

Review

Assessing the Value of Sustainability in the Citrus Supply Chain

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Abstract

Agriculture plays a fundamental role in ensuring global food security in the context of a growing population; however, it is also responsible for the substantial consumption of natural resources and greenhouse gas emissions. In this context, the adoption of sustainable practices represents a key strategy to improve agri-food supply chains, including the citrus sector. This study applies the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol to conduct a systematic review aimed at assessing the economic value generated by environmental, social, and economic sustainability practices along the citrus supply chain. The analysis focuses in particular on the role of sustainability certifications, examining both their potential benefits and the constraints associated with their adoption for producers and markets. Positioned at the beginning of the supply chain, producers play a pivotal role in the adoption of sustainable practices, whereas consumers, at the end, are instrumental in assigning market value to sustainability attributes through their purchasing decisions. The results highlight that, although consumer interest in ethical and environmentally friendly citrus products is increasing, this demand is often constrained by the lack of clear, standardized, and easily interpretable sustainability indicators. The review also reveals a significant imbalance in the existing literature, with economic assessments predominantly focused on environmental and production-related outcomes, while the economic value generated by social sustainability practices remains largely unexplored. Moreover, the review emphasizes the strategic role of policymakers in fostering sustainable transitions by providing economic incentives and facilitating access to finance, particularly for smallholders. Overall, the findings suggest that sustainability can generate economic value in the citrus supply chain; however, its effectiveness strongly depends on market recognition, certification credibility, supply chain organization, and institutional support.

Keywords: sustainability certifications; economic value; citrus supply chain; stakeholders; market dynamics



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1. Introduction

Food production represents one of the most fundamental pillars of human well-being and economic development worldwide [1]. Agriculture plays a crucial role in ensuring food security for a rapidly growing global population; however, it also exerts significant environmental pressures, including intensive land use, high water consumption, substantial energy demand, and greenhouse gas emissions (GHG) [1–3]. Particularly, the agri-food system accounts for approximately 20% of global land use, 70% of freshwater consumption, and 32% of global energy use, and it is responsible for nearly one-third of global greenhouse gas emissions (corresponding to 3.3 billion tons of GHG emissions per

year), highlighting the urgency of the transition toward more sustainable production and supply chain models [1,2].

The challenges facing contemporary agricultural systems are multidimensional and interconnected. Climate change, water scarcity, especially in Mediterranean regions such as Southern Italy [4], soil degradation, biodiversity loss, the inefficient management of agricultural and post-harvest waste, price volatility, and the unequal value distribution along supply chains all threaten the long-term viability of farming systems, especially for smallholders [5–7]. Despite these challenges, agriculture remains a major source of employment, accounting for approximately 26.7% of the global labor force in 2019, underscoring its significant social and economic relevance [1].

In response to these global pressures, sustainability has become a central concept in agricultural and food system research. Sustainable agriculture aims to balance environmental protection, economic viability, and social equity by ensuring that current resource use does not compromise future generations' ability to meet their needs [8,9]. This multidimensional perspective is also reflected in the United Nations 2030 Agenda for Sustainable Development, particularly in goals related to decent work and economic growth (SDG 8) and sustainable cities and communities (SDG 11), emphasizing the role of agriculture beyond food production alone [10].

Agri-food supply chains play a pivotal role in translating sustainability principles into practice, by connecting farmers, processors, distributors, retailers, and consumers in complex networks of value creation [5,11]. In contrast to other industrial supply chains, food systems, and citrus supply chains, in particular, are strongly influenced by biological processes, food safety requirements, product quality standards, and climatic conditions, which intensify sustainability-related challenges [1,9]. Each stage of the citrus supply chain, from production and transportation to storage and retailing, contributes to the overall environmental, economic, and social performance of the system [1,9,11].

Despite the economic importance of the citrus sector, sustainability has received comparatively limited attention in the literature, particularly regarding its economic dimension [9]. While numerous studies focus on environmental impacts, often through Life Cycle Assessment (LCA) and related methodologies [12–15], the extent to which sustainable practices generate tangible economic value along the citrus supply chain remains insufficiently explored [16,17].

Against this backdrop, the present study provides a comprehensive overview of the existing literature by analyzing sustainability dynamics within the citrus agri-food supply chain, with a primary focus on the economic dimension, particularly in terms of resilience and value creation, while also considering environmental and social dimensions as complementary components of sustainability.

By adopting a holistic supply chain perspective, this research seeks to identify critical hotspots, assess opportunities for improvement, and support the development of more resilient and sustainable citrus production models capable of aligning productivity goals with environmental stewardship and social well-being. The analysis seeks to address the following research questions:

RQ1: Under what conditions does sustainability generate economic value in citrus supply chains?

RQ2: How do certifications influence profitability across different market contexts?

RQ3: What are the main barriers to sustainability adoption for citrus producers?

Using the PRISMA 2020 protocol, this review examines sustainability from different perspectives, with particular attention being paid to the role of certifications and policy support mechanisms.

The manuscript is organized as follows: The section entitled “Overview of the Global Citrus Sector” provides an overview of the global citrus sector; Section 2 describes the

methodology employed; Section 3 presents the results of the systematic literature review, including VOSviewer (version 1.6.20) mapping and additional economic analysis; Section 4 provides a discussion of the findings; and Section 5 concludes the study by outlining the directions for future research.

Overview of the Global Citrus Sector

Among fruit crops, citrus represents a globally important sector due to its wide geographic distribution, high production volumes, and prominent role in international trade. According to FAOSTAT, global citrus production exceeded 160 million tons in 2023, cultivated on more than 10 million hectares worldwide [18]. Oranges alone account for nearly 70 million tons of annual production, with a global gross production value of approximately USD 29 billion (Figure 1), highlighting the economic importance of the citrus sector [18]. Major producing countries include China, Brazil, India, Mexico, and the United States (Figure 2), while international trade flows further expose the sector to market dynamics and sustainability requirements [19]. However, citrus production is often characterized by fragmented farm structures, the dependence on seasonal labor, and the exposure to volatile international markets, which can further hinder the adoption of sustainable practices, particularly among small- and medium-sized enterprises [7,8,11,20–22].

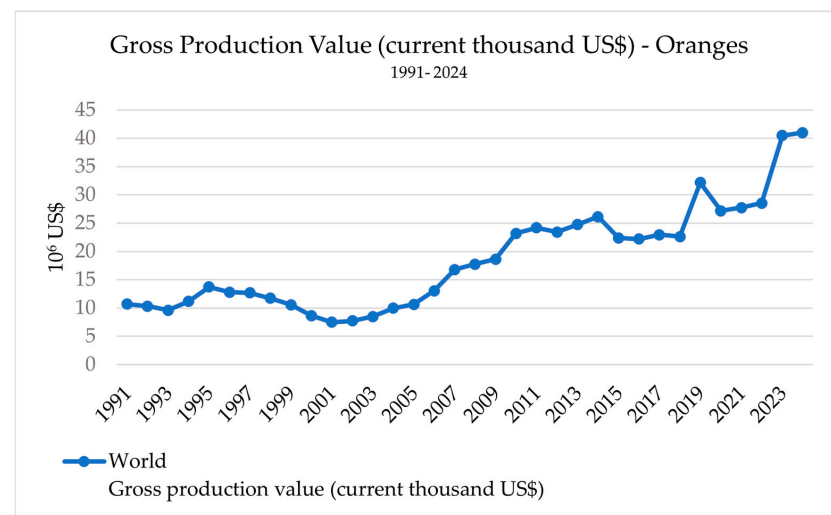


Figure 1. World average Gross Value of Oranges [18].

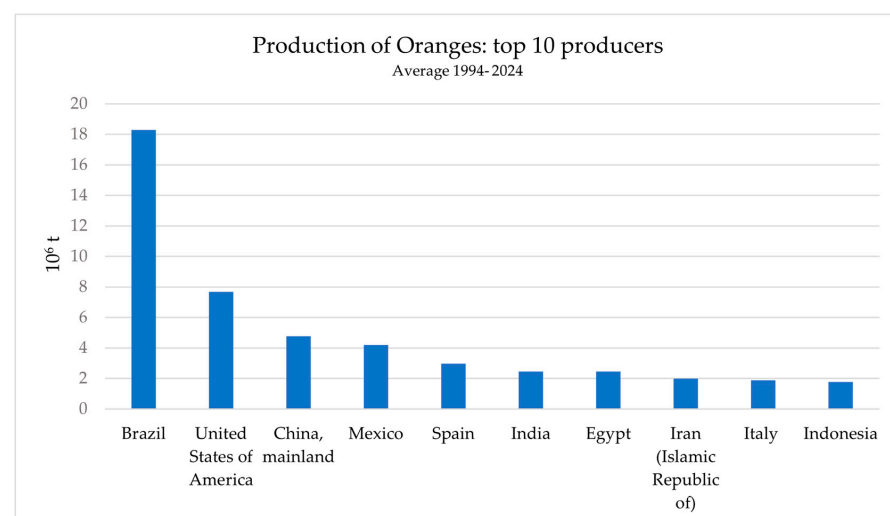


Figure 2. Average of production in the top 10 producers [18].

2. Materials and Methods

2.1. Systematic Review

A systematic review is designed to provide original and comprehensive insights based on robust and rigorous evidence [23,24]. Conducting a high-quality systematic review requires careful attention to be paid to three key aspects. First, the data collection process must involve a comprehensive search of relevant scientific publications across multiple sources to ensure both relevance and completeness. Second, a well-defined protocol should guide the systematic identification and collection of evidence, thereby providing clear guidance for the review process and minimizing ambiguity. Finally, the selection of studies should prioritize empirical evidence and follow a rigorous and transparent strategy, thereby ensuring the replicability of the findings [25].

The review was conducted in accordance with the PRISMA protocol, and the PRISMA 2020 checklist is provided as Supplementary Material. It is an evidence-based set of guidelines designed to support the transparent reporting of systematic reviews and meta-analyses [26]. The protocol provides a replicable, robust, and transparent framework, and consists of several stages. It is widely recognized and accepted across multiple fields, providing a standardized approach that facilitates consistency in reviews and enables readers to interpret and compare findings more easily [27].

Research projects are typically structured around three key elements: the research objectives, the methodology employed, and the outcomes and their potential application [26]. This study followed the same three-step framework. First, the research questions were clearly defined. Next, the study was conducted following the PRISMA protocol to guide the systematic identification, screening, and analysis of the literature. Finally, the results were evaluated and interpreted to derive meaningful conclusions. The literature included in this review was retrieved from Elsevier Scopus database, a comprehensive database of international scientific literature.

Data Collection

To address the research question (RQ1, RQ2, and RQ3) multiple tests were conducted using different combinations of keywords including supply chain, orange, citrus, sustainability, value, market, grow, farm, Mediterranean grow, and fruit. Boolean operators [AND, OR], quotation marks [“ ”], and brackets [()] were used to narrow the scope of the searches. The final keywords selected for the string to conduct the research were (“orange” OR “citrus”) AND “sustainability” AND (“supply chain” OR “market” OR “value”). The chosen keywords were selected to encompass ensuring comprehensive coverage of the relevant literature in line with the research topic. The search was performed in the “article title”, “abstract”, and “keywords” fields. The final search was executed on 9 March 2026, covering all literature published up to 31 December 2025.

To assess the robustness and sensitivity of the search strategy, a supplementary search was also performed. This additional step included the use of terms related to sustainability standards and economic outcomes, including “organic”, “GlobalG.A.P.”, “Fairtrade”, “life cycle assessment”, “profitability”, and “willingness to pay”, as well as an expanded search string: ((“citrus” OR “orange”) AND (“supply chain” OR “value chain” OR “market”) AND (“sustainability” OR “sustainability adoption” OR “sustainability index”) AND (“compliance” OR “certification” OR “standard*”). This supplementary search retrieved 16 additional records. These records were screened at title, abstract, and full-text level using the same eligibility criteria as the primary review. All relevant studies identified through this process were already included in the final dataset and no additional eligible studies were identified. This sensitivity analysis confirms that the original search strategy was

sufficiently comprehensive for capturing the relevant literature on sustainability in citrus supply chains.

In accordance with the PRISMA protocol, a set of inclusion and exclusion criteria was established prior to the literature search. The search was restricted to journal articles and review papers; therefore, other document types, including conference paper, book chapter, conference review, book, and errata, were excluded. Another exclusion criterion concerned the language of publication: only publications written in English were considered, given its widespread use as the primary language of scientific communication. All records retrieved from the database search were imported into Mendeley reference management software (version 2.144.0). An initial screening was conducted based on titles and abstracts to assess the relevance studies. Subsequently, the full texts of potentially eligible articles were examined to determine their suitability for inclusion in the review. Studies included if they investigated sustainability-related practices within the citrus supply chain and reported environmental, social, and/or economic performance outcome. During the full-text assessment, studies were excluded when they did not focus on citrus supply chains, did not address sustainability-related issues, failed to report relevant sustainability outcomes, or did not satisfy the predefined inclusion criteria. The number of records excluded at each stage, together with the corresponding reasons for exclusion, is reported in the PRISMA flow diagram (Figure 3). To enhance methodological rigor, the screening process was conducted independently by three authors, who reached consistent results. Any discrepancies in study selection were resolved through discussion until consensus was achieved. The inclusion and exclusion criteria are summarized in Table 1. No temporal restrictions were applied to the search strategy, as the objective was to capture all relevant literature available up to the date of the review.

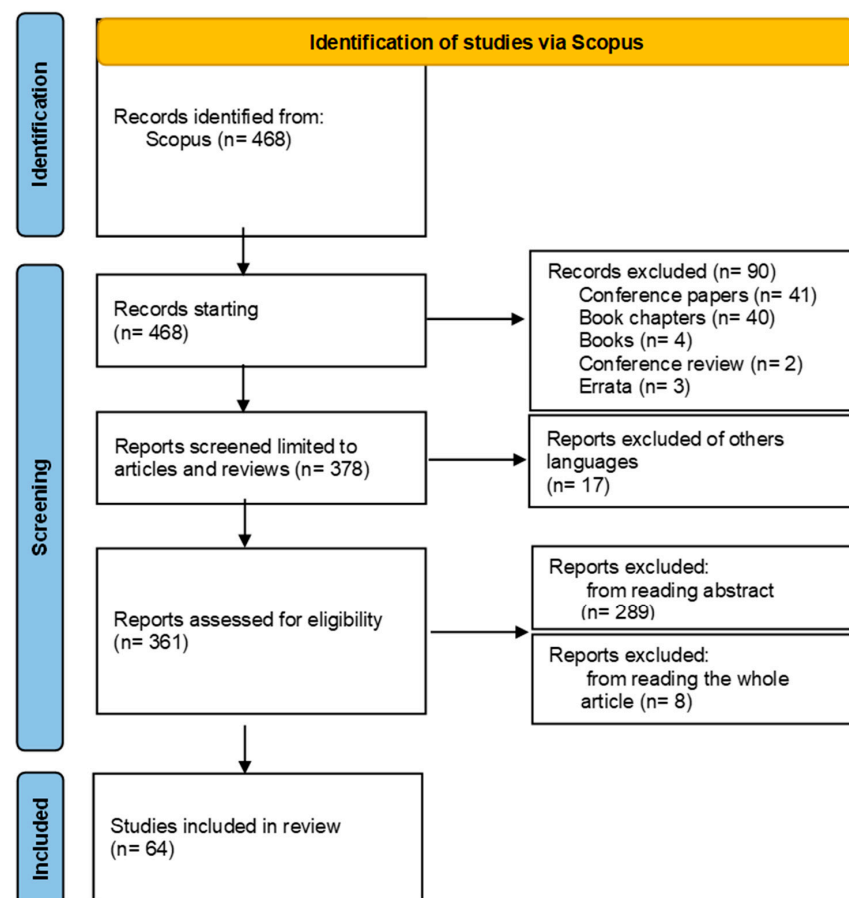


Figure 3. PRISMA 2020 flow diagram.

Table 1. Inclusion and exclusion criteria.

Inclusion Criteria	
▪	Full-text papers from Scopus
▪	Full-text studies on sustainability-related practices in citrus supply chain reporting environmental, social, and/or economic performance outcomes
▪	Full-text papers (articles and reviews) published in a peer-reviewed journal
▪	Full-text written in English
Exclusion criteria	
□	Conference papers, book chapters, conference review, books, and errata
□	Non-English languages
□	Excluded from reading abstract
□	Excluded from reading the whole article

2.2. VOSviewer

All selected papers were uploaded to Mendeley, a software tool used to facilitate the management of bibliographic references. After the selection process based on the PRISMA protocol, the papers were organized into the “Favorites” group within Mendeley and subsequently exported in “.ris” format. The “.ris” files enabled the articles to be imported into another software program, VOSviewer. The free Java-based software VOSviewer developed at the Centre for Science and Technology Studies at Leiden University in Netherlands and it was used to create maps based on network data [28]. VOSviewer is able to generate a so-called co-occurrence maps, identifying the most frequently mentioned keywords: In the map, each word is represented by a node with a high level of occurrence. The size of the node depends on the frequency of occurrence. The network between the nodes correspond to connection frequency degree, and it helped to visualize the relationships between the keywords [29]. The keywords are grouped in various colors, that allow us to identify them in different clusters based on how often those words are linked together [30], while the density map highlighted the intensity of their occurrence across the selected papers [30]. The statistical analysis carried out with VOSviewer selected the most frequently used words in the 64 papers and the relationship between these words. The maps have been created based on text data. The data was read from the reference manager file in “.ris” format, after selecting the file. The next steps were as follows:

- Fields from which terms are extracted: title and abstract fields;
- Counting method: full counting;
- Minimum number of occurrences of a term: 10;
- Number of terms selected: all 37 terms identified.

Before creating the map, the final step was verifying that generic keywords not strictly related to the research topic had been excluded, including addition, area, tool, scenario, use, order, approach, model, system, case, study, analysis, research, year, and paper. Finally, twenty-two keywords had been identified to create the maps. A network map and a density one were extracted. The network map represents the words with a high level of co-occurrence; the items were grouped in clusters. Instead, the density visualization map allows us to highlight the most frequent keywords present in the papers, employing different intensity color. By default, the colors blend from yellow to blue—in particular, high density of items with yellow, medium density with green, or low density with blue [27].

2.3. Economic Analysis

Among the papers selected, some of them included an economic analysis involving different aspects: production costs, selling price, income, Farm Net Value (the difference between the total value of assets and the value of liabilities), Gross Production Value (total

value of production obtained at market prices, before subtracting production costs), Profit (calculated by subtracting all costs from income or from total production value), and Net Present Value (value of all present and future cash flows by subtracting the initial value of the investment, which allows us to evaluate the profitability of an investment).

Direct comparisons among countries were not performed. Economic differences observed across studies are influenced by a wide range of factors, including market organization, consumer purchasing power, institutional and regulatory frameworks, supply chain structures, marketing strategies, currency differences, and the years in which the studies were conducted. Furthermore, the application of inflation adjustments, taxation schemes, and economic updating procedures is often inconsistent or not feasible across datasets. As a result, establishing a direct and linear comparison among countries would be methodologically unreliable. A further limitation is the heterogeneity of the economic information reported in the literature, further limiting the possibility of conducting a comprehensive and standardized cross-country comparison.

3. Results

The results are organized into three main sections. The first section provides an overview of the literature; the second reports the bibliometric analysis; the third presents the findings based on thematic analysis.

3.1. Overview of Selected Literature

A total of 64 papers were identified and subjected to a full review. A descriptive analysis of the included studies extracted from Elsevier Scopus was conducted to illustrate the geographical distribution of the research and the annual distribution of publications. The geographical distribution was determined primarily according to the study location; when this information was unavailable, the authors' institutional affiliation was used. As some studies involved multiple countries, the total number of country occurrences may exceed the number of reviewed papers. The results demonstrate a considerable interest in sustainability along the citrus supply chain, with various papers from different countries (Figure 4). Italy emerged as the leading contributor, with 13 publications, followed by Germany (7). Turkey (6) and Brazil, France, Iran, and Spain (5 publications each) also showed substantial research activity. Mexico contributed 4 studies, while Argentina, China, Colombia, and the United Kingdom each accounted for 3 publications. Chile, Egypt, Taiwan, and the United States were represented by 2 studies each. The remaining countries, including Austria, Iceland, Jordan, the Netherlands, Pakistan, Poland, Saudi Arabia, South Africa, Sweden, Switzerland, Thailand, and Tunisia, contributed 1 publication each (Figure 5). The major prominence of sustainability studies in the Italian citrus sector reinforces the perception of Italy as a country strongly committed to sustainability. This commitment is further reflected in Italy's position as one of Europe's leading countries in organic farming, a production system aimed at minimizing environmental impacts [31]. Furthermore, among the 64 papers systematically selected using the PRISMA protocol, the temporal coverage of publications on this research topic spans from 2007 to 2025. This indicates a relatively recent research interest; although no time filter was applied, the earliest publications on this topic date back only to 2007. As shown in Figure 6, the number of publications has increased over the years.

The systematic review identified articles aiming to address sustainability in agri-food supply chains as follows: only 12 out of 64 articles explicitly investigated the economic value generated by sustainability practices in the citrus sector; 14 contributions focused primarily on environmental performance, often employing Life Cycle Assessment (LCA) and related methodologies to evaluate environmental impacts [13,15–17,32–36]. Other

studies adopted alternative environmental assessment approaches, such as Water Footprint analysis [37,38], the Material Input per Service unit (MIPS) method [14], or energy demand assessments [39,40]. In contrast, five studies adopted an integrated perspective combining the environmental, economic, and social dimensions of sustainability [1,9,22,41,42].

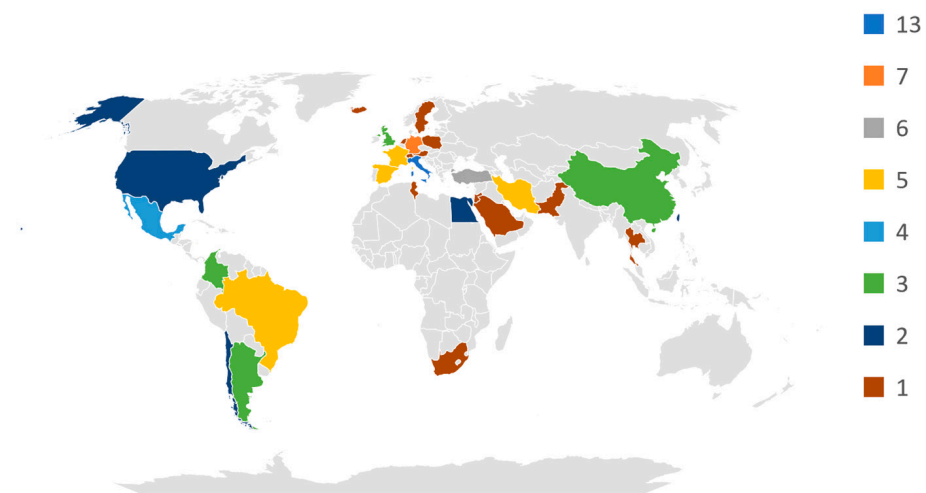


Figure 4. Geographical distributions of studies—visualization map.

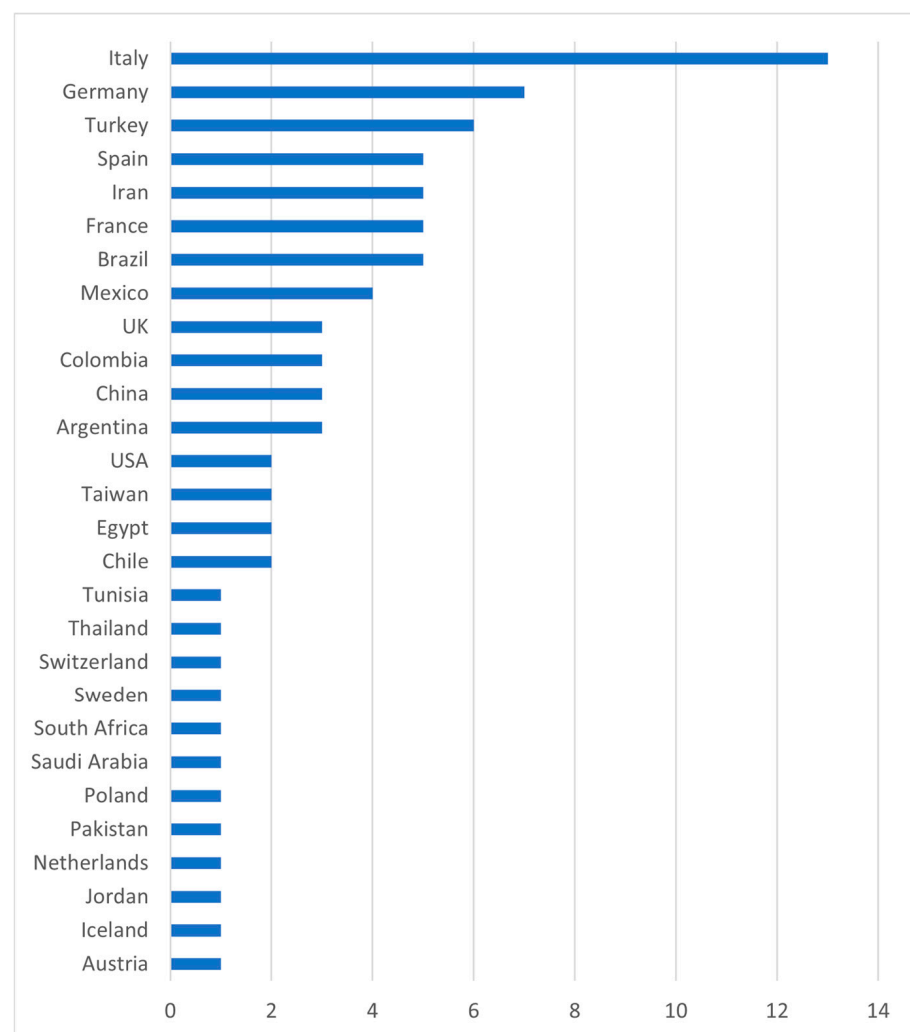


Figure 5. Geographical distributions of papers.

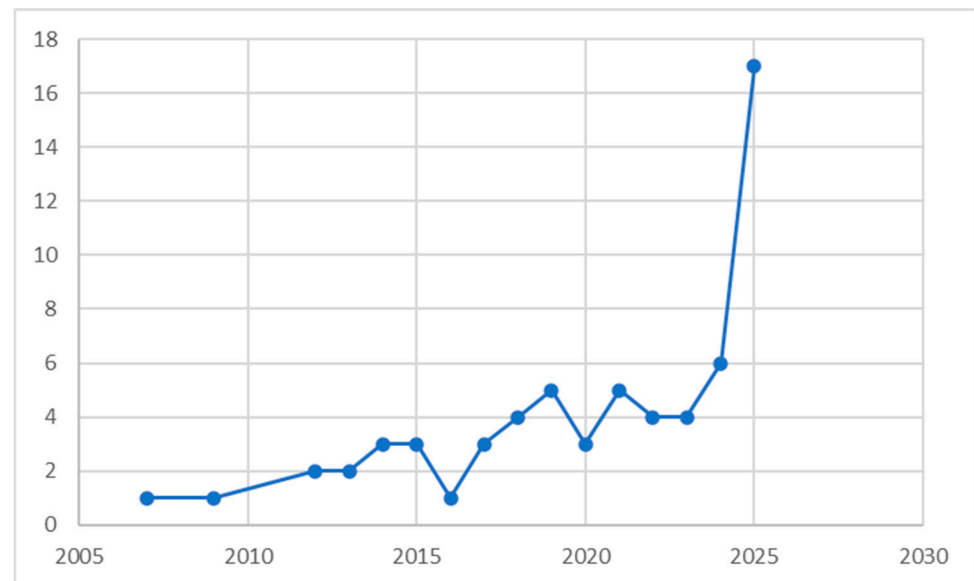


Figure 6. Number of publications per year.

3.2. Bibliometric Analysis (VOSviewer)

The bibliometric analysis conducted using VOSviewer identified coherent thematic clusters. Nevertheless, given the relatively small dataset of 64 eligible studies, the resulting network should be interpreted as exploratory and complementary to the findings of the systematic review.

Figure 7 shows a co-occurrence map based on title and abstract keywords, employing VOSviewer software. The co-occurrence analysis allowed us to identify four different clusters:

- Cluster 1 (red color) grouped together eight items: agriculture, citrus, citrus farmer, citrus supply chain, farmer, impact, supply chain, and sustainability.
- Cluster 2 (green color) grouped together six items: environmental impact, fertilizer, input, orange, producer, and production.
- Cluster 3 (blue color) grouped together five items: consumer, food, fruit, product, and waste.
- Cluster 4 (yellow color) grouped together three items: farm, gap, and good agricultural practice.

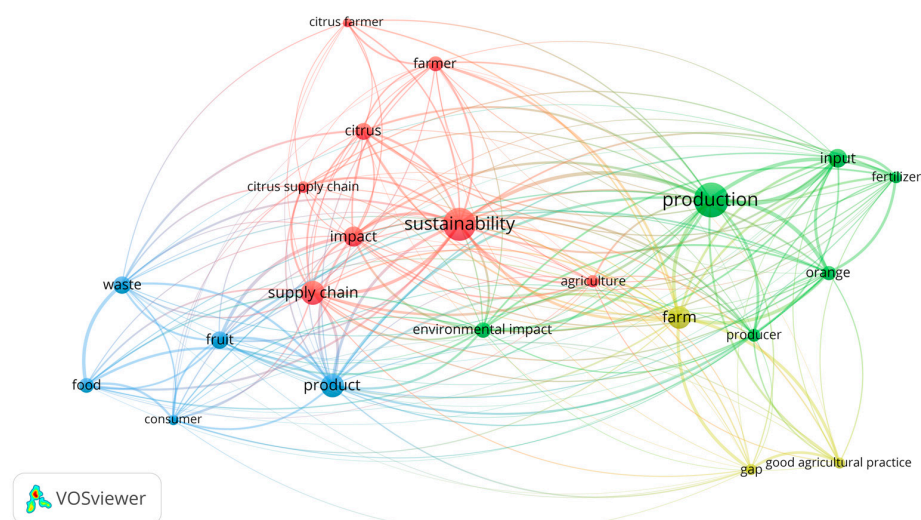


Figure 7. Title and abstract co-occurrence map.

Cluster 1 encompasses a broader dimension of the research topic. It highlights the central role of agriculture in the citrus sector and emphasizes the importance of farmers as key actors within the citrus supply chain, with a focus on the overall sustainability and impact of citrus production systems. Cluster 1 is particularly relevant to RQ1, as it emphasizes the production stage as the primary focus of the sustainability assessment within the citrus supply chain. The centrality of farmers and agricultural production in this cluster highlights their key role in generating economic value and influencing the sustainability performance across the supply chain.

Cluster 2 groups together topics related to the initial stages of the citrus fruit supply chain, with a particular emphasis on citrus production and orange cultivation. This cluster highlights the environmental dimension of orange farming, underscoring the pivotal role of fertilizers as a primary input, that directly influences both productivity and ecological impact. Cluster 2 is relevant to both RQ1 and RQ3. Regarding RQ1, it confirms that the production phase is a key focus of sustainability research within the citrus supply chain, highlighting the relationship between economic performance, production efficiency, and input management. With respect to RQ3, this cluster identifies a major challenge to sustainability implementation, namely, the need to reduce the environmental impacts associated with agricultural inputs, particularly fertilizers. This suggests that optimizing fertilizer use and improving resource efficiency may represent a viable strategy for overcoming the barriers to sustainability adoption.

Cluster 3 focuses on the consumption side of the citrus supply chain, particularly from an environmental perspective. It addresses food and fruit products more broadly, emphasizing that waste is generated at every stage of the supply chain. The cluster highlights the importance of understanding consumer behavior, improving product handling, and implementing strategies to reduce fruit and food waste. Overall, Cluster 3 reflects the growing research interest in linking consumption patterns with sustainable practices during the distribution and post-harvest phases of the citrus supply chain. This cluster is relevant to RQ2, as it shows that market and consumer-side factors, including waste reduction and the demand for sustainable products, may influence the profitability of sustainability practices and the effectiveness of certification schemes in different market contexts.

Cluster 4 focuses on Good Agricultural Practices (GAPs) at the farm level and represents a forward step toward improved farm resource management. It emphasizes GAPs as a strategic approach to enhancing farm sustainability. This cluster directly relates to RQ2 and RQ3, since Good Agricultural Practices (GAPs) are often linked to certification systems that can enhance market access and profitability, but may also present adoption challenges for producers due to compliance requirements and implementation costs.

The central keywords are production, sustainability, and farm, which exhibit the highest total link strength, with values of 775, 605, and 544, respectively. In terms of occurrence, production remains the most frequent keyword (77 occurrences), followed by sustainability (71 occurrences), while supply chain ranks third (44 occurrences) (Figure 8).

Figure 9 presents the density map based on the keywords extracted from the titles and abstracts of the selected papers. The results confirm the findings obtained from the previous map. In particular, production and sustainability are highlighted in yellow, indicating the highest number of occurrences. Therefore, the density analysis provides additional evidence in support of RQ1, indicating that production-related activities represent the primary focus of the sustainability assessment within the field.

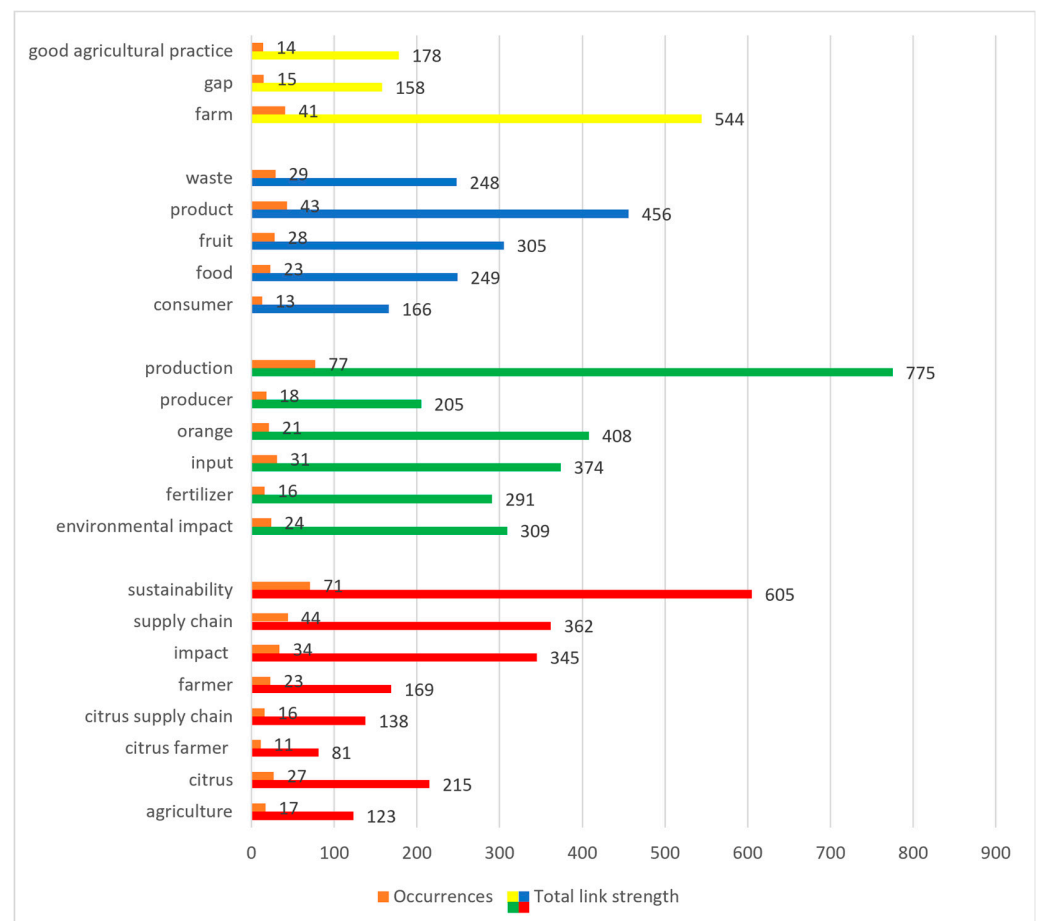


Figure 8. Occurrences and total link strength for each item.

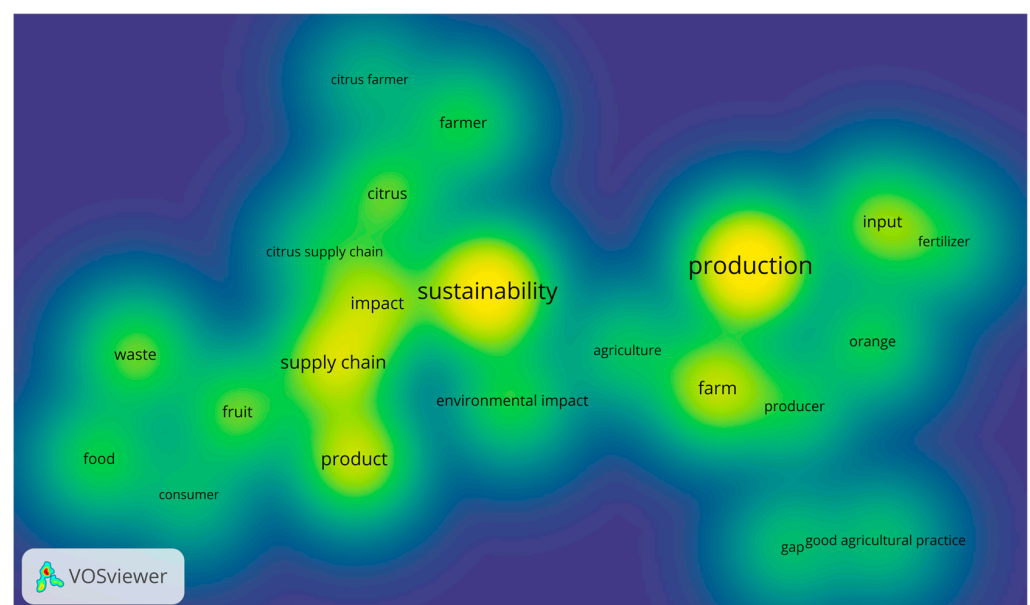


Figure 9. Density map based on title and abstract keywords.

3.3. Thematic Analysis

3.3.1. Environmental Sustainability Assessment Approaches

The reviewed literature applies a wide range of environmental assessment methodologies to citrus production systems; as stated before, Life Cycle Assessment (LCA) emerges as the most frequently adopted approach. Across different geographical contexts, LCA studies

consistently identify irrigation, fertilizer application, and energy consumption for farm operations as the main environmental hotspots in citrus production [13,15–17,32,33,35,36]. For a further environmental assessment, the Water footprint analysis highlights the critical role of blue water consumption in Mediterranean and semi-arid regions, underscoring the vulnerability of citrus systems to water scarcity and climate variability [37,38]. Overall, these studies indicate that environmental impacts are highly context-dependent and strongly influenced by system boundaries, yield levels, and management practices, with citrus production systems often relying on non-renewable resources [43]. Integrating broader system perspectives into environmental assessments has therefore become increasingly important. In this regard, several studies emphasize the relevance of circular economy approaches, particularly the inclusion of processing activities, by-product valorization, and waste recovery within the assessment boundaries [2,44–46]. These strategies significantly improve the overall environmental performance by reducing waste and increasing resource efficiency [13,47]. In addition, the increased adoption of renewable energy sources and improved input management practices could further enhance energy efficiency and reduce environmental impacts in citrus production systems [43]. Despite the growing body of research, the substantial methodological heterogeneity across studies continues to hinder cross-study comparability. This highlights the need for harmonized indicators and system-level benchmarks in the assessment of cleaner environmental systems [48]. One relevant approach is the Sustainability Assessment of Food and Agriculture systems (SAFA), a comprehensive framework developed by the Food and Agriculture Organization (FAO) to support consistent sustainability evaluations [49].

In addition, in recent years, agricultural practices have increasingly been integrated with technological innovations to enhance the environmental performance of citrus production systems. Digital technologies and market access platforms are playing an increasingly important role in promoting sustainable practices, as farmers participating in e-commerce platforms gain better access to information and stronger market incentives for high-quality products [50].

3.3.2. Supply Chain Organization and Sustainability

While farm-level practices are important, the literature increasingly highlights the role of supply chain organization in determining the sustainability performance of citrus systems [11,45]. Agricultural supply chains operate in highly uncertain environments and are frequently exposed to disruptions arising from production variability, market fluctuations, and logistical constraints [7,22]. Effective risk management strategies, including the identification and assessment of potential supply chain risks, are therefore essential to ensure operational stability and resilience [51,52].

In the citrus sector, cooperative structures and collective marketing arrangements play a key role in improving sustainability outcomes [20,21]. These organizational models enable smallholders to access certification schemes, reduce logistics costs, and improve waste management practices [7,20,45]. Conversely, producers operating in fragmented supply chains often face significant barriers when attempting to adopt cleaner production practices and sustainability-oriented innovations [7,53].

Within citrus supply chains, circular economy principles are particularly relevant due to the large quantities of by-products and organic waste generated during processing [13,19]. Closed-loop supply chain models facilitate the recovery, recycling, and reuse of materials, contributing to reduced environmental impacts and improved resource efficiency [54]. However, the implementation of circular strategies is often constrained by technological limitations, high investment costs, the limited collaboration among stakeholders, and insufficient policy support [53]. Supply chain optimization approaches further

demonstrate the potential to improve both environmental and economic performance [5,51]. Logistics optimization and waste reduction strategies significantly reduce the environmental impacts while increasing resource efficiency [2,19]. These approaches also enable the valorization of by-products or also waste and promote a more equitable redistribution of value among supply chain stakeholders [44,46,55]. Coordination among supply chain actors represents another crucial dimension. Collaborative planning and information sharing can substantially improve logistical performance, enhancing delivery reliability, inventory management, and cost efficiency [22,56]. Innovation management within agricultural value chains also contributes to sustainability transitions. Coordinated innovation strategies across the production, processing, and commercialization stages facilitate the adoption of environmentally friendly technologies and strengthen knowledge exchange among stakeholders [27,57]. Optimization models have also been developed to support the design of resilient citrus supply chains, integrating sustainability and resilience considerations into network design decisions [19,58]. These models evaluate alternative scenarios involving supplier diversification, backup processing facilities, and flexible logistics configurations, demonstrating how integrated planning can significantly improve supply chain resilience [58].

Finally, policy frameworks and institutional support mechanisms play an important enabling role. Investment subsidies, technical assistance programs, and governance reforms can facilitate the transition toward more sustainable and cleaner citrus supply chains [59,60].

3.3.3. Certification Impacts and Market Recognition

Within these supply chain structures, certification schemes represent one of the main governance mechanisms used to promote sustainable practices and enhance market transparency. The reviewed studies examine a broad range of certification schemes, including Organic, GlobalG.A.P., Fairtrade, Good Agricultural Practices (GAPs), and geographical indications, such as PDO (Protected Designation of Origin) and PGI (Protected Geographical Indication) [61]. Table 2 summarizes the certification schemes examined in the literature and the corresponding country contexts [8,21,36,42,62–70]. Overall, certification schemes contribute to the adoption of improved environmental practices and stronger social cohesion, and facilitate access to international markets [62,64]. However, their economic effectiveness largely depends on governance structures, enforcement mechanisms, and consumer recognition [21,69]. Although sustainable practices generate clear environmental and social benefits, their adoption is often constrained by economic, social, and institutional barriers, including the limited access to resources and insufficient financial incentives [8]. In the absence of well-organized producer networks, certification schemes may increase compliance costs and create additional economic pressures for farmers [68]. From an environmental perspective, organic management practices are widely recognized as an effective approach to enhance soil quality and mitigate climate change impacts [36,71]. Organic farming systems have been shown to increase soil carbon storage and improve key soil quality indicators, including nutrient availability and biological activity [72]. These improvements strengthen soil resilience and contribute to the long-term sustainability of citrus production systems, particularly in semi-arid regions [71].

Among the various certification schemes, the adoption of Good Agricultural Practices (GAPs) has been shown to facilitate access to export markets and increase product competitiveness. The adoption of GAPs improves food safety standards, enhances consumer trust, and, in some cases, allows producers to obtain higher selling prices due to the improved product quality [65,67]. However, the evidence on price premiums remains mixed, as some studies report no significant price differences between GAPs and conventional products [70].

Table 2. Summary of papers taken in consideration in Certification Impacts and Market Recognition.

Author(s)	Focus	Country
Amekawa [8]	Q-GAP (Quality-Good Agricultural Practices)	Thailand
Belmin et al. [62]	GIs (Geographical Indications)	Corsica, France
Beltrán-Esteve et al. [42]	Organic	Spain
Di Vita et al. [63]	Conventional/Integrated/Organic PGI	Italy
Millet et al. [64]	GI	France
Mook et al. [21]	Fairtrade, Organic, GLOBALG.A.P.	Netherlands and United States
Razzaghi Borkhani & Mohammadi [65]	GAPs	Iran
Sgroi et al. [66]	Organic	Italy
Söyler & Atli [67]	GAPs	Turkey
Strano et al. [36]	Conventional/Organic	Italy
Tudisca et al. [68]	PDO	Italy
Turra et al. [69]	Fairtrade, Integrated Production, Organic, RAS, GLOBALG.A.P.	Brazil
Yilmaz et al. [70]	Good Agricultural Practices	Turkey

Certification schemes tend to create greater value when supported by credible monitoring systems, a strong market demand, and integration within coordinated supply chains. In fragmented markets, overlapping certification schemes may generate competition rather than complementarity, increasing compliance costs and reducing net benefits for producers [64]. In some contexts, industry-driven business-to-business standards, such as GlobalG.A.P., compete with consumer-oriented labels, like Fairtrade and Organic. While this competition may create challenges, it also contributes to the development of knowledge and facilitates access to international markets [21].

3.3.4. Economic Performance of Sustainable Citrus Systems

Economic performance represents another key dimension in the assessment of sustainable citrus production systems. Among the 64 selected papers, 12 specifically analyze economic outcomes along the citrus supply chain (Table 3).

Table 3 provides an overview of the studies included in the review, reporting the geographical area, the citrus products investigated, and the corresponding references. The studies cover a production context mainly related to Mediterranean citrus-growing regions; only two study are outside the Mediterranean region [51,73]. The reviewed literature focuses on several citrus species, mainly oranges, mandarins, lemons, and mixed citrus orchards, reflecting the diversity of the production systems and market conditions analyzed. The identified studies were published between 2014 and 2025, spanning more than a decade of research on economic performances in the citrus supply chain.

Table 3. Overview of the studies included in the economic assessment of Citrus systems.

References	Study Area	Citrus Product
[1] Alzubi et al. (2023)	Jordan	Clementine, grapefruit, lemon, orange, pomelo
[36] Strano et al. (2017)	Italy	Bergamot
[42] Beltrán-Esteve et al. (2012)	Spain	Mandarin, orange

Table 3. *Cont.*

References	Study Area	Citrus Product
[51] Iñigo Martínez et al. (2025)	Argentina	Lemon
[63] Di Vita et al. (2018)	Italy	Clementine
[66] Sgroi et al. (2015)	Italy	Lemon
[67] Söyler & Atli (2018)	Turkey	Orange, mandarin
[68] Tudisca et al. (2014)	Italy	Orange
[70] Yilmaz et al. (2017)	Turkey	Lemon, mandarin
[74] Testa et al. (2015)	Italy	Lemon
[73] Mohammadshirazi et al. (2015)	Iran	Orange
[75] Söyler et al. (2023)	Turkey	Grapefruit

As summarized in Table 4, the studies included in this review do not consistently report the same economic indicators. Data on selling prices, production costs, income, and net present value (NPV) are available only for a subset of studies; consequently, the results are presented descriptively.

Table 4. Summary of the studies evaluating the economic performance of citrus production systems.

Selling Price	Production Costs	Income	NPV
[1]	[1]		
[36]	[36]		[36]
[42]		[42]	
[51]	[51]		[51]
	[63]		
[66]	[66]		[66]
[67]		[67]	
[68]	[68]		
	[70]		
[74]	[74]	[74]	[74]
[73]	[73]	[73]	
	[75]		

Comparisons within the same country should be interpreted with caution. The reviewed studies often examine different production systems (e.g., conventional, organic, and integrated), as well as different citrus species and product categories, which may vary substantially in terms of quality attributes, fruit size, market destination, and commercial value [76]. Consequently, the economic outcomes reported are affected by numerous context-specific variables, limiting the comparability of the results. Therefore, any comparison of economic performance across studies should be considered indicative rather than conclusive.

Organic citrus products generally achieved higher selling prices than conventional products [36,42,66]. In some cases, price premiums were associated with collective marketing arrangements, such as Producer Organizations and Protection Consortia, which strengthened bargaining power, improved market access, and contributed to price stabilization [36,66]. The adoption of Good Agricultural Practices (GAPs) was also associated

with higher selling prices, increasing the price up to approximately 47%, in some cases [67]. However, the economic benefits of certification and quality assurance schemes are context-dependent and influenced by local market conditions, sometimes with only marginal or negligible differences between GAP-certified and non-certified products [70].

Organic production systems generally show lower input costs than conventional systems due to the reduced use of fertilizers and pesticides, although this pattern is not universal across all citrus types [36,66,74]. Across all production costs, labor represents the dominant cost component, accounting for approximately 40–45% of total production costs, primarily due to harvesting and pruning operations [63,66,68,75]. Material and service costs represent the second-largest cost category and are typically higher in conventional farms due to the greater input intensity (including fertilizers, pesticides, and water) [66].

Economic indicators such as income, farm net value, profit, and Net Present Value (NPV) highlight the high sensitivity of citrus farming to price and yield fluctuations. Some studies report higher incomes for organic and conventional systems [42,74]. Moreover, minimum income levels tend to be lower in organic systems, reflecting a higher exposure to market and production risks.

Long-term investment analyses based on NPV calculations generally favor organic systems over conventional ones in the long term, despite the lower yields, due to the higher selling prices and policy support mechanisms [36,66,74]. However, sensitivity analyses demonstrate that organic profitability is highly dependent on agri-environmental payments. Without public support, even moderate decreases in selling prices or increases in production costs can render organic investments economically unviable [74]. In addition, the careful design of the logistics, storage, and processing stages can increase NPV and enhance the economic performance and operational efficiency of citrus production, while balancing environmental trade-offs [51].

3.3.5. Consumer Demand and Market Dynamics

The success of sustainable citrus production ultimately depends on the market demand and consumer behavior; yet, studies focusing specifically on citrus consumers remain limited. The existing research on consumer preference reports a positive willingness to pay a premium for sustainable citrus products, particularly when environmental attributes are combined with quality, origin guarantees, and food safety assurances [77,78]. Digital tools and behavioral interventions can further influence sustainable food choices by increasing consumers' awareness of environmental impacts and promoting more environmentally friendly diets, thereby contributing to the reduction in the carbon footprint associated with food consumption [79]. However, willingness to pay varies across consumer segments and geographical contexts, reflecting the differences in income levels, cultural preferences, and trust in certification schemes. The growing consumer awareness of environmental and ethical issues has increased the demand for certified food products, although this demand remains constrained by information asymmetries and the lack of standardized sustainability indicators [80,81]. The consumer recognition of specific quality and health attributes can further enhance product value. For instance, fresh bergamot fruits command substantially higher prices than those destined for processing, highlighting the economic potential of targeted quality differentiation [36]. Certifications, geographical indications, and eco-labels therefore play a key role in reducing information gaps and influencing both producers' strategies and consumers' purchasing decisions. However, the effectiveness of eco-labels depends on their credibility and interpretability, underscoring the importance of clear and trustworthy communication [80]. Geographical differences also emerge in consumer behavior. Demand for certified citrus products tends to be stronger in European

markets than in emerging economies, highlighting the role of institutional maturity and regulatory frameworks in shaping market dynamics [21,69,77].

4. Discussion

Recent years have witnessed a growing body of research addressing the sustainability challenges in citrus production systems. Despite this increasing academic attention, the literature remains fragmented across different disciplinary perspectives, including environmental assessment, agricultural management, supply chain analysis, and consumer studies [11,16]. This fragmentation has limited the development of a comprehensive understanding of sustainability dynamics within citrus systems. The present review highlights the multifaceted nature of sustainability in citrus production. It synthesizes these perspectives by explicitly addressing the three research questions (RQ1, RQ2, and RQ3), structured as follows.

RQ1: Assessing the value of sustainability in citrus supply chains requires moving beyond the assumption that sustainable practices inherently generate environmental, economic, or social benefits. Instead, sustainability should be understood as a multidimensional process whose outcomes depend on the interaction between environmental performance, economic incentives, and supply chain governance. From the environmental perspective, sustainability generates economic value within citrus supply chains only under specific and context-dependent conditions. Sustainable practices can improve environmental performance and strengthen the long-term resilience of production systems; however, their economic outcomes are not inherently superior to those of conventional systems [63,66].

Economic benefits emerge primarily when sustainability attributes are effectively recognized and rewarded by the market, supported by a stable demand, adequate price premiums, and efficient supply chain organization [21,77]. Furthermore, extending these aspects to the entire supply chain makes it difficult to assess, and there is no evidence in the current literature. In this regard, sustainability does not represent a fixed production model but emerges from the broader institutional and market context in which agricultural systems operate [82,83]. A central challenge lies in the coexistence of different logics of value within agri-food systems. Agricultural production simultaneously operates within the ecological, economic, and social domains, each characterized by different priorities and temporal horizons. Environmental sustainability typically produces long-term benefits related to ecosystem conservation, resource efficiency and resilience to climatic variability. However, these benefits are not always immediately reflected in farm-level profitability or market prices. As a result, producers often face structural trade-offs between short-term economic performance and long-term environmental sustainability [84]. This tension highlights the importance of interpreting sustainability as a relational and systemic concept, whose value is distributed and captured along the value chain.

Therefore, improved economic performance can be achieved through the optimization of production inputs while maintaining or increasing output levels. Organic production, compared with conventional systems, may reduce the dependence on external inputs, lowering production costs and potentially improving producers' profit margins [36,66,74]. However, the generation of economic value depends not only on production practices but also on market conditions. Although citrus products generally benefit from a stable market demand, the economic returns associated with sustainability initiatives vary according to consumer preferences, purchasing power, and regional market characteristics. Consequently, organic production is not always economically advantageous for producers, despite its environmental benefits [42,63]. Moreover, several social benefits associated with sustainable citrus production, such as employment generation, the maintenance of

rural economies, and the preservation of agricultural landscapes, are rarely recognized or rewarded directly by the market [74]. As a result, these contributions often remain excluded from conventional assessments of economic value, despite their importance for rural development and territorial sustainability. Finally, economic value can be enhanced not only at the production stage but throughout the entire supply chain. The more efficient logistics, reduced waste, and improved coordination among supply chain actors can increase the overall value generated and distributed across the chain [5,11]. However, the studies included in this review primarily examined supply chain optimization from the perspective of reducing spoilage rates and minimizing citrus waste [2], rather than exploring its broader implications for economic value creation across the entire citrus supply chain.

RQ2: Certification schemes are critical in facilitating this value creation. In citrus supply chains, certifications function not only as tools for product differentiation, but also as coordination mechanisms that reduce information asymmetries, enhance traceability, and strengthen trust among stakeholders [21,69]. Voluntary certification schemes such as organic labels, geographical indications (GIs), FairTrade, and GLOBALG.A.P. inherently encompass environmental values, and some also address ethical, social, and economic aspects. These schemes can facilitate access to premium market segments and enable higher selling prices [62,64]. Nevertheless, their profitability effects vary significantly across regions and market contexts. In mature and well-organized markets, certifications are more likely to generate stable price premiums and improved economic performance. Conversely, in emerging or fragmented markets often involving numerous intermediaries, certifications alone often fail to generate sufficient economic returns due to the limited consumer awareness, weak market recognition, or unequal value distribution along the supply chain [70,77]. Producers, processors, distributors, and consumers play complementary roles in shaping the sustainability outcomes. When governance mechanisms fail to align incentives across these actors, sustainability initiatives may generate environmental benefits without ensuring adequate economic returns for producers [83]. Supply chain governance therefore represents a critical dimension in determining the effectiveness of sustainability strategies. Citrus supply chains include multiple interconnected stages, from cultivation and harvesting to processing, logistics, and distribution, each contributing to the overall environmental, economic, and social footprint of the system. In conclusion, the impact of certification schemes on profitability cannot be generalized across different countries and market contexts. Their effectiveness depends on supply chain characteristics, consumer demand, and the extent to which certified products are rewarded through price premiums or improved market access. Where certification is valued by the market, it may contribute positively to value creation. However, where market recognition is limited, certification may represent an additional cost for producers without generating corresponding economic benefits.

RQ3: The review also identifies several structural barriers that limit the adoption of sustainable practices in citrus production. These include high initial investment costs, lower yields in some production systems, and a limited access to credit [8,42]. These constraints are particularly critical for small- and medium-sized producers operating in contexts characterized by price volatility, narrow profit margins, and a limited risk-bearing capacity [7]. Additional barriers include insufficient technical assistance, the limited availability of advisory services, inadequate infrastructure, and uneven policy support across regions [60]. In developing and transition economies, structural inefficiencies in marketing systems, high transportation costs, and power imbalances along the supply chain further reduce the economic feasibility of sustainability adoption [7]. Under these conditions, sustainability initiatives may be perceived as an additional source of risk, rather than as a strategic opportunity for long-term competitiveness [85].

It is essential to acknowledge several limitations of this review. First, the analysis is based exclusively on the Scopus database, which, although comprehensive, may not capture the full body of the relevant scientific literature. In addition, no formal risk-of-bias evaluation was conducted. A further limitation relates to the scope and structure of the evidence base. The distribution of the literature is skewed toward upstream, production-level studies, with limited attention being paid to downstream stages such as processing, retail, and logistics. Similarly, only a small number of studies (12 out of 64) explicitly assess the economic outcomes associated with sustainability practices or certification schemes. This restricts the robustness and generalizability of conclusions related to economic value and profitability, which are based on a relatively limited empirical foundation compared with the broader environmental literature. The review also excludes citrus by-products from the system boundaries. Although citrus by-products can be valorized into high-value compounds such as carbohydrates, organic acids, polyphenols, essential oils, and limonene, their inclusion would have significantly expanded and further complicated the supply chain framework. For this reason, their exclusion was necessary to maintain a manageable analytical scope. In terms of geographical coverage, the reviewed studies show a strong concentration in Europe, with limited evidence from other continents. This geographic imbalance restricts the global representativeness of the findings. In addition, the methodological heterogeneity across studies complicates direct comparisons of economic and sustainability outcomes. The evidence base is also characterized by a scarcity of longitudinal studies capable of capturing long-term dynamics related to certification adoption, market evolution, and policy changes, as most of the existing research relies on static or short-term analyses. Finally, despite the increasing attention being paid to the environmental and economic dimensions, social sustainability remains comparatively underexplored, further limiting the comprehensiveness of the evidence base.

The implication, from a policy perspective, is that the sustainability transitions in citrus supply chains require integrated frameworks that combine environmental regulation with economic incentives and capacity-building initiatives. Investments in innovation, knowledge transfer, and technical assistance can help producers adopt more sustainable practices while maintaining economic viability. At the same time, policies aimed at improving transparency and strengthening coordination among supply chain actors may facilitate the diffusion of sustainability practices across the sector. For supply chain actors, the findings highlight the importance of collaborative governance mechanisms capable of aligning sustainability objectives with economic incentives. Strengthening the long-term relationships between producers, processors, and retailers may improve information sharing, reduce transaction costs, and enable collective investments in sustainable technologies and resource management strategies.

5. Conclusions

This review highlights that the value of sustainability in citrus supply chains is inherently context-dependent and cannot be reduced to a single performance metric. Sustainable practices contribute to environmental improvement, resource efficiency, and long-term system resilience; yet, their economic benefits are contingent upon effective market recognition, supply chain coordination, and supportive institutional frameworks. Our analysis indicates that sustainability creates economic value primarily when environmental and social attributes are rewarded through a stable demand, price premiums, and governance mechanisms that reduce information asymmetries and strengthen trust among stakeholders. Since the studies included in this review are concentrated primarily in the Mediterranean region, the findings should be interpreted within this geographical context and should not be generalized uncritically to citrus supply chains operating in other regions of the

world. The study further emphasizes that supply chain organization plays a pivotal role in shaping sustainability outcomes. Coordinated structures, cooperative models, and collective investments can enhance both the economic and environmental performance, particularly for small- and medium-sized producers facing structural constraints such as a limited access to credit, market volatility, and lower bargaining power. Policy interventions are equally critical for fostering sustainable transitions. Incentives, technical assistance, and regulatory support should be designed in a differentiated manner to account for farm-specific characteristics, territorial conditions, and market contexts. Uniform approaches risk favoring well-resourced actors while limiting opportunities for smaller producers, thereby undermining equity and overall supply chain resilience.

Future research should continue to explore the interplay between environmental, economic, and social dimensions of sustainability, with particular attention being paid to market dynamics, technological innovation, and social equity. To strengthen the robustness and comparability of the evidence, future studies should also incorporate standardized quality appraisal tools and methodological frameworks. Future studies should also extend their focus beyond the Mediterranean region and examine sustainability dynamics in other major citrus-producing regions worldwide, thereby improving the external validity and global relevance of the existing evidence base. A key priority is the development and widespread adoption of standardized sustainability indicators that integrate all three dimensions of sustainability. Such indicators would facilitate more consistent and comparable assessments across citrus supply chains, enabling the identification of a more homogeneous study subset and supporting quantitative meta-analyses and subgroup analyses.

Greater attention should also be devoted to social sustainability, which remains comparatively underrepresented in the literature. Future investigations should address issues such as the equity value distribution among stakeholders and the broader social impact across the supply chain. Additionally, further research on consumer behavior will be essential in order to understand how sustainability attributes are perceived, valued, and translated into purchasing decisions. This would provide critical insights into demand-side constraints and opportunities for sustainable citrus products. Research efforts should also extend beyond the production stage to include processing, logistics, retail, and by-product valorization. Expanding the analytical scope to the entire citrus value chain would provide a more integrated understanding of sustainability performance and value creation, while highlighting opportunities for circular economy strategies and resource efficiency improvements.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su18136724/s1>, the PRISMA 2020 checklist. Reference [86] is citation in Supplementary Materials.

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References

1. Alzubi, E.; Shbikat, N.; Noche, B. A system dynamics model to improving sustainable performance of the citrus farmers in Jordan Valley. *Clean. Prod. Lett.* **2023**, *4*, 100034. [CrossRef]
2. Anwar, K.; Türkay, M. Inbound logistics optimization for fresh oranges with waste management. *J. Food Eng.* **2025**, *391*, 112411. [CrossRef]
3. Scuderi, A.; Timpanaro, G.; Cammarata, M. Analysis of global warming potential: Organic vs. conventional tomatoes. *Agric. Econ. Czech Acad. Agric. Sci.* **2023**, *69*, 267–275. Available online: <https://ideas.repec.org/a/caa/jnlage/v69y2023i7id104-2023-agricecon.html> (accessed on 9 March 2026). [CrossRef]
4. Timpanaro, G.; Cammarata, M.; Urso, A. Analysis of Trade Flows of Ornamental Citrus Fruits and Other Rutaceae in the Mediterranean Basin and Potential for *Xantomonas citri* Introduction. *Agriculture* **2020**, *10*, 171. [CrossRef]
5. Alzubi, E.; Kassem, A.; Melkonyan, A.; Noche, B. Enhancing economic-social sustainability through a closed-loop citrus supply chain: A life cycle cost analysis. *Resour. Conserv. Recycl. Adv.* **2024**, *21*, 200199. [CrossRef]
6. Bartolini, F.; Bazzani, G.M.; Gallerani, V.; Raggi, M.; Viaggi, D. The impact of water and agriculture policy scenarios on irrigated farming systems in Italy: An analysis based on farm level multi-attribute linear programming models. *Agric. Syst.* **2007**, *93*, 90–114. [CrossRef]
7. Naseer, M.A.R.; Ashfaq, M.; Hassan, S.; Abbas, A.; Razzaq, A.; Mehdi, M.; Ariyawardana, A.; Anwar, M. Critical issues at the upstream level in sustainable supply chain management of agri-food industries: Evidence from Pakistan’s citrus industry. *Sustainability* **2019**, *11*, 1326. [CrossRef]
8. Amekawa, Y. Understanding the local reality of the adoption of sustainable practices and farmer livelihoods: The case of pummelo farming in Chaiyaphum, Northeast Thailand. *Food Secur.* **2013**, *5*, 793–805. [CrossRef]
9. Fesharaki, M.H.; Safarzadeh, H. Modeling the Sustainable Supply Chain Network Design for Food-Agricultural Industries considering Social and Environmental Impacts. *Comput. Intell. Neurosci.* **2022**, *2022*, 6726662. [CrossRef] [PubMed]
10. United Nations. THE 17 GOALS, Department of Economic and Social Affairs. Available online: <https://sdgs.un.org/goals> (accessed on 6 June 2025).
11. Beshara, S.; Kassem, A.; Fors, H.; Harraz, N. A Comprehensive Review and Mapping Citrus Supply Chains from a Sustainability Perspective across the European Union, Middle East, and Africa. *Sustainability* **2024**, *16*, 8582. [CrossRef]
12. Cammarata, M.; Tadiello, T.; Scuderi, A.; Millar, N.; Basso, B. Regenerative practices can lead to carbon-negative orange groves in Sicily. *J. Agric. Food Res.* **2024**, *19*, 101615. [CrossRef]
13. Machin Ferrero, L.M.; Wheeler, J.; Mele, F.D. Life cycle assessment of the Argentine lemon and its derivatives in a circular economy context. *Sustain. Prod. Consum.* **2022**, *29*, 672–684. [CrossRef]
14. Mancini, L.; Lettenmeier, M.; Rohn, H.; Liedtke, C. Application of the MIPS method for assessing the sustainability of production–consumption systems of food. *J. Econ. Behav. Organ.* **2012**, *81*, 779–793. [CrossRef]
15. Yang, M.; Long, Q.; Li, W.; Wang, Z.; He, X.; Wang, J.; Wang, X.; Xiong, H.; Guo, C.; Zhang, G.; et al. Mapping the environmental cost of a typical citrus-producing county in China: Hotspot and optimization. *Sustainability* **2020**, *12*, 1827. [CrossRef]
16. Falcone, G.; Fazari, A.; Vono, G.; Gulisano, G.; Strano, A. Application of the LCA approach to the citrus production chain—A systematic review. *Clean. Environ. Syst.* **2024**, *12*, 100156. [CrossRef]
17. Frankowska, A.; Jeswani, H.K.; Azapagic, A. Life cycle environmental impacts of fruits consumption in the UK. *J. Environ. Manag.* **2019**, *248*, 109111. [CrossRef] [PubMed]
18. FAOSTAT, Food and Agricultural Organization of the United Nations. Available online: <http://www.fao.org/faostat/en/#data/FBS> (accessed on 12 May 2026).
19. Goodarzian, F.; Ghasemi, P.; Santibanez Gonzalez, E.D.; Tirkolaee, E.B. A sustainable-circular citrus closed-loop supply chain configuration: Pareto-based algorithms. *J. Environ. Manag.* **2022**, *328*, 116892. [CrossRef] [PubMed]
20. Manenzhe, T.D.; Zwane, E.M.; Van Niekerk, J. Performance and Sustainability of Commercial Cooperatives and Sole Proprietorships Citrus Farms in Mpumalanga Province, South Africa. *South Afr. J. Agric. Ext.* **2020**, *48*, 70–83. [CrossRef]
21. Mook, A.; Overdeest, C. What drives market construction for fair trade, organic, and GlobalGAP certification in the global citrus value chain? Evidence at the importer level in the Netherlands and the United States. *Bus. Strat. Environ.* **2021**, *30*, 2996–3008. [CrossRef]

22. Peña-Orozco, D.L.; Gonzalez-Feliu, J.; Salazar-Aguirre, L.T.; Arenas-Ruiz, M.A. Sustainability Fruit Supply Chain Design in the Context of Decentralized Smallholders: Modelling Framework and Sensitivity Analysis. *LOGI–Sci. J. Transp. Logist.* **2023**, *14*, 43–54. [\[CrossRef\]](#)
23. Palmatier, R.W.; Houston, M.B.; Hulland, J. Review articles: Purpose, process, and structure. *J. Acad. Mark. Sci.* **2018**, *46*, 1–5. [\[CrossRef\]](#)
24. Peterson, J.; Pearce, P.F.; Ferguson, L.A.; Langford, C.A. Understanding scoping reviews: Definition, purpose, and process. *J. Am. Assoc. Nurse Pract.* **2017**, *29*, 12–16. [\[CrossRef\]](#) [\[PubMed\]](#)
25. Pakseresht, A.; Ahmadi Kaliji, S.; Canavari, M. Review of factors affecting consumer acceptance of cultured meat. *Appetite* **2022**, *170*, 105829. [\[CrossRef\]](#) [\[PubMed\]](#)
26. Bakare, M.S.; Abdulkarim, A.; Zeeshan, M.; Shuaibu, A.N. A comprehensive overview on demand side energy management towards smart grids: Challenges, solutions, and future direction. *Energy Inform.* **2023**, *6*, 4. [\[CrossRef\]](#)
27. Zarbà, C.; Chinnici, G.; Matarazzo, A.; Privitera, D.; Scuderi, A. The innovative role of blockchain in agri-food systems: A literature analysis. *Food Control* **2024**, *164*, 110603. [\[CrossRef\]](#)
28. Van Eck, N.J.; Waltman, L. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* **2010**, *84*, 523–538. [\[CrossRef\]](#) [\[PubMed\]](#)
29. Guo, Z.; Huang, L.; Lai, S. Global knowledge mapping and emerging research trends in the microbiome and asthma: A bibliometric and visualized analysis using VOSviewer and CiteSpace. *Heliyon* **2024**, *10*, e24528. [\[CrossRef\]](#) [\[PubMed\]](#)
30. Van Eck, N.J.; Waltman, L. *VOSviewer Manual*, version 1.6.20; Manual for VOSviewer; Universiteit Leiden: Leiden, The Netherlands, 2023.
31. Willer, H.; Schlatter, B.; Trávníček, J. (Eds.) *The World of Organic Agriculture. Statistics and Emerging Trends*; Research Institute of Organic Agriculture FiBL: Frick, Switzerland; IFOAM–Organics International: Bonn, Switzerland, 2026. Available online: <https://www.fibl.org/en/shop-en/1861-organic-world-2026> (accessed on 12 May 2026).
32. Coltro, L.; Mourad, A.L.; Kletecke, R.M.; Mendonça, T.A.; Germer, S.P.M. Assessing the environmental profile of orange production in Brazil. *Int. J. Life Cycle Assess.* **2009**, *14*, 656–664. [\[CrossRef\]](#)
33. Heller, M.C.; Keoleian, G.A.; Willett, W.C. Toward a life cycle-based, diet-level framework for food environmental impact and nutritional quality assessment: A critical review. *Environ. Sci. Technol.* **2013**, *47*, 12632–12647. [\[CrossRef\]](#) [\[PubMed\]](#)
34. Luo, R.; Zhang, J.; Slegers, P.M.; Zhuang, M.; Zhang, Z.; Zhang, X.; Li, X.; Claassen, G.D.H. Environmental advantages of green-labelled navel oranges in China: A supply chain perspective. *Resour. Environ. Sustain.* **2025**, *22*, 100273. [\[CrossRef\]](#)
35. Ramos, S.; Larrinaga, L.; Albinarrate, U.; Jungbluth, N.; Ingolfssdottir, G.M.; Yngvadottir, E.; Landquist, B.; Woodhouse, A.; Olafsdottir, G.; Esturo, A.; et al. SENSE tool: Easy-to-use web-based tool to calculate food product environmental impact. *Int. J. Life Cycle Assess.* **2016**, *21*, 710–721. [\[CrossRef\]](#)
36. Strano, A.; Falcone, G.; Nicolò, B.F.; Stillitano, T.; De Luca, A.I.; Nesci, F.S.; Gulisano, G. Eco-profiles and economic performances of a high-value fruit crop in southern Italy: A case study of bergamot (*Citrus bergamia* Risso). *Agroecol. Sustain. Food Syst.* **2017**, *41*, 1124–1145. [\[CrossRef\]](#)
37. Imbernón-Mulero, A.; Martínez-Alvarez, V.; Ben Abdallah, S.; Gallego-Elvira, B.; Maestre-Valero, J.F. A Comparative Water Footprint Analysis of Conventional versus Organic Citrus Production: A Case Study in Spain. *Agriculture* **2024**, *14*, 1029. [\[CrossRef\]](#)
38. Martínez, M.E.I.; Garolera De Nucci, L.P.; Machado, W.D.; Arena, A.P. Sustainability of citrus production: Implications from a water footprint analysis in Tucumán, Argentina. *Water Environ. J.* **2025**, *39*, 353–368. [\[CrossRef\]](#)
39. Albino, J.C.T.; Callado, S.M.G.E. Agro-ecological evaluation of tropical farming systems using emergy: In Rio de Janeiro-Brazil. *Emir. J. Food Agric.* **2012**, *24*, 361–370.
40. Franco Junior, N.C.; Milan, M.; Romanelli, T.L. Energy demand in citrus production under varied operational efficiency values. *Eng. Agríc.* **2014**, *34*, 746–754. [\[CrossRef\]](#)
41. Bajdor, P.; Pawełoszek, I.; Fidlerova, H. Analysis and assessment of sustainable entrepreneurship practices in Polish small and medium enterprises. *Sustainability* **2021**, *13*, 3595. [\[CrossRef\]](#)
42. Beltrán-Esteve, M.; Picazo-Tadeo, A.J.; Reig-Martínez, E. What makes a citrus farmer go “organic”? Empirical evidence from Spanish citrus farming | ¿Qué conduce a un citricultor a ser ‘orgánico’? Evidencia empírica a partir de la citri-cultura española. *Span. J. Agric. Res.* **2012**, *10*, 901–910. [\[CrossRef\]](#)
43. Söyler, O.; Ugurluay, S.; Eren, Ö. Determination of Greenhouse Gas Emissions and Energy Efficiency in Orange (*Citrus sinensis*) Production in Türkiye: The Example of Hatay Province. *Appl. Fruit Sci.* **2025**, *67*, 129. [\[CrossRef\]](#)
44. Alzubi, E.; Noche, B. A Multi-Objective Model to Find the Sustainable Location for Citrus Hub. *Sustainability* **2022**, *14*, 14463. [\[CrossRef\]](#)
45. Falasco, S.; Ferla, G.; Caputo, P.; Mura, B.; Borrello, B.; Marson, M.; León Bravo, V.; Caniato, F. The impacts of food chains: Are alternative food networks sustainable? *Clean Technol. Environ. Policy* **2025**, *27*, 8315–8330. [\[CrossRef\]](#)

46. Shahsavani, I.; Goli, A.; Hajiaghaei-Keshteli, M. A circular economy approach to design a citrus supply chain network. *Ann. Oper. Res.* **2024**, 1–50. [\[CrossRef\]](#)
47. Bozzano, G.; Raymo, M.; Manenti, F.; Rulli, M.C.; Girotto, F.; Piazza, L. Prompting sustainability in the citrus derivatives industry: A case study. *Clean. Eng. Technol.* **2021**, *4*, 100127. [\[CrossRef\]](#)
48. Siebert, A.; O'KEeffe, S.; Bezama, A.; Zeug, W.; Thrän, D. How not to compare apples and oranges: Generate context-specific performance reference points for a social life cycle assessment model. *J. Clean. Prod.* **2018**, *198*, 587–600. [\[CrossRef\]](#)
49. Scuderi, A.; Chinnici, G.; Zarbà, C.; Cammarata, M.; Gravagno, R.M. Sustainability assessment of blood orange production in Sicily through the application of the SAFA framework. *Clean. Environ. Syst.* **2025**, *18*, 100293. [\[CrossRef\]](#)
50. Wang, Z.; Qiao, D.; Luo, L. How does e-commerce participation improve citrus farmers' adoption level of green control technique (GCT): Evidence from China. *Environ. Dev. Sustain.* **2025**, 1–32. [\[CrossRef\]](#)
51. Iñigo Martínez, M.E.; Fuentes, R.; Ploper, A.; Paz, D.; Arena, A.P. Optimizing supply chains of citrus products with analysis across several design configurations. *Environ. Syst. Decis.* **2025**, *45*, 13. [\[CrossRef\]](#)
52. Sarmiento, I.J.; Sanchez-Partida, D.; Baquela, E.-G.; Caballero-Morales, S.-O. Comprehensive risk management in agricultural supply chains: Strategies and approaches—Case of Persian lime in Veracruz. *Acta Logist.* **2025**, *12*, 455–467. [\[CrossRef\]](#)
53. Yusuf, H.; Fors, H.; Galal, N.M.; Elhabashy, A.E.; Melkonyan, A.; Harraz, N. Barriers to implementing circular citrus supply chains: A systematic literature review. *J. Environ. Manag.* **2025**, *373*, 123963. [\[CrossRef\]](#) [\[PubMed\]](#)
54. Gharye Mirzaei, M.; Goodarzi, F.; Taghipour, A.; Muñuzuri, J. Sustainable closed-loop supply chain network under uncertainty considering green technologies: Toward the circular economy. *J. Oper. Res. Soc.* **2025**, *77*, 1204–1224. [\[CrossRef\]](#)
55. Stone, J.; Garcia-Garcia, G.; Rahimifard, S. Development of a pragmatic framework to help food and drink manufacturers select the most sustainable food waste valorisation strategy. *J. Environ. Manag.* **2019**, *247*, 425–438. [\[CrossRef\]](#) [\[PubMed\]](#)
56. Vargas-Muñoz, J.C.; Sanchez-Nitola, F.A.; Adarme Jaimes, W.; Rios, R. Enhancing Logistical Performance in a Colombian Citrus Supply Chain Through Joint Decision Making: A Simulation Study. *Logistics* **2025**, *9*, 30. [\[CrossRef\]](#)
57. Zartha Sossa, J.W.; Botero Montoya, L.H.; Palacio Piedrahíta, J.C.; González Candia, J.; Gutiérrez Cano, L.F.; Orozco Mendoza, G.L.; Gutiérrez Posada, N.; Hernández Zarta, R.; Gómez Salazar, J.O.; Zapata Valencia, J.C. Sustainable Innovation Management Model (MGI) for Agro-Industrial Citrus Chain. *Agriculture* **2025**, *15*, 1069. [\[CrossRef\]](#)
58. Bishara, S.; Harraz, N.; Elwany, H.; Fors, H. Optimizing Resilient Sustainable Citrus Supply Chain Design. *Logistics* **2025**, *9*, 66. [\[CrossRef\]](#)
59. Ajroudi, N.H.; Dhehibi, B.; Lasram, A.; Dellagi, H.; Frija, A. Toward Sustainable Water Resources Management in the Tunisian Citrus Sector: Impact of Pricing Policies on Water Resources Reallocation. *Water* **2022**, *14*, 1791. [\[CrossRef\]](#)
60. Castillo-Martínez, S.I.; Díaz-José, J.; Leyva-Ovalle, O.R.; Ramírez-Rivera, E.J.; Díaz-José, O.; Murguía-González, J.; Grass Ramírez, J.F.; Cruz-Castillo, J.G. Urgently needed transition pathways toward sustainability in agriculture: The case of Persian lime (*Citrus latifolia* Tanaka) production in Veracruz, Mexico. *Environ. Dev. Sustain.* **2024**, *26*, 2111–2130. [\[CrossRef\]](#)
61. EUR-Lex. Access to European Union Law. Available online: <https://eur-lex.europa.eu/legal-content/it/ALL/?uri=CELEX:31992R2081> (accessed on 12 May 2026).
62. Belmin, R.; Casabianca, F.; Meynard, J.-M. Contribution of transition theory to the study of geographical indications. *Environ. Innov. Soc. Transit.* **2018**, *27*, 32–47. [\[CrossRef\]](#)
63. Di Vita, G.; Stillitano, T.; Falcone, G.; de Luca, A.I.; D'Amico, M.; Strano, A.; Gulisano, G. Can sustainability match quality citrus fruit growing production? An energy and economic balance of agricultural management models for 'PGI clementine of Calabria'. *Agron. Res.* **2018**, *16*, 1986–2004. [\[CrossRef\]](#)
64. Millet, M.; Keast, V.; Gonano, S.; Casabianca, F. Product qualification as a means of identifying sustainability pathways for place-based agri-food systems: The case of the GI Corsican grapefruit (France). *Sustainability* **2020**, *12*, 7148. [\[CrossRef\]](#)
65. Razzaghi Borkhani, F.; Mohammadi, Y. Perceived outcomes of Good Agricultural Practices (GAPs) technologies adoption in citrus farms of Iran (reflection of environment-friendly technologies). *Environ. Sci. Pollut. Res.* **2019**, *26*, 6829–6838. [\[CrossRef\]](#) [\[PubMed\]](#)
66. Sgroi, F.; Candela, M.; Di Trapani, A.M.; Foderà, M.; Squatrito, R.; Testa, R.; Tudisca, S. Economic and financial comparison between organic and conventional farming in Sicilian lemon orchards. *Sustainability* **2015**, *7*, 947–961. [\[CrossRef\]](#)
67. Söyler, O.; Atli, H.F. A research on the determination of contributions of good agricultural practices at citrus production on agricultural enterprises from the points of technology and economy. *J. Tekirdag Agric. Fac.* **2018**, *15*, 87–94.
68. Tudisca, S.; di Trapani, A.M.; Sgroi, F.; Testa, R. Economic evaluation of PDO introduction in Sicilian orange farms. *Qual. Access Success* **2014**, *15*, 99–103.
69. Turra, C.; Vian, C.E.F.; Nielsen, F.A.G.; Santos, P.S.; Penteado, L.F.F. Overview of the Brazilian Citriculture Certification. *J. Agric. Environ. Ethics* **2014**, *27*, 663–679. [\[CrossRef\]](#)
70. Yilmaz, H.; Gül, M.; Akkoyun, S.; Aydin, B.; Bilgili, M.E. The economic analysis regarding the good agricultural practices of citrus production in Turkey: A case of Adana Province. *Custos Agronegocio* **2017**, *13*, 262–274.

71. Pereira, D.G.C.; de Alencar, G.V.; Escobar, M.E.O.; Mendonça, E.d.S.; de Oliveira, T.S. Effect of Organic Farming on Soil Carbon Reserves and Quality in Citrus Groves in the Brazilian Semi-Arid Region. *Soil Use Manag.* **2025**, *41*, e70080. [\[CrossRef\]](#)
72. Cammarata, M.; Timpanaro, G.; Scuderi, A. Regenerative agriculture meets the Carbon Market: Exploring economic potential in Mediterranean orange groves. *Environ. Chall.* **2025**, *20*, 101257. [\[CrossRef\]](#)
73. Mohammadshirazi, A.; Akram, A.; Rafiee, S.; Bagheri Kalhor, E. On the study of energy and cost analyses of orange production in Mazandaran province. *Sustain. Energy Technol. Assess.* **2015**, *10*, 22–28. [\[CrossRef\]](#)
74. Testa, R.; Foderà, M.; Di Trapani, A.M.; Tudisca, S.; Sgroi, F. Choice between alternative investments in agriculture: The role of organic farming to avoid the abandonment of rural areas. *Ecol. Eng.* **2015**, *83*, 227–232. [\[CrossRef\]](#)
75. Söyler, O.; Eren, Ö.; Uğurluay, S. An Analysis of Energy Use Efficiency and Environmental Prices of Grapefruit (*Citrus paradisi*) Production in Turkey: A Case of Hatay Province. *Erwerbs-Obstbau* **2023**, *65*, 871–878. [\[CrossRef\]](#)
76. Belmin, R.; Casabianca, F.; Julhia, L.; Meynard, J.-M. Multi-level management of harvest for fresh fruit: The case of Corsican clementine. *Agron. Sustain. Dev.* **2021**, *41*, 41. [\[CrossRef\]](#)
77. Di Vita, G.; Vecchio, R.; Borrello, M.; Zanchini, R.; Maesano, G.; Gulisano, G.; Brun, F.; D’Amico, M. Oh my darling clementine: Heterogeneous preferences for sustainable citrus fruits. *Renew. Agric. Food Syst.* **2021**, *36*, 557–568. [\[CrossRef\]](#)
78. Huang, W.-S.; Kuo, H.-Y.; Tung, S.-Y.; Chen, H.-S. Assessing consumer preferences for suboptimal food: Application of a choice experiment in citrus fruit retail. *Foods* **2021**, *10*, 15. [\[CrossRef\]](#) [\[PubMed\]](#)
79. Chiu, M.-C.; Tu, Y.-L.; Kao, M.-C. Integrating TPB and gamification to promote green eating behaviors: A case study of food carbon footprint tracking system. *Environ. Dev.* **2025**, *54*, 101153. [\[CrossRef\]](#)
80. Evans, D.M.; Mylan, J. Market coordination and the making of conventions: Qualities, consumption and sustainability in the agro-food industry. *Econ. Soc.* **2019**, *48*, 426–449. [\[CrossRef\]](#)
81. Miranda-Ackerman, M.A.; Azzaro-Pantel, C. Extending the scope of eco-labelling in the food industry to drive change beyond sustainable agriculture practices. *J. Environ. Manag.* **2017**, *204*, 814–824. [\[CrossRef\]](#) [\[PubMed\]](#)
82. Bag, S. Restorative supply chain practices in a circular economy and supply chain sustainability performance: The moderating effect of the perceived professional status of supply chain managers. *Benchmarking Int. J.* **2025**, *32*, 166–193. [\[CrossRef\]](#)
83. Pananond, P.; Gereffi, G.; Pedersen, T. An integrative typology of global strategy and global value chains: The management and organization of cross-border activities. *Glob. Strategy J.* **2020**, *10*, 421–443. [\[CrossRef\]](#)
84. Hakimi, F.; Sehli, S.; Hashem, A.; Avila-Quezada, G.D.; Abd_Allah, E.F. Comparative analysis of organic and conventional farm sustainability in peri-urban zones of Rabat, Morocco: Insights and perspectives. *Cogent Food Agric.* **2025**, *11*, 2463562. [\[CrossRef\]](#)
85. Schulte, J.; Hallstedt, S.I. Company Risk Management in Light of the Sustainability Transition. *Sustainability* **2018**, *10*, 4137. [\[CrossRef\]](#)
86. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ* **2021**, *372*, n71. [\[CrossRef\]](#) [\[PubMed\]](#)

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