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Navigating the future of agri-food supply chain: A conceptual framework using bibliometric review

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ABSTRACT

The Agri-Food Supply Chain (AFSC) has gained worldwide attention among researchers for its diverse applications. With market expansion and globalization, one of the most challenging issues in the AFSC to connect these diverse research fields with contemporary supply chain trends. Accordingly, it becomes imperative to understand the emerging research structure within the AFSC. This study aims to conduct a comprehensive review of the literature related to the AFSC and proposes a conceptual framework covering the antecedents and outcomes of structural associations among the AFSC factors. This study employs a bibliometric analysis methodology, encompassing 303 papers retrieved from the Scopus database between 1997 and 2021. A rigorous inclusion and exclusion process was carried out by using articles whose titles contained only 'agri-food' and 'supply chain' terms. This systematic approach ensured a feasible dataset for analysis. Microsoft Excel and VOSviewer were used for an in-depth analysis of prolific authors, article trends, institutions, countries, influential articles, and source titles within the domain of AFSC. Co-occurrence analysis was conducted to identify seven core research themes, namely: agri-food supply chain system; agri-food supply chain management; agri-food supply chain industry; agri-food supply chain risk factors; agri-food supply chain information; agri-food supply chain advancement; agri-food supply chain risk management; This study makes a significant contribution by constructing a comprehensive conceptual framework that logically organizes these thematic factors, aligning future research with emerging trends. Additionally, this research highlights the imperative of global collaboration across diverse regions and fields within AFSC to build more resilient supply chains capable of adapting to evolving conditions.

1. Introduction

Agri-food supply chain (AFSC) is associated with the stages of agricultural food production, particularly 'farm to fork' of production, processing, trade, distribution, and consumption [1]. These supply chains provide customers with sustainable, economic, healthy, and adequate food, feed, fibre, and fuel, ensuring smooth and efficient operation in an increasingly unpredictable economic market [2]. However, it is extremely stressful for operating managers to develop such an AFSC owing to numerous interconnected driving factors [3,4]. AFSC aims to explore activities from production to distribution, supplying agricultural or horticultural products from farmers to the end market [5]. Scientists in the field of agricultural economy and management suggest early adoption of agri-food supply chains to achieve a smooth

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supply system [6,7]. AFSC was established by the organisation responsible for the production (farmers), distribution, processing, and marketing of agricultural products for end-users. Food and other supply chains carry goods and services to the market through various processes to meet customer demands [8]. However, consumable products, a type of agri-food product, have caused significant damage to farmers and consumers. The complex nature of supply chains can be attributed to their characteristics, including price variability, demand, and shelf life, and high demand and uncertainty in supply, accuracy, and safety standards. Additionally, consumer demand has shifted to higher-quality products, resulting in a shorter shelf life of agricultural products [9–11].

The term AFSC was first used by scholars in agricultural management and economics [6,7]. Additionally, AFSC terminology was used in the fields of agriculture (e.g. agricultural economics, development studies, and agricultural science) and business management. However, few publications have focussed on agri-food supply chains [12]. This study used the term 'agri-food supply chain' in line with the core AFSC principle. This term is widely known by agricultural economists, but not by supply chain management (SCM) researchers. However, in SCM studies, supply chain value research emphasizes value acquisition through integrated performance [13,14]. Therefore, the AFSC is a network of businesses working together to provide products and services to meet consumer needs through diverse processes and activities [15]. The difference between AFSC and other supply chains lies in the significance of food quality, safety, and weather uncertainty [6]. Their short lifespan, demand, and price variation are additional essential features of agri-food, making the supply chain more complicated and difficult to manage than other supply cahin companies. Similar to other supply chains, the AFSC comprises a network of collaborating organizations engaged in various processes and activities. Their collective goal is to deliver products and services to the market, ultimately meeting the demands of customers [15]. Other noteworthy attributes of agri-foods encompass their limited shelf life and the inherent variability in both demand and pricing. These aspects collectively render the management of the underlying supply chain more intricate when compared to other supply chains [6].

To enhance the stud's effectiveness, the agri-food supply chain term as an appropriate component of the literature in the AFSC domain. Although the Web of Science (WoS) and Scopus databases are highly interconnected, with overlapping indexes in the journal, they index different journals. Scopus includes the most cited and referenced abstracts on a wide range of subjects [16,17]. Many researchers have utilised relevant bibliometric analysis on various issues such as, 'traceability in agri-food' [12], 'block chain technology in the food and agriculture industry' [18], 'short supply chains in agri-food sector' [19,20], 'IoT technology in food safety' [21] and 'synthesize the state of the art of research on food waste' [22]. This implies that AFSC's diverse research field will likely require the implementation of a structure within the organization. One potential approach to achieving this is to broaden the understanding of the supply chain concerning emerging research trends, taking into account other research perspectives on the expansion and globalization of the agri-food market. Thus, this study aims to comprehensively review AFSC-related literature and propose a conceptual framework for its structural associations. From our knowledge, there have been no recent attempts a similar work, and the goal is to provide a significant contribution in this area. While investigating publication and collaboration trends, researchers can employ this information to pinpoint future research topics, probe research gaps, and uncover patterns [23]. This process can facilitate a more streamlined and insightful understanding of the publication structure within AFSC research. Accordingly, the study seeks to answer the following research questions.

RQ1: what are the current trends in AFSC studies?
RQ2: Which authors, institutions, and countries along with their co-authorship and collaboration networks, are contributing most to the evolution of AFSC?
RQ3: what are the most productive source titles and highly cited publications in AFSC?
RQ4: What are the most prolific themes for future research directions in AFSC?
RQ5: How can AFSC themes be integrated into a comprehensive framework, and what learning is directed from this integration?

To answer the research questions, this study adopted a bibliometric technique to identify trends in various domains and uncover the current status [24,25]. Bibliometric analysis allows researchers to define fields of research, explore future research directions, and engage with other institutions and countries [26]. Therefore, this study conducted a bibliometric review to investigate previous works and assess the developmental trends of research published on the AFSC as a whole, from 1997 to July 2021, using the Scopus database. Scopus is considered the largest cited and referenced abstract database, encompassing a wide range of subject areas. The use of Scopus aims to include subjects not covered in the Web of Science [16,17]. The tools for bibliometric analysis and visualization, such as VOSviewer Version 1.6.15, were employed to conduct this analysis [27].

Furthermore, the bibliometric analysis of the AFSCprovides key benefits by systematically uncovering research trends and gaps for researchers and policymakers to prioritize the future research agenda. The results present collaboration patterns and key themes that serve as a basis for developing a conceptual framework for strategic decision-making and innovations. Additionally, this analysis enhances stakeholders' understanding of the evolving landscape, enabling them to align their efforts with new challenges and opportunities that can drive more innovative and effective practices within the AFSC sector.

2. Method of bibliometric analysis

Bibliometric studies provide a wide range of options for understanding the significance of all studies. A quantitative and qualitative technique of bibliometric analysis is used for the publication of journals and articles, including their corresponding citations over time [28]. It can differentiate the present status of research by measuring the scientific outcome of a country and institution and has played a major role in the past in influencing policymaking and improving the knowledge of science [28]. This also allows researchers to identify and help them to determine the scope of study topics, and plan their focused mind and projection trends [29]. This method can provide a statistical output for calculating and estimating the number and growth trends of a particular subject [30]. This is supported by a recent bibliometric study in transport and supply chain management [31]. The study reviewed the literature using databases like Scopus and Web of Science (WoS) to collect a large pool of publications and relevant articles. Scopus also gives the flexibility to search across a variety of bibliographic areas [32]. For this reason, the study employed bibliometric analysis of prior research to comprehensively analyze global research trends within a specific field based on results from the Scopus database [33]. A bibliometric analysis of the literature related to AFSC was conducted using VOSviewer software to visualize citation patterns, co-citation relationships, keyword co-occurrences, and collaboration networks pertaining to AFSC topics. These established tools are appropriate for answering the research questions [34,35]. In addition, the h-index was used to assess the impact of publications on authors and provide insight into the current interest [29]. Fig. 1 illustrates the flowchart of the study.

2.1. Data source and search strings

The documents used in this study were obtained from the Scopus database. The important keywords of AFSC were 'agri-food' and 'supply chain' which appeared in the topics of each article [36,37]. This study focussed on the title of the articles, as it represented a topic that was relevant to the research area and purpose. According to Ref. [38], the

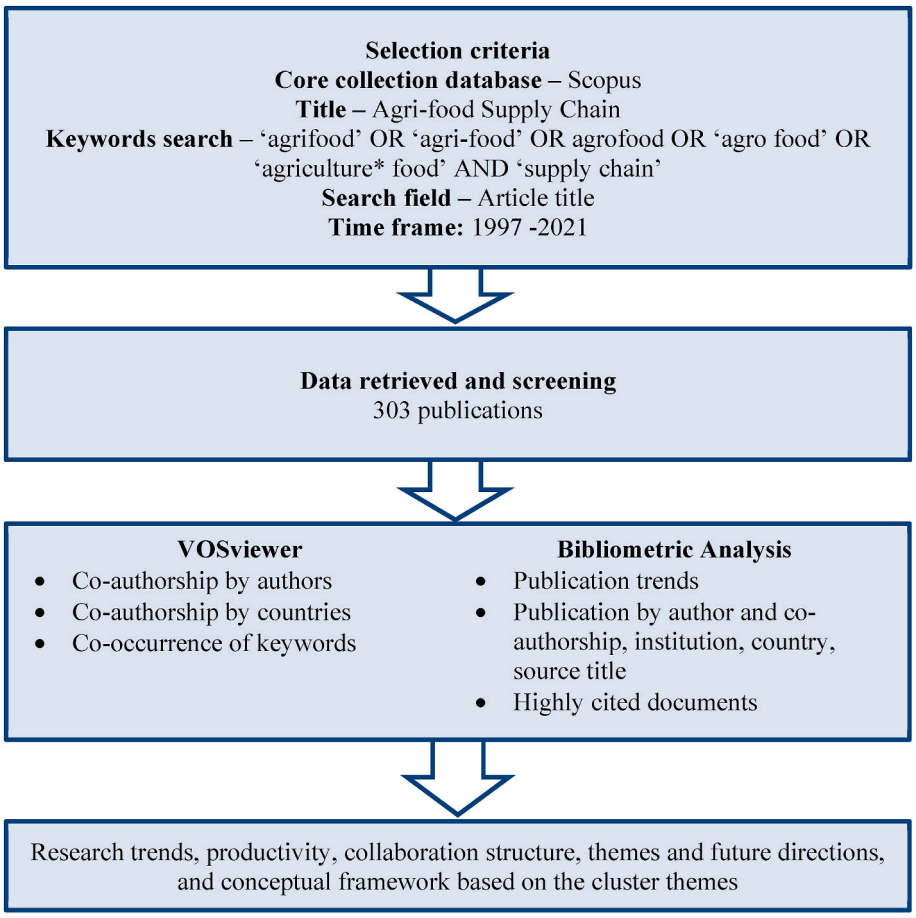

Fig. 1. The flowchart of agri-food supply chain study.

title of an article should incorporate information that could be used to capture the attention of readers because it would be the first element observed by readers. The search query strings used included TITLE ('agrifood' OR 'agri-food' OR 'agrofood' OR 'agro food' OR 'agriculture* food') AND TITLE ('supply chain'). The search results for the main topics were analyzed based on the type of document, year, authors, institutions, countries, source title, documents, and keywords. In addition, this study used (i) Microsoft Excel to calculate the frequencies of published materials and design the relevant table and (ii) VOSviewer to build and visualize bibliometric networks. A total of 303 documents were discovered from the query to conduct a bibliometric analysis. The results revealed seven core document types in the publications listed in Table 1. The most frequently used documents were journal articles, which covered more than half (187; 61.72 %) of the total publications, followed by conference papers (68; 22.44 %), book chapters (21; 6.93 %), review papers (18; 5.94 %), editorials (6; 1.98 %), books (2; 0.66 %), and notes (1; 0.33 %).

Table 1
Type of AFSC-related documents.

No.	Document type	Total document (*N=303*)	Percentage
1	Journal article	187	61.72
2	Conference paper	68	22.44
3	Book chapter	21	6.93
4	Review paper	18	5.94
5	Editorial	6	1.98
6	Book	2	0.66
7	Note	1	0.33
	Total	**303**	**100.00**

3. Results and findings

To achieve the objectives of this study, the results and findings were organized accordingly.

3.1. Publication trends

Yearly published AFSC-related documents are shown in Fig. 2. One document was published in 1997 and forty-eight in 2020, indicating a significant growth in publications over the years. Prior to 2006, there were approximately three publications per year. Remarkably, the number of publications in 2012 and 2013 drastically increased, which effectively makes a potential consideration for the AFSC's new research perspective. Steady growth in AFSC-related publications was reported from 2015 to 2019, and the most significant AFSC research was published in 2020. This scenario demonstrates the importance of AFSC and indicates that many scholars are dedicated to this field. Over the past 24 years, AFSC publications have grown in the Scopus database, and the scientific community has been expected to express a strong interest in this topic. This may be due to the high intensity of AFSC and the advancement of strategies. For example, farmers and consumers are influenced by agri-food goods. Higher demand and uncertainty in supply, accuracy, and safety concerns have complicated the supply chain network, thus challenging the current AFSC analysis [10,11]. Moreover, the implications of AFSC research have been discussed in terms of challenge reduction.

3.2. Publication by author and co-authorship network

A total of 764 authors contributed to the AFSC research from 1997 to

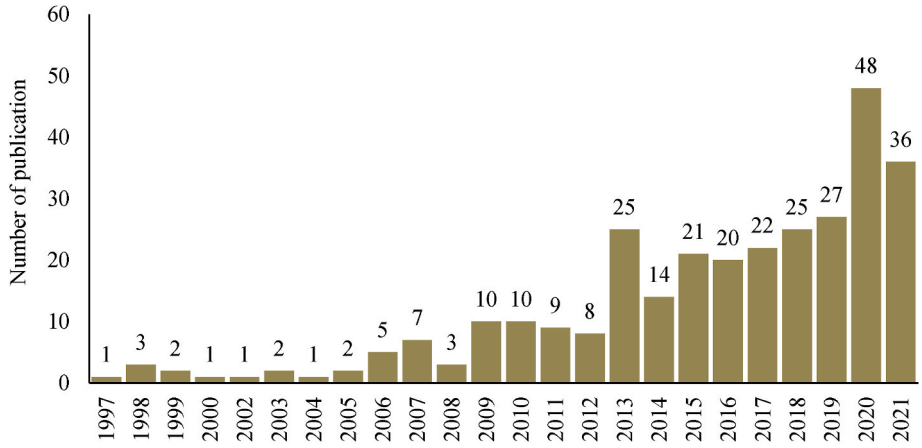

Fig. 2. Number of publications per year on AFSC.

2021. The leading authors in the AFSC domain were identified by the h-index, total citations, and number of publications. Table 2 lists the top 20 authors who contributed to most AFSC documents. It was found that M. Hisjam from Universitas Sebelas Maret, Indonesia, W. Sutopo from Universitas Sebelas Maret, Indonesia, and S. Liu from the University of Plymouth, United Kingdom were the top three (3) contributors to the field. M. Hisjam published articles related to AFSC since 2012 with 8 publications, 44 citations, and 4 h-index, followed by S. Liu since 2017 with 8 publications, 38 citations, and 4 h-index and finally W. Sutopo with 8 publications, 44 citations and 4 h-index since 2012. Notably, two of the top 20 authors originated in Indonesia and the United Kingdom. In addition, other prolific authors, namely D. H. Taylor with 4 h-index and 373 citations, P. Akhtar with 4 h-index and 81 citations, and H. Panetto with 2 h-index and 73 citations can also be considered as researchers with significant contributions to AFSC.

Furthermore, co-authorship network visualization revealed collaboration among authors in the AFSC research domain. Authors with interconnections were selected based on the number of documents produced by each author and links. Of the 764 authors, 67 met these thresholds. Fig. 3 shows that most documents with other associated links (links 33, 8 documents) were contributed by Liu, followed by Zhao (links 21, 6 documents), Chen (links 16, documents 4), Lopez C (links 10, documents 4), Alemany (links 11, documents 4), and Panetto (links 11, documents 4), considering that co-authors of publications could contribute to advancing research and exchange [39]. This necessitates cooperation between authors in the field of AFSC, especially among different countries or future research fields, such as business, management and accounting, computer science, engineering, agricultural and biological sciences, decision sciences, and social sciences.

3.3. Publications by institution

Next, the documents were analyzed to identify institutions based on author affiliations to determine the research focus on the most influential institutes in the field of AFSC. The results showed that 598 institutions had published 303 documents. The top ten organizations contributing to the AFSC resource study are listed in Table 3. Wageningen University & Research (19, 6.27 %) is the most active institution in AFSC studies worldwide, followed by the University of Plymouth, Universitat Politècnica de València, and Aristotle University of Thessaloniki with 11 (3.63 %), 9 (2.97 %), and 8 (2.64 %) publications, respectively. In addition, Wageningen University & Research was positioned at the top for collaborative publications among national and international organizations. The dynamic publication trend can be increased by promoting the international cooperation of research partners.

Table 2
Most productive authors that published four or more publications in the AFSC domain.

No.	Author	Affiliation	Country	TP	NCP	TC	*h*	1PY
1	Hisjam, M.	Universitas Sebelas Maret	Indonesia	8	8	44	4	2012
2	Liu, S.	Plymouth Business School	United Kingdom	8	5	38	4	2017
3	Sutopo, W.	Universitas Sebelas Maret	Indonesia	8	8	44	4	2012
4	Yuniaristanto	Universitas Sebelas Maret	Indonesia	6	6	40	4	2012
5	Zhao, G.	University of Plymouth	United Kingdom	6	4	32	3	2017
6	Alemany, M.M.E.	Universitat Politècnica de València	Spain	5	4	36	2	2017
7	Esteso, A.	Universitat Politècnica de València	Spain	5	4	36	2	2017
8	Aidonis, D.	International Hellenic University	Greece	4	3	36	3	2014
9	Akhtar, P.	University of Kent	United Kingdom	4	4	81	4	2015
10	Bennekrouf, M.	École Supérieure en Sciences Appliquées de Tlemcen	Algeria	4	3	31	2	2011
11	Boudahri, F.	Université Abou Bekr Belkaid Tlemcen	Algeria	4	3	31	2	2011
12	Chen, H.	University of Plymouth	United Kingdom	4	3	24	3	2017
13	Iakovou, E.	Texas A&M University	United States	4	4	31	3	2014
14	Lopez, C.	University of Southampton	United Kingdom	4	3	29	3	2017
15	Malindretos, G.	Harokopio University	Greece	4	3	34	2	2014
16	Ortiz, A.	Universitat Politècnica de València	Spain	4	3	35	2	2017
17	Panetto, H.	Université de Lorraine	France	4	2	73	2	2020
18	Sporleder, T.L.	The Ohio State University	United States	4	2	34	2	2003
19	Taylor, D.H.	Cranfield University	United Kingdom	4	4	373	4	2005
20	Vlachos, D.	Aristotle University of Thessaloniki	Greece	4	4	31	3	2014

TP = Total publication; NCP=Number of cited papers; TC = Total citation; h = h-index; 1PY = Year of 1st publication.

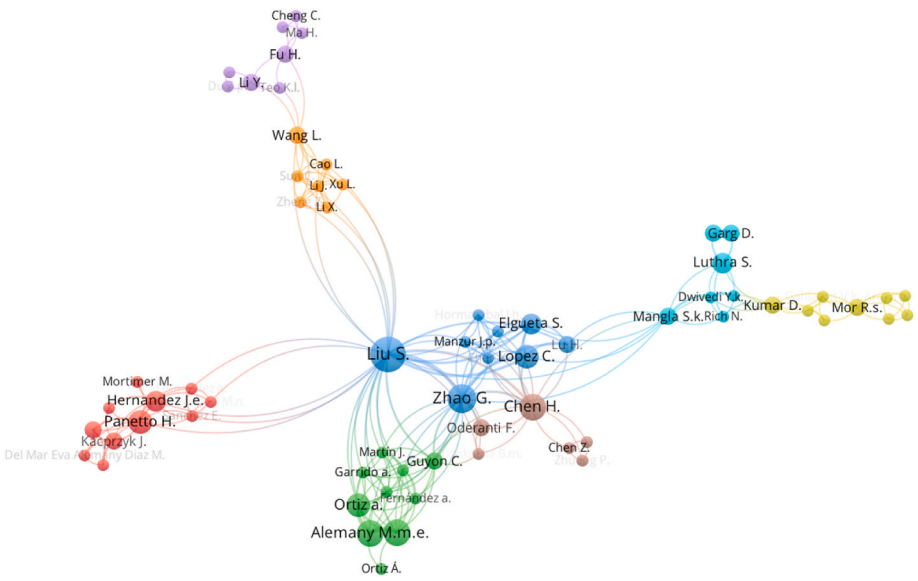

Fig. 3. Co-authorship network in AFSC study.

Table 3
Top 10 productive institutions.

No.	Affiliation	Total Publication	Percentage
1	Wageningen University & Research	19	6.27
2	University of Plymouth	11	3.63
3	Universitat Politècnica de València	9	2.97
4	Aristotle University of Thessaloniki	8	2.64
5	Universitas Sebelas Maret	8	2.64
6	Cardiff Business School	6	1.98
7	Plymouth Business School	6	1.98
8	The Ohio State University	5	1.65
9	CNRS Centre National de la Recherche Scientifique	5	1.65
10	Università degli Studi di Foggia	5	1.65

3.4. Publication by country and collaboration network

Based on the authors' affiliations, 57 countries contributed to articles on AFSC. Table 4 shows the ten most productive countries, classified according to the total number of publications. The top 10 countries accounted for 90.43 % of all the publications. The United Kingdom (51, 16.83 %) is the largest publishing country, followed by China (40, 13.20 %), Italy (36, 11.88 %), the United States (27, 8.91 %), France (24, 7.92 %), the Netherlands (23, 7.59 %), India (21, 6.93 %), Spain (20, 6.60 %), Greece (17, 5.61 %), and Indonesia (15; 4.95). Among all countries, the United Kingdom and the United States are the highest cited countries, with 1603 and 1063 citations, respectively.

Meanwhile, a collaboration network among countries in the field of AFSC documents was revealed using the VOSviewer software, as shown in Fig. 4. Cooperation was established among 51 of the 57 countries. Fig. 4 shows collaboration involving 51 items, 12 clusters, 107 links, and a total link strength of 154. The thickness of the line in each country is determined by the frequency of co-authorship. Based on the collaboration network, the United Kingdom, United States, Italy, France, Netherlands, China, and Spain have an adequate collaboration network. Notably, the United Kingdom has more partnerships with France, Italy, Brazil, and India, but the United Kingdom has more exchanges with China, Spain, and the United States on AFSC studies. In addition, the results revealed geographical clusters of collaboration networks, such as European countries, including Germany, the Netherlands, France, Italy, Denmark, and Spain. Countries such as Algeria, Egypt, Tanzania, and Brazil are proposing lesser cooperation. Nevertheless, effective cooperation among productive countries can strengthen AFSC resources.

Table 4
Top 10 most contributing countries of AFSC from 1997 to 2021.

No.	Country	Total Publication	Percentage	Total Citation
1	United Kingdom	51	16.83	1603
2	China	40	13.20	188
3	Italy	36	11.88	631
4	United States	27	8.91	1063
5	France	24	7.92	406
6	Netherlands	23	7.59	589
7	India	21	6.93	220
8	Spain	20	6.60	353
9	Greece	17	5.61	541
10	Indonesia	15	4.95	196

3.5. Publication by source title

The top source titles that published four or more documents are listed in Table 5. Emerald, MDPI, and Elsevier are the top three publishers with the highest number of publications on AFSC. The most productive source title on the AFSC is Sustainability, with 14 papers, followed by the Journals of Cleaner Production and Supply Chain Management, both with nine papers. IFIP Advances in Information and Communication Technology, with eight papers, ranked fourth. The highest number of citations (719) was obtained for Supply Chain Management. Notably, some authors chose articles based on citations.

The CiteScore can affect certain authors' decisions to select the article that best suits their topic in terms of the journal's impact. As presented in Table 5, CiteScore ranges from 0.8 to 13.1 for the top 15 journals. In addition, the SJR (SCImago Journal Rank) and SNIP (Source Normalised Impact) for the top 13 journals were used to measure the impact of journal citations. SJR reflects the journal's scientific credentials, whereas SNIP measures the impact of contextual citations. A higher number for this index indicates better journal quality. For SNIP, a value greater than one indicates that the journal's quality is adequate, and values below one imply that the quality is below average (OSA, 2015). Compared to CiteScore, SJR and SNIP are newer metrics in Scopus that provide more insight, clarity and better information on the impact of the current journal status.

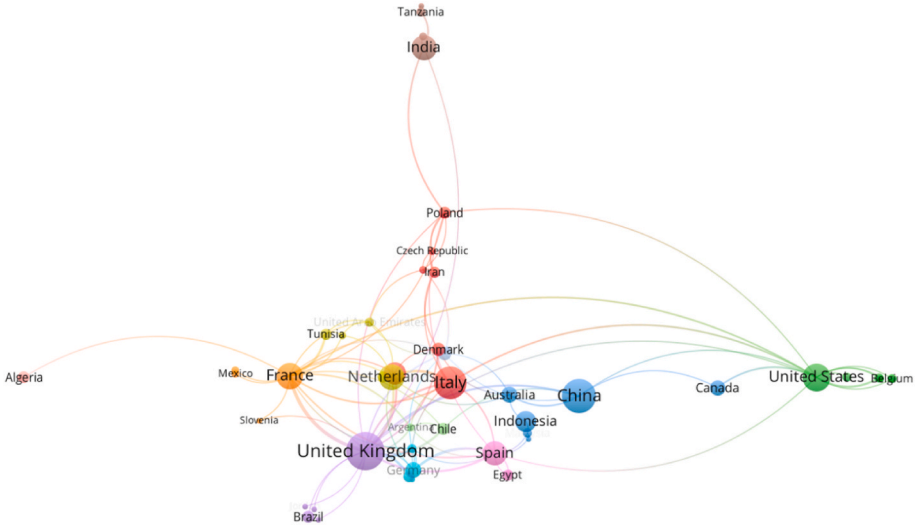

Fig. 4. Collaboration network among countries in AFSC research.

Table 5
Top journals that published four or more documents related to AFSC.

No.	Journal Name	TD	TC	Cite Score	SJR	SNIP	Publisher
1	Sustainability Switzerland	14	84	3.9	0.612	1.242	MDPI
2	Journal of Cleaner Production	9	346	13.1	1.937	2.475	Elsevier
3	Supply Chain Management	9	719	9.3	2.036	2.258	Emerald
4	IFIP Advances in Information and Communication Technology	8	21	1.0	0.189	0.390	Springer Science and Business Media
5	Journal on Chain and Network Science	6	57	NA	NA	NA	Wageningen Academic Publishers
6	British Food Journal	5	93	3.5	0.510	0.857	Emerald
7	Economia Agro Alimentare	4	45	1.2	0.236	0.351	FrancoAngeli
8	European Journal of Operational Research	4	582	9.5	2.161	2.745	Elsevier
9	International Food and Agribusiness Management Review	4	105	2.4	0.474	0.901	Wageningen Academic Publishers
10	International Journal of Sustainable Agricultural Management and Informatics	4	18	0.8	0.222	0.541	Inderscience
11	International Journal on Food System Dynamics	4	75	2.0	0.340	0.654	CENTMA Research
12	Lecture Notes in Engineering and Computer Science	4	17	8.2	1.331	1.866	Taylor & Francis
13	Production Planning and Control	4	26	3.6	0.699	1.629	Springer Nature

TP = Total document; SJR = SCImago Journal Rank (SJR) 2020; SNIP = Source normalised impact per article 2020; TC = Total citation; CS = Cite Score 2020.

3.6. Highly cited documents

Table 6 shows the top 20 highly cited publications in AFSC research with associated information, such as authors, article title, source title, total citations, and citations per year from 1997 to 2021. The most cited article is entitled 'Application of planning models in the AFSC: A review' by Ahumada and Villalobos (2009) in the European Journal of Operational Research, with a total of 503 citations and 41.92 citations per year. 'An agri-food supply chain traceability system for China based on RFID & blockchain technology,' by Ref. [40] the 13th International Conference on Service Systems and Service Management, ICSSSM 2016 and 'A conceptual framework for supply chain collaboration: Empirical evidence from the agri-food industry' by Doukidis et al., 2007, source title in Supply Chain Management are the second and third most highly cited articles, representing 468 and 266 citations, and 93.6 and 19 citations per year, respectively.

3.7. Keywords and co-occurrence analysis

Keywords are the main content of publications, and the purpose of keyword analysis is to identify important research topics in AFSC. A co-occurrence network of all keywords were used to highlight research topics in the field. The most commonly used keywords are represented by the font size and larger circles [58]. The lines between the keywords reflect their correlation strength [25]. For a better understanding, the related keywords are commonly listed, as indicated by the same colour.

A total of 1641 keywords were extracted from the Scopus database by applying VOSviewer software, and keywords were set as six for each stage with a minimum number of occurrences. The results showed that 60 keywords satisfied the threshold value and produced seven different clusters and 730 links, which are shown in different colours in Fig. 5. The keywords 'agri-food supply chain', 'food supply', and 'supply chains' gave expected results because they were among the main terms. The links between the agri-food supply chain (links 58; occurrences 135), food supply (links 59; occurrences 119), and supply chains (links 58; occurrences 119) revealed highly connected keywords. The seven main themes were developed based on the clusters of AFSC and are described as follows.

(i) Cluster 1: **The agri-food supply chain system** refers to 'agricultural products – links 33, occurrences 16', 'logistics – links 15, occurrences 6', 'multi-objective optimization – links 25, occurrences 7', 'stochastic systems – links 18, occurrences 6', 'social aspects – links 12, occurrences 8', 'transportation cost – links 12, occurrences 6', 'integer programming – links 17, occurrences 6', among others.
(ii) Cluster – 2: **Agri-food supply chain management** contains keywords such as 'decision-making – links 39, occurrences 19' 'supply chain management – links 55, occurrences 76', 'sustainable supply chains – links 18, occurrences 7', 'food safety – links 22, occurrences 13'.

Table 6
Top 20 highly-cited publications in the AFSC domain.

No	Authors	Title	Source	TC	CY
1	[41]	Application of planning models in the agri-food supply chain: A review	European Journal of Operational Research	503	41.92
2	[40]	An agri-food supply chain traceability system for China based on RFID & blockchain technology	13th International Conference on Service Systems and Service Management, ICSSSM 2016	468	93.6
3	[42]	A conceptual framework for supply chain collaboration: Empirical evidence from the agri-food industry	Supply Chain Management	266	19
4	[5]	Performance measurement in agri-food supply chains: A case study	Supply Chain Management	232	16.57
5	[43]	Blockchain-based traceability in Agri-Food supply chain management: A practical implementation	2018 IoT Vertical and Topical Summit on Agriculture - Tuscany, IOT Tuscany 2018	175	58.33
6	[44]	A Review on agri-food supply chain traceability by means of RFID technology	Food and Bioprocess Technology	153	19.13
7	[45]	Closer vertical co-ordination in agri-food supply chains: A conceptual framework and some preliminary evidence	Supply Chain Management	145	6.9
8	[46]	Value chain analysis: An approach to supply chain improvement in agri-food chains	International Journal of Physical Distribution and Logistics Management	135	8.44
9	[47]	Agrifood supply chain management: A comprehensive hierarchical decision-making framework and a critical taxonomy	Biosystems Engineering	127	18.14
10	[48]	Food and finance: the financial transformation of agro-food supply chains	Journal of Peasant Studies	118	16.86
11	[49]	Risk and resilience in agri-food supply chains: The case of the ASDA PorkLink supply chain in Scotland	Supply Chain Management	114	14.25
12	[50]	Towards a framework for improvement in the management of demand in agri-food supply chains	Supply Chain Management: An International Journal	99	6.6
13	[51]	Strategic considerations in the development of lean agri-food supply chains: A case study of the UK pork sector	Supply Chain Management	92	6.13
14	[52]	Enablers to implement sustainable initiatives in agri-food supply chains	International Journal of Production Economics	90	30
15	[6]	Information technology in agri-food supply chains	International Food and Agribusiness Management Review	84	3.65
16	[53]	Sustainable agro-food supply chain design using two-stage hybrid multi-objective decision-making approach	Computers and Operations Research	82	27.33
17	[54]	Corporate investments in supply chain sustainability: Selecting instruments in the agri-food industry	Journal of Cleaner Production	82	20.5
18	[55]	Performing the economy, performing science: From neoclassical to supply chain models in the agrifood sector	Economy and Society	81	5.79
19	[56]	Collaboration behavioural factors for sustainable agri-food supply chains: A systematic review	Journal of Cleaner Production	71	23.67
20	[57]	Food safety standards and agri-food supply chains: An introductory overview	European Review of Agricultural Economics	71	5.92

TC = Total Citation; CY=Citation per Year.

(iii) Cluster 3: **The agri-food supply chain industry** is presented by the keywords 'agri-food industry – links 27, occurrences 14', 'agroindustry – 23 links, occurrences 12', 'food market – links 14, occurrences 6', 'resilience – links 15, occurrences 7', 'supply chain performance – 15 links, occurrences 8', 'virtual corporation– links 14, occurrences 6', among others.

(iv) Cluster – 4: **Agri-food supply chain risk factor** is covered by the keywords such as 'climate change – 27 links, occurrences 6', 'environmental impact – links 27, occurrences 8', 'life cycle – links 20, occurrences 8', 'life cycle assessment – links 16, occurrences 7'.

(v) Cluster 5: **Agri-food supply chain information** is characterised by the keywords such as 'information sharing – links 12, occurrences 6' and 'information technology - links 18, occurrences 7'.

(vi) Cluster 6: **Agri-food supply chain advancement** is indicated by the keywords such as 'agricultural robots – 20 links, occurrence 10 ', 'blockchain– links 21, occurrences 19' 'traceability– links 19, occurrences 13', and 'cost-effectiveness– links 20, occurrence 8'.

(vii) Cluster 7: **Agri-food supply chain risk management** presented by the keywords such as 'risk assessment – links 30, occurrences 13,'' and 'risk management - links 15, occurrences 10'.

This proves that several studies related to agri-food supply chains might be covered in a broader area when AFSC analysis is considered as an operational approach to handle the relevancy of decision-making in AFSC networks and supply chain management. From 1997 to 2021, the research areas were connected to the methods of the AFSC studies. The development trend of AFSC research topics first focused on supply chains and then gradually concentrated on 'agri-food supply chain' topics that significantly impacted the network vulnerability in agri-food industries for sustainable growth. Methods for identifying, mapping, and quantifying AFSC thus posed additional challenges in future studies. Overall, the study of AFSC resources was captured from the perspective of concepts, methods, and applications in various new sectors, such as agricultural robots, multi-objective optimization, social aspects, integer programming, virtual corporations, life cycle assessment, information

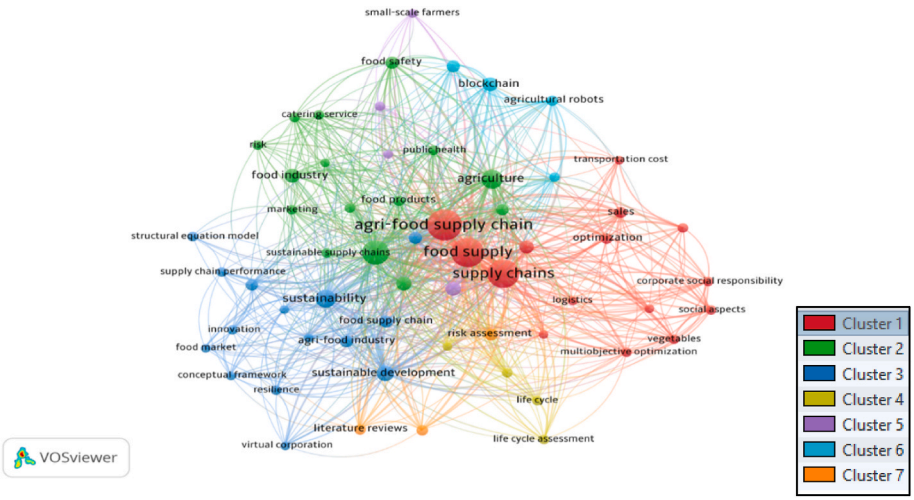

Fig. 5. Network visualization mapping with keywords co-occurrence.

technology, and traceability.

4. Discussions, future research direction and conceptual framework

4.1. General discussion

In view of the significant growth of AFSC research in today's complex systems, researchers have an important role in ensuring the smooth functioning of the supply chain system [10,11]. Thus, supply chain risk mitigation is important for the development of a dynamic AFSC network. This study presents a quantitative investigation of AFSC documents based on the Scopus core collection database. A bibliometric analysis of 303 documents from AFSC studies was conducted to identify trends, co-authorship and collaboration networks, productive source titles, highly cited documents, prolific themes, and future directions in the AFSC research domain.

The descriptive analysis revealed the present trend in AFSC research (RQ1). AFSC research has received growing interest in the last twenty-four years. The results showed an increase in the number of articles published, indicating that the topic is in a stage of development. Therefore, alternative study guidelines might be expected: an exploration of new topics, a more in-depth examination of less studied areas, or even addressing the 'current challenges' through new frameworks. It might also prove to be effective in exploring new international collaborations to expand the area of research. Therefore, AFSC development concerns should be integrated with supply chain risk factors and network challenges, which could be resolved when considered as a whole.

Among the wide range of academic publications available on AFSC (RQ2), the UK is a highly productive country, followed by China, Italy, France, and the Netherlands. Notably, only a few studies have been conducted in Asian and African countries such as India, Indonesia, Brazil, Egypt, and Tanzania. However, authors from the UK played a significant role in the international co-authorship network. However, this geographic concentration raises concerns about global inclusivity, as many regions, especially in African and Asian AFSC is concerned, as these regions have unique production practices and rely heavily on food production for their economies. Their specific challenges and opportunities are often overlooked, which could hinder the stakeholders' efforts toward sustainable development and food security. To address this gap, it is vital to increase funding and resources for research in these areas, supported by collaborations between international funding bodies, governments, and local entities. Efforts should also focus on building research training programs and fostering collaborations between local and international researchers. Additionally, establishing policies that incentivise academic and industrial research will further encourage greater involvement and development.

Accordingly, the extent of collaboration among universities in less-developed countries in AFSC research is unclear. Countries, institutions, and academic corporations are often linked to the transfer of knowledge and technology, which is important to the world's economies. It is interesting to see how these cooperative activities control and manage the aspects of intellectual property that are critical for controlling original innovations. The findings show that collaboration between authors remains quite low, and much of it is centralised in Europe. A few authors, such as Liu, S. Chen, H, and Lopez, C, play a leading role in the collaboration network. Although they have a modest relationship, they function as knowledge exposers among groups. Furthermore, our data reveal that Hisjam and Sutopo have significant publications, but without a significant collaborative connection, Resulting from limited cooperation within a restricted group. Thus, improved collaboration among researchers is essential. Similarly, Keyword Co-occurrence mapping analysis is crucial to generating research trends within the AFSC field. This study analyzes 1641 keywords from Scopus using VOSviewer software and selects terms with frequency values of more than 60 for further analysis, obtaining seven clusters and 730 connections. Among these keywords, a significant term emerged, such as 'agri-food supply chain' which recorded 135 occurrences and 58 links, and 'food supply' and 'supply chains', each with 119 occurrences and 59 links. These findings underscore the interconnected subject areas within AFSC research, paving the way for further analysis based on the identified clusters.

Regarding the most productive source title (RQ3), Sustainability Switzerland (14), by MDPI, published the highest number of articles related to AFSC and is considered the most specialised journal in AFSC. Interestingly, almost a quarter of the AFSC-related publications and almost half of the total AFSC citations in the article were responsible for relatively few journals of the authors. A similar effect was discovered in publishing patterns that show high levels of journal sources and citations in several papers, which matches the areas of interest of these journals. Moreover, associations were observed among journals such as 'European Journal of Operational Research', 'IFIP Advances in Information and Communication Technology', and 'Lecture Notes in Engineering and Computer Science', implying that some of the best journals in the field of AFSC have experienced growing attention on this sector.

Regarding highly cited documents (RQ4), articles have been published in several journals. The 'application of planning models in the agri-food supply chain: A review' is among the most significant documents. The diversity of journals indicates the involvement of various

fields and researchers from several disciplines, including traceability, RFID technology, risk and resilience, information technology, behavioural factors, and food safety standards. Research on AFSC development involves multidisciplinary and interdisciplinary work that offers opportunities and challenges. The extent of AFSC development is increasing scholars' involvement from various perspectives, emphasizing the need to understand the complexity and diversity of AFSC development. Numerous approaches and research methods from other disciplines may also be used to develop AFSC research. Cooperation and communication among scholars in various research fields can inspire novel ideas. Further studies may help explore and uncover more concepts related to AFSC development.

4.2. Future research direction

The analysis of keywords and co-occurrence, often referred to as co-word analysis, has revealed abundant themes and potential avenues for future research within the AFSC domain (RQ4). Drawing from the outcomes of cluster analysis, several implications for future AFSC research can be discerned, extracted from the delineation of seven distinct clusters.

4.2.1. ***Cluster 1**: agri-food supply chain system*

Cluster 1 summarises the importance of combining logistics with decision-making models [39,59,60] and utilizing Route LogiX and GIS technologies [61]. To advance the research, scholars should focus on actionable insights to further research in this area including, developing effective strategies for integrating logistics and decision-making processes, using emerging technologies to increase small-scale farmers' efficiency, and optimizing linear (LP) and dynamic programming (DP) to overcome challenges in global trade [41]. In addition, examining the drivers of protein, fruit and vegetable demand in emerging markets can help to adapt supply chains [61,62]. Finally, an efficient market channel establishment that supports small-scale producers requires that farmers, policymakers and technology providers work together to promote collaboration among themselves [63].

4.2.2. ***Cluster 2**: agri-food supply chain management*

Cluster 2 includes directions for future research such as the need to improve supply chain management [63], develop sustainable supply chains, ensure agricultural sustainability [64], and achieve value creation [65]. Several contributions suggest developing sourcing strategies for importing companies related to the impact of food safety standards on developing countries to identify the real scenario or contextual character of the accumulated findings [66,67]. Therefore these directions should prioritize addressing the emerging challenges brought about by evolving demands in the agri-food sector, as well as adapting to the changing landscape of the industry. This includes navigating a global marketplace and adhering to increasingly rigorous food safety regulations [68].

4.2.3. ***Cluster 3**: agri-food supply chain industry*

The focus of cluster 3 is on the emergence of a diverse network from out of traditional industrial food supply chain modes [69]. There are several actionable insights for future studies, including research on quality production methods and building a knowledge-based modelling framework for improving risk resilience in the agri-food sector [7,70]. Researchers should study the unique properties of this sector and understand how product properties and industry structure impact collaborative practices [49,71,72]. Further, analysis of the potential of virtual corporations to promote resilience and adaptability may facilitate the evolution of networks to facilitate higher levels of AFSC development [42].

4.2.4. ***Cluster 4:** agri-food supply chain risk factors*

Cluster 4 focuses on AFSC risk factor studies. Supply chain risks in agriculture are characterised by various factors, including climate change [73]. Therefore, examine how climate change affects agri-food supply chains, considering elements such as extreme weather events, shifts in precipitation patterns, and fluctuations in temperature. Develop strategies for adaptation and the implementation of sustainable practices to mitigate environmental risks and foster long-term sustainability [74,75]. An essential future research direction involves encouraging cooperation among various stakeholders within the agri-food industry, encompassing producers, distributors, retailers, and governmental bodies, to collaboratively tackle supply chain risks [76]. Investigate the possibilities of building public-private partnerships as a means of enhancing risk management strategies [77].

4.2.5. ***Cluster 5:** agri-food supply chain information*

To better understand real-world scenarios, future studies in agri-food supply chains should integrate IoT devices to collect real-time data on characteristics of the supply chain such as temperature, humidity and product condition [78,79]. IoT sensors should be developed at an affordable cost while employing robust data collection and advanced analytics for optimization data collection. In addition, resilience, sustainability, food safety and resource optimization can be facilitated by exploring collaborative data-sharing platforms [80].

4.2.6. ***Cluster 6:** agri-food supply chain advancement*

Few articles in cluster 6 have reported the development of mechanisms for studying resilience [49]. The detailed relationships between coordination mechanisms in supply chain traceability [79,81], while research should prioritize the development of advanced traceability systems and technologies that offer real-time monitoring of food items throughout the entire supply chain. This will enhance food safety and traceability by exploring the potential of blockchain and Radio Frequency Identification (RFID) technologies [78,79]. Consequently, this would ensure customers have access to food that is both safe and of higher quality.

4.2.7. ***Cluster 7:** agri-food supply chain risk management*

Future research should focus on developing a susceptible infected remove (SIR) model to assess the risk and manage risks for agri-food supply networks which are more complex than traditional supply chains [82]. Risk modelling methodologies should be improved to enhance overall supply chain management effectiveness [82,83]. In addition, Blockchain and IoT integration can develop secure and scalable solutions for real-time monitoring, data sharing, risk mitigation and overall disruption reduction, and enhance supply chain resilience [84].

4.3. Conceptual framework

In terms of conceptual framework development, which comprises seven main cluster themes (RQ5), these clusters encompass various factors of AFSC and propose a conceptual framework depicted in Fig. 6. Fig. 6 presents the conceptual framework, along with the structural linkages established through the main theme of cluster analysis, supported by previous studies. These studies serve as evidence in favour of the validity and support of the proposed framework for the AFSC study (Refer to clusters 1–7). This proposed conceptual framework collectively contributes to a more robust understanding, providing AFSC researchers with a structured and comprehensive strategy for in-depth analysis. It enhances researchers' ability to identify the complexities, challenges, and opportunities within the supply chain in the following ways:

The AFSC system (cluster 1) encompasses the network of producers, distributors, retailers and consumers connected to the production, processing and distribution of food and agricultural products [47,85]. This system utilizes technology that enables real-time dynamic modelling and simulation, facilitating immediate responses to market trends, environmental factors, and supply chain challenges [60,86].

Furthermore, by improving stakeholder coordination, streamlining

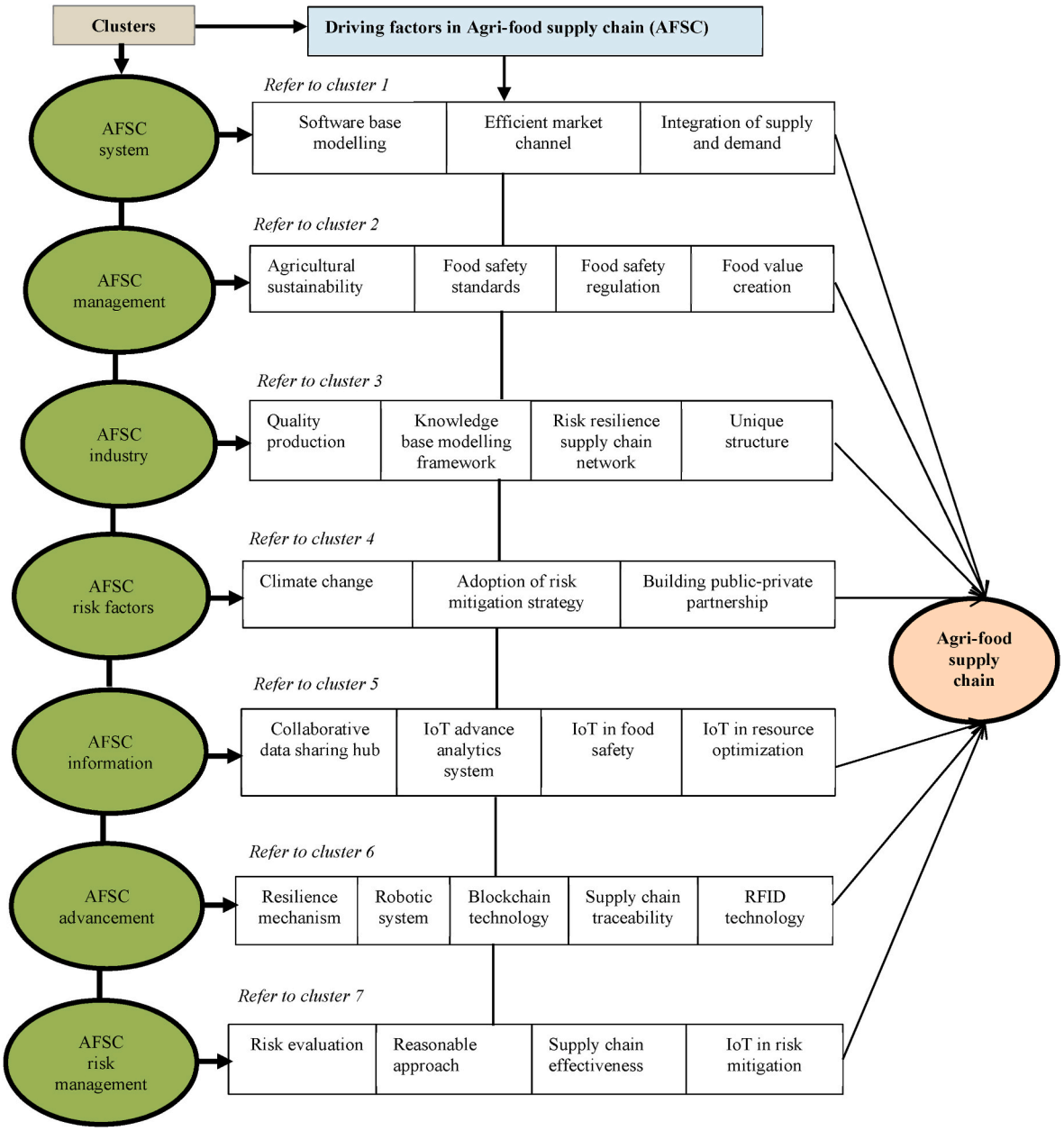

Fig. 6. A comprehensive conceptual framework for the AFSC research domain is based on seven main clusters.

distribution, and reducing lead times, efficient market channels ensure the prompt delivery of fresh, high-quality food to the market [86,87]. This holistic viewpoint illustrates the interconnections between different stages and stakeholders, fostering a clearer understanding of optimizing resource allocation and mitigating the bullwhip effect. The coordination of supply chain activities with consumer demand empowers the system to efficiently meet customer expectations, thereby reducing stockouts, overstocks, and costly adjustments [37,49].

AFSC management (Cluster 2) involves the strategic coordination and optimization of all the activities associated with the AFSC (activities of resource supply, agri-food production, processing, distribution, and consumption of agri-food products). The purpose is to enhance efficiency and sustainability and to achieve food safety while ensuring consumer demands [88,89]. Within this conceptual framework of AFSC management, the integration of sustainable agricultural practices, including the adoption of organic farming techniques, reduced chemical inputs, and the implementation of eco-friendly crop management strategies, effectively minimizes the environmental footprint and promotes responsible resource utilization [90]. Severe food safety regulations guarantee that agricultural products meet quality criteria and present minimal health risks. Throughout the entire supply chain, these regulations verify the safety, absence of contaminants, and compliance of food products with regulatory requirements, thereby enhancing consumer confidence and reinforcing the reliability of the AFSC [91,92]. While the AFSC system can offer consumers innovative, healthy, and nutritious choices, product line extensions encompass innovations in packaging and creative product identification. This enhances consumer satisfaction and contributes to the growth of the AFSC economy [93]. This theme facilitates the discovery of methods to enhance overall performance, reduce expenses, and improve efficiency for a sustainable food supply chain [94].

AFSC industry (Cluster 3) includes all entities and activities in the production, processing, distribution and provision of food and agricultural products. This industry connects many stakeholders such as farmers, manufacturers, distributors, retailers and consumers so that the quality and safety of food for the food chain [42,95]. Within the domain,

the crucial significance of validating advanced standards in production is emphasized through the effective implementation of quality production processes, strict adherence to established industry norms, and the integration of cutting-edge technologies, all working together to ensure the expected quality of food products [9]. The integration of knowledge-based modelling consistently nurtures a culture driven by data-driven insights and predictive modelling, orchestrating the optimization of supply chain operations, reduction of waste, enhancement of traceability, and facilitation of well-informed, strategic decision-making [96]. In this industry, the prioritization of a resilient network to combat risks is of utmost importance. This commitment to resilience drives the establishment of robust supply chain networks, ensuring swift and efficient recovery from a multitude of potential disruptions [97]. Furthermore, the promotion of a unique structural approach emphasizes the importance of nurturing creative and innovative designs within the AFSC sector [98], which may include the pursuit of vertical integration and the embrace of sustainable practices. These efforts, in turn, play a pivotal role in enhancing both efficiency and sustainability within the industry [99].

AFSC risk factors (Cluster 4) reflect the uncertainties and the potential disruptions that can affect the efficiency and safety of the food supply chain. These risks can arise from various sources including environmental (for example, climate change), economic (and so on), regulatory, and logistical (which can influence food quality, availability and price) [85,100]. This theme encompasses climate change, involving shifts in weather patterns, increased occurrences of extreme events, and alterations in growth conditions. These changes necessitate proactive risk assessment and the development of adaptable measures to enhance the resilience and sustainability of the supply chain [101]. Moreover, it is imperative to employ risk mitigation techniques that involve various measures such as diversifying sourcing regions, establishing redundancy in transportation, and applying advanced forecasting technologies [102]. These strategies play a vital role in minimizing vulnerabilities and maintaining a reliable food supply. Besides, collaborative public-private partnerships are crucial in enabling the exchange of knowledge and resources among various stakeholders [103]. These partnerships enable collaboration among government bodies, industry stakeholders, and communities to collaboratively tackle intricate risk elements, boosting the supply chain's ability to recognize and mitigate hazards, ultimately building overall resilience.

AFSC information (Cluster 5) refers to data and insights exchanged among the stakeholders involved in the production, processing, distribution, and sale of agricultural products. Due to the importance of this information for ensuring efficiency and traceability throughout the supply chain, food quality, safety and sustainability [104,105]. Within the AFSC information theme, the collaborative data-sharing hub acts as a central platform for real-time data exchange on crop conditions, product quality, inventory, and market demand among stakeholders like farmers, manufacturers, distributors, and retailers. This fosters transparency, minimizes information gaps, and promotes data-driven decision-making, optimizing supply chain operations [106]. The incorporation of IoT technology enables real-time monitoring of temperature, humidity, product states, and transportation routes. Through advanced analytics, supply chain participants can detect irregularities, forecast potential disruptions, and enhance route planning and resource allocation. This advancement leads to enhanced product quality, reduced waste, and increased cost-effectiveness [107]. At the same time, IoT sensors actively monitor environmental conditions during transportation and storage, effectively ensuring food safety. In cases of quality concerns, IoT-based traceability facilitates the swift identification and precise recovery of products, thereby enhancing both consumer safety and compliance with regulatory standards [108]. The approach of IoT optimization in agri-food supply enhances the efficient use of real-time IoT sensors and manages resource consumption, minimizing waste and fostering sustainability. This approach results in decreased resource expenses and a reduced environmental footprint, contributing to a more eco-friendly supply chain.

The proposed conceptual framework provides a roadmap for tackling key challenges in the operations of stakeholders in real-world AFSC and enables stakeholders to effectively apply it in real-world AFSC scenarios. The framework helps farmers, manufacturers and distributors realize more about how different supply chain elements work together to optimize processes, increase collaboration and ultimately improve performance. This framework helps stakeholders identify current practices, identify areas for improvement and develop targeted strategies to address strategic issues like waste reduction, resource management, and market access. Furthermore, the framework can also be used to assess the impact of such external factors as policy changes or climate conditions and to allow stakeholders to adapt their operations accordingly. Finally, the application of this conceptual framework can advance more resilient, sustainable, and innovative practices throughout the AFSC.

AFSC technological advancement (cluster 6) incorporating innovative technologies like blockchain, Internet of Things (IoT) and artificial intelligence (AI) assists in boosting efficiency, traceability and sustainability in food production and distribution processes [21,40]. The AFSC's technological advancement theme, focusing on resilience mechanisms, encompasses emergency strategies, redundant solutions, and the assessment of potential energy risks. This approach enables the supply chain to swiftly rebound from disturbances arising from factors such as natural disasters, market fluctuations, or other unexpected events [109]. On the other hand, the integration of robotic systems has demonstrated the ability to enhance productivity, reduce operational costs, and elevate quality standards. Supply chain optimization reaps the rewards of robotic technologies, as they minimize human errors and increase output [109]. Similarly, blockchain technology enhances the reliability of communication throughout the supply chain by instilling accountability and enabling the tracking of all transactions. Supply chains can gain advantages from blockchain technology as it promotes accountability and reduces the occurrence of fraudulent activities [110]. The application of RFID technology enables real-time tracking and monitoring of items and assets throughout the entire supply chain. Implementing this system leads to enhanced inventory management, reduced losses, and streamlined logistics. Supplements operational efficiency by enabling precise and automated data collection [81].

AFSC risk management (Cluster 7) identifies, assesses, and finds ways to mitigate risks that will disrupt the flow of agricultural products from the producers to the consumers. The goal of this process is to make resilience and supply continuity of meeting food quality and safety, and food supply, while reducing vulnerabilities to environmental, economic and operational factors [100,111]. Under the AFSC risk management theme, the risk evaluation process involves identifying potential disruptions, evaluating their consequences, and prioritizing them based on their significance. By gaining a comprehensive understanding of the risk landscape, the supply chain can improve its capacity to predict and manage potential disruptions, thus ensuring its resilience [112]. The framework endorses a rational risk management approach, emphasizing the need to balance the costs of risk mitigation strategies with potential disruption consequences. According to Ref. [113], supply chain participants can attain effective and sustainable risk management through a cost-efficient and efficient strategy, aligning risk management activities with financial viability and overall sustainability. Effectiveness is achieved by identifying critical points within the supply chain, implementing mitigation strategies and establishing contingency plans. While supported by Ref. [37], a proficient supply chain demonstrates the capability to adapt swiftly to changes, maintain its operations, and meet customer demands. The incorporation of IoT technology for risk mitigation offers the benefit of early warning systems, enabling proactive decision-making. Consequently, this approach leads to a mitigation of the adverse impacts of disruptions and enhances the overall resilience of supply chains [114].

5. Conclusion

This study undertook a comprehensive review of the existing scientific literature pertaining to agri-food supply chains. Utilizing bibliometric analysis tools, 303 documents sourced from the Scopus database were scrutinized to discern research trends within the realm of AFSC. The analysis unveiled key aspects of research in the AFSC domain, including document types, geographical distribution, affiliations, featured journals, prolific authors, prominent keywords, and citation patterns. Notably, a substantial body of AFSC publications cited 764 different authors, spanned 212 journals, originated from 57 countries, and were affiliated with 21 distinct organizations. A remarkable growth trajectory was observed, with the number of publications on AFSC surging from less than three articles in the early 2000s to 48 articles in 2020. This trend suggests significant development and predicts an anticipated yearly increase in AFSC research output. Additionally, it was discerned that countries such as the United Kingdom, the United States, and Italy have been prolific in publishing papers and engaging in robust international collaborations. These countries also offer valuable opportunities for researchers from other regions, such as Egypt, Algeria, Tanzania, and Brazil, to foster their research partnerships and expand their scientific reach.

The keyword analysis employed by the researchers to discover their papers reveals strong associations with topics concerning agri-food supply chains. These keywords effectively represent the core structure of cited references, suggesting that research in this field has been appropriately directed during its development. Furthermore, this study delves into areas of current exploration, including agricultural robotics and multi-objective optimization, as well as emerging areas like social aspects, integer programming, virtual corporations, life cycle assessment, information technology, and traceability, which hold promise for future investigations. Thus, research in AFSC resources encompasses multiple disciplines, spanning business, management, accounting, computer science, engineering, agricultural and biological sciences, decision sciences, social sciences, and more. The increasing interest in AFSC research contributes to a deeper comprehension of resource development in agri-food supply chains, offering comprehensive insights for future research based on the seven primary themes identified through cluster analysis. From a societal perspective, these studies highlight the contributions of AFSC research to social aspects, supply chain management, industry interconnections, and the dynamic relationships between supply chain risk and advanced information, ultimately boosting stakeholder confidence in best practices.

These study findings contribute significantly to the field in several ways. Firstly, the examination of publication patterns assists researchers in gaining a better understanding of global agri-food-related research, enabling them to make informed choices regarding suitable journals for publication and potential collaborations. Secondly, by mapping the scholarly landscape of this field, it identifies its positioning concerning prominent themes and intellectual structures using co-occurrence and co-citation analysis. Thirdly, governments and policymakers can utilize this analysis to identify leading countries and institutions in agri-food research globally. This knowledge is invaluable for comprehending and anticipating shifts in agri-food research directions, allowing for targeted resource allocation to foster, support, and sustain new developments. Finally, the conceptual knowledge structure unveils seven primary themes and their evolution, providing insights into both well-established and emerging areas in the field, which can guide future research directions.

However, this study comes with several limitations. To begin, the search was confined to articles with 'agri-food' and 'supply chain' in their titles, which may not encompass all the research related to AFSC within Scopus. Some researchers might not categorize their work under AFSC in the title but could instead use relevant terms within the abstract and keywords. Although the study relies on the Scopus database comprehensively, there may be bias to the study's findings resulting from incomplete representation of the research landscape in such a database that may exclude relevant research not indexed within it. This is especially pertinent as the research on AFSC is transdisciplinary. Furthermore, a geographic bias is apparent, with a focus on studies from specific regions, possibly underrepresenting the distinct challenges and opportunities in other, particularly less-developed regions. Although this study has successfully analyzed contributions across the entire study period, future research may benefit from conducting similar analyses over specified time frames. It is also recommended that future studies compare results from multiple databases, such as Web of Science and Scopus, Google Scholar, Science Direct, and PubMed and explore the necessity of fostering cooperation across diverse regions and fields within the global context of AFSC. Despite these limitations, this study offers valuable insights into the domain of AFSC.

CRediT authorship contribution statement

Abdul Kafi: Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Conceptualization. **Nizamuddin bin Zainuddin:** Writing – review & editing, Resources, Methodology. **Mohd Fitri Mansor:** Data curation. **Mohamed Najib Bin Salleh:** Supervision. **Adam bin Mohd Saifudin:** Funding acquisition. **Nurhaizal Azam Arif:** Validation. **Syairah Aimi Shahron:** Visualization. **Ravi Ramasamy:** Investigation. **Ibrahim Hassan mohamud:** Visualization, Resources.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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