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Sustainability of agricultural trade supply chains status, opportunities, and future directions

Yongtao Shen[a*] and Boonsub Panichakarn[a]

[a]*Faculty of Logistics and Digital Supply Chain, Naresuan University, 99 Moo.9, Thapo, Mueang, 65000, Phitsanulok, Thailand*

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This study examines the sustainability of Agricultural Trade Supply Chains (ATSC) from the perspective of agricultural sustainable development, with a focus on five key aspects: production, processing and storage, transportation and logistics, trade, and consumer and market. Based on an analysis of 756 academic papers published between 2013 and 2022, scientific metric techniques were used to identify changes in the field's sustainability. The study highlights opportunities for the development of a sustainable agricultural product trade supply chain, including the use of blockchain technology to improve transparency and traceability, increasing consumer demand for sustainable and eco-friendly products, corporate zero-deforestation commitments, bioenergy market expansion, and the role of farm advisors in promoting sustainable production methods. This paper contributes to a structured understanding of the status and future directions of ATSC sustainability, emphasizing the importance of joint efforts across all links of the supply chain to meet the sustainable needs of consumers and promote environmental protection and social-friendly markets.

1. Introduction

With the world's population growing and people's living standards improving, there is an increasing demand for high-quality food in large quantities. Most of our food comes from agriculture, which includes planting, farming, and fishing. Advances in technology have enabled humans to extract more raw materials from nature and produce more goods. Agriculture today is not just about producing food, fuel, or clothing, but it has also become a resource that can be traded internationally due to growing productivity (Nelson et al., 2009). The global population is expected to reach 9.7 billion by 2050, which means that the demand for food will continue to grow. According to the United Nations Food and Agri-culture Organization (FAO), food production must increase by at least 70% to meet the demand of the world's population in 2050 (FAO, 2017). The expansion of agriculture and the increasing productivity of food production have led to the development of an agriculture trade supply chain that involves various stages, including production, processing, distribution, and marketing. This has brought about significant economic benefits, with the global trade value of agriculture reaching $1.7 trillion in 2018 (WTO, 2019). In recent years, scholars have focused on the impact of climate change and environmental issues in supply chains. While industrial emissions are traditionally seen as the main cause of environmental problems, agriculture is responsible for half of the green-house-gas emissions in the food industry (Friel et al., 2009), with agricultural trade exacerbating the issue (Sarkodie et al., 2019). The agricultural trade and global supply chain faces various challenges, including environmental pollution, land degradation, and low incomes for producers, that threaten the sustainability of agriculture. Therefore, studying the sustainability of the agricultural trade supply chain (ATSC) is crucial for developing a sustainable agricultural development strategy.

* Corresponding author
E-mail address yongtaos61@nu.ac.th (Y. Shen)

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The scientific knowledge map, which is derived from bibliometric analysis, can effectively demonstrate the relationship between literature and aid researchers in comprehending the research status and development trend of a certain field (Chen, 2017). By means of statistical analysis of literature citations, authorship, journals, and other relevant information, a scientific knowledge map of the agricultural trade supply chain (ATSC) can be established from the perspective of sustainable agricultural products. This approach facilitates a better understanding of the current situation and development trend of ATSC in five dimensions: sustainability of agricultural production, sustainability of agricultural processing and storage, sustainability of transportation and logistics, sustainability of agricultural trade, and sustainability of consumer market. In this study, CiteSpace will be employed to generate knowledge maps, including reference co-citation, keyword co-occurrence, burst analysis, and country co-occurrence. The objectives of this study are threefold: (1) to determine the definition of ATSC; (2) to explore the knowledge structure of ATSC from the perspective of agricultural sustainability; and (3) to identify the research hotspots and development trends of ATSC sustainability.

2. The State of Research

2.1 Agricultural sustainability

With growing concerns about climate change and the depletion of natural resources, more and more individuals are recognizing the importance of taking action to reduce their impact on the environment. This heightened awareness has been driven by a variety of factors, including increased media coverage of environmental issues, the advocacy of influential figures, and a greater emphasis on sustainable practices by businesses and governments alike. And the study of agricultural sustainability is an important part of overall sustainability since it is intertwined with the existential issues facing humanity, such as food, environmental and economic. First, food challenges vary across countries and regions. Underdeveloped regions, such as Africa, face issues such as low yields, climate change, and food insecurity. On the other hand, Asia encounters challenges like growing demand that is not met, undernourishment, and unsustainable agricultural production (Grote et al., 2021). Especially after the outbreak of COVID-19, food issues have become a hot topic, and any scholars prefer to study food safety through food stability, availability, access, and utilization (Adhikari et al., 2021; Devereux et al., 2020; Laborde et al., 2020; Niles et al., 2020). Moreover, environmental issues have troubled humans for years. The scale and complexity of environmental issues have increased, driven by factors such as population growth (Khan et al., 2021), urbanization (Yang et al., 2020), and economic development (Khan et al., 2019). Nowadays, environmental issues such as climate change (O'Neill et al., 2020), biodiversity loss (Tickner et al., 2020), and pollution are major global challenges that require urgent action. In addition, economic factors play a crucial role in the sustainability of agriculture, as agricultural production is not only influenced by natural conditions but also market forces. According to a study, economic factors such as food demand, input costs, and government policies can impact both the short-term profitability and long-term sustainability of farming practices (Kremen et al., 2012). Therefore, it is essential to consider economic factors when developing strategies to promote agricultural sustainability.

2.2 Agricultural Trade Supply Chain and Sustainability

Agriculture is one of the world's largest economic sectors, and sustainable agricultural development plays an important role in today's global economic and environmental agenda (Lang, 2013). Sustainable agricultural development needs to cover the entire agricultural supply chain (ASC), including production, processing, storage, transport, trade, and consumers, to ensure minimal environmental, social, and economic impacts.

Firstly, the sustainability of agricultural production is the basis of the sustainability of the agricultural trade supply chain. The sustainability of production links includes the protection of soil and water resources, the rational use of fertilizers and pesticides, and the improvement of agricultural production methods (Horrigan et al., 2002). Jung et al. (2021) introduced the use of the latest technological advances in remote sensing and artificial intelligence (AI) to improve the resilience of agricultural systems and integrate big data into predictive and normative management tools. The application of WebGIS framework also helped for the smart farms (Delgado et al., 2019). Although nanotechnology has be-come one of the technologies that have changed traditional agriculture, such as nano additives, nano fertilizers, nano pesticides, nano growth promoters, etc. but toxicity and safety problems still exist in the application of nanotechnology (Ashraf et al., 2021).

Secondly, the sustainability of processing and storage of agricultural products is related to the maintenance of quality and freshness of agricultural products, as well as energy consumption and environmental pollution. Applying renewable energy such as solar energy into the cooling and drying processes of agriculture products plays an important role in sustainable farm produce (Lamidi et al., 2019).

Thirdly, the transportation and logistics of agricultural products involve transportation, packaging, storage and distribution, and its sustainability is related to the quality and food safety of agricultural products, as well as environmental and social benefits. Gerassimidou et al. (2021) proposed a sustainable decision matrix to support the use of bio-based plastic food packaging as an alternative to petrochemical based plastics, as its side effects on production, consumption and management systems have not been explored. Meanwhile, Fuel cost optimization is the core issue of agriculture logistics since fuel consumption is most directly linked to transportation, loading and storage infrastructure. The fragmentation of transport and storage infrastructure should be addressed through a combination of farm-operated trucks and transport outsourcing (Gao et al., 2019).

Fourthly, the sustainability of agricultural trade includes different levels of trade patterns, such as international trade, regional trade, and local trade. In international trade, the import and export of agricultural products involves policies, regulations and standards of different countries and regions, and their sustainability is related to economic, environmental, and social impacts. International trade positively affects global progress to-wards nine environment-related SDG targets but reduces the SDG target scores of over 60% of evaluated developing countries in research about impacts of international trade on global sustainable development, which conclude that distant trade contributes more to achieving global SDG targets than adjacent trade, and enhancing accounting for virtual resources in trade is essential for achieving sustainable development for all(Xu et al., 2020). Renewable energy is a facet of agricultural energy and has demonstrated a positive relationship with international trade. Furthermore, renewable energy has been found to have a beneficial impact on environmental quality and plays a constructive role in supporting ecological sustainability. These findings suggest that policies promoting the use of renewable energy sources can contribute to enhancing economic growth while fostering sustainable development aligned with environmental goals. Incorporating eco-friendly measures into policies and practices will aid in comprehending the role of renewable energy in supporting eco-environmental sustainability and encouraging international trade (Khan et al., 2020).

Fifthly, consumer and market sustainability include aspects such as consumer habits and needs, marketing strategies and sales channels. Consumer awareness and demand for sustainability are important factors in the sustainability of agricultural trade supply chains. Consumers associate sustainable products with being environmentally friendly, healthier, using fewer chemicals and having better quality. However, consumers are not fully aware of the importance of sustainability, tending to associate it with just organic farming and higher quality (Sánchez-Bravo et al., 2021). To ensure food security, a holistic approach to managing the agricultural value chain is required, encompassing all pre-harvest and post-harvest activities. This necessitates the development of a new food marketing management system that entails a thorough evaluation of all components involved in the process (GÖKKÜR & SINAV, 2020).

3. Methodology

3.1 Database

Web of Science (WoS) is a comprehensive research database that covers over 21,000 scholarly journals, conference proceedings, and books in various fields of study. It provides access to high-quality research literature, including citation data that allows researchers to track the impact of their work and identify influential publications in their field. And as a database that offers a powerful search engine that enables us to find relevant articles quickly and easily, and references. In addition, it provides tools for analyzing citation patterns and identifying trends in research, which can be useful for developing new ideas and collaborations. Generally, the WoS is widely used by researchers and institutions around the world, making it an essential resource for staying up to date with the latest developments in any field.

The literature in this research investigated the selection of WOS and concentrated on the database of Social Sciences Citation Index (SSCI) and Science Citation Index Expanded (SCI-EXPANDED). The research obtained a total of 756 relevant scientific papers by using search rules ("Agricultural supply chain" AND "Sustainability" OR "Sustainable").

3.2 Setting on CiteSpace

After loading the database into CiteSpace, we select author, institution, country, keyword, reference, and cited author, respectively, in Node Types blank. This article plans to collect studies from the past decade; therefore, the Time Slicing is set to 2013 Jan to 2022 Dec, and the Years Per Slice is 1. The title, abstract, author keywords (DE), and keywords plus (ID) have been chosen in the Text Processing blank.

Generally, there are 7 node types we can choose in CiteSpace (version of 5.7.R5) which are included by Author, Institution, Country, Keyword, Reference, Cited Author, and Cited Journal. Each result above those 7 node types normally show Count, Centrality, Year, and the node-types element. Count means the frequency that happened, it could be the published paper number of a country or area, the number of keywords that are mentioned in the database, or other frequency that is relevant to our choice in node types. Each node in the map that CiteSpace is linked by one or more lines. Theoretically, the node which is connected by more lines represents the more significant node, which is quantified as centrality (Zeng & Hengsadeekul, 2020). CiteSpace will draw a map for each analysis under the node-type that we choose. The size of the node determines the count, and an outer purple circle will be displayed on the node whose centrality is more than 0.10. The bigger node represents the more count, and the thicker purple circle means the bigger centrality.

4. Results

4.1 Network of Co-authors' Countries

Fig. 1 presents a map of countries involved in research on agricultural supply chains from the perspective of contributing to agricultural sustainability. There are 330 nodes and 349 connections, with a density of 0.0064. The largest node is the USA, indicating its highest frequency of contribution in this field, followed by China, Italy, and England. Each node is surrounded by a purple circle representing the relevance and connection of each country's research in this field. The thickest purple circle is around England, followed by Ethiopia and Sweden. Notably, China and Italy have a higher frequency of contribution but fewer collaborations with other countries or regions compared to the other 13 countries, resulting in fewer connecting lines between these two countries and the rest. Table 1 displays the top 15 countries ranked by their centrality and frequency in the network generated by country node type, along with their debut year, corresponding centrality score and frequency. "Centrality" refers to the importance of each country in connecting other nodes in the network. "Frequency" refers to the published number. The higher the centrality score, the more critical the country is in maintaining connections within the network. The table shows that England ranks first in centrality, followed closely by Ethiopia and Sweden. The USA is the most prolific publisher of articles with 204 publications, followed by China and Italy with 81 and 66 publications respectively. The debut year of each country is also shown in the following country. Because we set the period from 2013 to 2022, any country with a debut year of 2013 is likely to start publishing articles in this field in an earlier year in 2013.

International cooperation is crucial for sustainable development. We are pleased to see that cooperation among countries, led by England, is taking shape. At the same time, we hope that China and Italy can engage in closer cooperation with other countries in the future.

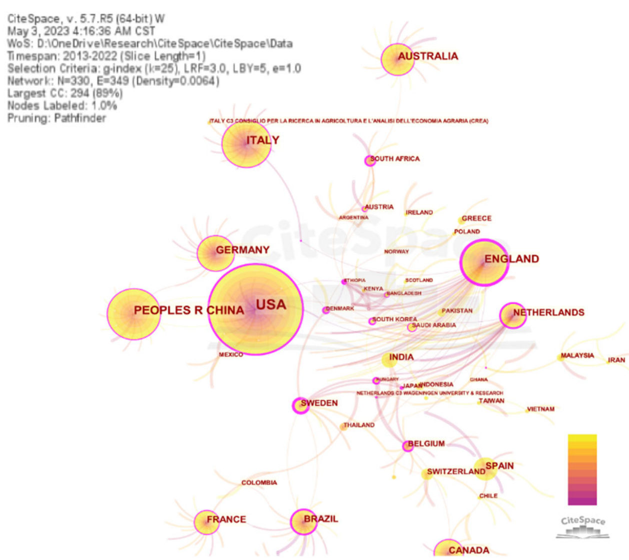

Fig. 1. Network of Co-authors' Countries

Table 1

List of Top 15 Countries Ranked by Centrality and Frequency

	Centrality	Countries (Year of Debut)	Frequency	Countries (Year of Debut)
1	0.55	ENGLAND (2013)	204	USA (2013)
2	0.47	ETHIOPIA (2013)	81	PEOPLES R CHINA (2013)
3	0.41	SWEDEN (2015)	66	ITALY (2014)
4	0.39	USA (2013)	60	ENGLAND (2013)
5	0.36	NETHERLANDS (2013)	48	GERMANY (2015)
6	0.28	BRAZIL (2013)	41	AUSTRALIA (2014)
7	0.26	HUNGARY (2015)	33	BRAZIL (2013)
8	0.25	BELGIUM (2015)	31	NETHERLANDS (2013)
9	0.23	DENMARK (2017)	29	CANADA (2013)
10	0.23	JAPAN (2015)	29	FRANCE (2015)
11	0.23	SOUTH AFRICA (2014)	29	SPAIN (2013)
12	0.20	AUSTRALIA (2014)	27	INDIA (2017)
13	0.20	SOUTH KOREA (2016)	19	SWEDEN (2015)
14	0.18	ITALY (2014)	16	SWITZERLAND (2016)
15	0.18	PEOPLES R CHINA (2013)	15	BELGIUM (2015)

4.2 Co-occurring Keywords

Keywords are used to concisely describe the contents of a document and serve as a significant means of understanding a research area (Chen, 2013). A picture of the Network of keywords co-occurring was generated in Fig. 2, which contains 384 nodes and 648 connecting lines, with a density of 0.0088, indicating that keywords in the field have some degree of association. Analyzing keywords aids in identifying the scope and features of a research field, thereby clarifying its academic development. Through keyword analysis, we can examine the distribution of keywords within a field to scout its landscape. To highlight the most influential and crucial words in the field from 2013 to 2022, we will generate keywords with the strongest citation bursts, which will showcase the hotspots and frontier areas of research in this field over the past decade.

Each key word is marked with a cross-shaped node, and these nodes are connected by lines. The more lines that a node is connected to, the higher the centrality of this point in this field. The larger that node is, the higher frequency of the key word represented by this point in this field. As shown in Fig. 2, sustainability, agriculture, supply chain, management, system, and impact appear more frequently in this field because the cross-shaped nodes representing these keywords are significantly larger than other nodes. Although it is difficult to see which points are connected by the most lines from the figure, we can see that the larger the node is not the more lines there are, which means the higher the frequency of the keyword cannot represent a higher centrality. For instance, food, impact, system, and agriculture are obviously not connected by too many lines compared with other key words.

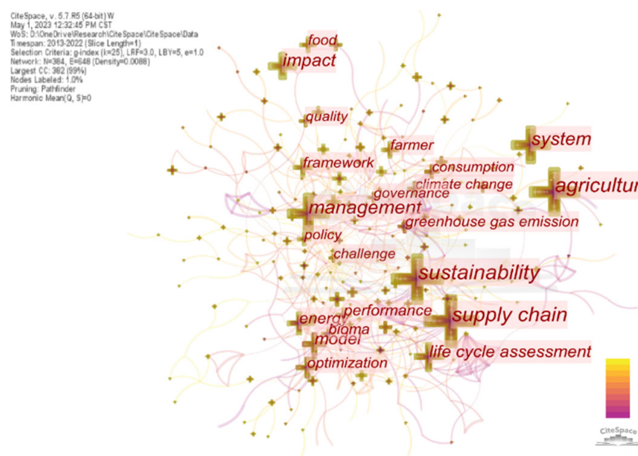

Fig. 2. Network of keywords co-occurring

Table 2 shows the top 10 keywords with high centrality and high frequency as generated by CiteSpace through co-occurring author keywords. The keywords of centrality and their debut years are greenhouse gas emission (2013), model (2013), sustainable development (2018), initiative (2017), environmental impact (2014), supply chain (2013), challenge (2017), carbon (2018), corporate social responsibility (2013), and consumption (2013). The keywords of frequency and their debut years are sustainability (2013), agriculture (2013), supply chain (2013), management (2014), system (2014), impact (2016), life cycle assessment (2014), model (2013), energy (2014), and performance (2016). In the context of agriculture supply chains, these keywords represent important concepts that drive sustainable development efforts.

“Centrality” refers to the importance or influence of a keyword in a network of scientific papers. In the context of this analysis, the centrality of a keyword indicates its level of importance and prevalence in the literature on the ASC from the perspective of agricultural sustainability. These keywords are important in the research on the ASC from the perspective of agricultural sustainability, as they reflect key concerns and challenges in this area. For example, greenhouse gas emissions and environmental impact highlight the ecological impact of agricultural practices on the environment, while sustainable development and corporate social responsibility emphasize the need for long-term planning and ethical considerations in the ASC.

“Frequency” refers to the number of times a keyword appears in the titles or abstracts of articles within a given period. In the context of agricultural sustainability and the ASC research, the “Frequency” score for each keyword indicates the level of attention and importance that researchers have placed on that concept during the specified time frame. A higher frequency score suggests that the keyword is more commonly used and has been a key focus of research in the field. For example, the high frequency of keywords like “sustainability”, “agriculture”, and “supply chain” in the table implies that these concepts have received significant attention and emphasis in recent years. This may suggest that there is a growing recognition of the importance of sustainable agriculture and supply chain management in addressing environmental, social, and economic challenges facing modern agricultural food systems. Similarly, the relatively lower frequency of keywords like “energy” and "performance" may indicate that while these concepts are also important, they have not been as extensively studied or emphasized in the context of agricultural sustainability and supply chain research.

Table 2
List of Top 10 keywords of centrality and frequency

	Centrality	Keywords (Year of Debut)	Frequency	Keywords (Year of Debut)
1	0.23	greenhouse gas emission (2013)	197	sustainability (2013)
2	0.21	model (2013)	189	agriculture (2013)
3	0.20	sustainable development (2018)	180	supply chain (2013)
4	0.20	initiative (2017)	127	management (2014)
5	0.18	environmental impact (2014)	107	system (2014)
6	0.17	supply chain (2013)	81	impact (2016)
7	0.17	challenge (2017)	70	life cycle assessment (2014)
8	0.14	carbon (2018)	65	model (2013)
9	0.14	corporate social responsibility (2013)	54	energy (2014)
10	0.13	consumption (2013)	46	performance (2016)

Table 3 presents the top 20 keywords related to agricultural sustainability from 2013 to 2023, along with the strength scores and their begin and end year, which presents a list of keywords related to agricultural sustainability in the context of the ASC. These keywords are important in the research on agricultural sustainability as they reflect key concerns and challenges in this area.

Greenhouse gas emissions (2013-2015) and nitrous oxide emissions (2014-2015) highlight the environmental impact of agriculture and the importance of reducing green-house gas emissions for sustainable practices. Biofuels (2014-2017), bioenergy (2014-2019), ethanol (2014-2018), and palm oil (2015-2019) reflect the need to balance energy production with sustainable land use and avoid damaging ecological impacts such as deforestation. Cattle (2015-2018) and food waste (2016-2018) address issues of waste reduction and ethical treatment of animals. The concept of short food supply chains (2020-2022) explores ways to reduce food miles and increase local sourcing for more sustainable food systems. LCA (2017-2018), carbon footprint (2017-2019), standard (2018-2020), and certification (2019-2020) all relate to the measurement and verification of sustainable practices. Knowledge (2019-2020) highlights the need for research and education on sustainable agriculture, while waste (2020-2022) addresses waste reduction and circular economy practices. Generally, from these keywords, it is evident that initial research efforts during this decade concentrated on greenhouse and nitrous oxide emissions, particularly in relation to biomaterials, biofuels, and bioenergy. Subsequent research focused on biological practices such as cattle farming and palm oil production. The next stage of research emphasized sustainable practices that encompassed carbon footprint, standards, knowledge, and certification. More recently, there has been a growing interest in addressing sustainability through short food supply chains and research of waste. In addition, Brazil and the USA as countries in this table, can be taken seriously. Examining the keywords before and after their appearance, it is plausible to speculate that Brazil has made notable contributions to the advancement of biological practices, while the United States may have particularly contributed to life cycle analysis, carbon footprint and standard setting.

Briefly, these keywords reflect the complex challenges and opportunities involved in creating the ASC with agriculture sustainability. By incorporating these concepts into their work, researchers and practitioners can identify areas for intervention and innovation to improve the sustainability of the ASC.

Table 3
Top 20 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2013 - 2022
Greenhouse gas emission	2013	3.56	2013	2015	
bioma	2013	2.85	2013	2015	
biofuel	2013	5.96	2014	2017	
scale	2013	3.04	2014	2017	
ethanol	2013	2.90	2014	2018	
nitrous oxide emission	2013	2.47	2014	2015	
bioenergy	2013	2.44	2014	2019	
cattle	2013	3.13	2015	2018	
brazil	2013	2.92	2015	2016	
palm oil	2013	2.85	2015	2019	

Keywords	Year	Strength	Begin	End	2013 - 2022
fuel	2013	2.68	2015	2018	
food waste	2013	2.57	2016	2018	
lca	2013	3.41	2017	2018	
carbon footprint	2013	2.81	2017	2019	
united states	2013	2.66	2017	2018	
standard	2013	2.47	2018	2020	
knowledge	2013	3.54	2019	2020	
certification	2013	2.42	2019	2020	
short food supply chain	2013	3.08	2020	2022	
waste	2013	2.54	2020	2022	

4.3 Co-authorship Network

In terms of the ASC researchers from the perspective of agricultural sustainability, according to Figure 3, the density is 0.0046, the nodes are 315, and the connecting lines are 227. As the figure shows, there are few connections between dots, indicating a lack of cooperation among authors in this field. The names of Chianan Wang who from National Kaohsiung University of Science and Technology, and Evagelos D. Lioutas and Chrysan-thi Charatsari who are from Greece present the biggest format in the figure. The former published the most articles with a total of 5 articles though the network shows limited connection between him and other scholars, and the last two contributed 4 articles. Nevertheless, we still find that some authors do collaborate with other authors, which have related to others by lines in the figure. Ilona E. de Hooge, Jessica Aschemann-Witzel, and Harald Rohm formed the largest research collaboration to conduct valuable research on food waste, which have been mutually connected by lines in the figure. In addition, waste management research centered on Shristi Kharola and Sachin Kumar Mangla also has many scholars. Generally, the density of collaborative networks is low, meaning that most academics collaborate less. Furthermore, the generated network shows that there are few connections between authors, with only a few authors collaborating on a certain topic, and authors also lack cooperation across topics.

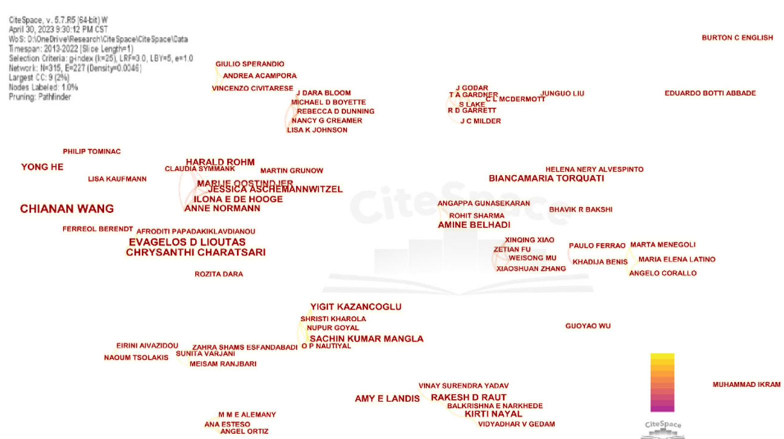

Fig. 3. Network of co-author

4.4. Document Co-citation Network

Compared to traditional co-citation analysis, CiteSpace provides additional information by including indicators and subject tags from cited literature, as well as year-to-year concept tags for tracking cluster evolution, and hierarchical representations of conceptual terms extracted from cited article titles and abstracts. This enables a more comprehensive and detailed analysis of the literature in each field, highlighting important connections and trends that may not be apparent in traditional co-citation analysis (Chen & Song, 2019). When two papers are cited simultaneously in the references of a third paper, this is considered as the establishment of a co-citation relationship between the two papers (Boyack & Klavans, 2010). Document co-citation analysis involves selecting representative literature as analysis objects and using network analysis to divide them into clusters, revealing the structure and evolution path of a specific domain (Liao et al., 2018). Citespace can complete a series of algorithms to determine the determined clustering properties and terminologies by frequency inverse document frequency, log-likelihood ratio (LLR) (Dunning, 1994), and mutual information (MI) (Chen, 2014). By using CiteSpace with node type "Reference," we generated a list of the highest centrality and citation frequency literatures out of 756 studies. In the resulting document co-citation network displayed in Fig. 4, font size represents the centrality of the article, while node size indicates the cited frequency of the article, as seen in Table 4. Articles with higher centrality (above 0.1) signify research inter-sections across interdisciplinary studies on the sustainability of agriculture trade supply chain. For example, Garrone P's (2014) paper, "Opening the black box of food waste reduction", published in "Food Policy", holds the highest centrality (0.49). His study proposed an Availability-Surplus-Recoverability-Waste management model by conducting 30 case studies to address food waste reduction strategies (Garrone et al., 2014). On the other hand, Kamble SS's (2020) review paper, "Achieving sustainable performance in a data-driven agriculture supply chain: A review for research and applications", published in the *International Journal of Production Economics*, has the highest cited frequency. The paper highlights the weaknesses of agriculture supply chains, including industrialization degree, management, information accuracy, and supply chain efficiency, and proposes a da-ta-driven capability and sustainable performance-based application framework (Kamble et al., 2020).

Table 4
Top 10 Document co-citation ranked by centrality and cited frequency.

	Centrality	Cited Reference	Frequency	Cited Reference
1	0.49	Garrone P (2014)	24	Kamble SS (2020)
2	0.48	Garnett T (2013)	19	Kamilaris A (2019)
3	0.47	Brautigam KR (2014)	17	Notarnicola B (2017)
4	0.47	Popp J (2013)	16	Galvez JF (2018)
5	0.47	Badia-Melis R (2015)	16	Lezoche M (2020)
6	0.29	Rueda X (2017)	15	Saberi S (2019)
7	0.29	Govindan K (2018)	15	Poore J (2018)
8	0.25	Gobel C (2015)	15	Willett W (2019)
9	0.21	Balaji M (2016)	12	Sharma R (2020)
10	0.17	Godfray HCJ (2010)	12	Wolfert S (2017)

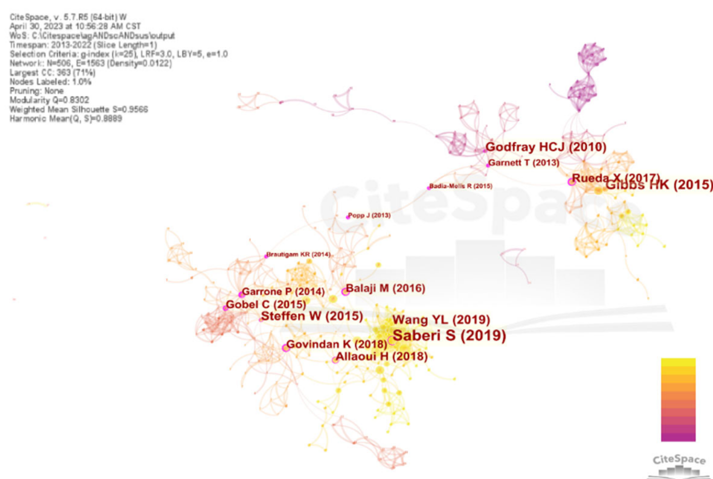

Fig. 4. Document co-citation map

4.5 Detailed structure of the Sustainability of Agriculture Trade Supply Chain

The sustainability of agriculture trade supply chain is visualized in Fig. 5 using a cluster map based on "title". The modularity Q value, which equals 0.8302, indicates that the map is a qualified one with 506 nodes and 1563 links. There are 14 research clusters related to the sustainability of agricultural trade supply chain, which are divided into different research topics listed in Table 5. The silhouette value, ranging from 0.894 to 1.000, suggests that the research within each cluster has a high level of relationship. Moreover, the research topics extracted by the LLR algorithm and MI algorithm highlight their independent research characteristics while also indicating their interrelatedness. Hence, the top 5 largest clusters are elaborated in detail below.

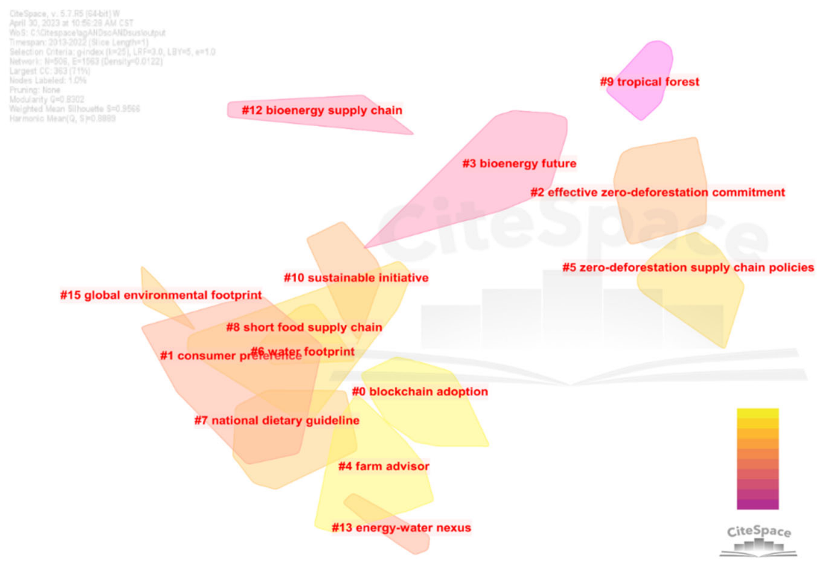

Fig. 5. Cluster Map of Sustainability of Agriculture Trade Supply Chain

Table 5
Fourteen Clusters of Sustainability of Agriculture Trade Supply Chain

Cluster	Size	Silhouette	Year	LLR
0	62	0.935	2019	blockchain adoption
1	42	0.894	2014	consumer preference
2	38	0.969	2015	effective zero-deforestation commitment
3	32	0.963	2012	bioenergy future
4	28	0.990	2018	farm advisor
5	28	0.944	2017	zero-deforestation supply chain policies
6	24	0.952	2016	water footprint
7	23	0.944	2016	national dietary guideline
8	22	0.984	2017	short food supply chain
9	19	0.989	2010	tropical forest
10	16	0.994	2015	sustainable initiative
12	11	1.000	2012	bioenergy supply chain
13	10	1.000	2013	energy-water nexus
15	8	1.000	2017	global environmental footprint

4.5.1 Blockchain Adoption

Significant food losses occur in the food supply chain due to the lack of technical infrastructure and a range of organizational issues (Food and Agriculture Organization, FAO). Although blockchain technology (BT) is considered a disruptive technology to achieve sustainable supply chain performance, it has not been that effective in improving agricultural sustainability performance to some extent (Ali et al., 2021). This phenomenon might be due to transparency limitations of sustainability, lack of collaboration of stakeholders in the supply chain, unbalanced data control, lack of commitment, and not close cooperation with the government (Zkik et al., 2022). Therefore, scholars are making efforts to address these issues. For instance, Leduc et al. (2021) proposed a farming marketplace platform based on blockchain to assess commitment to the quality of performance of proposed food tracking and traceability platforms. However, the success of sustainable supply chains also depends on food regulation and supply chain integration (Ali et al., 2021). Hence, the development of appropriate blockchain technology policies is essential to support the development of sustainable supply chains in agriculture. Additionally, from the perspective of social cooperation, blockchain technology could be integrated into the existing system to achieve data transparency and increase opportunities for social cooperation (Mangla et al., 2021).

4.5.2 Consumer Preference

The ability of a consumer to carry out intended behaviors is influenced by their perceived level of control over the behavior, as well as their attitude towards the behavior and the subjective norms related to it. This concept, known as perceived behavioral control, was first introduced by Ajzen (1985). Additionally, subjective norms refer to a consumer's beliefs regarding whether others think they should engage in the behavior. There are many research articles that have mentioned that almost one third of the amount of food wasted happened by consumer and along the food supply chain (Bräutigam et al., 2014; Buzby & Hyman, 2012). But the amount of food wasted at home has not decreased but continued to increase (Kretschmer et al., 2013). Therefore, exploring consumer preferences in choosing products is very important because it can help supply chains and policy makers reduce the waste of foods and thus reduce the inefficient use of resources. de Hooge et al. (2017) investigate the tendency of consumers to select products that rank second in terms of appearance, those that are close to their expiration date, and those that have been slightly damaged in packaging, both while shopping in supermarkets and when making choices at home, and demonstrated that discount is the main reason for suboptimal food products selling since when consumers considered they received the suitable discount, they are willing to buy all kinds of suboptimal food products. Simultaneously, Rohm et al. (2017) also offer a scheme to improve resource efficiency in the food chain by promoting the distribution and consumption of sub-optimal foods. In addition, food wasting of consumers requires the cooperation of stakeholders within the food supply chain, solutions include incentivizing and empowering consumers to avoid food waste, changing the environment of customer's food selecting (Aschemann-Witzel et al., 2017).

4.5.3 Effective Zero-deforestation Commitment

Zero-deforestation commitments (ZDCs) is a kind of initiative business behavior that refers to eliminate the impact of logging activities on forests and promote forest conservation and sustainable management, such a commitment would typically involve a company's product procurement and supply chain to ensure that the products purchased do not lead to deforestation and logging (Lambin et al., 2018). While this is a meaningful initiative, there are plenty of limitations because of the diverse commitment content. Garrett et al. (2019) proposed an assessment criterion to evaluate the effectiveness of ZDCs and applied proposed criteria to assess 52 commitments of corporates. The empirical results reveal limitations from aspects: covering market, lack of third-party real time deforestation monitoring, implementation deadlines. Hence, the ZDCs should be embedded into corporates' strategy and establish a sanction-based enforcement mechanism. For instance, a case study of the sustainable agriculture network (SAN) in Brazil illustrated how the governance (policy and project) of SAN affect the expansion of cattle program, and the result found that the governance of SAN may enable an effective pathway between strategic complementarity and interventions to enhance sustainability and reduce forest destruction (Alves-Pinto et al., 2015). Besides, the effective establishment of a governance mechanism depends on the availability and accessibility of environmental resources, markets, knowledge, actors, and networks. These factors can significantly influence the success or failure of the mechanism (Hajjar et al., 2019).

4.5.4 Bioenergy Future

Biomass resources are natural materials obtained from various sources, including agricultural crops, aquatic plants, forest products, residues, manures, and wastes. Forestry biomass and agriculture biomass are the two primary types of feedstocks used for bioenergy production (Hoogwijk et al., 2003). By promoting the use of bioenergy in agriculture, the sector can become more sustainable and contribute to achieving climate change mitigation and adaptation goals. However, the implementation of bioenergy projects should consider potential trade-offs with food security, biodiversity, and land use, among other factors. Hence, a country with a strong ambition for bioenergy make progresses, the UK has established targets for renewable energy and greenhouse gas emissions that are legally binding, they are willing to explore bioenergy from four perspective: food focus, economic focus, conservation focus, and energy focus (Welfle et al., 2014).

4.5.5 Farm Advisor

The approach to farm advisory work has evolved significantly from the focus on authoritative guidance to the adoption of more diverse advisory systems (Nettle et al., 2017). Nowadays, Agriculture 4.0 already existed, and the characteristics are closely related to technology, such as the internet of things (IoT), big data, blockchain, artificial intelligence (AI), etc. such technologies integrated the farming system into cyber-physical-social (Lioutas et al., 2019).

On the one hand, the major outcomes related to sustainable agriculture supply chains, circular economy, integrated enabling technologies, and supply chain performance indicate that the Internet of Things and information communication technology have a significant impact on addressing food security, traceability, and food quality (Nayal et al., 2021). From the perspective of organization's managers, the application of new technology into the agriculture supply chain will increase the resilience of the supply chain, especially when Covid-19 (Yadav et al., 2021).

On the other hand, it is not clear whether the use of these technologies is good or bad for the sustainable development of agriculture. A responsible research framework was proposed to focus on these issues and the result shown that for the sustainability of agriculture supply chain, the use of digital technologies, which are linked to the process of land capitalization, is leading to increasing inequalities in terms of land access and farmer independence and the use of these technologies cannot be considered responsible innovation at present (Duncan et al., 2022). Therefore, new responsibilities of farm advisors are created. Charatsari et al. (2022) illustrated that the shift towards Agriculture 4.0 necessitates the development of a novel mindset, where information and technology are deemed more trustworthy than human counsel and leads to new responsibility gaps. Meanwhile, the consideration of farm advisors, they see agriculture 4.0 as a disruption rather than a promise. In addition, Jackson and Cook (2022) highlights the notion of the "technology fallacy", which suggests that digital transformation is not solely about technology, but also involves organizations, individuals, learning, and processes. Although digital technologies facilitate change, the pace of transformation ultimately depends on the people involved.

5. Conclusion

Agricultural trade supply chain from the perspective of agricultural sustainable development reflects the sustainable concept of the whole process from farmland to table, which requires the joint efforts of all links to adopt eco-friendly production, processing, storage, transportation, and trade methods to meet the sustainable needs of consumers and promote the development of environmental protection and social friendly market.

This research is based on 756 academic papers on the sustainability of ATSC by using a specific search term. Various scientific metric techniques such as network of co-author country, co-authorship network, keyword co-occurrence network and burst detection, and document co-citation network were used to examine changes in sustainability of ATSC studies published from 2013 to 2022.

The study analyzed keywords and the relevant in terms of mediation centrality and frequency. A co-occurring network was created using keywords, followed by keyword burst detection to identify the evolution and potential future direction of the field. Those indicate an evolutionary process based on emission issues, progressing from energy and fuels to sustainable practices. Furthermore, according to the Co-authorship Network and Network of Co-authors' Countries, there is still room for improvement in collaboration between countries and scholars. We call on China and Italy to deepen their cooperation with other countries. At the same time, we urge scholars to collaborate more in research on the ATSC from a perspective of agricultural sustainability including waste management and short food supply chain in the future.

Using the scientometric analysis, this study has developed a more focused knowledge structure for the sustainability of ATSC into five key aspects. The objective is to provide a structured approach to describe the status and future directions of the sustainability of ATSC. Opportunities for the development of a sustainable agricultural product trade supply chain come from multiple perspectives including technology application, market demand, corporate action, industry development, and professional support. Firstly, block-chain technology can improve the transparency and traceability of the supply chain and facilitate sustainable agricultural trade. With blockchain, the flow of products and information can be openly monitored along the supply chain. Secondly, consumer preference for sustainable and eco-friendly products is increasing, creating strong market opportunities for sustainable agricultural trade. As consumers become more ethically and environmentally conscious, demand for sustainable products will continue to rise. Thirdly, corporate zero-deforestation commitments help improve supply chain sustainability by reducing deforestation impact. Companies are increasingly pledging to eliminate deforestation in their supply chains and production. By strictly monitoring these commitments and mitigating risks, corporations can make their supply chains more sustainable and eco-friendlier. Furthermore, the future development of the bioenergy market brings opportunities to the agricultural product trade supply chain. As bioenergy technologies advance and adoption increases, the market for agricultural feedstocks and products will expand, boosting both supply and demand sides of the supply chain. Lastly, farm advisors can help farmers adopt more sustainable production methods, thereby improving supply chain sustainability. With their professional knowledge, farm advisors can provide customized advice to help farmers choose and implement sustainable agricultural practices based on specific needs and conditions.

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Data availability

Data in this paper is openly available in a public repository. The data supporting this study's findings are available on the Web of Science at [www.webofscience.com]. The tool in this paper is CiteSpace, which is available at [https://sourceforge.net/projects/citespace/].

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References

Adhikari, J., Timsina, J., Khadka, S. R., Ghale, Y., & Ojha, H. (2021). COVID-19 impacts on agriculture and food systems in Nepal: Implications for SDGs. *Agricultural Systems, 186*, 102990. https://doi.org/https://doi.org/10.1016/j.agsy.2020.102990

Ajzen, I. (1985). From Intentions to Actions: A Theory of Planned Behavior. In J. Kuhl & J. Beckmann (Eds.), Action Control: From Cognition to Behavior (pp. 11-39). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-69746-3_2

Ali, M. H., Chung, L., Kumar, A., Zailani, S., & Tan, K. H. (2021). A sustainable Blockchain framework for the halal food supply chain: Lessons from Malaysia. *Technological Forecasting and Social Change, 170*, 120870. https://doi.org/https://doi.org/10.1016/j.techfore.2021.120870

Alves-Pinto, H. N., Newton, P., & Pinto, L. F. G. (2015). Reducing Deforestation and Enhancing Sustainability in Commodity Supply Chains: Interactions between Governance Interventions and Cattle Certification in Brazil. Tropical Conservation Science, 8(4), 1053-1079. https://doi.org/10.1177/194008291500800414

Aschemann-Witzel, J., de Hooge, I. E., Rohm, H., Normann, A., Bossle, M. B., Grønhøj, A., & Oostindjer, M. (2017). Key characteristics and success factors of supply chain initiatives tackling consumer-related food waste – A multiple case study. *Journal of Cleaner Production, 155*, 33-45. https://doi.org/https://doi.org/10.1016/j.jclepro.2016.11.173

Ashraf, S. A., Siddiqui, A. J., Elkhalifa, A. E. O., Khan, M. I., Patel, M., Alreshidi, M., Moin, A., Singh, R., Snoussi, M., & Adnan, M. (2021). Innovations in nanoscience for the sustainable development of food and agriculture with implications on health and environment. Science of The Total Environment, 768, 144990. https://doi.org/https://doi.org/10.1016/j.scitotenv.2021.144990

Boyack, K. W., & Klavans, R. (2010). Co-citation analysis, bibliographic coupling, and direct citation: Which citation approach represents the research front most accurately? *Journal of the American Society for Information Science and technology, 61*(12), 2389-2404. https://doi.org/https://doi.org/10.1002/asi.21419

Bräutigam, K.-R., Jörissen, J., & Priefer, C. (2014). The extent of food waste generation across EU-27: Different calculation methods and the reliability of their results. *Waste Management & Research, 32*(8), 683-694. https://doi.org/10.1177/0734242x14545374

Buzby, J. C., & Hyman, J. (2012). Total and per capita value of food loss in the United States. *Food Policy, 37*(5), 561-570. https://doi.org/https://doi.org/10.1016/j.foodpol.2012.06.002

Charatsari, C., Lioutas, E. D., Papadaki-Klavdianou, A., Michailidis, A., & Partalidou, M. (2022). Farm advisors amid the transition to Agriculture 4.0: Professional identity, conceptions of the future and future-specific competencies. *Sociologia Ruralis, 62*(2), 335-362. https://doi.org/https://doi.org/10.1111/soru.12364

Chen, C. (2014). The citespace manual. *College of Computing and Informatics, 1*(1), 1-84.

Chen, C. (2017). Science Mapping: A Systematic Review of the Literature [10.1515/jdis-2017-0006]. *Journal of Data and Information Science, 2,* 1-40.

Chen, C., & Song, M. (2019). Visualizing a field of research: A methodology of systematic scientometric reviews. *PLoS One, 14*(10), e0223994. https://doi.org/10.1371/journal.pone.0223994

de Hooge, I. E., Oostindjer, M., Aschemann-Witzel, J., Normann, A., Loose, S. M., & Almli, V. L. (2017). This apple is too ugly for me!: Consumer preferences for suboptimal food products in the supermarket and at home. *Food Quality and Preference, 56*, 80-92. https://doi.org/https://doi.org/10.1016/j.foodqual.2016.09.012

Delgado, J. A., Short, N. M., Roberts, D. P., & Vandenberg, B. (2019). Big Data Analysis for Sustainable Agriculture on a Geospatial Cloud Framework [Review]. *Frontiers in Sustainable Food Systems, 3*. https://doi.org/10.3389/fsufs.2019.00054

Devereux, S., Béné, C., & Hoddinott, J. (2020). Conceptualising COVID-19's impacts on household food security. *Food Security, 12*(4), 769-772. https://doi.org/10.1007/s12571-020-01085-0

Duncan, E., Rotz, S., Magnan, A., & Bronson, K. (2022). Disciplining land through data: The role of agricultural technologies in farmland assetisation. *Sociologia Ruralis, 62*(2), 231-249. https://doi.org/https://doi.org/10.1111/soru.12369

Dunning, T. (1994). Accurate methods for the statistics of surprise and coincidence. *Computational linguistics, 19*(1), 61-74.

FAO. (2017). The future of food and agriculture – Trends and and challenges. https://www.fao.org/3/i6644e/i6644e.pdf

Friel, S., Dangour, A. D., Garnett, T., Lock, K., Chalabi, Z., Roberts, I., Butler, A., Butler, C. D., Waage, J., McMichael, A. J., & Haines, A. (2009). Public health benefits of strategies to reduce greenhouse-gas emissions: food and agriculture [10.1016/S0140-6736(09)61753-0]. *The Lancet, 374*(9706), 2016-2025. https://doi.org/10.1016/S0140-6736(09)61753-0

Gao, T., Erokhin, V., & Arskiy, A. (2019). Dynamic Optimization of Fuel and Logistics Costs as a Tool in Pursuing Economic Sustainability of a Farm. *Sustainability, 11*(19), 5463. https://www.mdpi.com/2071-1050/11/19/5463

Garrett, R. D., Levy, S., Carlson, K. M., Gardner, T. A., Godar, J., Clapp, J., Dauvergne, P., Heilmayr, R., le Polain de Waroux, Y., Ayre, B., Barr, R., Døvre, B., Gibbs, H. K., Hall, S., Lake, S., Milder, J. C., Rausch, L. L., Rivero, R., Rueda, X., . . . Villoria, N. (2019). Criteria for effective zero-deforestation commitments. *Global Environmental Change, 54*, 135-147. https://doi.org/https://doi.org/10.1016/j.gloenvcha.2018.11.003

Garrone, P., Melacini, M., & Perego, A. (2014). Opening the black box of food waste reduction. *Food Policy, 46*, 129-139. https://doi.org/https://doi.org/10.1016/j.foodpol.2014.03.014

Gerassimidou, S., Martin, O. V., Chapman, S. P., Hahladakis, J. N., & Iacovidou, E. (2021). Development of an integrated sustainability matrix to depict challenges and trade-offs of introducing bio-based plastics in the food packaging value chain. *Journal of Cleaner Production, 286*, 125378. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.125378

Giampietro, M., & Mayumi, K. (2009). The Biofuel Delusion: The Fallacy of Large Scale Agro-Biofuels Production. The Biofuel Delusion: The Fallacy of Large Scale Agro-Biofuels Production, 1-318. https://doi.org/10.4324/9781849770200
GÖKKÜR, S., & SINAV, E. (2020). Sustainable Agriculture and New Food Marketing Management System. *Eurasian Journal of Agricultural Research, 4*(1), 45-55.
Grote, U., Fasse, A., Nguyen, T. T., & Erenstein, O. (2021). Food security and the dynamics of wheat and maize value chains in Africa and Asia. *Frontiers in Sustainable Food Systems, 4*, 617009.
Hajjar, R., Newton, P., Adshead, D., Bogaerts, M., Maguire-Rajpaul, V. A., Pinto, L. F. G., McDermott, C. L., Milder, J. C., Wollenberg, E., & Agrawal, A. (2019). Scaling up sustainability in commodity agriculture: Transferability of governance mechanisms across the coffee and cattle sectors in Brazil. *Journal of Cleaner Production, 206*, 124-132. https://doi.org/https://doi.org/10.1016/j.jclepro.2018.09.102
Hoogwijk, M., Faaij, A., van den Broek, R., Berndes, G., Gielen, D., & Turkenburg, W. (2003). Exploration of the ranges of the global potential of biomass for energy. *Biomass and Bioenergy, 25*(2), 119-133. https://doi.org/https://doi.org/10.1016/S0961-9534(02)00191-5
Horrigan, L., Lawrence, R. S., & Walker, P. (2002). How sustainable agriculture can address the environmental and human health harms of industrial agriculture. *Environmental Health Perspectives, 110*(5), 445-456. https://doi.org/doi:10.1289/ehp.02110445
Jackson, E. L., & Cook, S. (2022). The complex adoption pathways of digital technology in Australian livestock supply chains systems. Crop and Pasture Science, -. https://doi.org/https://doi.org/10.1071/CP21593
Jung, J., Maeda, M., Chang, A., Bhandari, M., Ashapure, A., & Landivar-Bowles, J. (2021). The potential of remote sensing and artificial intelligence as tools to improve the resilience of agriculture production systems. *Current Opinion in Biotechnology, 70,* 15-22. https://doi.org/https://doi.org/10.1016/j.copbio.2020.09.003
Kamble, S. S., Gunasekaran, A., & Gawankar, S. A. (2020). Achieving sustainable performance in a data-driven agriculture supply chain: A review for research and applications. *International Journal of Production Economics, 219*, 179-194. https://doi.org/https://doi.org/10.1016/j.ijpe.2019.05.022
Khan, I., Hou, F., & Le, H. P. (2021). The impact of natural resources, energy consumption, and population growth on environmental quality: Fresh evidence from the United States of America. *Science of The Total Environment, 754*, 142222. https://doi.org/https://doi.org/10.1016/j.scitotenv.2020.142222
Khan, S. A. R., Sharif, A., Golpîra, H., & Kumar, A. (2019). A green ideology in Asian emerging economies: From environmental policy and sustainable development. *Sustainable Development, 27*(6), 1063-1075. https://doi.org/https://doi.org/10.1002/sd.1958
Khan, S. A. R., Yu, Z., Belhadi, A., & Mardani, A. (2020). Investigating the effects of renewable energy on international trade and environmental quality. *Journal of Environmental Management, 272*, 111089. https://doi.org/https://doi.org/10.1016/j.jenvman.2020.111089
Kremen, C., Iles, A., & Bacon, C. (2012). Diversified Farming Systems: An Agroecological, Systems-based Alternative to Modern Industrial Agriculture. *Ecology and Society, 17*(4), Article 44. https://doi.org/10.5751/ES-05103-170444
Kretschmer, B., Smith, C., Watkins, E., Allen, B., Buckwell, A., Desbarats, J., & Kieve, D. (2013). Recycling Agricultural, Forestry & Food Wastes and Residues for Sustainable Bioenergy and Biomaterials (Part of the Project'Technology Options for Feeding 10 Billion People').
Laborde, D., Martin, W., Swinnen, J., & Vos, R. (2020). COVID-19 risks to global food security. *Science, 369*(6503), 500-502. https://doi.org/doi:10.1126/science.abc4765
Lambin, E. F., Gibbs, H. K., Heilmayr, R., Carlson, K. M., Fleck, L. C., Garrett, R. D., le Polain de Waroux, Y., McDermott, C. L., McLaughlin, D., Newton, P., Nolte, C., Pacheco, P., Rausch, L. L., Streck, C., Thorlakson, T., & Walker, N. F. (2018). The role of supply-chain initiatives in reducing deforestation. *Nature Climate Change, 8*(2), 109-116. https://doi.org/10.1038/s41558-017-0061-1
Lamidi, R. O., Jiang, L., Pathare, P. B., Wang, Y. D., & Roskilly, A. P. (2019). Recent advances in sustainable drying of agricultural produce: A review. *Applied Energy*, 233-234, 367-385. https://doi.org/https://doi.org/10.1016/j.apenergy.2018.10.044
Lang, J. T. (2013). Elements of public trust in the American food system: Experts, organizations, and genetically modified food. *Food Policy, 41*, 145-154. https://doi.org/https://doi.org/10.1016/j.foodpol.2013.05.008
Leduc, G., Kubler, S., & Georges, J.-P. (2021). Innovative blockchain-based farming marketplace and smart contract performance evaluation. *Journal of Cleaner Production, 306*, 127055. https://doi.org/https://doi.org/10.1016/j.jclepro.2021.127055
Liao, H., Tang, M., Luo, L., Li, C., Chiclana, F., & Zeng, X.-J. (2018). A Bibliometric Analysis and Visualization of Medical Big Data Research. *Sustainability, 10*(1), 166. https://www.mdpi.com/2071-1050/10/1/166
Lioutas, E. D., Charatsari, C., La Rocca, G., & De Rosa, M. (2019). Key questions on the use of big data in farming: An activity theory approach. *NJAS: Wageningen Journal of Life Sciences, 90-91*(1), 1-12. https://doi.org/10.1016/j.njas.2019.04.003
Mangla, S. K., Kazancoglu, Y., Ekinci, E., Liu, M., Özbiltekin, M., & Sezer, M. D. (2021). Using system dynamics to analyze the societal impacts of blockchain technology in milk supply chainsrefer. *Transportation Research Part E: Logistics and Transportation Review, 149,* 102289. https://doi.org/https://doi.org/10.1016/j.tre.2021.102289
Nayal, K., Raut, R., Lopes de Sousa Jabbour, A. B., Narkhede, B. E., & Gedam, V. V. (2021). Integrated technologies toward sustainable agriculture supply chains: missing links. *Journal of Enterprise Information Management*, ahead-of-

print(ahead-of-print). https://doi.org/10.1108/JEIM-09-2020-0381

Nelson, G. C., Rosegrant, M. W., Koo, J., Robertson, R., Sulser, T., Zhu, T., Ringler, C., Msangi, S., Palazzo, A., & Batka, M. (2009). Climate change: Impact on agriculture and costs of adaptation (Vol. 21). Intl Food Policy Res Inst.

Nettle, R., Klerkx, L., Faure, G., & Koutsouris, A. (2017). Governance dynamics and the quest for coordination in pluralistic agricultural advisory systems. *The Journal of Agricultural Education and Extension, 23*(3), 189-195. https://doi.org/10.1080/1389224X.2017.1320638

Niles, M. T., Bertmann, F., Belarmino, E. H., Wentworth, T., Biehl, E., & Neff, R. (2020). The Early Food Insecurity Impacts of COVID-19. *Nutrients, 12*(7), 2096. https://www.mdpi.com/2072-6643/12/7/2096

O'Neill, B. C., Carter, T. R., Ebi, K., Harrison, P. A., Kemp-Benedict, E., Kok, K., Kriegler, E., Preston, B. L., Riahi, K., Sillmann, J., van Ruijven, B. J., van Vuuren, D., Carlisle, D., Conde, C., Fuglestvedt, J., Green, C., Hasegawa, T., Leininger, J., Monteith, S., & Pichs-Madruga, R. (2020). Achievements and needs for the climate change scenario framework. *Nature Climate Change, 10*(12), 1074-1084. https://doi.org/10.1038/s41558-020-00952-0

Rohm, H., Oostindjer, M., Aschemann-Witzel, J., Symmank, C., L. Almli, V., De Hooge, I. E., Normann, A., & Karantininis, K. (2017). Consumers in a Sustainable Food Supply Chain (COSUS): Understanding Consumer Behavior to Encourage Food Waste Reduction. *Foods, 6*(12), 104. https://www.mdpi.com/2304-8158/6/12/104

Sánchez-Bravo, P., Chambers V, E., Noguera-Artiaga, L., Sendra, E., Chambers Iv, E., & Carbonell-Barrachina, Á. A. (2021). Consumer understanding of sustainability concept in agricultural products. *Food Quality and Preference, 89*, 104136. https://doi.org/https://doi.org/10.1016/j.foodqual.2020.104136

Sarkodie, S. A., Ntiamoah, E. B., & Li, D. (2019). Panel heterogeneous distribution analysis of trade and modernized agriculture on CO2 emissions: The role of renewable and fossil fuel energy consumption [https://doi.org/10.1111/1477-8947.12183]. *Natural Resources Forum, 43*(3), 135-153. https://doi.org/10.1111/1477-8947.12183

Tickner, D., Opperman, J. J., Abell, R., Acreman, M., Arthington, A. H., Bunn, S. E., Cooke, S. J., Dalton, J., Darwall, W., Edwards, G., Harrison, I., Hughes, K., Jones, T., Leclère, D., Lynch, A. J., Leonard, P., McClain, M. E., Muruven, D., Olden, J. D., . . . Young, L. (2020). Bending the Curve of Global Freshwater Biodiversity Loss: An Emergency Recovery Plan. *BioScience, 70*(4), 330-342. https://doi.org/10.1093/biosci/biaa002

Welfle, A., Gilbert, P., & Thornley, P. (2014). Securing a bioenergy future without imports. *Energy Policy, 68,* 1-14. https://doi.org/https://doi.org/10.1016/j.enpol.2013.11.079

WTO. (2019). World TradeStatistical Review 2019. https://www.wto.org/english/res_e/statis_e/wts2019_e/wts2019_e.pdf

Xu, Z., Li, Y., Chau, S. N., Dietz, T., Li, C., Wan, L., Zhang, J., Zhang, L., Li, Y., Chung, M. G., & Liu, J. (2020). Impacts of international trade on global sustainable development. *Nature Sustainability, 3*(11), 964-971. https://doi.org/10.1038/s41893-020-0572-z

Yadav, S., Luthra, S., & Garg, D. (2021). Modelling Internet of things (IoT)-driven global sustainability in multi-tier agri-food supply chain under natural epidemic outbreaks. *Environmental Science and Pollution Research, 28*(13), 16633-16654. https://doi.org/10.1007/s11356-020-11676-1

Yang, C., Zeng, W., & Yang, X. (2020). Coupling coordination evaluation and sustainable development pattern of geo-ecological environment and urbanization in Chongqing municipality, China. *Sustainable Cities and Society, 61*, 102271. https://doi.org/https://doi.org/10.1016/j.scs.2020.102271

Zkik, K., Belhadi, A., Rehman Khan, S. A., Kamble, S. S., Oudani, M., & Touriki, F. E. (2022). Exploration of barriers and enablers of blockchain adoption for sustainable performance: implications for e-enabled agriculture supply chains. *International Journal of Logistics Research and Applications*, 1-38. https://doi.org/10.1080/13675567.2022.2088707