessment in the processing stages.

Technical innovations within citrus SCs play a significant role to support sustainability transformations. Advanced technologies, e.g., to optimise the irrigation system (Cayuela et al., 2022), support farmers to increase farm efficiency, thus opening new markets. Another example is using edible coating as a sustainable alternative to a modified atmosphere to extend the shelf life (Boninsegna et al., 2023) or producing citrus essential oil to be used as a coating material to extend fruit shelf life (Chetia et al., 2023). Traceability technologies are another crucial innovation supporting both controlling plant diseases (Porto et al., 2011b) and assurance the safety of citrus fruits (Hu et al., 2022) while aiming to decrease the amount of CLW generated in the SCs. Nevertheless, adopting advanced technology to transform value and SCs requires an efficient knowledge management system to support decision-making from setting the transformation strategy toward required actions (Rosa et al., 2018). In addition, strategic network design of the SC while optimising transportation activities by selecting the optimum facility location enhances the overall sustainability performance of citrus SCs

(Munoz Torres et al., 2022). Accordingly, there is a pressing need for more comprehensive analyses that integrate technical advancements into broader discussions of sustainability transformations.

Existing literature reviews on ASCs tend to emphasise short-term operational challenges, such as logistics efficiency, quality control, or improvements in specific key performance indicators (KPIs), often without considering broader strategic dimensions (see Table 1). By overlooking strategic elements, including the adoption of transformation practices for long-term sustainability, market positioning, and stakeholder collaboration, these reviews offer incomplete insights into the overarching dynamics of ASCs. Furthermore, particular literature reviews on citrus SCs and their sustainability, such as (Cabot et al., 2022; Idamokoro and Hosu, 2022; Palei et al., 2023), tend to adopt a siloed approach, focusing on individual segments or stages of the SC rather than considering the system as a whole. While this approach may yield valuable insights into specific operational functions, they often neglect the interdependencies and interactions between different SC components. Moreover, the existing literature on ASCs lacks a forward-looking perspective, failing to anticipate emerging trends or future challenges that may shape the strategic landscape of SCs.

Table 1 Summary of review studies conducted on citrus SCs and position the current study in literature

Reference	*Scope*	*Number of papers*	*Time considered*
Cabot et al. (2022)	Reviewed studies applied life cycle assessment (LCA) within citrus SC based on cyclic production and regional responsibilities.	23	2009–2022
Palei et al. (2023)	Reviewed studies and methodologies related to citrus disease detection in farms. Citrus grading in post harvesting stages using machine vision technologies.	52	2010–2021
Rasera et al. (2023)	Reviewed literature focused on exploring water usage and irrigation alternatives in response to water scarcity and seeking management solutions to enhance the resilience of the production system, while considering the potential effects of climate change.	178	1992–2022
Idamokoro and Hosu (2022)	Studies focused on citrus waste and animal feedstock.	565	Not specified
This review	Uniquely synthesise operational and sustainable practices across citrus supply chains, offering strategic foresight and systems-level insights that go beyond what has been previously overlooked in literature. It aims to support sustainability transformation and enhance the socio-technical performance of ASCs.	871	2010–2023

Consequently, aligning SC objectives with organisational goals as well as identifying systemic risks and opportunities, need to be considered in state-of-the-art literature reviews. By focusing on past or current practices, literature reviews miss the opportunity to provide strategic guidance for sustainability transformation and navigating uncertain and rapidly changing environments. As ASCs face increasing pressures from factors such as globalisation, technological advancements, and sustainability imperatives, there is a growing need for literature reviews that offer strategic insights and foresight to help stakeholders proactively address these challenges and capitalise on emerging opportunities.

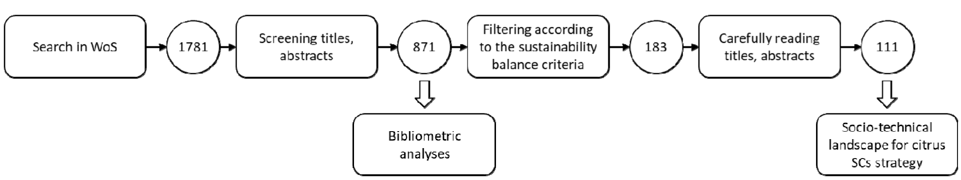
3 Research design

The methodology used in this paper adopts a hybrid approach, combining bibliometric analysis and qualitative content analysis to ensure both breadth and depth in examining sustainability practices within citrus SCs. Bibliometric analysis enables the identification of research trends, influential publications, and thematic clusters, while the systematic review allows a deeper examination of the papers specifically addressing citrus SCs or any of their stages. The content analysis focuses on the best practices found within retrieved studies. This methodology is divided into two levels: the first outlines the steps involved in conducting the bibliometric analysis (Donthu et al., 2021; Alzubi et al., 2025), while the second explains the criteria used to select eligible papers for the systematic literature review (Snyder, 2019).

3.1 Data collection

The data collection process involved several steps, summarised in Figure 1. The search was conducted in the Web of Science (WoS) database using a comprehensive query that combined citrus-related terms (e.g., ‘orange’, ‘lemon’, ‘mandarin’, ‘pomelo’) with sustainability-related keywords (e.g., ‘life cycle’, ‘CO_2’, ‘location’). Filters were applied to include only peer-reviewed journal articles in English, published between 1 January 2010 and 13 November 2023. To avoid irrelevant results, exclusion terms (e.g., ‘cement’, ‘oxidation’, ‘methyl orange’) were also applied. The full search string is provided in Appendix A. English has been identified as the language of analysis, and the documents included are peer-reviewed journal articles. This step resulted in retrieving 1,781 articles published.

Figure 1 Systematic literature review process



However, a second step has been conducted to ensure that the retrieved articles are relevant to the citrus SC. During manual screening, it was observed that some articles were incorrectly retrieved due to keyword ambiguity, for example, orange’ referring to colour rather than fruit, or ‘mandarin’ referring to language rather than produce. These articles were excluded through a title and abstract review, which resulted in excluding 910 articles, representing around 51.1% of the retrieved studies. The final dataset consists of 871 articles, representing 48.9%, exported in BibTeX format and analysed using the BiblioShiny interface for bibliometric mapping and thematic clustering.

3.2 Data analysis

The bibliometric analysis was conducted using BiblioShiny based on the dataset. It showed that around 3,486 authors participated in producing the 871 papers, which were published in 451 journals, with an annual growth rate of 9.1%. In addition, only 14 papers were published by a single author. At the same time, the average co-authorship per document was found to be 5, and the international collaboration between authors represented 26.3% of the papers. The trends are illustrated in Figure 2. A multistage screening and eligibility process was undertaken, which involved analysing the titles, abstracts, and conclusions sections of all 871 articles to identify scientific works focusing on the best practices in each citrus SC stage, including agricultural practices, operational practices, and sustainability practices of citrus and their byproduct SCs. The initial screening process was completed in November 2023, resulting in 183 eligible articles explicitly mentioning citrus or its derivatives, based on the sustainability transformation definitions representing around 21% of the studies, excluding 688 studies.

Figure 2 General statistics from the bibliometrics analysis, using BiblioShiny (see online version for colours)

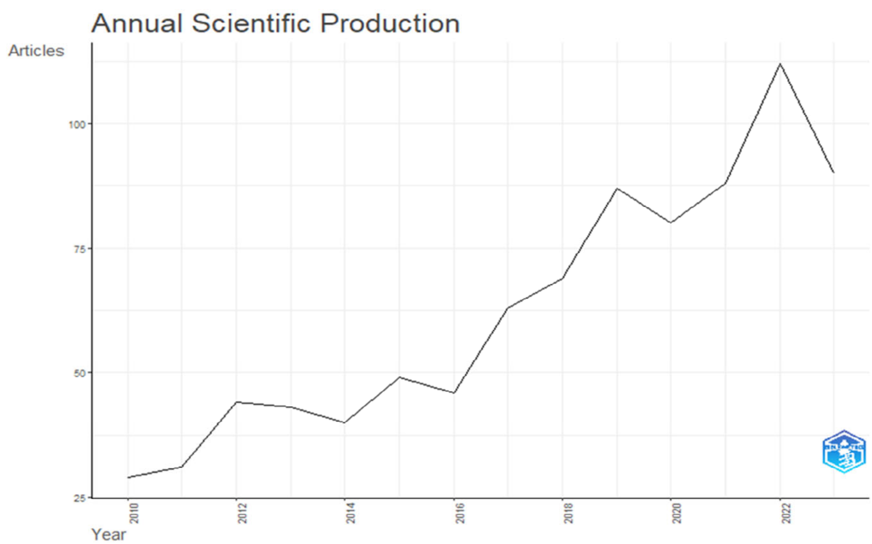
A second round of abstract analysis was conducted to specifically focus on studies related to sustainability practices within citrus SCs or specific stages within the citrus SC to ensure relevance to the sustainability transformation criteria, including digital technologies, sustainability relevance, and relationships to circular economy principles. This resulted in excluding another 72 papers. Finally, the remaining 111 papers were selected for the systematic literature review, providing a focused and high-quality dataset for analysing operational practices and strategic insights into sustainability transformation within citrus SCs. These findings offer insights into the evolution of research in this domain and help identify strategic practices and innovation pathways relevant to citrus SC sustainability.

4 Results of the bibliometric analysis

4.1 Descriptive analysis

The publication trend shown in Figure 3 reflects not only the rising volume of citrus-related research but also a shift in the underlying scientific agenda. The three-phase pattern, from slow growth (2010–2014), to rapid expansion (2015–2022), to a slight temporary decline in 2023, suggests that citrus SC and CLW research expands primarily in response to broader sustainability discourses rather than through internal disciplinary development alone. The acceleration around 2015 aligns with global policy attention to food waste, circular economy, and bioeconomy strategies, indicating that research activity follows external drivers such as regulatory changes, funding priorities, and public concern over agricultural sustainability. This implies that the field is strongly policy-responsive, with surges in interest occurring when sustainability becomes a strategic research priority. The more recent stabilisation suggests a possible maturation of the field, where foundational assessments have been established and future growth may rely on methodological diversification or deeper system-level analysis.

Figure 3 Number of publications per year, period from 2010 to 2023 (see online version for colours)



The concentration of publications in a small number of journals (Figure 4) reveals a field anchored in traditional horticultural and agronomic research but increasingly branching into interdisciplinary domains. Scientia Horticulturae's dominance indicates that primary production and crop-specific issues still shape much of the scientific discourse. However, the growing presence of journals such as *Sustainability*, *Journal of Cleaner Production*, and *Journal of Environmental Management* signals a gradual reorientation toward environmental assessment, waste valorisation, and systems modelling. This diversification reflects an ongoing transformation in citrus SC research: from describing biological or postharvest characteristics toward analysing resource efficiency, environmental impacts, and circular strategies. At the same time, the relatively limited presence of social-science or governance-oriented journals highlights a persistent gap, research remains largely techno- and production-centric, with limited engagement in areas such as behavioural change, policy innovation, or socio-economic drivers of sustainability transitions.

Institutional patterns (Figure 5) reinforce this observation. Leading universities, particularly the University of Florida and major Chinese institutions, are embedded in regions where citrus production represents a significant agricultural activity (Hammami et al., 2024). This alignment suggests that research output is tightly coupled with industry relevance, meaning that scholarship tends to prioritise local agronomic concerns (e.g., citrus greening, postharvest loss, disease management) and technological solutions for waste valorisation (University of Florida, 2025). While this ensures strong practical relevance, it may also narrow the thematic scope: institutions with strong horticultural traditions naturally emphasise technical and biological dimensions, potentially at the expense of cross-cutting issues such as SC governance, decision-making frameworks, or transformation-oriented research.

Figure 4 Most publishing journals about citrus and its SCs from 2010 to 2023 (see online version for colours)

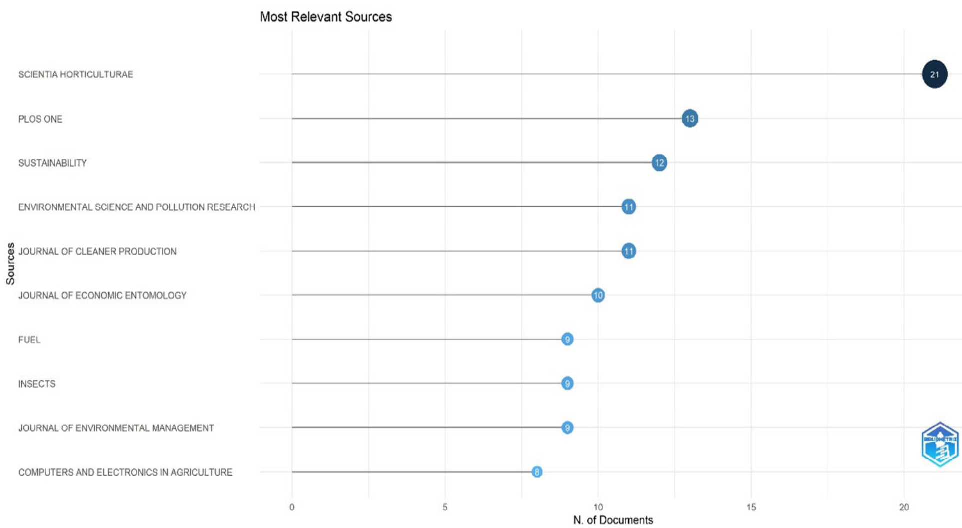
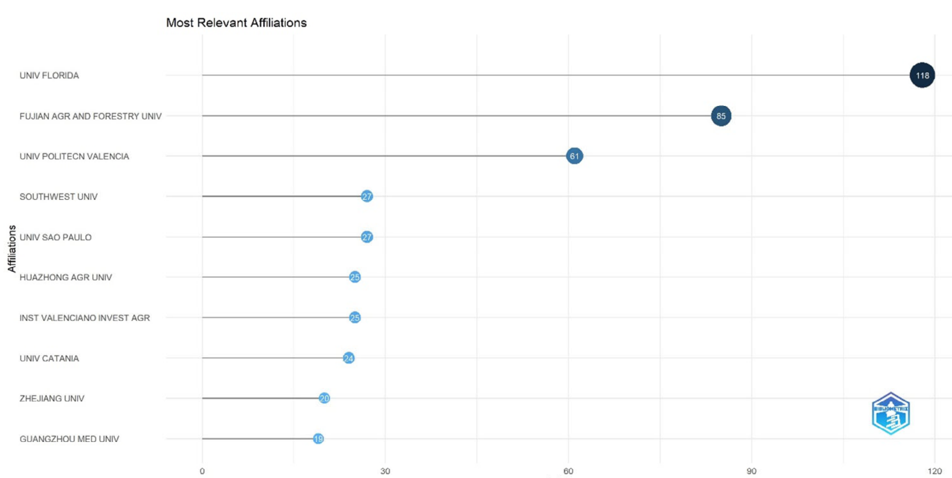


Figure 5 The top ten contributing institution to citrus SC from 2010 to 2023 (see online version for colours)



The significant contribution of Fujian Agriculture and Forestry University, along with other Chinese institutions represented in the top group, reflects China's growing investment in agricultural modernisation and circular bioeconomy strategies (Dong et al., 2024). Their high publication activity suggests an expanding research focus on citrus waste valorisation, environmental impacts, and SC optimisation, likely tied to the scale of China's citrus industry and increasing national interest in sustainability transitions (He and Chen, 2023). European universities such as the Universitat Politècnica de València contribute a different dimension to the field, emphasising technological innovation, SC digitalisation, and integrated valorisation pathways (Universitat Politècnica de València, 2021). Their contribution aligns with broader EU-level research agendas: EU funding instruments support sustainable, circular, and innovative agri-food value chain research (European Commission, 2025).

Overall, the institutional distribution shown in Figure 5 suggests that citrus SC research is propelled by three major drivers:

1 regional industry relevance

2 national sustainability and innovation agendas

3 access to international research funding frameworks.

This pattern underscores that the evolution of the field is not limited to scholarly interest alone but is tightly linked to broader economic, environmental, and policy contexts that shape research priorities across different regions.

Figure 6 Share of the international collaboration during the period from 2010 to 2023 in terms of the corresponding authors countries (see online version for colours)

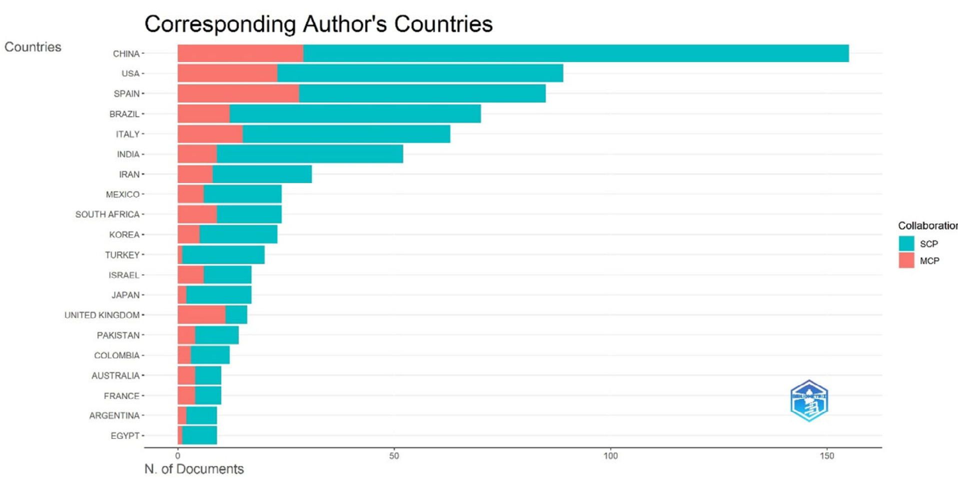
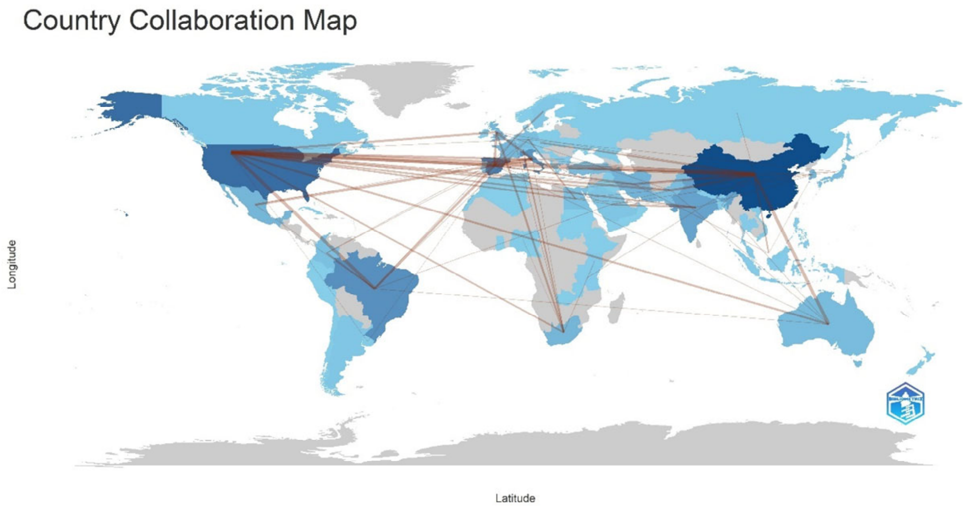


Figure 6 exposes a highly unfair yet increasingly interconnected global research landscape in the field of citrus SCs and CLW. While a wide range of countries contribute to the literature, the map shows a clear concentration of activity in major research economies, most notably China and the United States. Their prominence is reflected not only in high publication counts but also in their central role as hubs within the international collaboration network. The strong bilateral linkage between China and the

USA indicates that research in this domain is driven by cooperation between regions that have both large-scale citrus industries and extensive scientific infrastructures.

Figure 7 Publications density per countries, including the international research collaboration (see online version for colours)



Beyond these two dominant players, the network structure suggests that collaboration tends to follow geopolitical and regional research patterns. For example, European countries (such as Spain and Italy) show frequent cross-border cooperation, consistent with the collaborative funding instruments of the European Union. Meanwhile, emerging contributors in Latin America and the Mediterranean (Alzubi, 2024), regions with substantial citrus production, appear as secondary nodes, reflecting growing scientific engagement but more limited integration into the global network.

Overall, the collaboration patterns depicted in Figures 6 and 7 highlight two important dynamics in the field:

1 a core-margin structure, where a small group of countries drives most of the scientific exchange

2 the increasing globalisation of citrus sustainability research, as countries with shared agricultural and environmental challenges establish new co-authorship ties.

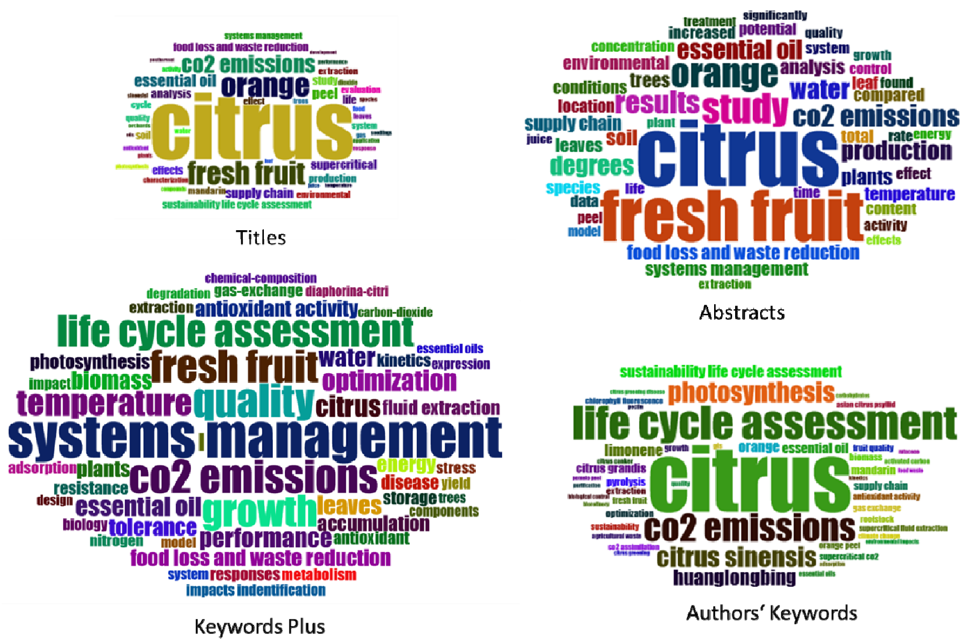
This underscores that advances in citrus SC and CLW research increasingly depend on international cooperation, particularly between high-capacity research systems and major citrus-producing regions.

Taken together, this research field is growing, increasingly interdisciplinary, but still shaped by structural biases. The dominance of horticultural journals and institutions rooted in major producing regions supports strong technical expertise but leaves gaps in systems transformation, governance, and socio-economic analysis. Similarly, the concentration of collaborative activity around a few scientific powerhouses promotes methodological advancement but risks overlooking region-specific sustainability challenges faced by less represented countries. These patterns imply that future research on citrus SCs must broaden its thematic and geographical inclusiveness to address sustainability in a more holistic manner. This includes integrating social sciences, expanding research participation from the Global South, and strengthening cross-regional collaboration to capture the full diversity of citrus production systems and waste streams.

4.2 Keywords analysis

The temporal evolution of terminology shown in Figure 8 reveals not just changing vocabulary but a substantive shift in how the citrus SC research community defines its core problems. Early terms, such as *citrus*, *fruit quality*, *postharvest*, or *storage*, cluster around production physiology and quality management, indicating that the field initially framed citrus research within a conventional horticultural paradigm. This early focus reflects a stage where SC considerations were largely technical and crop-centred, with limited attention to environmental or systemic concerns.

Figure 8 The keywords clouds on the level of titles, abstracts, keywords plus, and authors' keywords (see online version for colours)

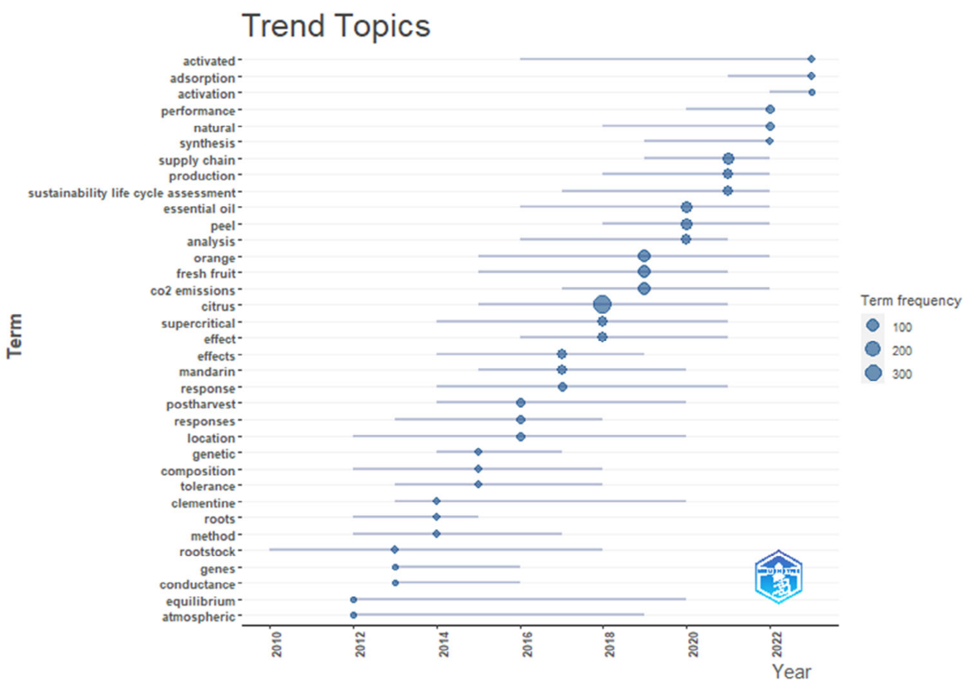


As newer terms begin to dominate the landscape, including *life cycle assessment*, *CO_2 emissions*, *valorisation*, *waste*, *circular economy*, and *resource recovery*, the terminology reveals a reorientation of research priorities. The rising prominence of these concepts indicates that citrus SC research has become increasingly driven by sustainability challenges such as environmental footprint reduction, waste minimisation, and the search for circular utilisation pathways. This shift mirrors external influences: global policy commitments to decarbonisation, consumer pressures for sustainable agri-food systems, and growing scientific recognition of citrus waste as an underutilised biomass resource.

More importantly, the clustering of sustainability-oriented keywords in recent years suggests a thematic convergence across different research streams. Instead of isolated studies on postharvest physiology or waste valorisation, researchers are increasingly integrating environmental assessment, supply-chain perspectives, and system-level thinking. This signals a gradual transition from technical problem-solving toward approaches that consider citrus SCs as complex, interdependent systems influenced by ecological, economic, and policy dimensions.

Figure 9 further emphasises this shift but also reveals emerging diversification. The rise of terms such as *activation*, *adsorption*, and *performance* demonstrates a rapidly expanding interest in converting citrus residues into engineered materials, especially for wastewater treatment and environmental remediation. This reflects a strategic move toward high-value circularity, where citrus by-products serve as feedstock for functional materials rather than low-value commodities (e.g., compost, animal feed). Such research expands the potential role of citrus waste beyond traditional food-chain applications and positions it within broader bio-based innovation domains.

Figure 9 Topics within the retrieved papers in the period from 2010 to 2023 (see online version for colours)



Yet, despite these transitions, the temporal patterns also expose a critical gap. From 2016 to 2022, the most influential trending terms remain centred on environmental assessment (*life cycle assessment*, *CO_2 emissions*) and valorisation (*essential oils*, *by-products*). Concepts associated with sustainability transitions, such as *innovation*, *technology adoption*, *decision-making*, *knowledge transfer*, *transparency*, or *value creation*, are largely absent. Their absence suggests that while the field has advanced technically and environmentally, it has not yet been fully engaged in the socio-technical processes required to achieve large-scale transformation of citrus SCs.

This gap has implications for both research and practice. Without explicit attention to organisational, behavioural, and governance mechanisms, innovations in valorisation or environmental assessment may remain isolated rather than adopted across supply-chain actors. For this reason, transformation-focused keywords are used in the subsequent analysis to identify and examine the limited set of studies addressing structural, institutional, and managerial transitions in citrus SCs. Their scarcity underscores the need for future research to bridge technical sustainability advances with the enabling systems that determine real-world implementation

4.3 Citation analysis

Tables 2 and 3 reflect two very different dimensions of scientific influence within the citrus-related research landscape. The locally cited papers (Table 2) represent works that have shaped discourse within the 871-paper dataset itself, revealing the internal intellectual structure of the field. In contrast, the globally cited papers (Table 3) capture studies that have achieved broader recognition outside this network, often because they address topics or methods with relevance far beyond citrus SCs.

Table 2 Lists the top ten local cited papers in the period from 2010 to 2023

Paper	*Journal*	*Local citations*	*Global citations*
Pergola et al. (2013)	*Journal of Environmental Management*	15	88
Beccali et al. (2010)	*Journal of Environmental Management*	12	86
Pourbafrani et al. (2013)	*Environmental Research Letters*	9	45
Syvertsen and Garcia-Sanchez (2014)	*Environmental and Experimental Botany*	9	127
Long et al. (2017)	*Frontiers in Plant Science*	9	84
Yang et al. (2012)	*Trees: Structure and Function*	8	100
Lo Giudice et al. (2013)	*Italian Journal of Food Science*	7	34
Boukroufa et al. (2015)	*Ultrasonic Sonochemistry*	7	241
Aguilera et al. (2015)	*Agronomy for Sustainable Development*	6	98
Martin-Gorriz et al. (2020)	*Journal Cleaner Production*	6	43

The local citation ranking shows that internal influence is shaped mainly by studies on environmental assessment, orchard management, and SC efficiency, which closely align with the core themes of citrus sustainability research. Works in *Journal of Environmental Management* and *Environmental and Experimental Botany* feature prominently, reflecting the importance of LCA, environmental performance, and plant stress responses within the field. Frequent citations of papers on orchard sustainability, plant physiology, and postharvest performance reinforce this pattern. In contrast, the globally cited papers extend into broader domains such as renewable energy, green chemistry, bioresource utilisation, and plant biotechnology. Many appear in high-impact multidisciplinary journals (e.g., energy and environmental science, nature communications, and bioresource technology), which contribute to their high citation counts. Their influence often stems from methodological advances, such as extraction methods, biomass conversion, or stress-response mechanisms, that appeal to multiple scientific disciplines.

Table 3 Top ten global cited papers during the period from 2010 to 2023

Paper	*Journal*	*Total citations*
Lin et al. (2013)	*Energy & Environmental Science*	728
Pfaltzgraff et al. (2013)	*Green Chemistry*	313
Boukroufa et al. (2015)	*Ultrasonic Sonochemistry*	241
Lasheen et al. (2012)	*Solid State Science*	226
Fernandez et al. (2015)	*Bioresource Technology*	210
Mann et al. (2012)	*PLOS Pathogens*	210
Lopez-Velazquez et al. (2013)	*Journal of Analytical and Applied Pyrolysis*	197
Hauenstein et al. (2016)	*Nature Communications*	187
Arnon et al. (2014)	*Postharvest Biology and Technology*	136
Zandalinas et al. (2016)	*BMC Plant Biology*	133

The limited overlap between the two tables, where only Boukroufa et al. (2015) appears in both, illustrates this divide clearly. Although its local citation count is modest within the dataset, its strong global citation performance indicates that the study's contribution to ultrasonic-assisted extraction techniques has been widely recognised across the broader scientific community. This gap between internal and external impact suggests that the citrus SC field is still relatively specialised: papers that are highly influential within the domain do not always attract the same level of attention globally, and vice versa.

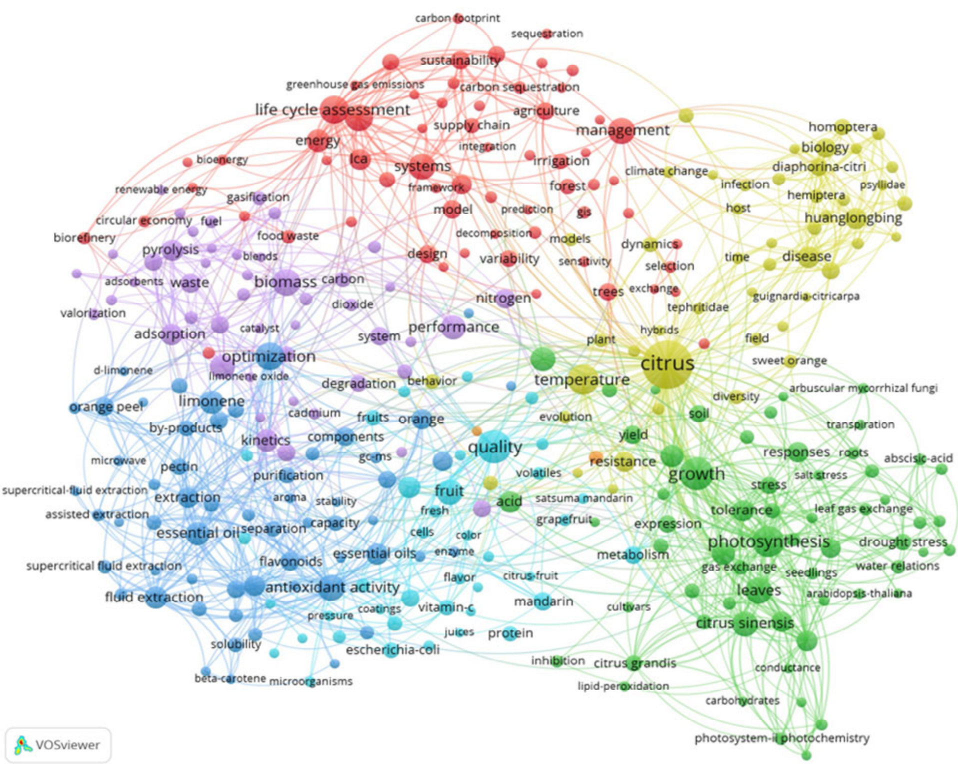
Table 4 Top ten papers in terms of average annual citation locally

Paper	*Journal*	*Average yearly citation*
Martin-Gorriz et al. (2020)	*Journal Cleaner Production*	2.00
Bonales-Revuelta et al. (2022)	*Journal of Cleaner Production*	2.00
Teigiserova et al. (2022)	*Science of the Total Environment*	2.00
Jokic et al. (2020)	*Separation Science and Technology*	1.67
Pergola et al. (2013)	*Journal of Environmental Management*	1.50
Long et al. (2017)	*Frontiers in Plant Science*	1.50
Safranko et al. (2021)	*Foods*	1.50
Mostashari-Rad et al. (2021)	*Journal of Cleaner Production*	1.50
Ortiz et al. (2020)	*Journal of Cleaner Production*	1.33
Yang et al. (2019)	*BioMed Research International*	1.25

Overall, the contrast between local and global citation patterns underscores a key insight: the internal development of citrus SC and CLW research is shaped by applied, domain-specific studies, while global visibility tends to favour papers that contribute broadly applicable methods and technologies. This distinction highlights opportunities for future research to integrate methodological advancements from the wider sustainability and bioresource fields into citrus-focused investigations.

Table 4 provides a normalised view of research influence by presenting average annual citations, helping offset the advantage older papers have in total citation counts. Most highly cited papers overall were published between 2013 and 2017, but only two papers, Pergola et al. (2013) and Long et al. (2017), appear in both the total citation and annual citation rankings, underscoring their sustained relevance. More recent studies, including Mostashari-Rad et al. (2021), Safranko et al. (2021), Bonales-Revuelta et al. (2022) and Teigiserova et al. (2022), rank prominently when assessed by yearly averages. These works focus on optimising pectin and essential oil extraction, aligning with current trends in food-waste valorisation, circular economy, and resource recovery. Interestingly, none of the top productive authors identified earlier appear among the most cited documents, reinforcing that publication volume does not necessarily translate into citation impact.

Figure 10 Clusters within the co-occurrence network, using VOSviewer (see online version for colours)



4.4 Co-occurrence network

To better understand thematic relationships within the literature, a co-occurrence network was constructed using VOSviewer, chosen for its intuitive interface and robust visualisation of keyword linkages. In Figure 10, six distinct clusters are identified, each representing a dominant theme in citrus SC and sustainability research.

The red cluster focuses on sustainability within citrus SC, encompassing terms such as life cycle assessment and carbon footprint, as well as design for sustainability. Meanwhile, optimisation within citrus SCs and aspects of the circular economy are depicted in purple and blue, respectively. These clusters share commonalities, with words related to byproducts extraction like pectin, essential oil, biomass, and extraction methods such as supercritical fluid extraction appearing across both the blue and purple clusters. Words representing nutrient attributes are observed in the light blue cluster, which includes terms such as kinetics, protein, vitamin C, flavour, and enzyme. Other words included are citrus derivatives like mandarin and grapefruit. However, the yellow cluster groups terms related to diseases affecting citrus farms, such as huanglongbing and citricarpa, along with their relationship to the temperature of the planting area. The green cluster introduces words related to citrus growth and plants, which include leaves, response, leaf gas exchange, soil, photosynthesis, and many others. These thematic concentrations, when interpreted alongside trend keywords identified in Subsection 3.2, offer a roadmap for selecting literature on best practices in citrus SCs. Together, they form the analytical foundation for proposing a socio-technical transformation strategy applicable to ASCs broadly, and citrus SCs in particular.

4.5 Sustainability transformation criteria

4.5.1 Coding scheme and analysis conducted

To systematically analyse the 111 selected papers for their coverage of sustainability transformation, a qualitative content analysis was conducted using a structured coding scheme. This scheme was built upon two primary structural dimensions and a set of analytic categories for transformation criteria.

1 Structural dimensions: The analysis was organised along two pre-defined (deductive) axes to categorise the focus of each paper:

- Sustainability dimensions: Based on the established triple bottom line framework, papers were categorised as addressing the economic, environmental, and/or social dimensions of sustainability.
- SC Stages: Papers were mapped to one or more of five key stages in the citrus SC: *farm*, *processing*, *logistics*, *retail*, and *consumption*. These stages were defined based on standard models of agricultural SCs.

2 Analytic categories: The sustainability transformation criteria were identified through a hybrid approach:

- Deductive from established frameworks and literature on sustainability transformations in SCs (e.g., Seuring and Müller, 2008; Melkonyan et al., 2019). These pre-defined frameworks included technology adoption, eco-design, traceability, and value creation.
- Inductive from an initial review of the literature, several recurring themes emerged that were not fully captured by the initial codes. The final set of analytic categories included *innovation*, *technology use*, *decision-making integration*, *knowledge management*, *eco-design*, *tracking* and *tracing* (often combined with transparency), and *value creation* (economic and social value generation).

3 Next step is to analyse the title, abstract, and keywords of each paper. Each paper was assessed for the presence of the aforementioned sustainability transformation criteria and then mapped against the structural dimensions (sustainability pillars and SC stages). The distribution and co-occurrence of these criteria is shown in Table 5, where '*total*' columns and rows will have overlaps because one paper can be counted in multiple cells.

Table 5 Cross table shows papers distribution for sustainability transformation criteria and SC stages

		*Supply chain stages**					
		F	*P*	*L*	*R*	*C*	*Sum*
Sustainability transformation criteria	Technology adoption	14	26	4	1	1	46
	Eco-design	6	18	4	2	0	30
	Innovation	2	8	2	1	0	13
	Decision-making	19	8	2	0	0	29
	Value creation	3	13	2	1	0	19
	Knowledge management	9	4	2	0	0	15
	Traceability	1	2	1	0	0	4
	Sum	54	79	17	5	1	

Notes: *F: farm, P: processor, L: logistics, R: retailer, and C: consumer.

4.5.2 Distribution of sustainability transformation criteria

An analysis of the sustainability transformation criteria revealed that 111 papers mentioned keywords such as innovation, technology use, decision-making integration, knowledge management, eco-design, tracking and tracing combined with transparency, and value creation within their abstracts. The most frequently discussed criterion was technology adoption, appearing in 46 papers, followed by the eco-design of products and networks within 30 papers, while 29 papers focused on decision-making and support (Figure 11). Additionally, 19 papers discussed value creation, 15 documents tackled knowledge transfer and management, and 13 articles discussed innovation principles in citrus SCs. Only four papers discussed traceability, while none mentioned transparency. When examining the literature through the lens of sustainability dimensions, the economic dimension was reflected in 53 papers, followed by the environmental dimension in 22 papers, and the social dimension in just three papers. A subset of studies addressed multiple dimensions, with 28 papers combining environmental and economic aspects, three papers integrating economic and social considerations, one paper combining environmental and social dimensions, and a single paper encompassing all three sustainability dimensions. The distribution of these papers based on their alignment with sustainability transformation terms and dimensions is illustrated in Figure 12, while detailed listings and associations are provided in Appendix B.

Figure 11 Number of papers using one or other criteria relevant for the criterial of sustainability transformation (see online version for colours)

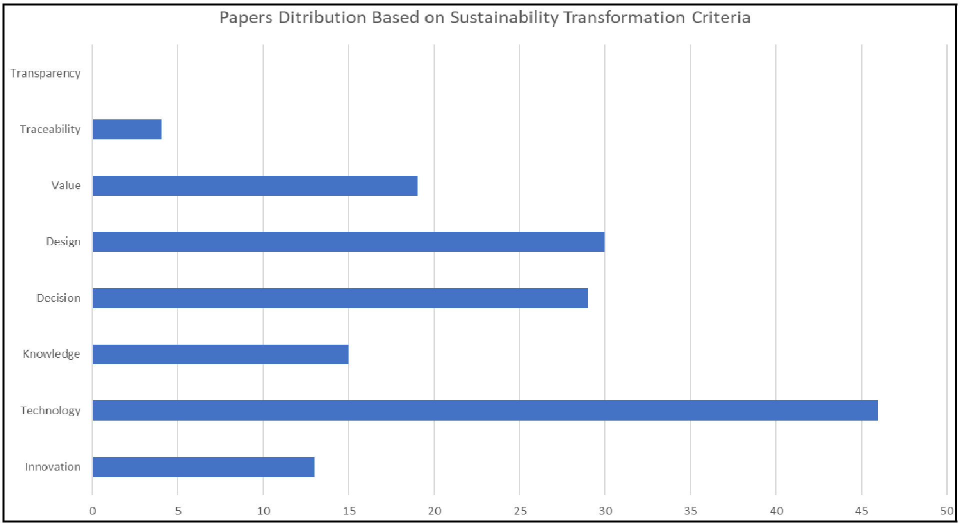
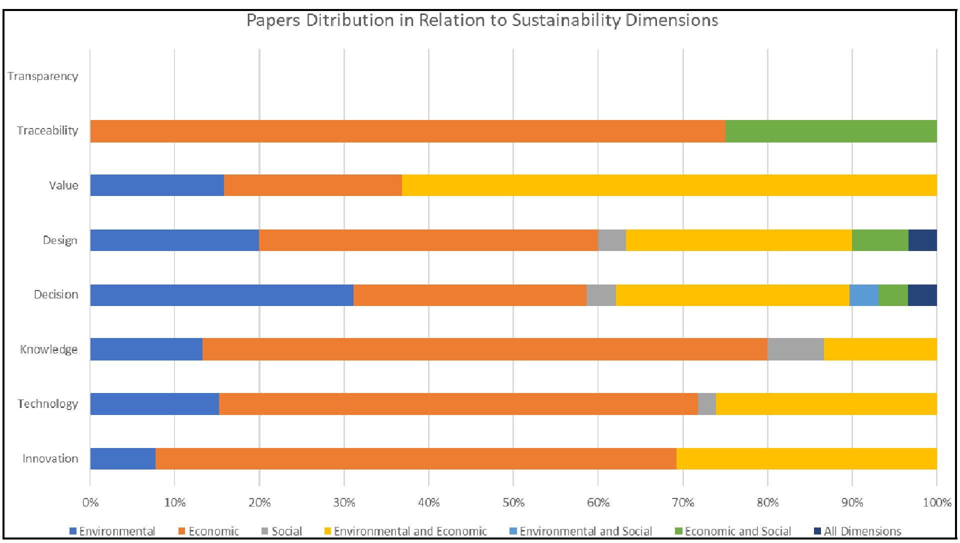


Figure 12 Papers distribution based on sustainability transformation criteria with reference (see online version for colours)



Integrating sustainability transformation criteria with SC stages reveals a strong emphasis on the processing and farm stages, addressed in 51 and 48 papers, respectively. In contrast, considerably fewer studies focus on the logistics stage, including aspects such as transportation, packaging, storage, and distribution. The retail and consumption stages receive minimal attention, with only two papers each discussing these downstream elements. reveals a strong emphasis on the processing and farm stages, addressed in 51 and 48 papers, respectively. In contrast, considerably fewer studies focus on the logistics stage, including aspects such as transportation, packaging, storage, and distribution. The retail and consumption stages receive minimal attention, with only two papers each discussing these downstream elements. Innovation mainly researched in the processing stage, accounting for approximately 61.5% of the relevant studiers, followed by 15.4% in both the farm stage and logistics stages. This distribution highlights a noticeable gap in researching innovation in downstream SC stages. Similarly, technology adoption is predominantly focused on the processing stage, encompassing around 56% of the papers, followed by around 30% on the farm stage. However, studies addressing technology adoption in logistics operations, such as blockchain or cold chain systems, remain limited, and virtually no work has addressed these advancements within the retail and consumption stages. This uneven distribution underscores that upstream stages of citrus SCs have received considerable attention, downstream stages remain underexplored, particularly in relation to transformative technologies and sustainability practices. Addressing this imbalance is essential for developing a holistic and inclusive strategy for sustainability transformation across the entire citrus SC continuum.

4.6 Geographical analysis

An analysis of the geographical scope of the reviewed studies reveals a heterogeneous and uneven global landscape. Rather than reflecting the location of authors' institutions, the selected studies focus on specific citrus-producing regions whose economic, environmental, and policy contexts shape the sustainability challenges under investigation.

4.6.1 Southern Europe (Italy, Spain, Greece, Turkey)

Studies focusing on Italy predominantly investigate sustainability assessment and LCA-based evaluations of citrus production and processing systems. These works align with Italy's policy emphasis on environmental impact reduction and circular bioeconomy strategies, as reflected in studies by Beccali et al. (2009, 2010).

Research covering Spain spans multiple SC stages, yet the sustainability dimensions addressed remain insufficiently classified, making it difficult to fully assess Spain's contribution to systemic transformation (Kassem et al., 2024). Only two studies focused in SC stages in Greece focus mainly on processing, indicating narrow thematic coverage (Mamma et al., 2008; Al-Sammarraie et al., 2022). In Turkey, literature reflects integration between citrus production and export logistics via cooperatives and regional alignment. Kassem et al. (2024) highlight stronger horizontal coordination and compliance mechanisms compared to peer countries, offering insights into institutional enablers of SC governance.

4.6.2 Latin America (Brazil, Colombia, Mexico)

Brazilian studies frequently examine the processing stage and waste valorisation, particularly energy optimisation, essential oil extraction, and bioactive compound recovery (Fermo et al., 2021; Ferreira et al., 2020; Barbosa et al., 2018; Barrales et al., 2018). One study examined the farm stage exclusively (Gehrke et al., 2021), while two others covered both farm and processing operations (Caixeta-Filho, 2006; Ferreira et al., 2016).

Colombian research targets both farm practices and processing. One paper focuses on farm-level strategies (Pena Orozco et al., 2021), while others examine citrus processing (Ortiz et al., 2020). Mexican studies explore processing and combinations of farm, transport, and export stages. Vaporisation research Rosas-Mendoza et al. (2020) considers energy recovery and bio-compound extraction, though scalability barriers are briefly acknowledged.

4.6.3 Middle East and North Africa (Jordan, Egypt, Morocco)

In Egypt, research concentrates mainly on farm practices including nutrient management, pest control, and irrigation optimisation (Alnaimy, 2017). One study explores processing (Al-Sammarraie et al., 2022). Stakeholder interviews highlight gaps in institutional support, weak SC coordination, and fragmentation between production, processing, and circularity efforts (Beshara et al., 2024).

Research on citrus SC in Jordan focuses on operational improvements related to logistics, CO_2 emissions reduction, harvest optimisation, and packaging innovations. These include harvest optimisation (Alzubi et al., 2023), transportation and CO_2 emissions reduction (Alzubi and Noche, 2022), the design for circular economy, packaging innovation (Alzubi, 2024), and social economic analysis of closed loop systems (Alzubi et al., 2024). Publications on Moroccan citrus production highlight farm-level practices (Lahlali et al., 2021) and CLW vaporisation (Meryem et al., 2023), though contributions remain modest in volume.

4.6.4 Asia (China, India, Iran)

The geographical coverage of Chinese citrus SC spans farming, retailing, processing, and transportation. Five publications span various SC stages, one each on farming (Gehrke et al., 2021), retailing (Ahrisa et al., 2021), processing (Chen et al., 2019), and transportation, reflecting a relatively balanced exploration across operational levels.

In India, research is heavily weighted toward CLW valorisation, particularly essential oils and pectin recovery (Chavan et al., 2018; Suri et al., 2022). In contrast, research on Iranian SCs offers some of the most integrated perspectives, covering all SC stages and developing CLSC models that include reverse logistics and network design (Cheraghalipour et al., 2018; Roghanian and Cheraghalipour, 2019; Liao et al., 2020).

4.6.5 North America (US)

Research conducted on US citrus regions (primarily Florida and California) centres on agronomic practices and climate mitigation, such as irrigation and canopy management (Morgan et al., 2022; Boman, 2012). Additional work covers retailing, cold chain logistics, and consumer behaviour (Chen et al., 2020).

4.6.6 Sub-Saharan Africa and South Asia (Benin, Bangladesh, Nigeria)

Studies from Bangladesh and Benin focus on farm-level practices, post-harvest losses, and cold-chain gaps in resource-constrained contexts (Begum et al., 2022; Afloukou et al., 2020). Studies from Bangladesh and Benin focus on farm-level practices, post-harvest losses, and cold-chain gaps in resource-constrained contexts.

4.6.7 Synthesis and gap identification

Overall, the geographical scope of the reviewed literature reveals:

1. strong regional clustering around specific thematic priorities (e.g., valorisation in India/Brazil, LCA in Italy, agronomics in the US, logistics in Jordan)
2. a lack of holistic, system-level assessments that integrate multiple SC stages
3. underrepresentation of key producer and exporter countries, particularly in Africa
4. limited attention to global interdependencies, despite citrus markets being highly interconnected through trade and processing flows.

Addressing these gaps is essential for developing cross-regional strategies, enabling globally resilient citrus SCs, and supporting evidence-based policymaking.

5 Transformation strategy to promote sustainability in citrus SCs

A strategic framework for transforming citrus SCs is proposed based on insights from the bibliometric analysis and grounded in socio-technical transformation theory. This framework, visualised in Figure 13, integrates three key dimensions of system transitions: niche innovations, the incumbent regime, and the external socio-technical landscape, following the multi-level perspective established by Verbong and Geels (2010), which distinguishes between niche innovations at the micro level, the incumbent regime at the meso level, and the broader socio-technical landscape at the macro level. The landscape level represents macro-level, long-term external pressures such as global sustainability demands, environmental policies, and evolving consumer expectations, which shape regime dynamics and influence micro-level innovations. In the context of citrus SCs, these forces define the trajectory toward circularity and resilience. At the niche level, innovations emerge in isolated SC stages, often addressing operational practices or specific stakeholder groups. The bibliometric review identified a variety of niche activities, such as irrigation and packaging to broader societal efforts such as stakeholder identification. Socio-technical innovations typically occur on a micro scale within discrete SC stages and involve distinct stakeholder groups. Transformation within the socio-technical system takes place at an intermediate level positioned between micro and macro scales. This level includes three key components: the technical system, the social system, and formal, normative, and cognitive rules.

1. The technical system consists of material and technological components that support SC planning and operations, particularly at the farm level. Innovations in this domain are categorised as follows:
   a. Farm practices, which encompass advances in technologies for irrigation, pesticide application and optimisation, and citrus fruit production.

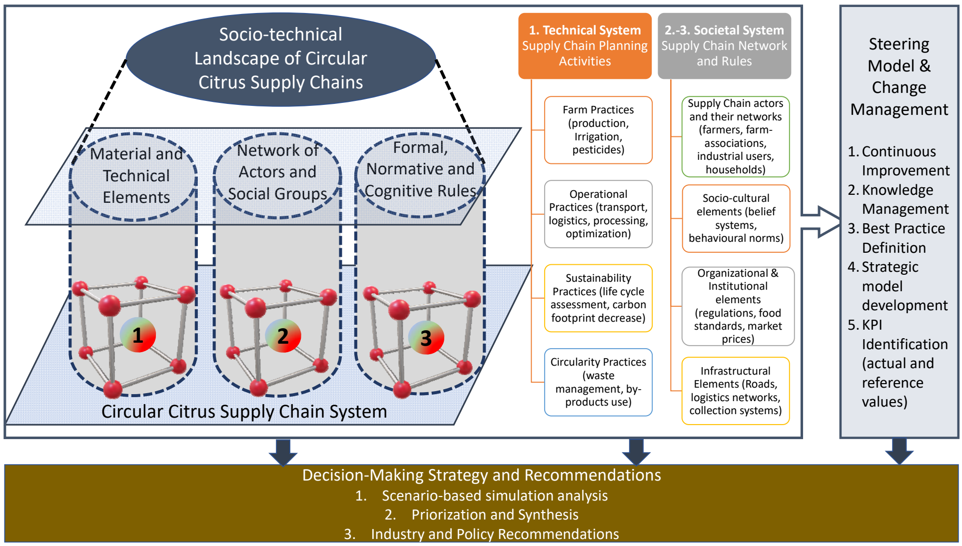
- b Operational practices, including improvements in citrus fruit transport and warehousing, as well as the design of logistics networks that incorporate efficient delivery mechanisms and new technologies.
- c Sustainability practices, such as measuring the carbon footprint of citrus production and transport and conducting life cycle assessments.
- d Circularity practices, which involve waste management and the utilisation of citrus byproducts such as peels and oils, further processed into value-added products like cosmetics.

2 The social system, including networks of actors/social groups, including farmers, farm associations, industrial users (e.g., fruit processing companies), and households. This system depends heavily on socio-cultural elements and behavioural norms, such as consumers' environmental awareness and preferences for bio-citrus products. It is also shaped by organisational and institutional components like food safety standards and regulations, and by infrastructural factors including road networks and collection systems that affect the efficiency of citrus byproduct SCs. The unrestricted global trade of citrus and its byproducts can, in some cases, diminish the potential for building regionally optimised circular SCs.

3 The formal, normative, and cognitive rules influence stakeholder behaviour, support institutional structures, and guide the adoption of sustainable and circular practices within the citrus sector. These rules form the foundation of both the technical and social systems. Literature analysis indicates that the main actors in citrus SCs are farmers, farm associations, industrial users (such as fruit processing companies), and households. Given the involvement of various stakeholder groups, this level is shaped significantly by socio-cultural factors and behavioural norms. For example, consumers' environmental awareness and preference for bio-citrus products. Additionally, organisational and institutional components, including regulations and food safety standards, along with infrastructural aspects such as road networks and collection systems, play a vital role in shaping the efficient and sustainable design of citrus byproduct SCs. In some cases, the unrestricted international trade of citrus and its byproducts may undermine the potential to develop regionally optimised circular SCs.

After identifying these components of the socio-technical landscape, the next step involves monitoring new practices reported in academic research and technical literature to enhance the knowledge management system. The main objective of this system is to define best practices across the citrus SC and establish KPIs for each stage, particularly those related to citrus byproducts. These KPIs will be categorised in alignment with the system structure illustrated in Figure 13. This process will support the development of a decision support platform for stakeholders including farmers, industry professionals, consumers, and policymakers. Through this platform, they will be able to collaboratively design and implement a circular SC model that integrates social and technological innovations across all stages. Ultimately, this approach will strengthen the resilience of the citrus SC and enable it to adapt effectively to external challenges.

Figure 13 Strategic approach to adopt best practices for socio-technical sustainability transformation in citrus SCs (see online version for colours)



6 Discussion and conclusions

6.1 Management summary

The paper conducted a bibliometric analysis to determine sustainability transformation criteria within citrus SCs. The analysis of keywords showed that those related to sustainability life cycle assessment and byproducts were the most used keywords, specifically in the period between 2014 and 2021. In comparison, the currently trending keywords are activation and adsorption due to their relevance to the use of CLW as a biomaterial for the pre-treatment process of wastewater. Overall, the analysis of sustainability transformation criteria resulted in 111 documents that considered one or more of the following words in their abstracts: innovation, technology use, decision-making integration, knowledge management, eco-design, tracking and tracing combined with transparency, and value creation. Notably, 36 papers discussed circularity practices and the production of byproducts. Among them, seven focused on essential oil extraction from peels, while another seven discussed the opportunity of using citrus pomace as feedstock for bioenergy or anaerobic digestion. Additionally, three studies concentrated on recycling this waste to produce compost or biofertiliser, thus closing the loop on the farm. However, further processing of such waste was also mentioned for various purposes, including producing cosmetics (Dacal-Gutierrez et al., 2022; Sun et al., 2023), bioplastic (Zhang et al., 2018; Giosafatto et al., 2014), limonene and ethanol (Machin Ferrero et al., 2022; Quispe-Fuentes et al., 2022), biochar (Lu et al., 2022; Yek et al., 2020), dietary fibre (Khanpit et al., 2022), pigment (Huang et al., 2021), fatty acid (Saul Garcia-Perez et al., 2017), pectin (Sultani et al., 2023), and dried peels (Martinez-Hernandez et al., 2019).

Attributes related to knowledge transfer place the farm stage in the lead, with approximately 60% of the papers dedicated to it. When combined with logistics, this figure rises to 67%, primarily focusing on agricultural practices such as irrigation management, weed control, canopy management, as well as disease and insect management, among others. However, the remaining papers predominantly concentrate on the processing stage, further accentuating the existing gaps in the literature concerning knowledge transfer for logistics and downstream stages. Additionally, 66% of the papers centre around decision-making or decision support on farms, discussing topics such as soil nutrient management, suitable planting locations, and marketing channels for farmers. Additionally, one-third of the papers under design classifications discuss the processing stage, dealing with process or product design, while 20% focus on the farms. Obviously, 68% of the studies discussed value creation concentrated on the processing stage because its waste constitutes around 50% of the processed citrus weight (Ortiz et al., 2020). These studies mainly focused on waste valorisation and value creation out of the generated waste such as directing it to produce biogas (Ortiz et al., 2020), compost (Alzubi et al., 2024), essential oil (Lopresto et al., 2019; Chetia et al., 2023), pigments of fatty acid (Saul Garcia-Perez et al., 2017), pectin (Boukroufa et al., 2015; Sultani et al., 2023), or other applications including bioplastic (Giosafatto et al., 2014) or dried fibre (Khanpit et al., 2022).

6.2 Theoretical implications

Besides the study's practical implications, the citrus SCs are of theoretical value for SC management in general. Sustainable supply chain management (SSCM) being defined as the "management of material, information and capital flows as well as cooperation among the companies along the SC while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social into account" (Seuring and Müller, 2008), SC researchers mainly stay within the boundaries of their (business management) discipline emphasising material/component or inventory flows as unit of analysis. Incorporating the insights from other (natural science) disciplines into SSCM extends the notion towards the "production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy" (Stegmann et al., 2020), having a considerable overlap with circular SC management (Mies and Gold, 2021). Thus, besides managing material, information and capital flows, (bio)mass and energy flows need to be incorporated into SSCM to fully assess the economic, environmental and social performance of SCs.

The present analysis particularly shows a significant gap in addressing social dimension of SSCM, such as socio-cultural influences, transparency, and the integration of holistic sustainability transformation approaches. To map the social impacts of a citrus SCs, the cross-actor matrix can be applied. It contains various socio-economic aspects be being relevant in the context of circular SCs, such as economic welfare, employment, infrastructure, participation and involvement, social cohesion and embeddedness, transparency, contractual agreements and work conditions, as well as socio-environmental performance. Citrus SCs thus have the potential to open up new value creation perspectives, which have a positive socio-economic impact and multiplicator effects at the Base-of-the-Pyramid. They can stimulate economic growth and generate employment, which lead to improvement in household welfare and reduction in poverty (Mvelase et al., 2023). In addition, citrus SCs offer the possibility for decentral production, distribution and usage, thereby spreading the value creation across rural and urban areas. At the same time, shorter fuel transport routes could potentially improve the carbon footprint.

6.3 Future research

Four main research gaps have been identified throughout the analysis:

a Research about sustainability transformation strategies considered mainly the economic or environmental dimensions, while only a few studies discussed the social dimension. Also, when it combines two or more dimensions in the analysis, environmental and economic dimensions were the most appearing in the retrieved papers. Only one paper discussed sustainability as a holistic approach to achieving the sustainability transformation within citrus SCs.

b There is a need for studies evaluating social dimension, especially the social-cultural elements such as environmental awareness of the consumers to use bio-citruses and elements including regulations, food safety standards, road, and collection systems to provide the efficient and sustainable design of citrus byproduct SCs.

c Considering the sustainability transformation definition, the predominating scope is technology use, representing around 29%. In comparison, only 3% of the papers considered traceability, and no paper was found to discuss transparency within the citrus SCs.

d The papers need to assess the sustainability transformation definition as a holistic approach within the scope of the citrus SC. Therefore, there is still a need for more papers to cover those gaps in the literature.

Future research should prioritise addressing the identified research gaps. For example, there is a need for more papers exploring the social dimension within ASCs, particularly within citrus SCs, and examining the integration of the social dimension with other sustainability dimensions. Furthermore, future studies could delve into analysing social-cultural elements such as consumer awareness of environmental impacts, regulatory frameworks, and food safety. Additionally, researchers might explore other dimensions of sustainability transformation criteria, such as traceability, transparency, knowledge transfer, innovation, design, and decision-making. Although transparency was not addressed in any of the papers in this study, it could be a valuable focus for future research. Moreover, there needs to be more research on holistic sustainability transformation, indicating a potential area for future investigation to evaluate sustainability transformation criteria comprehensively.

Finally, limitations of this paper might be that it considered only journal papers published in the English language and not any other language, which might lead to missing other documents published within the scope of citrus SCs. In addition, keywords identified in the methodology section have considered citrus derivatives like orange, mandarin, clementine, lemon, grapefruit, and pomelo. However, the research and this paper might consider other citrus products. Still, the paper provides a strategic approach to adopting best practices for the sustainability transformation within citrus SC. Future research might address these limitations.

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Declarations

All authors declare that they have no conflicts of interest.

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Appendix A

The full search string used for bibliometric data

"mandarin" OR "Life cycle" AND "pomelo" OR "life cycle" AND "clementine" (Title) OR "Life cycle" AND "citrus" OR "Life cycle" AND "orange" OR "Life cycle" AND "lemon" OR "Life cycle" AND "grapefruit" OR "Life cycle" AND "mandarin" OR "Life cycle" AND "pomelo" OR "life cycle" AND "clementine" (Abstract) OR "Life cycle" AND "citrus" OR "Life cycle" AND "orange" OR "Life cycle" AND "lemon" OR "Life cycle" AND "grapefruit" OR "Life cycle" AND "mandarin" OR "Life cycle" AND "pomelo" OR "life cycle" AND "clementine" (Author Keywords) OR "Location" AND "citrus" OR "Location" AND "orange" OR "Location" AND "lemon" OR "Location" AND "grapefruit" OR "Location" AND "mandarin" OR "Location" AND "pomelo" OR "location" AND "clementine" (Title) OR "Location" AND "citrus" OR "Location" AND "orange" OR "Location" AND "lemon" OR "Location" AND "grapefruit" OR "Location" AND "mandarin" OR "Location" AND "pomelo" OR "location" AND "clementine" (Abstract) OR "Location" AND "citrus" OR "Location" AND "orange" OR "Location" AND "lemon" OR "Location" AND "grapefruit" OR "Location" AND "mandarin" OR "Location" AND "pomelo" OR "location" AND "clementine" (Author Keywords) OR "CO2" AND "citrus" OR "CO2" AND "orange" OR "CO2" AND "lemon" OR "CO2" AND "grapefruit" OR "CO2" AND "mandarin" OR "CO2" AND "pomelo" OR "CO2" AND "clementine" (Title) OR "CO2" AND "citrus" OR "CO2" AND "orange" OR "CO2" AND "lemon" OR "CO2" AND "grapefruit" OR "CO2" AND "mandarin" OR "CO2" AND "pomelo" OR "CO2" AND "clementine" (Abstract) OR "CO2" AND "citrus" OR "CO2" AND "orange" OR "CO2" AND "lemon" OR "CO2" AND "grapefruit" OR "CO2" AND "mandarin" OR "CO2" AND "pomelo" OR "CO2" AND "clementine" (Author Keywords) NOT "cement" OR "Oxidation" OR "combustion" OR "methyl orange" OR "Limestone" OR "liming" OR "calcination" OR "mortar" OR "protein*" OR " calcium loop*" OR "polyaniline" OR "durability" (All Fields) and English (Languages) and Article (Document Types).

Appendix B

Table A1 Papers' filter based on sustainability transformation and their connection to supply chain stages and sustainability dimensions

Reference	*Supply chain stage*					*Sustainability*			*Sustainability transformation*							
	Farm	*Processing*	*Logistics*	*Retailing*	*Consumption*	*Environmental*	*Economical*	*Social*	*Innovation*	*Technology*	*Knowledge*	*Decision*	*Design*	*Value*	*Traceability*	*Transparency*
Goodarzian et al. (2023)			*			*	*	*				*	*			
Sinisterra-Solis et al. (2023)	*					*						*				
Ines Cabot et al. (2023)	*					*						*				
Sofoulaki et al. (2023)	*					*							*			
Bian et al. (2023)		*				*	*			*						
Jaigirdar et al. (2023)			*	*			*					*	*			
Boninsegna et al. (2023)		*					*		*							
Chetia et al. (2023)		*				*	*		*	*				*		
Buller et al. (2023)		*				*	*			*				*		
Nozawa et al. (2023)	*					*	*			*						
Gaikwad et al. (2023)	*					*	*			*	*					
Catalano et al. (2023)	*					*				*	*	*				
Salvatierra-Miranda et al. (2023)	*						*			*						
Grima-Olmedo et al. (2023)	*					*	*							*		
Del Rosario Garcia-Mateos et al. (2023)		*				*	*							*		
Sultani et al. (2023)		*				*	*						*	*		
Tasic et al. (2023)	*					*	*		*				*	*		
Kumar et al. (2023)			*				*	*		*	*					
Vargas et al. (2023)		*				*							*			
Li et al. (2023)			*				*							*		
Melo-Paez et al. (2023)		*				*			*							
Goodarzian et al. (2022)	*	*	*			*	*					*	*			
Machin Ferrero et al. (2022)		*				*								*		
Shrivastava et al. (2022)			*				*			*						
Munoz Torres et al. (2022)	*					*		*				*				
Quispe-Fuentes et al. (2022)		*				*	*			*				*		
Yang et al. (2022)	*					*				*						
Khanpit et al. (2022)		*				*	*					*				
Martinez-Ardila et al. (2022)			*				*		*	*		*		*		
Abbar and Wang (2021)			*				*			*					*	
Leon Pena-Orozco et al. (2022)	*						*	*				*				
Jreissat and Makatsoris (2022)				*	*		*						*			
Karetsos et al. (2022)	*							*			*		*			
Yaldiz et al. (2022)		*					*						*			
Lu et al. (2022)		*				*				*				*		
Cayuela et al. (2022)	*					*				*		*				
Banaeian et al. (2022)	*					*	*					*				

Table A1 Papers' filter based on sustainability transformation and their connection to supply chain stages and sustainability dimensions (continued)

Reference	*Supply chain stage*					*Sustainability*			*Sustainability transformation*							
	Farm	*Processing*	*Logistics*	*Retailing*	*Consumption*	*Environmental*	*Economical*	*Social*	*Innovation*	*Technology*	*Knowledge*	*Decision*	*Design*	*Value*	*Traceability*	*Transparency*
Lima et al. (2022)		*					*				*		*			
Lindberg et al. (2022)	*	*				*				*						
Kourgialas et al. (2022)	*					*				*		*				
Jendoubi et al. (2021)	*						*						*			
Aregay et al. (2021)	*						*					*				
Villabona-Ortiz et al. (2021)						*	*							*		
Prestipino et al. (2021)		*				*							*			
Qubaja et al. (2021)	*					*						*				
Srivastava et al. (2021)		*					*			*						
Mazis et al. (2021)	*					*						*				
Berry et al. (2021)			*				*						*			
Liao et al. (2020)			*			*	*						*			
Jung et al. (2020)		*				*							*			
Tran et al. (2020)	*						*				*					
Xu et al. (2020)	*						*			*						
Tercan and Dereli (2020)	*					*	*					*				
Alberto Olvera-Vargas et al. (2020)	*						*			*						
Famoso et al. (2020)		*				*	*					*				
Cacace et al. (2020)		*				*	*			*						
Yek et al. (2020)		*					*		*							
Vasconez et al. (2020)	*						*					*				
Akolade et al. (2020)		*					*			*						
Saha et al. (2020)		*					*						*			
Marin-Buzon et al. (2020)	*						*			*						
Durkin et al. (2019)	*					*						*				
Mendez et al. (2019)	*		*				*				*					
Yoon et al. (2019)		*					*			*						
Lopresto et al. (2019)		*					*		*	*	*			*		
Joglekar et al. (2019)	*	*				*							*			
Martinez-Hernandez et al. (2019)		*					*							*		
Zabihi et al. (2019)	*						*					*				
Yang et al. (2019)	*						*				*					
Seidl et al. (2019)		*					*			*	*					
Stone et al. (2019)		*				*				*		*		*		
Cheraghalipour et al. (2018)			*				*					*				
Raimondo et al. (2018)		*	*			*	*		*				*			
Paniagua-Martinez et al. (2018)		*					*		*	*						

Table A1 Papers' filter based on sustainability transformation and their connection to supply chain stages and sustainability dimensions (continued)

Reference	*Supply chain stage*					*Sustainability*			*Sustainability transformation*							
	Farm	*Processing*	*Logistics*	*Retailing*	*Consumption*	*Environmental*	*Economical*	*Social*	*Innovation*	*Technology*	*Knowledge*	*Decision*	*Design*	*Value*	*Traceability*	*Transparency*
Siddique et al. (2018)	*						*					*				
Zhang et al. (2018)		*	*			*							*			
Cristobal et al. (2018)		*					*			*						
Rosa et al. (2018)	*						*				*					
Miranda-Ackerman and Azzaro-Pantel (2017)			*		*	*	*					*	*	*		
Miranda-Ackerman et al. (2017)		*	*			*	*					*	*			
Won et al. (2017)						*	*			*						
Li et al. (2017)		*					*			*						
Abbar and Wang (2021)		*					*			*						
Ferrarezi and Testezlaf (2017)	*						*			*			*			
Hyatt-Twynam et al. (2017)	*						*				*					
Basset-Mens et al. (2016)	*					*					*					
Navarro-Hellin et al. (2016)	*					*	*			*						
Li et al. (2015)		*					*			*						
Luca et al. (2015)	*							*				*				
Sun et al. (2015)	*		*				*			*						
Boukroufa et al. (2015)		*				*	*			*				*		
Sanchez-Velazquez et al. (2015)	*						*						*			
Kourgialas and Karatzas (2015)	*		*				*						*			
Olcan (2015)	*		*				*						*			
Xue et al. (2015)		*					*	*					*			
Sugiura et al. (2014)	*					*	*					*				
Sampedro et al. (2014)		*				*	*			*	*					
Giosafatto et al. (2014)		*				*	*		*							
Pourbafrani et al. (2013)		*				*	*						*	*		
Sahota et al. (2013)		*					*			*						
He et al. (2012)		*					*			*						
Huang (2012)			*				*	*		*			*		*	
Ortuno et al. (2012)		*					*			*						
Luo et al. (2012)	*						*				*	*				
Porto et al. (2011a)	*						*								*	
Contreras-Oliva et al. (2011)			*				*		*							
Porto et al. (2011b)	*						*		*	*					*	
Pinheiro et al. (2011)		*					*			*						
Fabroni et al. (2010)		*					*			*						
Oliveira et al. (2010)		*					*				*					
Iglesias et al. (2010)	*					*						*				