Sustainability in the food sector: a bibliometric and network analysis of the literature

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Abstract: The issue of sustainability in the food sector is gaining increasing interest. Although this issue is of considerable interest to researchers and practitioners, to our knowledge there is not yet a literature review which illustrates the areas of greatest interest. The aim of this paper is to explore the status of sustainability research in the food sector, identifying the most discussed research fronts. The methodology adopted to carry out this literature review is network analysis through bibliometric tools, which are very effective in identifying current and new issues of interest. Starting from a sample of 601 articles, through the use of bibliometric tools four major clusters of research are identified: food waste management, environmental impact, models for sustainable supply chain design and consumers' behaviour towards food sustainability. These results can help researchers and practitioners to understand trendsetting topics, to detect potential research gaps and to outline future research avenues.

Keywords: sustainability; food sector; bibliometric analysis; network analysis; food waste; food sustainability.

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1 Introduction

The concept of sustainability, and more generally sustainable development, has become a priority for governments, organisations and businesses, which take this dimension into account in running their businesses (Vu et al., 2017). The term sustainable development

first appeared in the 1987 Brundtland Report and was defined as development that meets the basic needs of everyone, both in rich and poor countries, both now and in the future (Dawodu et al., 2017).

The broader concept of sustainability derives from this definition, and it can be summarised as "meeting our needs while not compromising the ability of future generations to meet theirs" (Hitchcock et al., 2009). In this definition the concept of sustainability is linked to three fundamental pillars: environmental perspective, economic perspective and social perspective. The three pillars are closely interlinked as sustainability aims to optimise not only economic but also social and environmental factors (Pero et al., 2017).

Specifically, the environmental dimension is based on the idea that the consumption of resources should be proportional to the capacity of those resources to regenerate, the social dimension concerns gender differences and class disparities, fostering cohesion and aggregation, while the economic dimension requires that an economically sustainable organisation should be able to use resources carefully and wisely, producing goods and services at minimum cost (Gibson, 2010).

In some industrial contexts characterised by a complex supply chain, such as the fashion industry, the agro-food industry or the construction industry, this triple approach is notably relevant (Dawodu et al., 2017).

Precisely, the agro-food industry, also called the agro-food system or agro-food supply chain, directly impacts the three above-mentioned dimensions in its various aspects, such as food production, processing, distribution, sale and end-of-life (Baldwin, 2011; Garnett, 2014; Bigliardi and Galanakis, 2020).

According to Fritz and Matopoulos (2008), companies operating in the agro-food sector often pursue sustainability objectives motivated by a double pressure, both internal and external. The latter concerns pressure that arise from the environment outside the company, for example from companies operating in the supply chain in which the company is inserted or from legislation imposed by the government. Government-sponsored regulations, in particular, are very effective in focusing attention on sustainability. In fact, numerous initiatives on transport, climate change, clean energy, etc. have been proposed in order to promote sustainable practices. In addition, with the advent of the information age, consumers have also begun to represent an important driver to stimulate sustainability within the company. They, in fact, have become increasingly aware of issues related to the three pillars mentioned above and have changed their purchasing attitude by beginning to demand products that meet sustainability standards (Crane, 2000; Chavez and Seow, 2012).

The scholars identified three distinct challenges that the agri-food industry faces when it comes to sustainability: the close link between food production and available resources, health issues and the complexity of the supply chain, which is made up of companies that are very dissimilar in size and sustainability focus (Cagliano et al., 2016).

The concept of sustainability has been extensively investigated and its application in the agro-food sector has been the subject of different literature reviews (Luo et al., 2018; Barth et al., 2017; Monasterolo et al., 2016; Michel-Villarreal et al., 2019). These reviews focused on the study of a specific area within the context of sustainability in the food sector, for example, Luo et al. (2018) focused on the supply chain, Barth et al. (2017) on the business model, Monasterolo et al. (2016) on the food security and Michel-Villarreal et al. (2019) on alternative food networks. Differently, our review aims to study the link between food and sustainability from a general point of view, with the aim to explore the

status of sustainability research in the food sector, identifying the most discussed research fronts. The methodology adopted to carry out this literature review is network analysis through bibliometric tools as it is very effective in identifying current and new issues of interest (Fahimnia et al., 2015).

Starting from a sample of 601 articles, through the use of bibliometric tools four major clusters of research are identified: food waste management, environmental impact, models for sustainable supply chain design and consumers' behaviour towards food sustainability. These results can help researchers and practitioners to understand which topics are trendsetting, to detect potential research gaps and to outline possible future directions for further investigations.

The remainder of the paper is structured as follows. The next section describes the methodology adopted for conducting the review and preliminary statistics of data. In Section 3 bibliometric analysis is presented and it is applied to the selected sample. Section 4 provides the network analysis, classifies the studies on the basis of keywords co-occurrences and describes the major research trends found. Section 5 concludes by highlighting the limitations of this review and proposing directions for future research.

2 Methodology

2.1 Database and inclusion criteria

In order to include all the literature concerning sustainability in the food sector, the Scopus database has been used. Indeed, it has been considered a reliable database by many scholars (e.g., Galati and Bigliardi, 2019) as it integrates all major publishers such as Emerald, Taylor and Francis, Springer, and Willey.

In order to select the studies to be included in the review, a query for the following keywords has been run on Scopus database: ('agro-food' OR 'agri-food' OR 'agro food' OR 'agri food') AND 'supply chain') AND TITLE-ABS-KEY ('sustainability'). The search was performed on the "title, abstract, and keywords" of the publications. In order to refine the sample of articles and to guarantee the effectiveness of the results found we applied several inclusion criteria: we focused on publications in journals and on specific document types ('article' and 'review') written in English only. A total of 217 contributions matched the search criteria.

Figure 1 shows the research methodology adopted in this paper.

**Figure 1** Research methodology (see online version for colours)
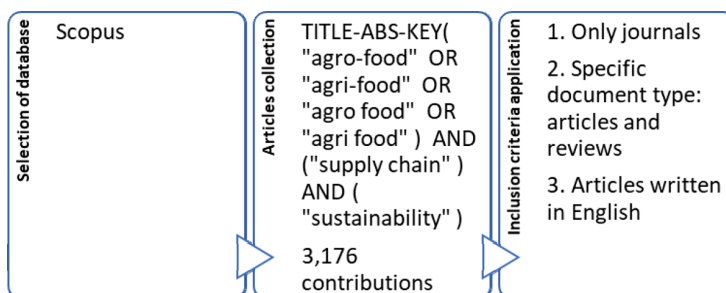
Once the sample has been selected, it has been analysed through the BibExcel software which allowed to create statistics about the authors, the journals, the affiliations and the most recurring words in titles and keywords. Afterwards, the VOSviewer software has been employed to perform a network analysis aimed at identifying the main research themes.

2.2   Initial data statistics

Figure 2 displays the trend of the publications in the sample. The graph shows how the literature related to sustainability in the agro-food sector has grown rapidly since 2017, where the number of publications has approximately tripled compared to the previous year. Prior to 2017, the number of publications was remarkably low, indicating that sustainability in agro-food sector as a topic has not captured much interest in the scientific community. The peak of publications was reached in 2021, with 53 scientific contributions, while the value for 2022 stands at 22, which is deemed high considering that the analysis has been conducted at the end of the first quarter. This constantly growing trend is consistent with the growing interest in sustainability, both from a general point of view and applied to different sectors, including the food one (Beske et al., 2014; Rashidi et al., 2020).

Figure 2   Publication trend (see online version for colours)
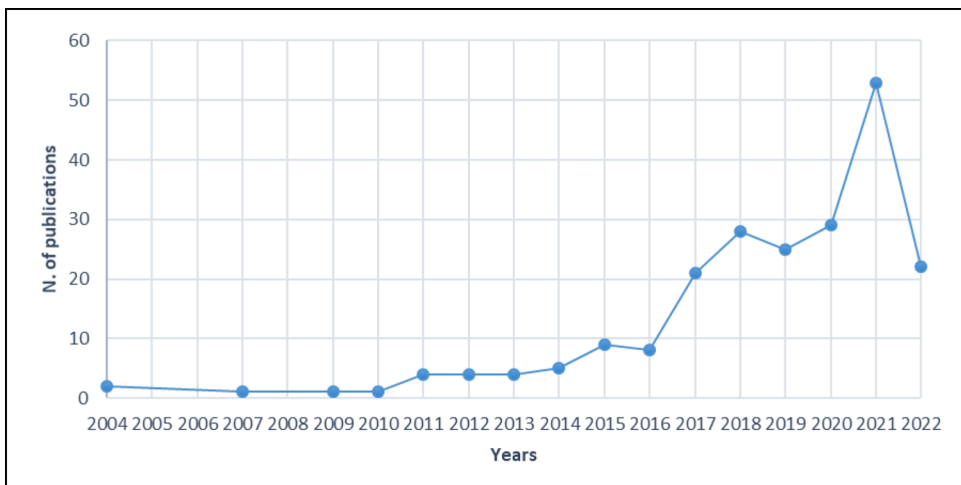
In order to analyse the impact of the publications included in the sample, the number of citations that each of them received has been considered. Figure 3 shows the trend of the publications compared to the trend of their citations. In total, 84.8% of the scientific contributions in the sample were cited at least once at the time of analysis. Looking at the trend of citations over time, we can see that the number of citations has progressively increased since 2017, in line with the increase in scientific production on the topic in question. The papers that received the highest number of citations are: Mangla et al. (2018) (133), Kamble et al. (2020) (183) and Banaeian et al. (2018) (256). The decreasing trend in citations is justified by the fact that recently published articles may not yet have received citations.

Figure 3 Comparison of citations and publication trends (see online version for colours)
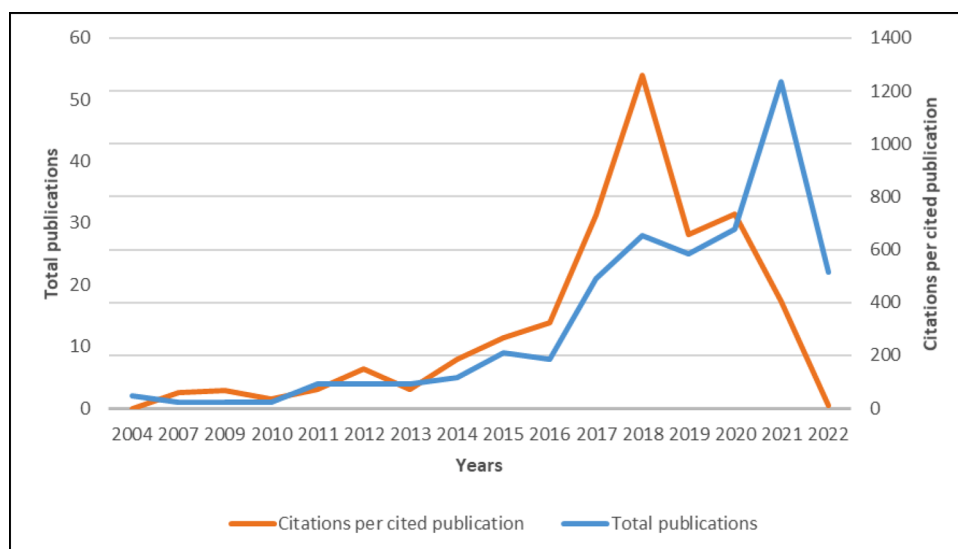
Table 1 Top 10 scientific journals

	2004–2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
Sustainability (Switzerland)					2	1		5	7	10	15	3	43
Journal of Cleaner Production			1			1	5	4	6	1	3		21
Sustainable Production and Consumption								1			1	4	6
Energies				1				1			1	1	4
Agriculture (Switzerland)						1			2			1	4
Agricultural and Food Economics						1			2	1			4
Journal of Rural Studies			1					1			1	1	4
Agriculture and Human Values			1						1		1	1	4
British Food Journal										1	3		4
International Food and Agribusiness Management Review	1	1		1							1		4
Agroecology and Sustainable Food Systems								1	1		1		3

Initial statistics show that 106 journals contributed to the publication of the 217 articles in the sample. Table 1 shows the 10 journals on which most articles were published. It is clear that the most influential journal is Sustainability (Switzerland), in which 43 papers were published, representing approximately 20% of all published articles.

3   Bibliometric analysis

Bibliometric analysis is a type of document analysis that uses mathematical and statistical techniques to analyse the distribution models of scientific publications, studying the quantitative relationships between them and allowing to subdivide them into homogeneous clusters (Garcia-Garcia et al., 2015). This type of approach allows to pursue a plurality of objectives as it allows to retrieve information such as author affiliation, number of citations and co-citations or the most frequently paired words. Specifically, bibliometric analysis gives the possibility to identify the most influential contributions, both in terms of publications and authors, in a specific field; to visualise the evolution of scientific research in a specific research area; to quantify the impact provided by specific countries or institutions and to trace possible future developments of research (Rashidi et al., 2020). In order to perform bibliometric analysis, the BibExcel software has been chosen. It has a high degree of flexibility as it allows to modify the input data coming from different databases, including Scopus, in order to make them suitable for different types of analysis (i.e., co-citation analysis, co-occurrence analysis, etc.). Moreover, BibExcel is able to dialogue with different network visualisation tools, including VOSviewer, providing the input data to perform network analysis (Persson et al., 2009).

The data of shortlisted papers that includes author name, title, abstract, journal, affiliation publication year and references are exported from Scopus in RIS format which is the one compatible with BibExcel. This information was used to perform several analyses, each of which required reformatting the RIS file into different formats, resulting in different file types. In particular, the source file used as the basis for carrying out all the analyses is in DOC format.

3.1   Most published authors

BibExcel allowed to extract the data of all the authors in the sample and to observe their frequency of publication. This information is relevant to the identification of the authors who most study the subject under analysis. The most published authors are those who have submitted the largest number of articles on the topic and are reported in Table 2. For the sake of completeness, the time frame within which each author has published articles concerning sustainability in the agri-food sector has been reported, as well as the total number of citations received for these publications.

Despite the size of the sample considered, it can be seen that there are not one or more authors who have significantly contributed. Most of them published only 1 or 2 papers related to sustainability in the agri-food sector. This can be explained with the narrowness of the analysed topic, i.e., specifically the agri-food sector. Indeed, most of the authors deal with sustainability but in different sectors and areas, from operations to supply chain, logistics, etc. Anastasiadis dominates the list with five published articles.

Table 2   The 10 most published authors

Author	No. of published papers	Time span	No. of citations
5	Anastasiadis, F.	2018–2021	25
3	Allaoui, H.	2015–2018	230
3	El Bilali, H.	2018–2021	117
3	Luthra, S.	2018–2021	206
3	Mangla, S.K.	2018–2019	230
3	Ruini, L.	2015–2019	94
2	D'amico, M.	2020–2021	21
2	Bremmers, H.	2004–2007	59
2	Nocella, G.	2018–2022	13
2	Borsellino, V.	2020	67

3.2   *Affiliation statistics*

Through BibExcel the affiliations of the authors have been extracted and are shown in Table 3. Wageningen University & Research in the Netherlands proved to be the organisation most interested in the study of sustainability in the food sector, contributing with the publication of 18 papers. Table 4 shows the 15 top contributing countries.

Table 3   The 15 top contributing organisations

Organisation	Location	No. of papers
Wageningen University & Research	Netherlands	18
Universitat Politècnica de València	Spain	7
Università degli Studi di Foggia	Italy	7
Alma Mater Studiorum Università di Bologna	Italy	7
Università degli Studi di Catania	Italy	6
Università degli Studi della Tuscia Viterbo	Italy	6
Aristotle University of Thessaloniki	Greece	5
Università degli studi di Bari Aldo Moro	Italy	5
University of Plymouth	UK	5
Università degli Studi di Palermo	Italy	4
Politecnico di Milano	Italy	4
Istituto Agronomico Mediterraneo di Bari	Italy	4
Università degli Studi di Padova	Italy	3
Università Cattolica del Sacro Cuore	Italy	3
Universität Bonn	Germany	3

Table 4   The 15 top contributing countries

Country	No. of papers
Italy	79
UK	36
Netherlands	21
Spain	19
United States	19
India	18
Australia	13
China	12
Greece	12
France	11
Germany	9
Brazil	8
Iran	6
Ireland	6
Malaysia	6

3.3   Keywords statistics

Similarly, an analysis was carried out to identify the words or phrases that appear most frequently in the titles or among the keywords of the identified articles. Table 5 lists the 20 most popular keywords among the keywords reported by the authors. Table 6, on the other hand, shows the words most frequently used in the titles. Since title words are considered individually to count frequencies, further analysis was conducted to see which words appear most frequently paired in titles. The results are shown in Table 7.

The comparison of these three tables shows that there is consistency in the use of words in titles and keywords. For example, the top keywords in all the three tables include a combination of agro-food, sustainability, supply chain and environment.

Table 5   The 20 most popular keywords

Word	Frequency	Word	Frequency
Sustainability	143	Food industry	20
Food supply	77	Agroindustry	20
Sustainable development	71	Food waste	19
Supply chains	60	Climate change	18
Supply chain management	57	Blockchain	18
Agriculture	34	Circular economy	18
Agri-food supply chains	29	Supply chain	17
Decision making	24	Food security	16
Food supply chain	22	Environmental sustainability	16
Environmental impact	20	Innovation	16

Table 6   The top 20 most recurring words in titles

Word	Frequency	Word	Frequency
Supply	97	Study	19
Agri-food	87	Management	18
Chain	65	Environmental	18
Food	58	Framework	16
Sustainable	58	Sector	14
Sustainability	53	Agro-Food	13
Chains	44	Performance	13
Systems	24	Economy	13
Assessment	23	Analysis	13
Case	22	Technology	12

Table 7   The 10 couples of words which appear most frequently in titles

Frequency	Word1	Word2
65	Chain	Supply
45	Agri-Food	Supply
38	Chains	Supply
34	Food	Supply
32	Supply	Sustainable
30	Agri-food	Chain
28	Supply	Sustainability
24	Agri-food	Sustainable
23	Agri-food	Sustainability
21	Chain	Sustainable

4   Network analysis

In the bibliometric literature, considerable attention is paid to the construction of bibliometric maps (Van Eck and Waltman, 2010), for this reason a network analysis was conducted on the selected sample of articles. Among the free software available to perform this type of analysis, VOSviewer has been chosen. This software is based on visualisation of similarities (VOS) technology and it is particularly suitable to build and visualise bibliometric maps, for instance author or journal maps based on co-citation data or keyword maps based on co-occurrence data.

The type of bibliometric map adopted in this paper is the distance-based map, where the distance between two elements is an indication of the strength of their relationship. The smaller the distance, the stronger the link and vice versa. This configuration is particularly suitable for identifying clusters of items as they tend to group naturally according to the length of the arcs connecting them (Van Eck and Waltman, 2010).

4.1   Keywords co-occurrence analysis: topical literature classification

In this paper, the map creation was carried out on the basis of keywords co-occurrence analysis. It is a commonly used research method to analyse the links between co-occurrence keywords by studying their co-occurrence relationship in a large sample of documents. The keywords express in a direct and concise way the fundamental concepts of the documents examined, enclosing in a nutshell the academic point of view of the authors.

For this reason, this analysis is particularly suitable to identify the research fronts of a given discipline, and catalogue them in homogeneous clusters (Zou et al., 2018). To conduct this analysis, we excluded the 'sustainability', 'agro-food', 'supply chain' keywords since they has been set as inclusion criteria and thus it would have biased the overall clusterisation process. Moreover, in running the network analysis the minimum number of occurrences of a keyword has been set at 5 in order to be sure of its relevance. In Figure 4, we can distinguish the four main clusters, within which the keywords show great similarity in respect of research topics. The number of keywords belonging to each cluster is presented in Table 8. The four clusters are analysed in the following sections.

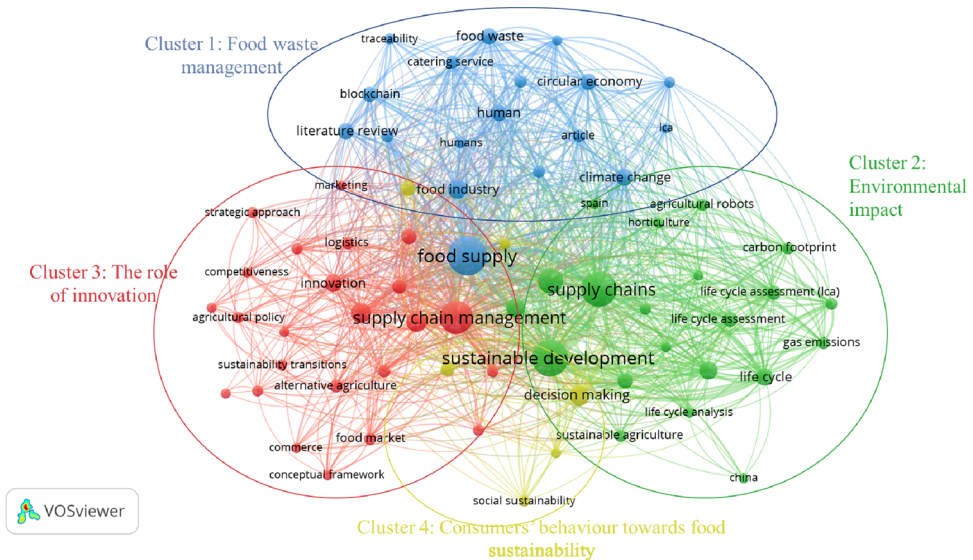**Figure 4**   Keywords co-occurrence network (see online version for colours)

Table 8   The four clusters

Cluster	No. of keywords
Food waste management	18
Environmental impact	21
The role of innovation	24
Consumers' behaviour towards food sustainability	6

4.1.1 Food waste management

One of the main issues affecting the agro-food sector is food wastage. Food waste refers to the unintentional waste or deliberate disposal of edible food mass at any level of the supply chain (de Moraes et al., 2020). The 2030 United Nations Agenda stressed the importance of addressing this issue as it has a major impact on each of the three dimensions of sustainability: economic, social and environmental. From an economic point of view, food waste results in reduced profits on the one hand and increased costs for waste disposal on the other. On a social level, food waste, resulting in a general increase in prices, can make access to food more difficult, leading to an increase in malnutrition and related diseases. Finally, from an environmental point of view, food waste generates an increase in methane gas emissions, causes unnecessary use of water to irrigate fields and encourages the unnecessary use of non-renewable energy (Gokarn and Kuthambalayan, 2017).

Food waste is present at any level of the agri-food supply chain, starting with the production of food and ending with its consumption in restaurants or at home. Generally speaking, it is possible to identify two macro-areas in which food waste is generated: more than half (Boliko, 2019) comes from economic activities linked to the food supply chain, while the remainder comes from poor consumer choices. In particular, the main causes leading to food waste have been summarised by Lanfranchi et al. (2017) in the following macro-areas: food overproduction, failure to meet market aesthetic standards, losses during the processing process, errors in the matching of supply and demand, waste during distribution activities and waste related to failure to meet the expiry date (Caraher et al., 2014; Chauhan et al., 2018; Pauer et al., 2019; de Moraes et al., 2020). In this regard, it is useful to specify that depending on the level of the agri-food supply chain, we speak of food loss or food waste, which are often mistakenly considered as synonyms. Although from a general point of view they involve the same issues related to the aforementioned three dimensions of sustainability, their meaning is slightly different. Food loss refers to a decrease in quality or quantity in the early stages of the supply chain, the direct consequence of which is a decrease in the amount of food available for consumption. Food waste, on the other hand, refers to the later stages of the supply chain and generally concerns aspects of food consumption. As far as the food loss is concerned, it can be produced at each of the following stages of the supply chain: production, post-harvesting, processing and distribution (Wang et al., 2019).

A more in-depth analysis of how the phenomenon of food waste can be curbed – even if only partially – is related to the food supply chain, which presents a waste of 30% of production, outlining a strong symptom of inefficiency. These data are confirmed by the fact that 88 million tonnes of food intended for European tables is lost between the different processes to make this food available (Annosi et al. (2021).

Digital technology is to be considered as a valid tool to address this issue, and in particular the blockchain. The incorporation of blockchain technology into the supply chain makes it possible to trace food all the way from the farm to the fork, i.e. it makes it possible to track food from the production and post-harvesting phase to the processing and distribution phase. In this way, it is possible to identify in advance the causes that would lead to an increase in waste, to identify products that are close to their expiry date before it has passed, and to identify at an early stage the anomalies during food production and processing that would cause unavoidable food losses (e.g., a malfunctioning of cold storage) (Saurabh and Dey, 2021; Kamble et al., 2020).

4.1.2   Environmental impact

A popular research front concerns the study of the environmental impact generated by the food sector (Mabhaudhi et al., 2019; Pereira, 2013; Dicks et al., 2013). The European Commission in its European Sustainable Production and Consumption policies (2008) focused on this sector, underlining the need to create more sustainable consumption and production patterns. In fact, the food sector is responsible for the consumption of large quantities of resources and produces a significant environmental impact at all stages of the supply chain, from cultivation to food processing, from distribution to disposal (Del Borghi et al., 2014).

Overall, food systems consume about 20–30% of the planet's natural resources (Nonhebel, 2004). However, the sustainability that concerns food supply chain actors is mainly economic, linked to the possibility of reducing costs, while environmental sustainability often takes second place (Accorsi et al., 2016). The result of this lack of interest is the negative contribution to climate change (Desjardins et al., 2007).

Aware of the importance of addressing the problem from an environmental sustainability point of view, many authors have proposed solutions to mitigate the environmental impact of the food sector. With regard to the impact caused by agriculture, Page et al. (2014) argue that the location of production and the technology used are key factors on which it must be acted.

A very common approach in the literature regarding sustainability in the food sector is based on life cycle thinking. Life cycle assessment (LCA) is one of the most valid tools to assess the environmental impact generated by a product, process or technology and identify hotspots for improvements (Takacs and Borrion, 2020; Kim et al., 2020; Gava et al., 2018). Although originally it was designed to be used in the industry systems, its adoption in agri-food systems has recently proved to be successful. In literature there are several examples of LCA application on different food products, such as tomato (Kim et al., 2020), edible oils (Khatri and Jain, 2017), cocoa (Ntiamoah and Afrane, 2008), rice (Saber et al., 2020), or technologies, such as RFID implementation in the fresh food supply chain (Bottani et al., 2014).

4.1.3   The role of innovation

In the literature, the concept of innovation is closely related to that of sustainability, which is considered a critical dimension of sustainable development and sustainable production and consumption. The topic of innovation was the subject of the 2030 Agenda for Sustainable Development, in which it is clearly expressed that the proposed sustainable development goals require a new approach to innovation in order to be achieved. This link becomes even more important when considering the agri-food sector, especially the early stage of the supply chain. According to Scialabba (2012), in fact, innovation is an indispensable concept when it comes to discussing the relationship between agriculture and sustainability.

As agricultural production is the basis of the agro-food supply chain, agricultural innovation is considered of crucial importance to address sustainability challenges related to food loss, climate emergency and food security. It follows that innovation plays a key role in the transition towards sustainable food systems (Bilali, 2018). In order to apply the principles of circularity to the agri-food sector, it is necessary to resort to product or technological innovations that can redesign physical and logistical processes and

reconfigure the entire supply chain. As far as sustainable agriculture is concerned, innovations are aimed at facilitating producers' access to productive resources in order to increase productivity and foster adaptability to climate change, at improving resource efficiency in agriculture and at ensuring social equity in order to contribute positively to food security (Dwyer, 2013). Especially in Europe, the concept of innovation is often applied to rural development, where it acquires the meaning of social innovation rather than technological innovation (El Bilali, 2018).

Another important aspect to be taken into account is the role of technology in fostering innovation in the agri-food sector and in agriculture in particular. One of the cornerstones of the so-called Agriculture 4.0 is precision farming, which increases the efficiency of the production process, adapting it to the variability of production and enabling the optimisation of the resources used to minimise waste. This is made possible by the application of smart sensors placed in certain areas of the field or on harvesting machines (Klerkx et al., 2019).

4.1.4 Consumers' behaviour towards food sustainability

A branch of literature has investigated consumer perceptions and attitudes towards food sustainability (Rizzo et al., 2020; Aschemann-Witzel et al., 2015). As the actions of individuals also contribute to sustainable development and the reduction of environmental impact, it is important to study consumers' purchase behaviour (Moser, 2015).

Due to the extensive media coverage of global warming, exploitation of natural resources and pollution, the awareness of individuals about the consequences of these factors and attention to the environment has increased in recent years.

The result is a greater propensity of consumers to buy less environmentally harmful products (Van Doorn and Verhoef, 2011). This trend has also affected consumer preferences for food products and consumers have begun to consider the issue of sustainability in their food choices as relevant (Panzone et al., 2016).

Today agri-food consumers pay more attention to the three fundamental pillars of the triple bottom line, namely environmental, social and economic sustainability, no longer choosing a food product based merely on its quality/price ratio (Civero et al., 2017; Shaw et al., 2000).

Many authors have evaluated consumers' interest in food sustainability issues through questionnaires and focus groups (Gilg et al., 2005; Vermeir and Verbeke, 2006). Mirroring the growing interest of Corporate Social Responsibility (CSR) initiatives, several scholars have focused on willingness to pay more for food products from companies practicing CSR (Civero et al., 2017; Packer et al., 2019). Others have studied how the presence of eco-labels and organic claims influences the purchase of sustainable food products (Van Doorn and Verhoef, 2011; de Andrade Silva et al., 2017; Sirieix et al., 2013).

A second stream of literature concerning consumer behaviour towards food sustainability relates to the two key concepts of food safety and food quality. In the agri-food sector, food quality can be defined as the set of product characteristics that allow to satisfy the declared or implicit needs of the final consumer (Pattara et al., 2017). In the marketing literature, in fact, quality has a multidimensional nature since the overall evaluation of a product can be explained in terms of perceived characteristics and corresponding objective evaluations for each of them. It is therefore possible to adapt a

marketing model, called the total quality food model (Grunert et al., 2004), to the agri-food sector. This model presents two dimensions on which food quality can be identified: a temporal one, in which quality is distinguished according to a temporal criterion between before and after purchase, and one in which the way in which the consumer deduces quality from a variety of signals or indicators linking the desirability of a product to motivating factors concerning human behaviour becomes relevant. In general, it is possible to identify three main evaluation factors by which consumers assess food quality: organoleptic properties, place and mode of production, brand and price (Pietrzyck et al., 2021).

The second key theme is food safety, related to the healthiness of food. In recent years, in fact, consumers have started to pay more and more attention to the impact of food on their health, increasing the demand for safe and differentiated foods, such as organic and non-GMO products, as they are perceived as healthier than traditional food alternatives (Saitone and Sexton, 2017).

Linking food quality and food safety aspects to the broader issue of sustainability is of paramount importance, as compliance with quality and safety standards cannot be separated from sustainability. However, the literature on this subject is rather scarce and the topic deserves a dedicated study (Pietrzyck et al., 2021).

5   Conclusions, limitations and future directions

The issue of sustainability in the agri-food sector is gaining increasing interest, as shown by the growing trend in publications especially in the last three years. Although this issue is of considerable interest to researchers and practitioners, there is not yet a literature review which illustrates the areas of greatest interest. For this reason, a bibliometric literature review followed by a network analysis has been conducted. The main research conclusions are summarised below.

As first, although agro-food and sustainability have been discussed in the literature since the beginning of 2000s, most of the publications are related to the last 10 years, with a boom from 2018 onwards. With regard to the distribution of articles by country, it has emerged that Italy, United Kingdom and Netherlands are the countries that have contributed most to the study of the topic. In fact, among the most productive organisations there are Italian universities such as Università degli Studi di Foggia, Alma Mater Studiorum University of Bologna and Università degli Studi di Catania, and universities in the Netherlands, such as Wageningen University & Research. Researchers interested in the study of this subject may consider these institutes as reference points for potential collaborations. Looking at the most influential authors, there are no researchers who have dealt with this topic more than anyone else. In the aspect of scientific journals, Sustainability (Switzerland) is by far the one in which the largest number of contributions have been published, proving to be a reference journal for sustainability and food topics.

In addition, a key role in this bibliometric review is played by the keywords. After identifying the words sustainable development, agriculture, food waste and supply chain as the most common ones, a network analysis based on co-occurrence keywords has been conducted in order to identify the main research topics. The most representative research areas are four: "food waste management", "environmental impact", "the role of innovation" and "Consumers' behaviour towards food sustainability".

Looking at the macro-themes investigated, the first cluster, food waste management, seems to be the one that most attracts researchers at the moment. In the literature, a distinction is made between food loss and food waste on the basis of the stage of the supply chain in which the waste is generated: the former derives from economic activity, while the latter from consumption activity. In general, the theme of food loss and waste gives rise to different lines of research. In particular, the use of technology, and more specifically digital technology, to minimise waste throughout the supply chain is of great interest. The analysis showed that the issue of food traceability is a hot topic among researchers, as it allows them to monitor the path taken by food from the moment it is produced to the moment it is consumed.

One limitation of this review is the choice of inclusion criteria to select the initial sample. Indeed, papers published in non-peer reviewed journals, books and papers written in languages other than English were not included in our research. Thus it is possible that other relevant contributions could have been left out. The inclusion of other keywords, such as sustainable or sustainable development, in addition to sustainability would also have given rise to different results. Moreover, we only carried out a network analysis based on keywords co-occurrence. Choosing a different method to map contributions, such as bibliographic coupling, could have led to a slightly different clustering of items.

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