Measuring Sustainable Practices in Agribusiness: A Bibliometric Analysis

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Abstract

As global concerns for sustainability matters have gained attention for businesses, industries, and economies, including agribusiness, the need to investigate the indicators that could evaluate sustainable performance in this sector has also risen. This paper aims to analyse the scientific production in the last decade (2011-2022) related to sustainable indicators (environmental, economic, social and ESG (Environmental, Social and Governance) in agribusiness. A bibliometric study was carried out using articles from the Scopus database. Afterwards, the most cited articles, journals and countries were analysed, and a thematic analysis of the keywords was carried out. Word maps, trend topics and thematic maps were carried out, as well as clustering analysis. Results indicate that research on sustainable indicators of agribusiness has increased over time. In recent years, the number of scientific papers on these topics has been increasing, probably associated with the approval of the United Nations 2030 Agenda in 2015. Italy has the most publications, the highest number of citations, and most extensive collaboration network. Most papers are published in two journals of higher impact. Life Cycle Assessment (LCA) is cited as the most usual method to assess agribusiness impact. Regarding the indicators to evaluate the sustainability of

agribusiness, there is a more significant predominance of environmental indicators compared to economic and social indicators. Clustering analysis shows clusters 2 “environmental indicators” and 8 “LCA” have greater impact and centrality. The study is limited in scope to the Scopus database. Further research should include the Web of Science (WOS) database.

Keywords: Sustainability. Indicators. Agribusiness. Bibliometric Study.

1. Introduction

Agricultural sustainability gained its prominence since the publication of the Brundtland Report in 1987, taking even more relevance in the 2030 Agenda (approved by the United Nations in 2015) within the Sustainable Development Goals (SDGs): a sustainable agribusiness model produces sufficient food to meet the demand existing both now and in the future. The Food and Agriculture Organisation (FAO) defines sustainable agriculture as the management and conservation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. This global challenge is linked to the principle of Agri-sustainability, the three pillars of economic, social and environmental sustainability in food production (PANI; JENA; PARIDA, 2020).

Agriculture is shifting to more sustainable practices around the world. The change is due to consumers' growing awareness of the industry’s environmental impact and growing preference for more sustainable food. Sustainability in agriculture is an issue which needs to be addressed with an integrated approach, where sustainable agribusiness is one of the essential means. Evidence corroborates the growing acceptance of sustainability among the major players in the agribusiness industry (BRENYA *et al.*, 2022). Although there is substantial literature on the topic, none provides a comprehensive overview of the research about sustainable indicators for measuring sustainability in agribusiness. Barth; Ulvenblad and Ulvenblad (2017) developed a systematic literature review to understand sustainable business model innovation in the agrifood sector regarding the three pillars of sustainability but did not address the issue of measurement and indicators. Silvestri et al. (2022) suggest that the Triple Bottom Line (TBL) approach of indicators (environmental, social, and economic) offers the best solution to ensure an easier transition to sustainability in the agri-food sector. This study considers the TBL approach suggested by Silvestri et al. (2022) to define the keywords search strings in the Scopus database. Using a bibliometric approach, the present study sought to analyse the scientific production in the last decade (2011-2022) related to sustainable indicators (environmental, economic, social and ESG) in agribusiness.

The following section provides a brief literature review on sustainability in the agribusiness industry. The third section describes the methodology underlying this study. The results are presented in section 4, and section 5 highlights the main conclusions and suggestions for future research.

2. Literature Review

Economic growth and sustainability become a source of competitiveness in companies as part of their strategic planning. In the business context, a sustainable company should reduce the use of natural resources and gas emissions and not have industrial process activities that degrade the environment. However, the current growth trajectory in agricultural production is unsustainable because of its adverse impacts on natural resources and the environment. Moreover, the fast growth of the population and food production leads to increased consumption of resources such as water, soil, nutrients, and labour, among others. In addition, agriculture faces several challenges to increase production sustainably.

Nowadays, sustainability is a concept widely addressed, but there is no exact definition. According to Brown et al. (1987), it consists of the resilience/survival of all biosphere components without compromising future generations. Due to the complexity of sustainability, it is divided into three dimensions (TBL): environmental, social and economic (ELKINGTON, 1998, 2004).

Agriculture is one of the sectors with the most significant impact on climate change, as being a primary producer of greenhouse gas (GHG) emissions. It is also a sector most affected by climate change (IPCC, 2021). Devitalised soils, increased pest prevalence and disease infestations, and decreased pollination are examples of climate change's impacts on agriculture (UN, 2022). On a social level, there is great inequality in the salaries between women and men working in agriculture (on average, women receive only 50-70% of what men receive). Furthermore, much of the food produced is wasted either by producers (13.3% of food is wasted after harvest and before it reaches retail markets) or consumers (17% of food). The recent impact of crises, such as COVID-19 and the war in Ukraine, have attenuated food production, causing exponential price increases in 2020 and 2021 and creating additional challenges to sustainability (FAO, 2021; UN, 2022).

From an economic perspective, adopting a Circular Economy (CE) approach offers solutions towards a more sustainable agricultural system, aiming to use raw materials first as products and then as reused/recycled products, to reduce inputs to the minimum possible and

to reduce energy use (JURGILEVICH *et al.*, 2016). A shift to a CE model in the agriculture sector could reduce CO_2 emissions by 60%, water consumption by about 70% and fertiliser use by 80% by 2050 (ELLEN MACARTHUR FOUNDATION, 2015). In this way, CE promotes greater efficiency in industries (agrifood and others). consequently reducing production costs (LASO *et al.*, 2018) benefiting producers and consumers. Thus, the agricultural sector is one of the primary sectors in the transition towards a more sustainable development oriented towards CE principles (POPONI *et al.*, 2022).

The term agribusiness is defined by Davis and Goldberg, (1957:2) as "the sum total of all operations involved in the manufacture and distribution of agricultural products; on-farm production operations; and the storage, processing and distribution of agricultural products and articles made from them. Thus, nowadays, agribusiness essentially encompasses the functions that the term agriculture denoted 150 years ago". Agribusiness presents several challenges to achieving sustainability, which cross the three pillars of sustainability. However, the sector's most significant challenges are inadequate financial support, excessive post-harvest loss, gender inequality, non-climatic policies and weak institutional controls (BRENYA *et al.*, 2022).It is necessary to measure and quantify the impact of agricultural business on the economy, the environment and society; therefore, specific methods and indicators are used to move towards a sustainable agricultural system.

Bibliometric studies in the field of sustainability and agriculture address sustainability as a whole in agriculture (SARKAR *et al.*, 2022) and, more specifically, the product value chain (LUO *et al.*, 2018; POPA, 2022), and indicators to assess sustainability in agribusiness (SILVESTRI *et al.*, 2022-; WOHLENBERG; SCHNEIDER; HOELTZ, 2020; YU; MU, 2022).

Sustainable indicators in agribusiness can have the following purposes: to assess the sustainability of agribusiness through Life Cycle Assessment (LCA), to identify best sustainable agricultural practices and to assist in decision-making (SILVESTRI *et al.*, 2022). A notable limitation in the agribusiness sector indicators is the lack of access to company information. Understanding how companies use the indicators is essential because it allows us to understand the advantages and disadvantages of applying specific indicators (SILVESTRI *et al.*, 2022-).

Despite the increased interest in this area, the studies evaluating sustainable agricultural development are still immature, and the collaboration between authors and institutions is not strong (YU; MU, 2022). The current bibliometric study aims to contribute additional data to this area.

3. Methodology

Bibliometric studies are based on statistical analysis methods that emerged in the 1950s (GODIN, 2006). This type of study provides information on various subjects. It allows, for example, to study the scientific impact and the collaboration between countries, authors, and universities on a particular topic. There is software that helps researchers perform bibliometric analyses. Herein, we use Biblioshiny, one of the most used software in this area (SARKAR *et al.*, 2022), to perform the bibliometric analysis on articles about sustainable agribusiness indicators (economic, social, and environmental). The utilised methodology is described below in Figure 1.

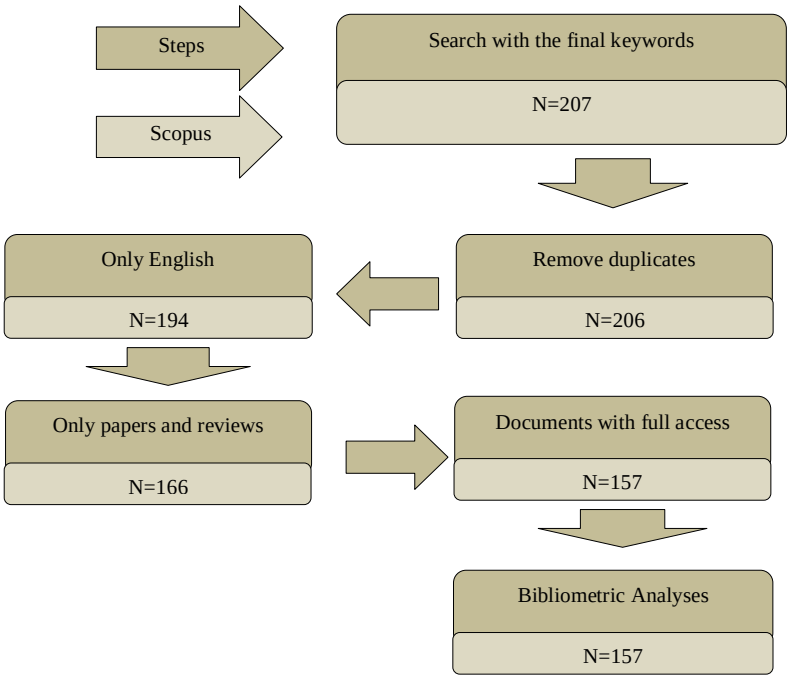

Figure 1: Steps followed until the final sample of articles.

The search was carried out in the Scopus database, one of the best databases to produce a reliable bibliometric survey (SILVESTRI *et al.*, 2022). The research criteria were "Title, Keywords, Abstract." The search strings used are "Environmental indicators" OR "Social indicators" OR "Economic indicators" OR "Sustainability indicators" OR "ESG" OR "Environmental Social Governance". The string "AND" was also used to restrict the search of the indicators to the area of agribusiness, ESG and report. The search was limited to

documents of the type "article" and "review" (in English), in the period 2011-2022 and to the areas of "Business, Management and Accounting" and "Econometrics and Finance".

As shown in Table 1, in June 2022, 157 documents (148 original articles and nine reviews) were identified. The documents were from 63 different sources, with a total of 643 authors.

Table 1: Database description (n=157).

Description	Results
MAIN INFORMATION ABOUT THE DATA	
Timespan	2011:2022
Sources (Journals, Books, others)	63
Documents	157
Annual Growth Rate %	8.69
Document Average Age	3.94
Average citations per document	18.89
References	9,144
DOCUMENT CONTENTS	
Keywords Plus (ID)	967
Author's Keywords (DE)	637
AUTHORS	
Authors	643
Authors of single-authored documents	9
AUTHORS COLLABORATION	
Single-authored documents	10
Co-Authors per document	4.38
International co-authorships %	35.67
DOCUMENT TYPES	
Original article	148
Review	9

Source: R Bibliometrix outputs.

4. Results

4.1. Total citations per year

As we can observe in Table 2, the number of articles published per year increased from 2015 onwards, particularly in 2018 (17 documents) and especially in 2021 (37 documents). However, regarding the average number of citations per article, the articles

published in 2012, 2014, and 2017 had, on average, over 30 citations per article. Recent years register fewer average citations per article, which is expected since they are more recent. Regarding MeanTCperYear, it is possible to observe that the number of citations per year has been growing, which shows the interest of researchers in these themes.

Table 2: Publications and citations per year.

Year	N	Mean Tc Per Art	Mean Tc Per Year	Citable years
2011	4	23.50	2.14	11
2012	7	39.57	3.96	10
2013	4	22.25	2.47	9
2014	6	30.83	3.85	8
2015	10	26.40	3.77	7
2016	15	27.40	4.57	6
2017	15	34.80	6.96	5
2018	17	20.41	5.10	4
2019	16	22.50	7.50	3
2020	16	13.69	6.84	2
2021	37	5.27	5.27	1
2022	10	0.30		0

Mean Tc Per Art – mean total citations per article; Mean Tc Per Year – mean total citations per year.

Source: R Bibliometrix outputs.

4.2. Most cited articles - Top 20

In

Table , we can observe the 20 most cited articles related to sustainable indicators in agribusiness. The most cited article is the one by Yakovleva N., with a total of 158 citations and an average of 14.36 citations per year. With a total number of citations above 100 are the articles by Egilmez G., Scholz K. and Banasik A. with 116, 112 and 107 citations, respectively. We also highlight the articles by Petit-Boix A., Abdella G., Schmitt E., Naidoo M. and Ahmad S., which have an average number of citations per year higher than 10.

Table 3: The 20 most cited articles.

Paper	Total Citations	Tc Per Year
Yakovleva N, 2012, Int J Prod Res	158	14.36
Egilmez G, 2014, Resour Conserv Recycl	116	12.89
Scholz K, 2015, Resour Conserv Recycl	112	14.00

Banasik A, 2017, Int J Prod Econ	107	17.83
Castellini C, 2012, J Clean Prod	83	7.55
Petit-Boix A, 2017, J Clean Prod	78	13.00
Schmitt E, 2017, J Clean Prod	73	12.17
Kalmykova Y, 2016, J Clean Prod	68	9.71
Naidoo M, 2018, J Clean Prod	64	12.80
Montgomery H, 2011, World Dev	59	4.92
Reutter B, 2017, J Clean Prod	57	9.50
Rothwell A, 2016, J Clean Prod	55	7.86
Strezov V, 2013, J Clean Prod	48	4.80
Ahmad S, 2019, J Clean Prod	46	11.50
Nicoletti Junior A, 2018, J Clean Prod	46	9.20
Cristóbal J, 2016, J Clean Prod	42	6.00
Jane Dillon E, 2016, Int J Agric Sustainability	42	6.00
Goggins G, 2016, J Clean Prod	40	5.71
Raman S, 2014, J Clean Prod	40	4.44
Abdella G, 2020, J Clean Prod	39	13.00

Tc Per Year – Total number of citations per year.

Source: R Bibliometrix outputs.

4.3. Authors with the most impact - Top 20

Table lists the 20 authors with the highest impact. The impact of an author is determined through the h-index, g-index, m-index, number of citations (Tc), number of published papers (Np) and the longevity of the paper (Py_Start). The authors Kucukvar M., Ridoutt B. and Špička J. all present an h-index of 3, meaning these authors have at least three articles and each with at least three citations and, a g-index of 3 meaning that the three most cited articles of each author have received a combined total of at least nine (3^2) citations. Regarding the m-index, Bulak M. and Abdella Gm are the most relevant authors. Finally, the authors with most citations are Kucukvar M. and Claassen G., with 162 and 115, respectively.

Table 4: The 20 authors with the highest impact.

Authors	h-index	g-index	m-index	Tc	Np	Py_Start
Kucukvar M	3	3	0.333	162	3	2014
Ridoutt B	3	3	0.333	81	3	2014
Špička J	3	3	0.333	14	3	2014
Abdella Gm	2	2	0.667	4	2	2020

				6		
Allès B	2	2	0.400	1	2	2018
				4		
Baudry J	2	2	0.400	1	2	2018
				4		
Bulak Me	2	2	0.667	4	2	2020
				6		
Claassen Gdh	2	2	0.333	1	2	2017
				15		
Depping V	2	2	0.333	3	2	2017
				9		
Falcone Pm	2	2	0.500	5	2	2019
				9		
Gabarrell X	2	2	0.333	9	2	2017
				0		
Galdeano-Gómez E	2	2	0.182	3	2	2012
				3		
Grunow M	2	2	0.333	3	2	2017
				9		
Hercberg S	2	2	0.400	1	2	2018
				4		
Imbert E	2	2	0.500	5	2	2019
				9		
Kesse-Guyot E	2	2	0.400	1	2	2018
				4		
Lairon D	2	2	0.400	1	2	2018
				4		
Langevin B	2	2	0.400	1	2	2018
				4		
Mezera J	2	2	0.200	1	2	2013
				7		
Morone P	2	2	0.500	5	2	2019
				9		

Tc – Total number of citations; Np – number of publications; Py_Start – longevity of the paper
Source: R Bibliometrix outputs.

4.4. Higher impact journals - Top 20

In this section, the impact of the journals was analysed (

Table). Regarding the h-index, g-index and m-index, the *Journal of Cleaner Production* stands out, with an m-index of 2.364. Then, we have the journal *Resources, Conservation and Recycling* with an m-index of 0.667 and a Tc of 333. In third place is *World Development*, with an m-index of 0.417 and a Tc of 141. We also highlight the *International Journal of Production Economic*s, with a Tc of 115, despite having an h-index and a g-index of 2.

Table 5: The 20 journals with the highest impact.

Journal	h-index	g-index	m-index	Tc	Np	Py_Start
Journal of Cleaner Production	26	36	2.364	1436	47	2012
Resources, Conservation and Recycling	6	10	0.667	333	10	2014
World Development	5	6	0.417	141	6	2011
British Food Journal	3	6	0.273	52	6	2012
Ecological Economics	3	3	0.300	56	3	2013
Food Policy	3	3	0.333	45	3	2014
International Journal of Agricultural Sustainability	3	3	0.273	79	3	2012
Marine Policy	3	3	0.429	24	3	2016
Agricultural and Food Economics	2	2	0.286	19	2	2016
Agricultural Economics (Czech Republic)	2	3	0.222	18	3	2014
Agris on-line Papers in Economics and Informatics	2	2	0.200	15	2	2013
Business Strategy and the Environment	2	2	0.250	49	2	2015
Custos e Agronegócios	2	3	0.250	15	4	2015
Environment, Development and Sustainability	2	2	0.182	32	2	2012
International Journal of Production Economics	2	2	0.333	115	2	2017
Studies in Agricultural Economics	2	2	0.286	30	2	2016
Accounting Perspectives	1	1	0.333	3	1	2020
Asian Social Science	1	2	0.100	15	2	2013
Business: Theory and Practice	1	1	0.500	3	1	2021
Canadian Journal of Agricultural Economics	1	1	0.091	12	1	2012

Tc – Total number of citations; Np – number of publications; Py_Start – longevity of the paper.

Source: R Bibliometrix outputs.

The *Journal of Cleaner Production and Resources, Conservation and Recycling* published about a third of the documents of the entire collection. Furthermore, according to the Scimago Journal & Country Rank, these two journals are in the first quartiles, with an h-index of 232 and 150, respectively.

Erro! Fonte de referência não encontrada.2 shows which journals have had the most substantial impact over the years. As can be seen, the *Journal of Cleaner Production* had significant growth from 2015 onwards. Additionally, *Resources, Conservation and Recycling* also stands out with an increasing impact since 2020. Over time there have been oscillations in the impact of journals, a situation motivated by the oscillation in the number of publications and respective citations of articles published in these journals, which consequently influence the indexes (h-index, g-index, and m-index). Another reason for the increase may be related to the creation of Agenda 2030 and the SDGs in 2015.

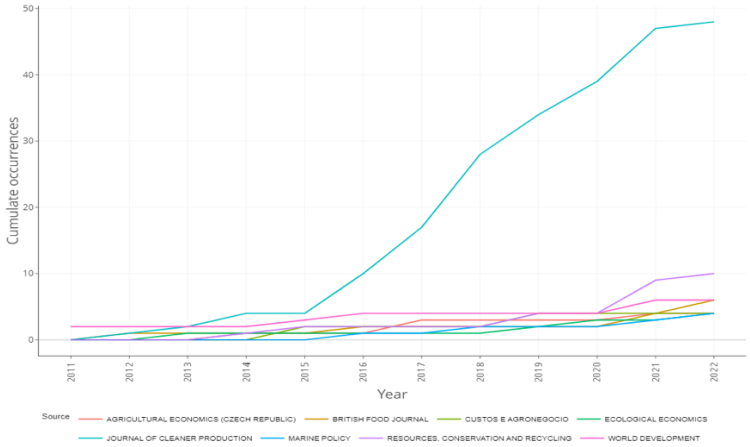

Figure 2: Evolution of the journals with the greatest impact.

Source: R Bibliometrix outputs

4.5. Country analysis

In this section, first, we analyse the publications produced in each country on sustainable indicators for agribusiness (Table 6). Italy is the country with the most publications (44), followed by Spain, France, and the USA with 29, 26, and 25, respectively. All the countries in the top 20 have at least six publications. Some countries have joint publications with other countries.

Table 6: The 20 countries with the most publications.

Country	N	Country	N
Italy	44	Australia	13
Spain	29	Serbia	12
France	26	Sweden	12
USA	25	Czechia Republic	10
Germany	23	Chile	8
UK	22	Kazakhstan	8
Ukraine	22	Denmark	6
Brazil	21	India	6
Netherlands	17	Pakistan	6
China	14	Qatar	6

Source: R Bibliometrix ouputs.

As we can see in Table 1, the most cited papers are from the USA and Italy, with a total of more than 300 citations, followed by Sweden and Australia, with more than 200 citations, and, finally, Spain, Netherlands, Germany, Japan, Ireland and the UK with more than 100 citations. However, regarding the average number of citations per article, the country that stands out on top is Japan, with about 60 citations per article, followed by Malaysia, Sweden, and the USA, with more than 40 citations per article. Italy has an average of 22 citations per article.

Table 1 The 20 countries with the most citations.

COUNTRY	TOTAL CITATIONS	AVERAGE ARTICLE CITATIONS
ITALY	330	22.00
USA	313	44.71
SWEDEN	234	46.80
AUSTRALIA	201	28.71
SPAIN	194	24.25
NETHERLANDS	186	31.00
GERMANY	151	16.78
JAPAN	123	61.50
IRELAND	118	39.33
UNITED KINGDOM	118	19.67
CHINA	84	16.80
SWITZERLAND	76	38.00
BRAZIL	66	16.50
FRANCE	50	8.33
MALAYSIA	47	47.00
QATAR	46	23.00
CZECHIA	44	7.33
PHILIPPINES	34	34.00
MEXICO	27	27.00
CANADA	24	12.00

Source: R Bibliometrix ouputs

Countries network was analysed (Figure 3), showing Italy as the country with the most extensive collaboration with other countries. The one with the smallest collaboration network

is Qatar. Most collaborations occur between European countries such as Italy, Spain, France, Poland, Ireland, Hungary, Serbia, Netherlands, and Germany. Interestingly, the United Kingdom has some collaborations with countries such as Italy and Spain despite being in another collaboration network. These data demonstrate a great tendency and interest in this theme on the part of European countries, compared to countries from other continents.

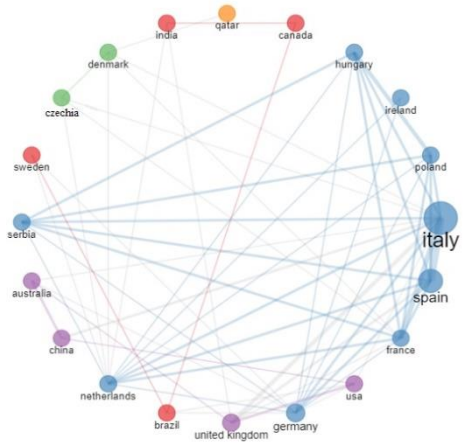

Figure 3: Collaboration network between countries.

Source: R Bibliometrix ouputs.

4.6. Word, trend topics and thematic maps

By the word map analysis of the frequency of keywords plus (Figure 4), it is concluded that the food industry theme (33), environmental indicators (30), environmental impact (28), LCA (24), life cycle (22), sustainability (19), sustainability indicators (18), are present in the researched articles. Despite not appearing in the word map, sustainable development (46) is also widely addressed in the analysed documents. This analysis reveals an improved approach to the environmental dimension of sustainability when faced with the economic and social dimensions.

Figure 4: Word map of keywords plus.

Source: R Bibliometrix ouputs.

The word map analysis of the frequency of the authors' keywords (Figure 5) shows that the most frequent word is LCA (21), followed by sustainability indicators (11), environmental indicators (six), food security (six), food waste (six), nutrition (six) and supply chain (six). The most frequent word is sustainability (24), although it is not found on the map. This result suggests a strong link between the use of LCA in assessing the sustainability of agribusiness. As we can observe, LCA is a commonly used method for quantifying services or products in sustainable terms. The indicators most frequently used are related to the environmental dimension of sustainability, namely carbon footprint, gas emissions, greenhouse gases, land uses, and food waste.

Figure 5: Word map of author's keywords.

Source: R Bibliometrix ouputs.

We also conducted a trend topic analysis on the authors' keywords (Figure) and keyword plus (Figure).

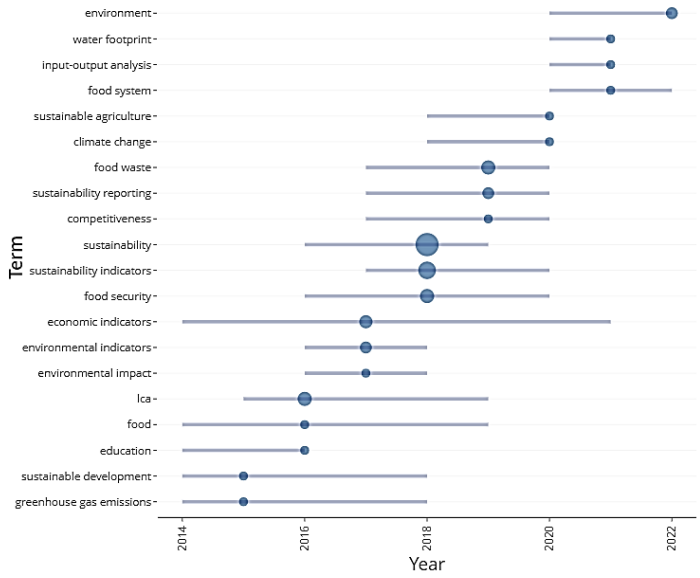

Figure 6: Trend topics (authors keyword).

Source: R Bibliometrix ouputs.

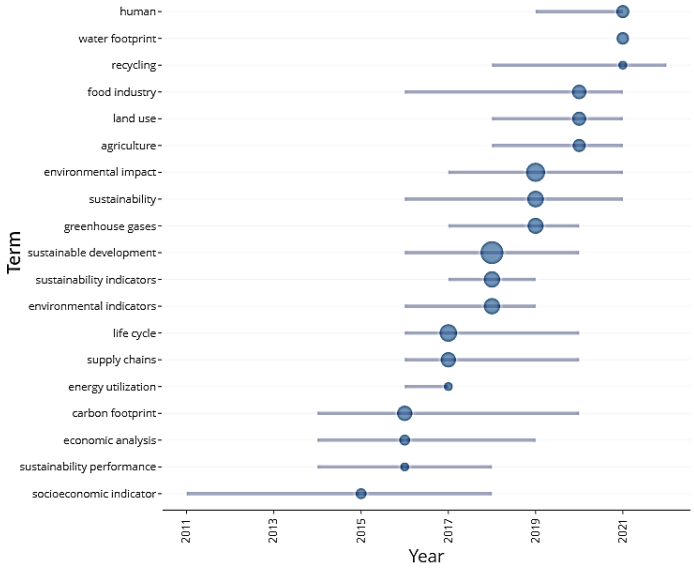

Figure 2 Trend topics (keyword plus).

Source: R Bibliometrix ouputs.

As we can see from the figures above, the themes that have emerged in recent years are related to the environment, water footprint, input-output analysis, food system, food industry, recycling, agriculture, land use, and environmental impact.

Additionally, a thematic analysis was carried out (Figure), and the authors' keywords were grouped by theme. The results verify that LCA, economic indicators and environmental

indicators are driving themes. The basic themes include sustainability and the environment. The niche themes are impact, bio-based products and geographic indications. Finally, emerging or declining themes include sustainable indicators, sustainability reporting and urban metabolism. Sustainable agriculture is a central but underdeveloped theme.

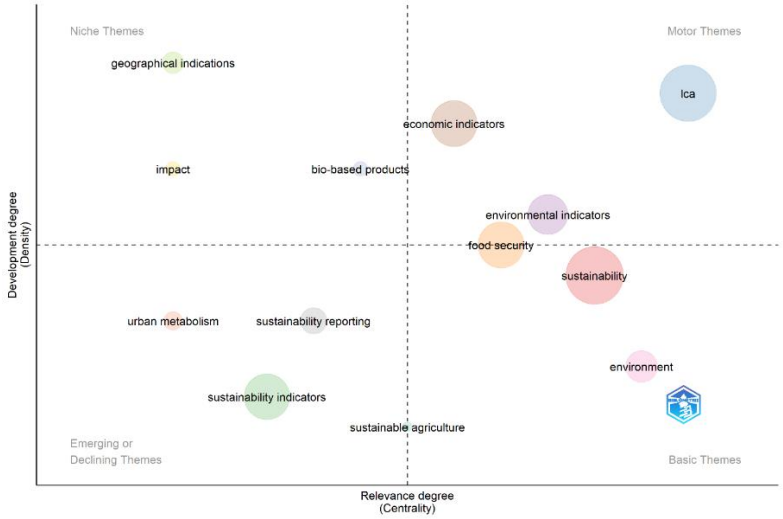

Figure 8: Thematic map, authors keywords.

Source: R Bibliometrix ouputs.

4.7. Co-occurrence and co-citation network

Through the co-occurrence network analysis of the keywords plus, Figure , four groups can be observed. In the red group, we found sustainable development, sustainability indicators, sustainability assessment, decision-making, agriculture, environmental protection, trade, economic analysis, sustainability performance, benchmarking and food consumption.

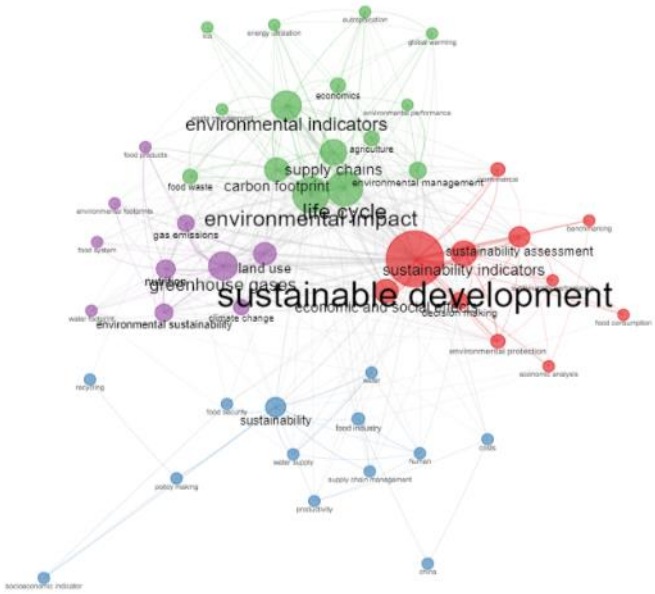

Figure 9: Co-occurrence network of keywords plus.

Source: R Bibliometrix ouputs.

The group in blue presents the food industry, sustainability, human, food safety, socio-economic indicator, policymaking, recycling, supply chain management, water, water supply, and China.

The green group feature environmental indicators, environmental impact, LCA, life cycle, supply chains, economic and social effects, environmental management, economy, energy use, costs, environmental performance, eutrophication, food system, global warming and productivity.

Furthermore, finally, the purple group presents greenhouse gases, carbon footprint, nutrition, land use, food waste, environmental sustainability, gas emissions, water footprint, climate change, waste management, environmental footprints, and food products.

Co-citation occurs when a third one cites two articles. This analysis allows us to observe the existence of a similarity between the research documents and thus understand if the topics addressed are related (ARIA; CUCCURULLO, 2017). As shown in Figure , the co-citation network analysis shows seven clusters, three of which are isolated. The remaining four clusters are grouped into two related groups. Thus, the sample themes are not all completely related.

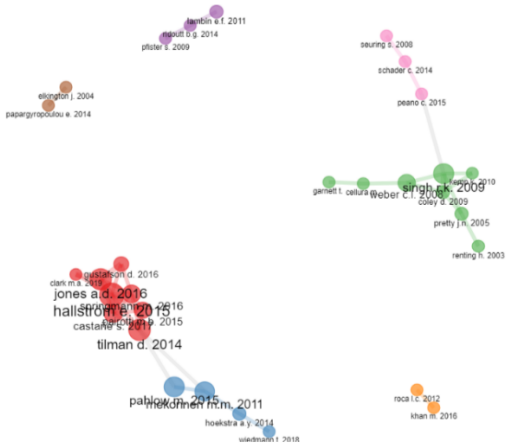

Figure 3 Co-citation network.

Source: R Bibliometrix ouputs.

4.8. Clustering

Erro! Fonte de referência não encontrada. is the result of clustering the keywords plus. It is possible to observe three clusters, one larger (red), related to sustainability and environmental impact, a second one (green) related to sustainable development, sustainable indicators and supply chain, and finally a smaller one (blue) related to environmental indicators, life cycle and LCA. The group with the highest impact is the red group, and the group with the lowest impact is the blue one, however it is the most central one.

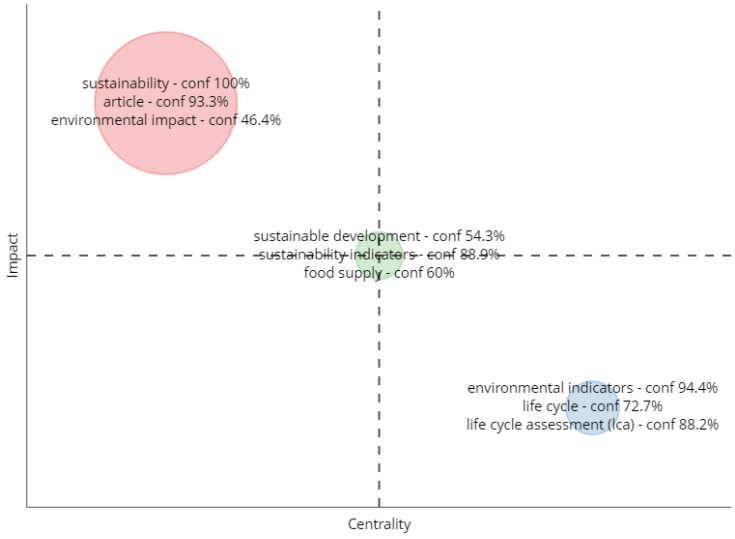

Figure 4: Clustering the documents by keywords plus.

Source: R Bibliometrix ouputs.

Figure 5 was obtained by grouping the documents by the authors' key words. In this way, eight groups/clusters were created. Clusters 2 and 8 are the ones that show a higher impact and centrality. These clusters are related to sustainability - conf 87.5% environmental indicator - conf 100% geographical indications - conf 100% and life cycle assessment - conf 100% sustainability - conf 12.5% sustainable agriculture - conf 100%. Clusters 1 and 4 are also relevant for sustainability indicators.

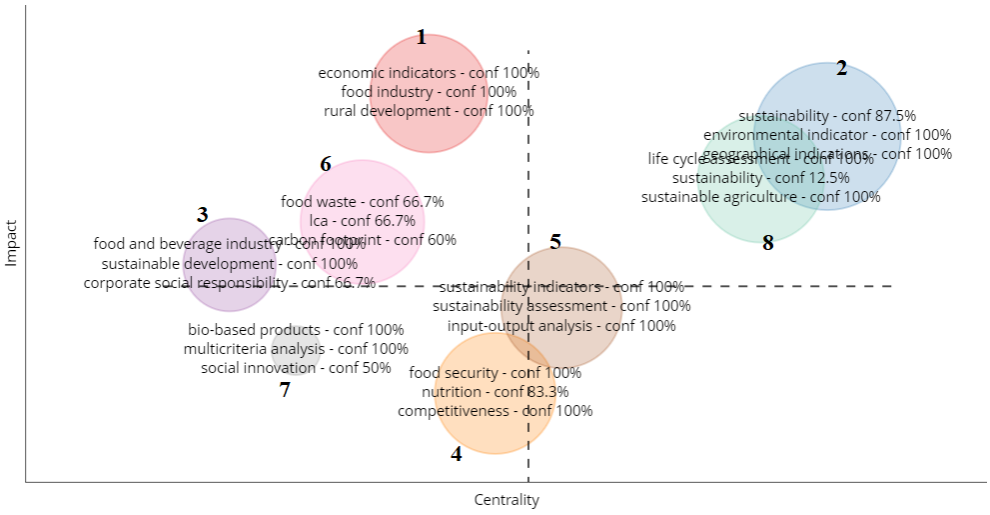

Figure 5 Clustering the documents by author's keywords.

Source: R Bibliometrix ouputs.

Table 8 details the frequencies, impacts and centrality of each cluster. The clusters with a more significant impact and centrality are clusters 2 and 8. Clusters 1, 2 and 5 are relevant to sustainability indicators. As the labels analysis shows, the created clusters address the sustainable, economic, and environmental indicators. The social indicators are not directly addressed; however, it is possible to verify the existence of rural development, social responsibility, social innovation, food security and nutrition in the clusters created.

Regarding the methods/techniques to evaluate agribusiness, the following are found: LCA, input-output analyses and multicriteria analyses (MCA). The clusters are related to agriculture since we have the food industry, food and beverage industry, food security, nutrition, food waste, bio-based products and sustainable agriculture present in the clusters.

Regarding methods/techniques to evaluate agribusiness, we find LCA, input-output analyses and MCA. Regarding indicators, it is possible to verify the presence of an environmental indicator, the carbon footprint.

Table 8: Clusters of author's keywords and respective labels, frequency, impact and centrality.

Group	Label	Freq.	Centrality	Impact
1	economic indicators - conf 100% food industry - conf 100% rural development - conf 100%	14	14	0.64
2	sustainability - conf 87.5% environmental indicator - conf 100% geographical indications - conf 100%	27	27	1.16
3	food and beverage industry - conf 100% sustainable development - conf 100% corporate social responsibility - conf 66.7%	2	8	0.47
4	food security - conf 100% nutrition - conf 83.3% competitiveness - conf 100%	8	15	0.69
5	sustainability indicators - conf 100% sustainability assessment - conf 100% input-output analysis - conf 100%	15	15	0.84
6	food waste - conf 66.7% LCA - conf 66.7% carbon footprint - conf 60%	15	16	0.59
7	bio-based products - conf 100% multicriteria analysis - conf 100% social innovation - conf 50%	16	3	0.51
8	life cycle assessment - conf 100% sustainability - conf 12.5% sustainable agriculture - conf 100%	3	17	1.09

Source: R Bibliometrix ouputs.

5. Conclusions and Future Research

This study addresses the scientific production, from the last decade, on the indicators to evaluate the sustainability performance in agribusiness. A large part of the studies is conducted in Europe, namely in Italy. These results are in line with the findings of Silvestri et al. (2022), Wohlenberg et al. (2020) and Yu and Mu (2022). The most extensive collaborations occur in Europe, namely between Italy, Spain, France and the UK. The European institutions are the ones that have the largest number of publications, highlighting Wageningen University (Netherlands). This institution is highlighted in studies on sustainable development (Yu & Mu, 2022) and on the sustainability of the value chain (Sarkar et al., 2022). Also, Asia presents studies in this area. China has a relevant role in studies on

sustainable development, being one of the first countries to propose and implement a sustainable development strategy (Yu & Mu, 2022).

The interest of researchers in assessing the sustainability of agribusiness has grown in recent years, and although sustainable development, sustainability in agriculture and agribusiness are a "hot topic" (SARKAR *et al.*, 2022; SILVESTRI *et al.*, 2022-; YU; MU, 2022) there is not much collaboration among authors. Our results indicate the existence of a weak network of collaboration between authors, which corroborates the results of previous studies (e.g., Yu & Mu, 2022).

In the keywords and themes analysis, we conclude that previous research mainly addresses the following areas: food industry, life cycle, sustainability, sustainability indicators and LCA, since these are the themes that stand out. Economic and environmental indicators and LCA are the driving themes of the research. Clustering analysis shows clusters 2 “environmental indicators” and 8 “LCA” have a more significant impact and centrality. Therefore, we conclude that the social pillar of sustainability does not have the same relevance/weight as the others.

Through the structural analysis, it is possible to conclude that the studies are related to sustainable developments in agribusiness, agriculture and value chain as well as product life cycle and environmental impact and environmental indicators. The three pillars of sustainability are mentioned, as well as some methods to evaluate the performance of a product. LCA is one of the tools used to assess sustainability in agribusiness. It is also possible to realise some of the environmental indicators used to evaluate agribusiness, such as water footprint, carbon footprint, land use and greenhouse gas emissions. Regarding the indicators, economic and environmental indicators are more prevalent in the sample compared to social ones. This result may reveal that there is still a focus on the environmental dimension of sustainability.

The research carried out with this bibliometric study highlighted that transforming agriculture and agribusiness into more sustainable sectors is essential. There is a growing interest in the scientific community about these topics.

One of the study’s limitations was using a single database, in this case, Scopus. Further research should include the Web of Science database. Another limitation concerns the research areas: we only focused on "Business, Management and Accounting" and "Economics, Econometrics and Finance". It would also be interesting to analyse the content of the most relevant articles of the sample to identify the optimal indicators measuring the sustainable performance of agribusiness.

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