Journal of Agriculture and Sustainability

Volume 16, 2023, 1

Research on Sustainable Agriculture Among QUAD Countries: A Bibliometrics Study

Manendra Kumar Singh

Department of Library & Information Science, Mizoram University, Aizawl, Mizoram, India

Email address: manebhu007@gmail.com

Abstract

This study formulates to understand state-of-the-art research in sustainable agriculture among QUAD countries. Bibliometric analysis has been used to identify hot areas, trends, and various research clusters in sustainable agriculture. This study examined such connections and relationships from a bibliometric approach using Scopus databases from 2002 to 2021. The topic and title/abstract/keyword search strategy have been used. The search query retrieved 17498 documents with bibliographic details in RIS and CSV format. VOSviewer and R software (Biblioshiny) were used for data analysis about authors, research keywords, institutions, countries, sources, and citations. The growth of research shows an upward tendency in the total number of publications; the United States has been designated the top QUAD nation, followed by India, Australia, and Japan. The top three author keywords were soil, agriculture, and yield found. The Science of The Total Environment ranked first in terms of literature publication, where the highest citation was received by the Journal of the American Chemical Society. International collaborations with QUAD countries indicate that China is on top of several research, whereas the United Kingdom and Germany because of natural allies of the USA. Between

2019 and 2021, Smallholder farmers, conservation agriculture, sustainable intensification, trade-off, crop rotation, soil health, life cycle, and assessment were found as hot spot research areas. Keyword analysis and time evolution of various essential sustainable Agriculture have shown that the research associated with contemporary problems in agriculture and utilization of technology. Nonetheless, while climate change influences agriculture, it is anticipated that, shortly, researchers will concentrate more on sustainable agriculture, green agriculture, and organic agriculture as a step toward lowering fertilizer usage for climate change mitigation.

Keywords: Sustainable agriculture; bibliometrics; QUAD; VOSviewer; bibliographic coupling; co-authorship; biblioshiny.

1. Background

Sustainable agriculture is a system of farming that satisfies the existing food demands of the human population in a manner to make sure the availability in future for coming generation (asi.ucdavis.edu., 2018; Introduction to Sustainable Agriculture, 2016). Various old techniques are in practice for enhancing the sustainability of agriculture in diverse places. Due to increase of human population sustainable food systems need to put in priority. Anthropogenic GHG (Green House Gas) is responsible for One-third of the emissions which are happened in the environment as a result of the colossal environmental imprint created by large-scale agriculture (Crippa, M. et al., 2021; Brown, L. R., 2012). In recent years, water shortages, water pollution, land degradation, deforestation, and other processes have been accelerating (www.fao.org., 2021) due to climate change (Rockström, Johan. et al., 2016). To resolve these issues, Sustainable agriculture is a method of farming that allows crops to be produced without harming existing environmental systems. The current examples of sustainable agricultural practices include permaculture, agroforestry, mixed farming, multiple cropping, and crop rotation techniques. (Hegde and Sudhakara, n.d.) Sustainability refers to the

capacity to endure and is a systemic concern. Sustainability does not mean a system has a limitless life span; instead, a sustainable system has achieved its projected life span per temporal and geographical scale. According to (Lopez-Serrano et al., 2020) research, at least one-fourth of the world's population might face water shortage, and a 40% global water deficit will exist by 2030 if immediate action is not going to take. It is found in an FAO study (ribamar, n.d.) that the worldwide demand for food and biofuels would reach 9.1 billion by 2050, necessitating a 70% increase in agricultural output of food and biofuels to fulfil requirement. The availability of these resources is contingent upon a stable climate and healthy hydrological cycles. The worldwide (Trigo et al., 2021) desire for ethical agriculture production is now essential for environmental protection. Healthy soil always plays a crucial role in sustainability (Dang et al., 2022). Still, in recent years, the amount of micropollutants in soil has increased, posing hazards to human health and ecological security. The danger of Soil remediation is enhanced by compost additions (Tokbergenova et al., 2018) analysed the rise of the agro-industrial complex; and highlighted and assessed issues with guaranteeing the sustainability of agriculture. Various certification and sustainability standards are available for organic certification, rainforest alliance, fair trade, label for sustainable farming (UTZ), Global Good Agricultural Practices (GAP), Bird Friendly (https://saiplatform.org). So that practices of sustainable agriculture need to promote among QUAD countries because they are holding the one of the biggest area of agriculture.

1.1 QUAD Countries

The Quadrilateral Security Dialogue (QSD), commonly known as the Quad (Rasheed, Zaheena., 2020; Power, John., 2021) refers to a strategic security dialogue between Australia, India, Japan, and the United States (Jamali and O'Connor, 2020). The 'Prime Minister of Japan, Shinzo Abe' initiated the discussion in 2007 with the support of 'United States Vice President Dick Cheney,' 'Indian Prime Minister Manmohan Singh, and 'Australian Prime Minister John Howard' (The Spirit of the Quad., 2021). The Quad

countries address major areas like critical and emerging technologies, cyber security, humanitarian aid, disaster relief, space research, maritime security, and counterterrorism (Australian Broadcasting Corporation., 2021). In addition, all heads of state of Quad countries participated in a virtual Quad meeting hosted by US President Joe Biden in March 2021 (Perth USAsia Centre., 2020). They created working groups on the resilience of the supply system, COVID-19 vaccines, climate change, and technological innovation (Kobara and Moriyasu, 2021; The Financial Express., 2021).

2. Literature Review

A significant amount of bibliometric analysis has been conducted on sustainable agricultural research to investigate a systematic update since a vast amount of data has been created on sustainability during the last two decades. Authors (Agnusdei and Coluccia, 2022) studied network and overlay visualization of term co-occurrences for four distinct clusters of research on sustainable agro-food supply chains. Compared to the economic and social pillars of the sustainability paradigm, the environmental pillar received more emphasis in content analysis. The study (Velten et al., 2015) identifies various aspects associated with managing and enhancing the research related to sustainable agriculture. The authors (Herrera-Calderon et al., 2021) primary objective of the study was to examine the scientific output (2015–2019) in the Pacific Alliance connected to "zero hunger" as an sustainable development goal (SDG). Elsevier confirmed the bibliometric study of the scientific literature, which was conducted using the Scopus database and zero-hunger-related search phrases. The study assessed the yearly output of original papers, prolific journals, top institutions, funding sources, authors, and the most influential original. Author (Akbari et al., 2020) conduct a bibliometric analysis of sustainability-related works on sustainable technology. Using various bibliometric analysis techniques, they analyzed 1122 records downloaded from the Web of Science (WoS) database between 1970 and 2019. Researchers (Zhang et al., 2019) performed bibliometric research on sustainable lifestyles using the extended

Science Citation Index (SCIE) and the Social Sciences Citation Index (SSCI). With visualization and summarising, findings provide information on the most active journals and the rise in the number of articles on second life and their scientific impact. Using bibliometric analysis, (Yuan and Sun, 2021) highlights the existing condition, hotspots, and growth tendencies in rice and climate change. In the study, author (Bertoglio et al., 2021) used digital technology in agriculture to enhance conventional agricultural techniques and promote sustainable agriculture objectives. A total of 4995 articles were retrieved from the Web of Science, and they identified many significant research streams, including 'Climate-Smart Agriculture,' 'Site-Specific Management,' 'Remote Sensing,' the 'Internet of Things, and uses of 'artificial intelligence.' The study demonstrates that the agri-food system needs significant changes to boost sustainability, minimize waste, and foster a shift towards healthy, sustainable diets. In the study, the author (Kulak, 2018) conducted research on Medicinal and aromatic plants (MAPs) and discovered that plant-based medications, health goods, pharmaceuticals, food additives, and cosmetics might help the economic well-being of rural residents and assist sustainable agriculture in developing nations. Using CiteSpace to do a bibliometric and visualization evaluation of relevant literature, (Li and Zhang, 2022) researched environmental contamination issues resulting from agricultural output. Eventually, study trends were analyzed and extrapolated future trending themes. The Green Innovation (GI) (Albort-Morant et al., 2017) research has received growing organizational relevance due to its contribution to the fulfilment of environmental demands while simultaneously enabling businesses to distinguish themselves from rivals and establish sustainable competitive advantages. In the study, author (Hamidov et al., 2014) examined the pattern of sustainable use of agricultural land in Central Asia by land use Functions framework, and the finding shows that various economic, environmental, and social aspects influence land use for sustainable agriculture. The study (Pulgarn et al., n.d.) examined "Sustainable development," where the highest-ranking categories were "Environmental Sciences,"

"Ecology," and "Economics." This study (Alvarenga et al., 2018) employs bibliometric and content-analytic techniques to evaluate scientific literature on "sustainable horticulture" to identify research flows with exploratory potential. It indicates that "sustainable horticulture" focuses only on the environmental element, with occasional references to the economic and social dimensions. In the study, authors (Montero-Navarro et al., 2021) provide an overview and synthesis of the available greenwashing data. The agriculture, food sector, and food retailing-related stories are particularly emphasized. Using the SciMAT and VOSviewer software tools, a bibliometric analysis of 351 documents extracted from the WoS database was conducted. The scholarly literature on greenwashing may be divided into three distinct periods: ground-breaking (2003–2010), trailblazing (2011–2015), and impressive development (2016–2020). According to literature review, no study has been done about mapping the research trends in sustainable agriculture among QUAD countries. The key objective of present study is to deepen comprehension of the research expansion throughout a specific period. The findings of our study can be utilized by the research policymakers of Quad countries or any individual government to promote sustainable agriculture for the benefit of the nations. In line with this purpose, we seek an answer to the following research questions:
RQ1. What are the main topics discussed in the sustainable agriculture research in QUAD literature?
RQ2. What are the emerging and niche topics to be further addressed in future studies?

3. Methodology

A bibliometric study examined the essential authors, countries, institutions, publishers, and keywords. The study explains the academic background and general and emerging research trends in sustainable agriculture among QUAD countries. As justified in various studies (Sweileh, 2020; Saleem et al., 2021; Kovaleva and Borgemeister 2022; Kumar Kar and Harichandan, 2022) bibliometric analysis is reliable and helpful in identifying the emerging trends in any discipline. The reason for choosing this research method is that

the quantitative approach in bibliometric techniques limits subjectivity, is replicable, and enables a more exhaustive analysis (Sarkar and Searcy 2016) which can serve as a guide to evaluate publication success while explaining the structural dynamics of the area of research (Taddeo et al., 2019; Kumar Kar and Harichandan 2022). Using bibliometrics as a quantitative method (Saleem et al. 2021) has spread to different disciplines over time and enables researchers to observe the emerging and future trends in single or across multiple domains.

3.1 *Data Acquisition and search terms*

This study analysed research in sustainable agriculture among QUAD countries, encompassing academic studies published between the years 2002 to 2021. The data were obtained from the Scopus database. The most reliable and widely recognized database for bibliographic data is Scopus (Elsevier in 2004) was utilized for data extraction since it is a source-neutral abstract and citation database with more than 23,452 peer-reviewed journals, 294 trade publications, and over 852 book series (De Groote and Raszewski, 2012; Elsevier, 2020; Faruk, Rahman, and Hasan, 2021). The data was collected on September 30, 2022, from the Scopus database Core Collection.

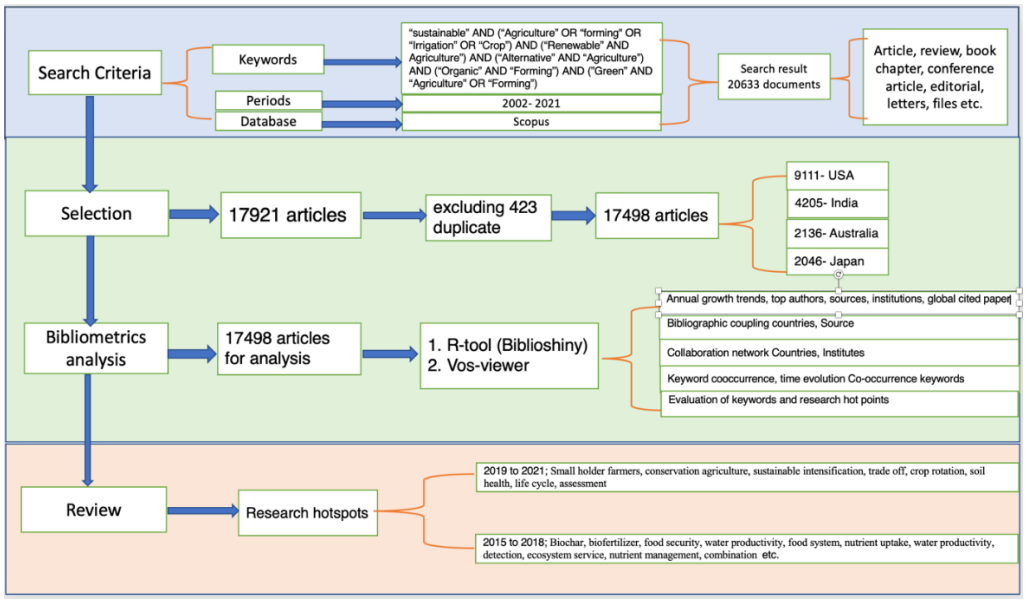

Figure 1.

Research flow chart

A combination of keywords along with logical operators AND, OR, and NOT (as shown in Figure 1) has been used to extract data from Scopus on the present topic. Scopus database includes citation information, Bibliographic information (Affiliation, Serial identifier, Publisher, Editors, Language, correspondence), Abstract, keywords (author keywords, index keywords), Funding details, and references. Selecting keywords to build a meaningful database covering all relevant publications on one subject matter is critical. In our case, rigorous work has been done to identify keywords for the search as appropriate as possible to maximize the relevant documents on sustainable agriculture in QUAD countries. At first, several review articles were extracted from Scopus and Google Scholar to enhance deep incite about the sustainable agriculture. For data download a search string of keywords ("sustainable", AND "agriculture OR forming" OR "irrigation" OR "crop" AND renewable,") has been used where subject areas Engineering, Chemistry, Nursing, Computer, Sociology, and Math excluded. For every QUAD countries this search string has been used with common parameters, and under study period 2002 to 2021. Scopus allows downloading data in formats like ExLibris, RIS Format, CSV, BibTeX, Plain Text, and Mendeley. The RIS and CSV format was found suaitable for data download and analysis. Study denied to consider any synonyms of keywords for a search query, as previous studies (Zhang and Li, 2021; Maucuer et al., 2022) did in their bibliometric analysis of the literature. This process was carried out to obtain an elaborate and comprehensive overview of the relevant literature instead of narrowing down the literature (Zyoud and Fuchs, 2020) will not serve the research aim of this study. The search query generated 17921 results on the Scopus database. The documents were extracted in the RIS file format to merge into a single RIS file. The latest R version 4.2.2 software has been used for data refinement, which removed 423 duplicate documents from the merged RIS file. After combining the refined data obtained from databases into a single file, cite space software was used to convert the Scopus RIS format

to Web of Science format for the final analysis through R software and Vos-viewer. Finally, N=17498 documents in Web of Science format were used for analysis.

3.2 ***Data management and analysis***

Using bibliometrix, an R-tool for comprehensive science mapping analysis (Aria and Cuccurullo, 2017), allows for presenting data graphically via category maps. For visualizing, mapping, and analyzing the subject framework, identifying current and emerging research topics, and summarizing the most influential scholars and publications (Kumar Kar and Harichandan 2022), Biblioshiny was used. Also, VOSviewer was applied to perform co-citation and bibliographic coupling analyses and visualize the bibliometric networks and keyword analysis (van Eck et al., 2010; Ding, 2019; Chistov et al., 2021). Researchers basically rely on author-defined keywords and publication titles to reflect the significant research findings and track the development of a particular study field (Mao et al., 2015; Du et al., 2014). We used VOS-viewer to extract all author-defined keywords from the database to conduct our research. Because the author's keywords are much more thorough than Keywords Plus, we used them as the basis for our study. Co-citation analysis is a technique for quantifying the relationships and connections between articles (van Eck and Waltman 2014). It is conducted to analyze and visualize the relationships between authors publications in a specific field and to create clusters of documents (Griffith et al., 1974; Mas-Tur et al., 2021; Small, 1973)[60, 61, 62]. A co-citation occurs when a third publication cites two publications at the same time, and the strength of the co-citation relationship between these two publications increases as the number of publications citing these two publications increases (Van Eck and Waltman, 2014; Phan, 2022) [63, 64]. Therefore, co-citations can identify critical publications and distinct themes (Small, 1973; Garfield, 1979; Frerichs and Teichert, 2021) [65, 66, 67]. Unlike co-citation analysis, which refers to one type of relationship in bibliometric networks, bibliographic coupling deals with the overlap in the reference lists of publications and occurs when two different publications cite the same third publication (Kessler, 1963; Mas-Tur et al., 2021)

[68, 69], and the bibliographic coupling relations between the publications increase in proportion to the number of references that the two publications use in common. Through bibliographic coupling, potential research themes can be identified.

Table 1 Details about data processed by R software

Timespan: 2002-2021				
Attributes	Results			
Country	USA	India	Australia	Japan
Sources (Journals, Books, etc)	2005	1221	770	896
Documents	9111	4205	2136	2046
Average years from publication	7.84	6.17	7.46	8.72
Average citations per documents	31.71	14.51	28.79	24.78
Average citations per year per doc	3.632	2.242	3.678	2.702
References	446983	188026	119362	94768
Keywords Plus (ID)	51194	24326	16418	18433
Authors	28753	10137	8087	6803
Author Appearances	46300	18409	11758	10113
Authors of single-authored documents	645	242	123	138
Authors of multi-authored documents	28108	9895	7964	6665
Single-authored documents	720	295	137	156
Documents per Author	0.317	0.415	0.264	0.301
Authors per Document	3.16	2.41	3.79	3.33
Co-Authors per Documents	5.08	4.38	5.5	4.94
Collaboration Index	3.35	2.53	3.98	3.53
h Index	197	98	103	104

4. Results and discussion

4.1. *Publication overview*

Table 1 gives information for downloaded data with statistics of sources, documents, citations, author keywords, etc. As illustrated in Figure 2, the publishing frequency for QUAD nations counted as a function of year. The data indicate that the number of publications in QUAD nations has grown since 2010. This increase may be attributed to rising worldwide concern about the impact of climate change on agriculture. The development of research in sustainable agriculture can be divided into before and after the year 2010. As seen in Figure 2, the rate of research expansion slowed until 2010, after which the number of research increased rapidly. This may be due to the use of novel seed types, advanced technologies such as drip irrigation, biotechnology, uses of drones, digital sensors, fleet management, uses of fewer (or no) toxic pesticides, awareness for the conservation of natural resources, and necessity for reduction of greenhouse gas emissions. The multi-author publication pattern dominates the single-author pattern among QUAD countries. In Table 1 highest single author N=720 documents were published by the USA, followed by India N=295, Australia N=137, and N=156 for Japan. The highest Author collaboration Index (N=3.98) was noted for Australia, followed by Japan (N=3.53), USA (N=3.35), and lowest (N=2.53) for India. The highest h-Index N=197 was pointed out for the USA, whereas the lowest N=98 for India, which shows that fewer cited publications are in high numbers. The distribution of research literature indicates that the USA has shared the highest (N=9109) publication and (N=31.84) Citation Index among the QUAD group. India is the second highest research contributor (N=4232), with the lowest CI value (N=14.59), which indicates the less impact of publications. In recent years growth in sustainable agriculture research has been noted because of the rise on earth temperature and its possible impact on lowering the production of agriculture commodity. The journal and citation index value indicates that the USA dominated in

publication and citations among QUAD countries. Australia shares (N=2173) publication with CI (N=28.85), and Japan with (N=2041) of literature and (N=24.75) citation index.

Table 2 Literature sharing among QUAD countries

Country	Documents	Citations	TLS	CI	AAY
United States	9109	290269	6900	31.84	455.45
India	4232	61778	2012	14.59	211.6
Australia	2173	62709	2706	28.85	108.65
Japan	2041	50529	1505	24.75	102.05

Note: TLS = Total link strength, CI = Citation Index, AAY = Average Article in Year

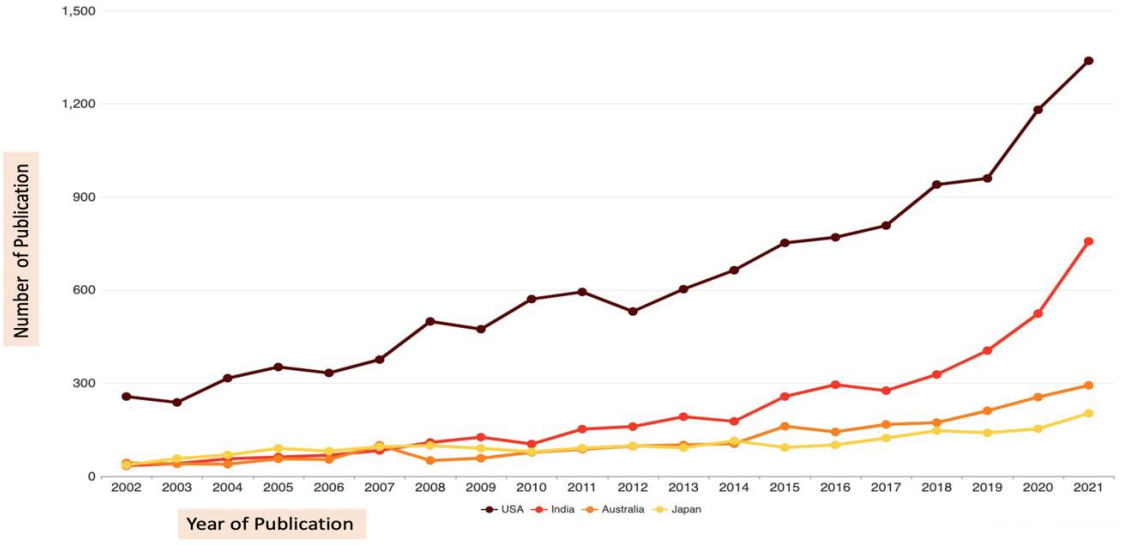

Figure 2.

Publication trend in Sustainable Agriculture during 2002–2021

4.2. Countries bibliographic coupling with QUAD group

With the help of R Software, we found that the USA dominates in QUAD countries regarding quality publications in sustainable agriculture research. The bibliographic coupling of countries analyzed by VOSviewer software which shown in Table 2, where China is the most collaborative country with (N=1504) publications, followed by the United Kingdom (N=653), Germany (N=467), Canada (N=4190, and Brazil (N=312) with QUAD countries. The number of citations shows that the document is acknowledged among researchers for its quality of research work. The highest number of citations (N=44951) was noted for China, followed by the United Kingdom (N=31505), Germany (N=7538), Netherlands (N=15084), and (N=14247) citations for Canada. The Citation Index is a ratio of the total number of citations multiplied by the total number of documents. The highest CI (N=62.9) was noted for Sweden, followed by the Netherlands (N=49.9), the United Kingdom, Switzerland (N=48.2), and France (N=42.2). Table 3 indicates that these ten listed countries are close to the QUAD countries regarding research in Sustainable agriculture. In Figure 3, five clusters are shown in different colors, whereas in cluster 1 (red), the USA is the leading research country as a natural collaborator of European countries like the United Kingdom, Germany, France, Switzerland, Sweden, Austria, Italy, and Belgium. India and Japan are in cluster 2 (green) with Southeast Asian and Middle Eastern countries like Indonesia, Bangladesh, Taiwan, South Korea, Turkey, Saudi Arabia, Iran, and Egypt. In cluster 3 (blue,) South Africa, Ghana, Kenya, Tanzania, Ethiopia, and Singapore show collaboration with QUAD countries. Cluster 4 (Yellow) is related to Colombia, Mexico, and Chile, whereas Cluster 5 (Magenta) has China, Canada, and Hong Kong. Figure 4 indicates that collaboration with QUAD countries in sustainable research outspread to Europe, Asia, North America, South America, and the African continent.

Table 3 Top ten Bibliographic coupling country

SN	*Country*	*Documents*	*Citations*	*CPP*	*TLS*
1	China	1504	44951	29.9	552829
2	United Kingdom	653	31505	48.2	357153
3	Germany	467	17538	37.6	255705
4	Canada	419	14247	34.0	199111
5	Brazil	321	11985	37.3	179057
6	Netherland	302	15084	49.9	201132
7	Italy	298	10764	36.1	180411
8	France	295	12459	42.2	155616
9	Switzerland	190	9158	48.2	109731
10	Sweden	178	11196	62.9	120593

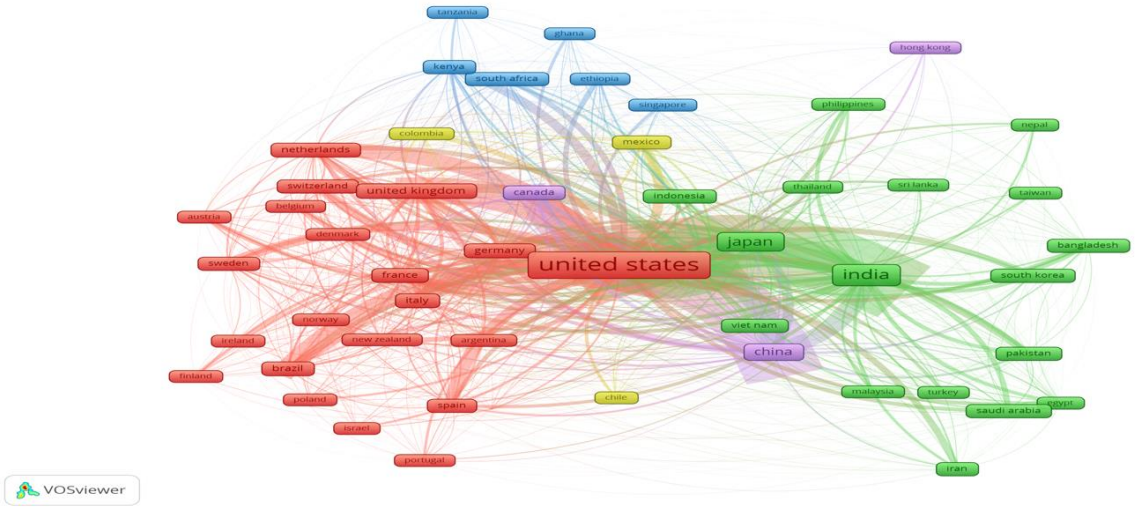

Figure 3.

Bibliographic coupling of countries

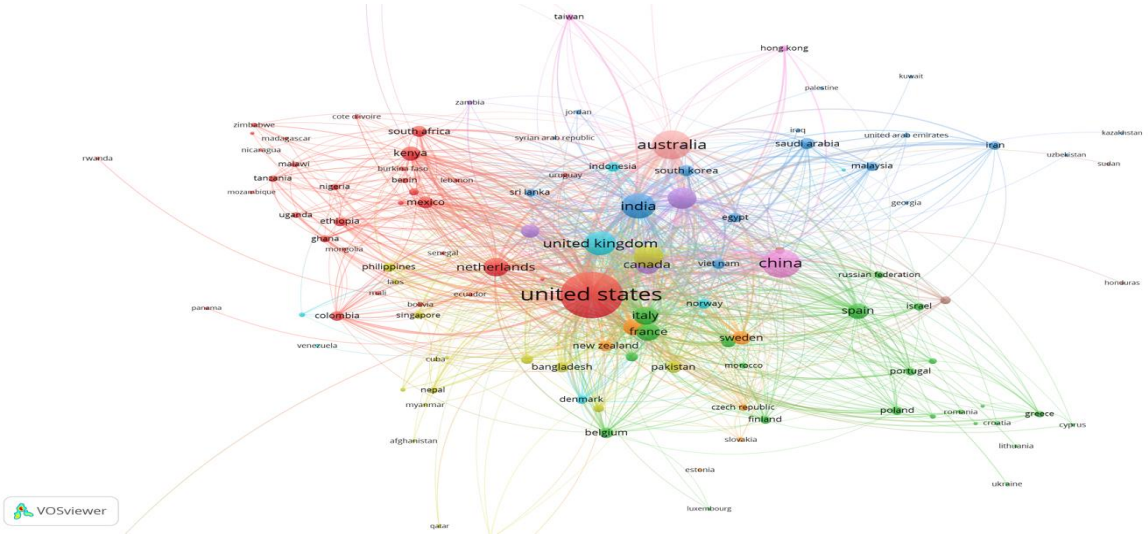

Figure 4.

Collaboration network of QUAD countries in sustainable Agriculture

4.3. *Author statistics*

In Table 1, the highest (N=28753) authors are contributing to publication for the USA in sustainable agriculture research, followed by India (N=10137), Australia (N=8087), and (N=6803) for Japan. Highest single author (N=720) and multi-authored (N=28108) documents were recorded for the USA followed by India (N=242) and (N=9895), Australia (N=123) and (N=7964), Japan (N=138) and (N=6665). The highest document per author N=0.415 account for India, followed by N=0.317 for the USA, N=0.301 for Japan, and the lowest N=0.264 for Australia. Analysis reveals that the highest Co-author per document N=5.5 was noted for Australia, followed by the USA (N=5.08), Japan N=4.94, and the lowest N=4.38 for India. The Collaboration Index highest (N=3.98) recorded for Australia, followed by Japan N=3.53, N=3.35 for the USA, and lowest N=2.53 for India. In this regards highest h Index N=197 was noted for the USA and the lowest N=98 for India. The h Index counted for QUAD countries based on the citations of downloaded data. The top 10 most productive authors on sustainable agriculture research who have published more than 50 documents are shown in Table 4, including h-index value, number of citations,

year of publications, and affiliation extracted from the Google Scholar database. The most productive author is "LAL RR" affiliated with Ohio State University, Columbus, USA, followed by "Zhang, YY" School of Geography and Development, University of Arizona, USA; "Singh AA," Agricultural and Food Engineering Department, IIT Kharagpur, India; "Wang YY," Center for Human Nutrition, Department of International Health, Johns Hopkins University, Baltimore, Maryland, USA; "Zhang XX" University of Maryland Center for Environmental Science, Frostburg, MD, USA.

Table 4 Top 10 authors in the Sustainable Agriculture Research

SR No.	Author	Affiliation	NP	TC	CPP	h-index	g-index	m-index	PY-start
1	LAL RR	The Ohio State University, Columbus, USA	116	5522	47.60	39	71	1.95	2003
2	ZHANG YY	University of Arizona, USA	105	4364	41.56	38	64	1.81	2002
3	SINGH AA	IIT Kharagpur, India	143	3652	25.54	36	55	1.8	2003
4	WANG YY	Johns Hopkins University, Baltimore, Maryland, USA	101	4905	48.56	36	68	1.714	2002
5	ZHANG XX	Appalachian Laboratory, University of Maryland MD, USA	101	3954	39.15	33	61	1.737	2004
6	SINGH SS	Univ. of Idaho, North East, Kimberly, USA	129	3272	25.36	32	53	1.524	2002
7	WANG HH	United States Department of Agriculture, California, USA	65	2337	35.95	31	47	1.55	2003
8	WANG JJ	University of Illinois, Champaign, Illinois, USA	80	2373	29.66	31	46	1.824	2006
9	ZHANG JJ	Iowa State University, 50011, Ames, IA, USA	81	3513	43.37	30	58	1.429	2002
10	LI YY	University of Florida, Homestead, FL, USA	113	2744	24.28	29	46	1.381	2002

Note: NP = Number of publications, TC = Total citations, PY start = Publication year starting.

Table 5 Top ten most global cited papers in sustainable agriculture

SR No.	Most Global cited Paper	Title	DOI	Total Citations	TC per Year	N TC
1	ALONSO DD, 2010, GREEN CHEM	Catalytic conversion of biomass to biofuels	10.1039/c004654j	1739	133.8	32.8
2	POWLES SS, 2010, ANNU REV PLANT BIOL	Evolution in action: plants resistant to herbicides	10.1146/annurev-arplant-042809-112119	1701	71.1538	19.1556
3	SUNKAR RR, 2004, PLANT CELL	"Novel and stress regulated microRNAs and other small RNAs from Arabidopsis w inside box sign"	10.1105/tpc.104.022830	1513	79.6	29.4
4	MASHTALIR OO, 2013, NAT COMMUN	Intercalation and delamination of layered carbides and carbonitrides	10.1038/ncomms2664	1456	145.6	46.8
5	WOOLF DD, 2010, NAT COMMUN	Sustainable biochar to mitigate global climate change	10.1038/ncomms1053	1404	108.0	26.5
6	TERADA MM, 2010, SYNTHESIS	Solution-processed small-molecule solar cells with 6.7% efficiency	10.1055/s-0029-1218801	1031	79.3	19.4
7	POWLES SS, 2010, ANNU REV PLANT BIOL	Chiral phosphoric acids as versatile catalysts for enantioselective transformations	10.1146/annurev-arplant-042809-112119	1016	78.2	19.2
8	WELCH RR, 2004, J EXP BOT	Evolution in action: Plants resistant to herbicides	10.1093/jxb/erh064	927	48.8	18.0
9	Ittersum MM, 2013, Field Crop Research	Yield gap analysis with local to global relevance-A review	10.1016/j.fcr.2012.09.009	877	97.44	15
10	Terada MM, 2008, Chemical Communications	Yield gap analysis with local to global relevance-A review	10.1039/b807577h	854	61	14

The Top ten most globally cited papers are aligned in Table 5 with the author name, year of publication, name of the journal, the title of the article, DOI, total citation, and per year citation. Alonso DD (2010) perform research on the Catalytic conversion of biomass to biofuels and has the highest (N=1739) citations. The remaining research work is closely related to plant resistance, novel and stress regulator, layered carbides, Sustainable biochar, small-molecule solar cells, Chiral phosphoric, and Yield gap analysis, a review from a local to a global perspective. The highly cited article focused on finding the solution for sustainable agriculture.

4.4. *Journals statistics*

The Statistical analysis of journals shows that are N=3153 sources relevant to sustainable agriculture after setting the minimum documents per journal N=20, then N=150 sources selected in the final threshold. The bibliographic coupling source depicted in Figure 5, in four clusters, were cluster 1st (red) listed N=43 journals related to agriculture systems and research, cluster 2nd (green) listed N=37 journals on horticulture, agronomy, plant nutrition, soil science, soil biology, etc. The cluster 3rd (blue) included N=34 journals on Biochemistry, Biomaterials, Pollution, Biological science, green energy, environmental sciences, etc. In the 4th cluster (yellow), N=6 journals are listed, associated with research area bioenergy, biofuel, bioproducts, biomass, ecological applications, etc. In Table 6 top ten sources are depicted based on the number of publications contributed by each of them, along with the value of h-index, g-index, m-index, total citations, and the total number of publications with year. These top 10 journals shared the N=1579 publications. The Journal of the "Science of The Total Environment" has published N=241 research in sustainable agriculture, followed by "American Chemical Society" N=221 publications. The journal accumulates the most citations, and h-index is "Journal of the American Chemical Society" with (citation=23450; h-index=85). The citation index indicates the ratio between the number of citations and

documents. The Journal of the American Chemical Society has the highest N=106.1 citation index.

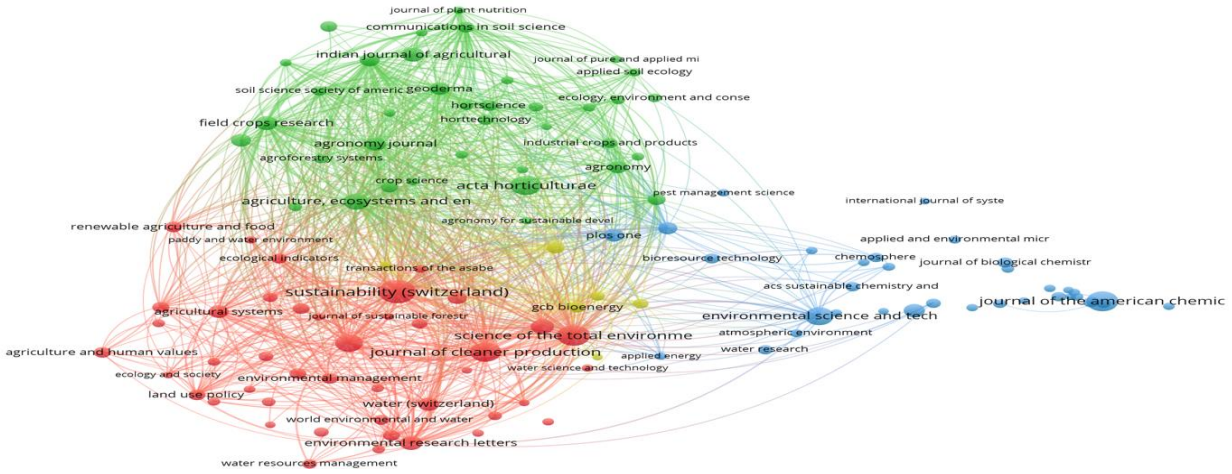

Figure 5.

Bibliographic coupling of source

Table 6 Top 10 Journals related to sustainable agriculture research

SR No.	Journal	NP	TC	CI	h_index	g_index	m_index	PY_start
1	SCIENCE OF THE TOTAL ENVIRONMENT	**241**	7233	30	47	67	2.6	2005
2	JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	221	**23450**	**106.1**	**85**	**147**	**4**	2002
3	JOURNAL OF CLEANER PRODUCTION	214	6397	29.9	42	68	2.2	2004
4	ENVIRONMENTAL SCIENCE AND TECHNOLOGY	181	10751	59.4	60	96	2.9	2002
5	AGRICULTURAL WATER MANAGEMENT	173	6618	38.3	44	73	2.1	2002
6	AGRICULTURE, ECOSYSTEMS AND ENVIRONMENT	146	8590	58.8	53	89	2.5	2002
7	FIELD CROPS RESEARCH	123	5274	42.9	34	69	1.7	2003
8	SOIL AND TILLAGE RESEARCH	98	5514	56.3	42	73	2.1	2003
9	GEODERMA	92	3908	42.5	37	59	1.8	2002
10	PLOS ONE	90	4238	47.1	36	63	2.6	2009

Note: NP = Number of publications, TC = Total citations, CI= Citations Index, PY-start = Publication year starting, IF = Impact factor.

4.5 *Research Institutions/Universities Performance*

In sustainable agriculture research, total N=510 affiliations of research institute/university were found. The top 20 most productive institutions are shown in Table 7 based on publication count and their share of documents in the QUAD group. The list includes fifteen USA-based institutions, two from Australia, Japan, and one from India. The "Agricultural Research Service" (managed by United States of Agriculture Department) has published highest N=344 documents (N=1.98%) of total QUAD countries research. The "University of California", with N=321 publications at second position (N=1.84%), followed by "The University of Tokyo," with N=311 publications (N=1.79%). The "University of Queensland" is the most publishing organization, with N=271 documents for Australia, were for the "Indian Council of Agriculture Research", with N=210 papers, managing the presence at 14th place in the top 20 most productive organizations. It gives incite that the institute and universities of USA actively engaged in sustainable agriculture research.

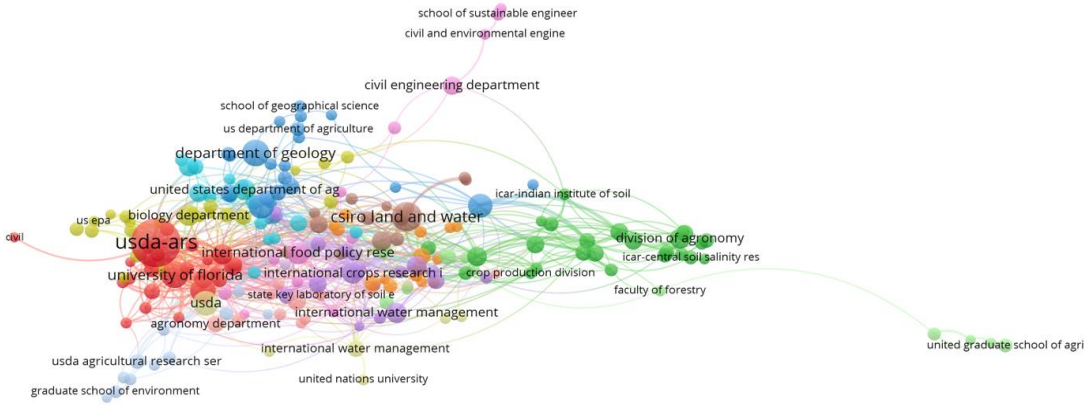

Figure 6.

Collaboration network among institutions

Table 7. Top 20 Organisation of QUAD countries in sustainable agriculture research

SN	Name of Institute	Country	Total Publications	Share in (%) QUAD	Administered by
1	USDA Agricultural Research Service	USA	344	1.98	United States Department of Agriculture
2	University of California, Davis	USA	321	1.84	U.S. state of California
3	The University of Tokyo	Japan	311	1.79	Public research university
4	Cornell University	USA	277	1.59	Private University
5	University of Florida	USA	273	1.57	State University System of Florida
6	The University of Queensland	Australia	271	1.56	Public research university
7	Michigan State University	USA	262	1.51	State University
8	University of California, Berkeley	USA	252	1.45	Public State research university
9	University of Wisconsin-Madison	USA	242	1.39	Public research university
10	University of Minnesota Twin Cities	USA	241	1.39	Public research university
11	University of Western Australia	Australia	222	1.28	Public research university
12	Texas A & M University	USA	221	1.27	Public State research university
13	Pennsylvania State University	USA	218	1.25	Public State research university
14	Indian Council of Agriculture Research	India	210	1.21	Government of India
15	The Ohio State University	USA	199	1.14	Public State research university
16	University of Michigan, Ann Arbor	USA	198	1.14	Public research university
17	Kyoto University	Japan	196	1.13	Public research university
18	NC State University	USA	194	1.11	Public State research university
19	Massachusetts Institute of Technology	USA	186	1.07	Public research university
20	University of Nebraska-Lincoln	USA	184	1.06	Public research university

The VOSviewer software was used to obtain a collaboration network among leading sustainable agriculture research institutions, setting the threshold of a minimum of 10 records published by each institution. In Figure 6, collaboration network scattered in fourteen different clusters illustrated in various colors were Cluster 1 (red) for US organizations, cluster 2 (green) for Indian organizations, and Cluster 3 (blue) for Australian organizations. Besides this, the rest of the cluster shows the mixed nature of research collaboration between national and international research institutions. It indicates that collaboration of research on sustainable agriculture among QUAD countries normally country centric which desperately needed to enhance within QUAD group as well as other with other nations.

4.6. ***Evaluation of keywords and hot spot research areas***

Keywords always indicates various approaches about scientific research. Table 8 lists the top 20 frequently used keywords with time of occurrence and relevance. The keyword Soil, followed by Agriculture and Yield, is often used in sustainable agriculture research. Most keywords underline the study's central component, including temperature, plant, farmer, concentration, growth, and land. Based on frequency, the monolayer is a frequent term, followed by Ionic liquid, self-assembly, organic solvent, poly apatite, and toluene. The most frequent and relevance word indicates that sustainable research focuses on critical areas which are responsible for altering the present fertility strength of soil, yield problem due to rise of temperature, and impact on agriculture. The result of frequently occurring keywords might assist researchers in understanding the study trend and various research gaps in sustainable agriculture.

Table 8 Keywords and number of occurrences (obtained by VOS viewer data mining)

SR No.	Term	occurrence	Relevance	Term	occurrence	Relevance
1	Soil	7496	0.35	Monolayer	119	3.67
2	Agriculture	6233	0.44	Ionic Liquid	101	3.46
3	Yield	5309	0.49	Self-assembly	146	3.24
4	Temperature	4532	0.71	Organic Solvent	251	3.17
5	Plant	4314	0.37	Poly	467	3.16
6	Farmer	4071	0.86	Apatite	109	3.13
7	Concentration	3166	0.53	Toluene	101	3.03
8	Growth	3150	0.23	Solvent	382	2.99
9	Paper	2801	0.66	Selectivity	216	2.97
10	Control	2599	0.32	Fabrication	173	2.94
11	Land	2552	0.63	Mechanical Property	128	2.93
12	Content	2540	0.48	Aqueous Solution	153	2.91
13	Structure	2338	0.74	Electrode	249	2.89
14	Acid	2330	1.38	Bone	180	2.88
15	Rice	2194	0.62	Catalyst	665	2.87
16	Challenge	2176	0.68	Chitosan	93	2.86
17	Country	2071	0.89	Ligand	274	2.80
18	Solution	2065	0.38	Nov	113	2.70
19	Biomass	2040	0.36	Room temperature	119	2.70
20	Food	1938	0.69	Electron microscopy	195	2.66

The title and abstract keyword analysis was performed using R software with unigram, bigram, and trigram parameters depicted in Table 9. The n-gram is a continuous sequence of n elements extracted from a text or audio sample. The n-grams text is often used in text mining and natural language processing jobs. The size 1 of n-gram is referred to as "unigrams," with size two as "bigrams" and size three as "trigrams." It is considered that N > 3 is often referred to as four or five grams, etc. The Unigram analysis reveals that sustainable, water, and soil are the most common terms in most research publications. The frequent bigram terms were sustainable agriculture, climate change, and sustainable development. The first three frequent trigram terms are the organic soil corban, oryza sativa rice, and life cycle evaluation.

Table 9 Keywords and number of occurrences (obtained by R software data mining)

	Unigram		Bigram		Trigram	
SN	term	Occurrence	term	occurrence	term	occurrence
1	sustainable	2228	sustainable agriculture	94	soil organic carbon	94
2	water	1652	climate change	64	rice oryza sativa	64
3	soil	1647	sustainable development	58	life cycle assessment	58
4	management	1370	food security	57	plant growth promoting	57
5	production	1298	cropping systems	48	greenhouse gas emissions	48
6	organic	1143	cropping	40	integrated nutrient management	40
7	agriculture	1108	soil organic	40	wheat triticum aestivum	40
8	india	1042	organic carbon	37	west bengal india	37
9	crop	950	river basin	35	north china plain	35
10	agricultural	939	plant growth	35	sustainable development goals	35

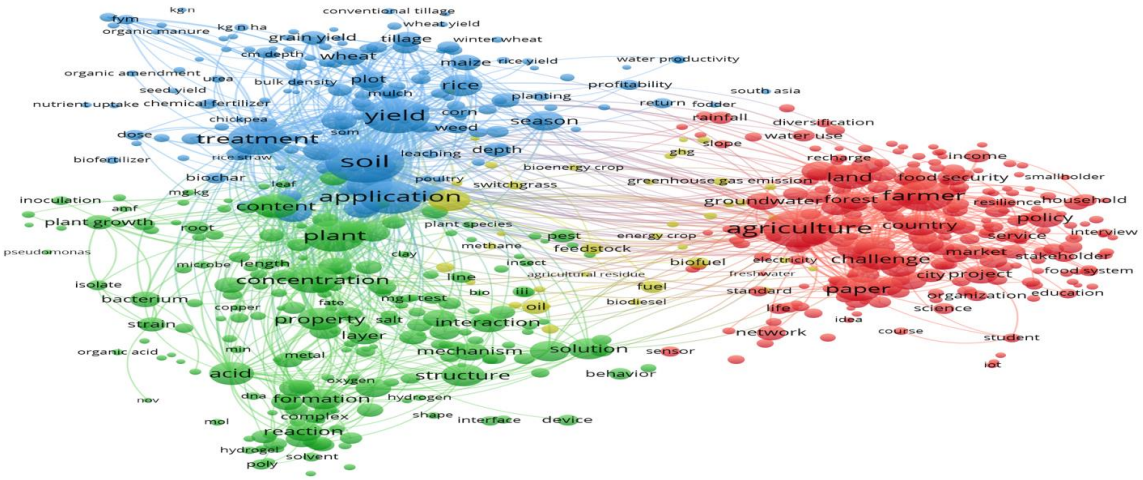

Figure 7.

keywords visualization with more than 100 occurrences

In the keyword visualization depicted in Figure 7, a minimum of more than 100 time-occurred terms were selected for analysis. The terms are grouped in four clusters, cluster 1 (red), cluster 2 (green), cluster 3 (blue), and cluster 4 (yellow). In cluster 1, terms like agriculture, farmer, land policy, food security, groundwater, rainfall, etc., indicate that terms mainly focus on formulating sustainable agriculture policies and procedures in cluster 2, plant, concentration, formation acid, plant growth, reaction, solution, etc. related to the first line of activity like plant growth, reaction, and various solutions. Based on the terms, soil treatment, type of yield, plant varieties, planting procedure, etc., cluster 3 indicates that the following research step involves knowing the level of sustainable agriculture. Rice, mage, wheat, grain, and chickpea are the most preferred plant covered under sustainable agriculture research because these crops are heavily dependent on consuming ground or rain water, fertilizers, and pesticides. The terms like organic manure, biochar, and biofertilizer enhance to avoid using chemical fertilizers to sustain agriculture. The consumption of fuel increases carbon density in the climate, so terms like biofuel, bioenergy crop, biodiesel, and energy crop in cluster 4 reveal that research in energy crops necessary to reduce the dependency on non-renewable energy sources which is necessary to promote sustainable agriculture.

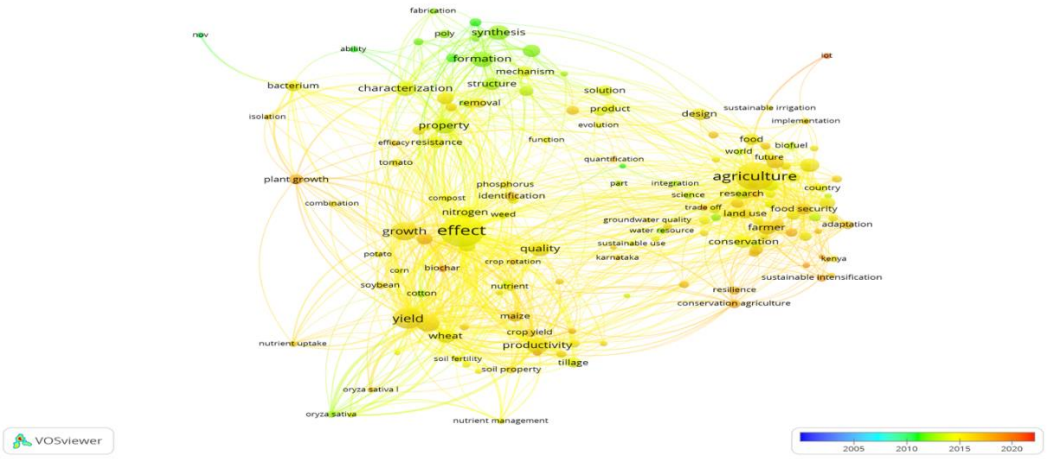

Figure 8.

Time evolution of term cooccurrence

In Fig. 8, overlay visualization of keywords co-occurrence based on title and abstract (nodes) constructed using VOSviewer. The nodes color (from blue to yellow) shows the average year in which they appeared, and the size of the nodes is the degree of occurrence (Zhang and Yuan, 2019; Guo et al., 2019). The color changes also indicate whether a particular keyword or research hotspot is newly introduced or old and mature (Palmblad and Van Eck, 2018). For example, Small holder farmers, conservation agriculture, sustainable intensification, trade off, crop rotation, soil health, life cycle, assessment were found as hot spot terms between the year 2019-21 for the research. Those keywords in purple and green color are the research hotspot between year 2001-2010. Biochar, biofertilizer, food security, water productivity, food system, nutrient uptake, water productivity, detection, ecosystem service, nutrient management, and combination depicted in yellow circle can be consider hot spot research areas between year 2015-2018.

5. Concluding remarks

The bibliometric analysis enables researchers to exhaustively evaluate the research field in which they have an academic interest. This study re-examined the scientific literature on Sustainable Agriculture using contemporary data analysis and visualization approaches. This study mapped the activity of QUAD countries in Sustainable agricultural research and illustrated the distribution of the most productive countries, publications, authors, and institutions. During 2010, the number of publications in QUAD countries increased, according to the statistics. It was found that research on sustainable agriculture accelerated after year 2015.This growth may be linked to a growing global concern over the impact of climate change on agriculture. Using R Software, we discovered that the United States has the highest number of high-quality publications in sustainable agricultural research among the QUAD nations which gives incite that USA sustaining agriculture for longer period. This study equally useful for researchers and policy makers to understand the condition of last twenty years and they can make the future strategies to strengthen sustainable agriculture. The Journal of the American

Chemical Society is the journal in sustainable agriculture with the highest number of citations, h-index, Citation index and impact factor. The affiliations of the top twenty universities reveal that fifteen are located in the United States. The USDA Agricultural Research Service is crucial to the United States Department of Agriculture's institutions.

The study of author-defined keywords revealed that several sustainable agricultural technologies had been developed and studied over the last decade, with current research hotspots focused on Biochar, biofertilizer, microbe, isolate, urea, food security, water productivity, and food system. Keywords such as Biochar, biofertilizer, microbe, isolate, urea, food security, water productivity, and food system that appeared around 2015 might be regarded as relatively new or popular study topics. Uses of Organic manure, Biochar, and biofertilizer indicate that chemical fertilizers are often avoided for cultivation. Terms such as biofuel, bioenergy crop, biodiesel, and energy crop reveal that sustainable agriculture necessitates the research on these energy crops to reduce the dependency on non-renewable energy resources. The agriculture on energy crops indicates that researcher and even countries understand the importance of research to mitigate the green house gas emission. The Unigram analysis suggests that sustainable, water, and soil are the phrases that appear most often in most research articles. Sustainable agriculture, climate change, and sustainable agriculture were the most common bigram phrases. The most common trigram words are organic soil corban, Oryza sativa rice, and life cycle assessment. Biochar, biofertilizer, microbe, isolate, urea, food security, water productivity, and food system are hotspot research areas in sustainable agriculture.

It is well known that the results of the bibliometric study are highly dependent on the data quality. For this study, the author made every possible effort to find research trends in sustainable agriculture among QUAD countries. Some limitations of the present investigation should also be mentioned. The publications were initially extracted from the Scopus database. To provide a more comprehensive map of research in sustainable

agriculture, it is necessary to conduct additional research examining the publications available in other databases and for other nations or groups of countries. Second, the Scopus topic search was conducted in English; that is, the keywords used for the investigation on Scopus were solely English. Third, the study focused on QUAD countries only so that other countries need to further map to know the research trends in sustainable research at world level. Thus, this study did not cover the publications with titles, abstracts, and keywords in other languages published in journals indexed by Scopus, and further studies are recommended for the bibliometric analysis of research in other languages. Finally, the results were based on the tests and examinations inherent in the statistical programs VOSviewer and Biblioshiny used for bibliometric analysis in the current study, and further studies are invited to use other programs for bibliometric analysis to reveal related results. Despite these limitations, the study provides valuable information and guidance on emerging trends in the sustainable agriculture among QUAD countries literature and provides layout for future research.

References:

Agnusdei, G. P., & Coluccia, B., (2022). Sustainable agrifood supply chains: Bibliometric, network and content analyses. In Science of the Total Environment (Vol. 824). Elsevier B.V. https://doi.org/10.1016/j.scitotenv.2022.153704

Akbari, M., Khodayari, M., Danesh, M., Davari, A., & Padash, H., (2020). A bibliometric study of sustainable technology research. In Cogent Business and Management (Vol. 7, Issue 1). Cogent OA. https://doi.org/10.1080/23311975.2020.1751906

Albort-Morant, G., Henseler, J., Leal-Millán, A., & Cepeda-Carrión, G., (2017). Mapping the field: A bibliometric analysis of green innovation. Sustainability (Switzerland), 9(6). https://doi.org/10.3390/su9061011

Alvarenga, T. H. de P., et al., (2018). Sustainable Horticulture: A bibliometric Study. International Journal of Advanced Engineering Research and Science, 5(8), 70–78. https://doi.org/10.22161/ijaers.5.8.9

Aria M, Cuccurullo C., (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of Informetric 11(4):959–975. https://doi.org/10.1016/j.joi.2017.08.007

Australia has been in a stalemate with China, but that could be about to change. Australian Broadcasting Corporation. (10 March 2021). (Retrieved 29 March 2023).

Bertoglio, R., Corbo, C., Renga, F. M., & Matteucci, M., (2021). The Digital Agricultural Revolution: A Bibliometric Analysis Literature Review. In IEEE Access (Vol. 9, pp. 134762–134782). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ (Retrieved 29 March 2023)

Brown, L. R., (2012). World on the Edge. Earth Policy Institute. Norton. ISBN 978-1-136-54075-2.

Chistov V, Aramburu N, Carrillo-Hermosilla J., (2021). Open eco-innovation: a bibliometric review of emerging research. J Clean Prod 311:127627. https://doi.org/10.1016/j.jclepro.2021.127627

Crippa, M.; Solazzo, E.; Guizzardi, D.; Monforti-Ferrario, F.; Tubiello, F. N.; Leip, A. (March 2021). Food systems are responsible for a third of global anthropogenic GHG emissions. Nature Food. 2 (3): 198–209. doi:10.1038/s43016-021-00225-9. ISSN 2662-1355.

Dang, Q., Zhao, X., Yang, T., Gong, T., He, X., Tan, W., & Xi, B., (2022). Coordination of bacterial biomarkers with the dominant microbes enhances triclosan biodegradation in soil amended with food waste compost and cow dung compost. Science of the Total Environment, 824. https://doi.org/10.1016/j.scitotenv.2022.153837

De Groote SL, Raszewski R., (2012). Coverage of Google Scholar, Scopus, and Web of Science: a case study of the h-index in nursing. Nursing Outlook 60(6):391–400. https://doi.org/10.1016/j.outlook. 2012.04.007

Ding X., (2019). Knowledge mapping of platform research: a visual analysis using VOSviewer. Adv Econ Bus Manage Res 110:454–463

Du et al., (2014). A bibliographic analysis of recent solar energy literatures: The expansion and evolution of a research field. Renew. Energy 66, 696–706.

Elsevier (2020). Scopus content coverage guide. Elsevier https://www. elsevier.com/ data/assets/pdf_file/0007/69451/Scopus_ContentCoverage_Guide_WEB.pdf. (Accessed 01 June 2023)

FAO – News Article: Food systems account for more than one third of global greenhouse gas emissions. https://www.fao.org/home/en/. (Retrieved on 22 April 2023).

Faruk M, Rahman M, Hasan S., (2021). How digital marketing evolved over time: a bibliometric analysis on Scopus database. Heliyon 7:e08603

Frerichs IM, Teichert T (2021). Research streams in corporate social responsibility literature: a bibliometric analysis. Manag Rev Q. https://doi.org/10.1007/s11301-021-00237-6

Garfield E., (1979). Is citation analysis a legitimate evolution tool. Scientometrics 1:359–375

Griffith BC, Small HG, Stonehill JA, & Dey S., (1974). The structure of scientific literatures II: toward a macro- and microstructure for science. Sci Stud 4(4):339–365. https://doi.org/10.1177/03063 1277400400402

Guo, Y., Huang, Z., Guo, J., Li, H., Guo, X., Nkeil, M.J., (2019). Bibliometric analysis on smart cities research. Sustainability 11 (13), 1–18.

Hamidov, A., Helming, K., & Balla, D., (2014). Research on Land Use Functions in Central Asia: A bibliometric analysis.

Hegde, D. M., & Sudhakara Babu, S. N., (n.d.). SUSTAINABLE AGRICULTURE.

Herrera-Calderon, O., et al., (2021). A bibliometric analysis of the scientific production related to "zero hunger" as a sustainable development goal: trends of the pacific alliance towards 2030. Agriculture and Food Security, 10(1). https://doi.org/10.1186/s40066-021-00315-8

https://saiplatform.org (Retrieved on 22 April 2023)

Introduction to Sustainable Agriculture. Ontario Ministry of Agriculture, Food and Rural Affairs. 2016. http://omafra.gov.on.ca/english/busdev/facts/15-023.htm (Retrieved on 10 October 2022)

Jamali, Naveed; O'Connor, Tom., (2020). US, China's Geopolitical Battle for Asia Shapes New Power Dynamic for Region. Newsweek. (Retrieved 13 April 2023).

Kessler MM., (1963). Bibliographic coupling between scientific papers. American Documentation 14(1):10–25. https://doi.org/10.1002/asi.5090140103

Kobara, Junnosuke; Moriyasu, Ken, (27 March 2021). "Japan will turn to Quad in 'new Cold War': Defense Ministry think tank". Nikkei Asia. (Retrieved 13 April 2023).

Kovaleva M, Filho WL, Borgemeister C., (2022). Gender issues within climate change research: a bibliometric analysis. Climate Development 14(8):725–740

Kulak, M., (2018). Bibliometric analysis of studies in medicinal and aromatic plants for rural development. Engineering for Rural Development, 17, 1253–1259. https://doi.org/10.22616/ERDev2018.17.N495

Kumar Kar S, Harichandan S., (2022). Green marketing innovation and sustainable consumption: a bibliometric analysis. J Clean Prod 361:132290. https://doi.org/10.1016/j.jclepro.2022.132290

Li, M., & Zhang, Y., (2022). A Bibliometric and Visualization Review Analysis of Agricultural Ecosystem Services Research. Low Carbon Economy, 13(01), 36–52. https://doi.org/10.4236/lce.2022.131003

Lopez-Serrano, M. J., Velasco-Muñoz, J. F., Aznar-Sánchez, J. A., & Román-Sánchez, I. M., (2020). Sustainable use of wastewater in agriculture: A bibliometric analysis of

worldwide research. In Sustainability (Switzerland) Vol.12, Issue 21, pp. 1–20. MDPI. https://doi.org/10.3390/su12218948

Mao, G., Zou, H., Chen, G., Du, H., Zuo, J., (2015). Past, current and future of biomass energy research: A bibliometric analysis. Renew. Sustain. Energy Rev. 52, 1823–1833.

Mas-Tur A, et al. (2021). Co-citation, bibliographic coupling and leading authors, institutions and countries in the 50 years of Technological Forecasting and Social Change. Technology Forecast Socio Chang 165:120487. https://doi.org/10.1016/j.techfore.2020. 120487

Maucuer R, Renaud A, Ronteau S, Muzellec L., (2022). What can we learn from marketers? A bibliometric analysis of the market- ing literature on business model research. Long Range Planning 55(5):102219. https://doi.org/10.1016/j.lrp.2022.102219

Montero-Navarro, A., González-Torres, T., Rodríguez-Sánchez, J. L., & Gallego-Losada, R., (2021). A bibliometric analysis of greenwashing research: a closer look at agriculture, food industry and food retail. British Food Journal, 123(13), 547–560. https://doi.org/10.1108/BFJ-06-2021-0708

Palmblad, M., van Eck, N.J., (2018). Bibliometric analyses reveal patterns of collaboration between ASMS members. J. Am. Soc. Mass Spectrom. 29 (3), 447–454.

Zhang, Y., Yu, Q., & Li, J. (2021). Bioenergy research under climate change: a bibliometric analysis from a country perspective. Environmental Science and Pollution Research, 28, 26427-26440.https://doi.org/10.1007/ s11356-021-12448-1

Phan Tan L., (2022). Bibliometrics of social entrepreneurship research: cocitation and bibliographic coupling analyses. Cogent Bus Manage 9(1):2124594. https://doi.org/10.1080/23311975.2022.2124594

Power, John., (2021). What is the Quad, and how will it impact US-China relations under the Biden administration?. South China Morning Post. (Retrieved 25 April 2023).

Pulgarín, A., Eklund, P., Garrote, R., & Escalona-Fernández, M. I., (n.d.). Evolution and Structure of Sustainable Development: A Bibliometric Study.

Quad Leaders' Joint Statement: "The Spirit of the Quad". White House. (2021). Public Domain This article incorporates text from this source, which is in the public domain. (Retrieved 12 March 2022)

Quad Summit 2021: Why is China Rattled?". The Financial Express. 14 March 2021. (Retrieved on 30 September 2022).

Rasheed, Zaheena, (2020). What is the Quad and can it counter China's rise?. Al Jazeera. (Retrieved 13 April 2023).

Ribamar., (n.d.). Sustainable Agriculture Efficient and Responsible Use of Natural Resources The Nature Conservancy Offices.

Rockström, Johan; et.al. (2016). Sustainable intensification of agriculture for human prosperity and global sustainability. Ambio. 46 (1): 4–17. doi:10.1007/s13280-016-0793-6. PMC 5226894. PMID 27405653.

Saleem F, Khattak A, Ur Rehman S, Ashiq M., (2021). Bibliometric analysis of green marketing research from 1977 to 2020. Publ 9(1):1. https://doi.org/10.3390/publications9010001

Sarkar S, Searcy C., (2016). Zeitgeist or chameleon? A quantitative anal- ysis of CSR definitions. J Clean Prod 135:1423–1435. https://doi. org/10.1016/j.jclepro.2016.06.157

Small H., (1973). Co-citation in the scientific literature: a new measure of the relationship between two documents. J Am Soc Inf Sci 24(4):265–269. https://doi.org/10.1002/asi.4630240406

Sweileh WM., (2020). Bibliometric analysis of peer-reviewed literature on food security in the context of climate change from 1980 to 2019. Agric Food Secur 9(1):11. https://doi.org/10.1186/ s40066-020-00266-6

Taddeo R, Simboli A, Di Vincenzo F, Ioppolo G., (2019). A bibliometric and network analysis of lean and cleaner production research (1990/2017). Sci Total Environ 653:765–775. https://doi.org/10. 1016/j.scitotenv.2018.10.412

Tokbergenova, A., Kiyassova, L., and Kairova, S., (2018). Sustainable development agriculture in the republic of Kazakhstan. In Polish Journal of Environmental Studies (Vol. 27, Issue 5, pp. 1923–1933). HARD Publishing Company. https://doi.org/10.15244/pjoes/78617

Towards a Quad-Plus Arrangement?". Perth USAsia Centre. (Retrieved 5 May 2023).

Trigo, A., Marta-Costa, A., and Fragoso, R., (2021). Principles of sustainable agriculture: Defining standardized reference points. Sustainability (Switzerland), 13(8). https://doi.org/10.3390/su13084086

Van Eck NJ, Waltman L, Dekker R, van den Berg J., (2010). A comparison of two techniques for bibliometric mapping: Multidimensional scaling and VOS. JASIST 61(12):2405– 2416. https://doi.org/10.1002/asi.21421

Van Eck NJ, Waltman L., (2014). Visualizing bibliometric networks. In: Ding Y, Rousseau R, Wolfram D (eds) Measuring scholarly impact. Springer International Publishing, pp 285–320. https:// doi.org/10.1007/978-3-319-10377-8_13

Velten, S., Leventon, J., Jager, N., & Newig, J., (2015). What is sustainable agriculture? A systematic review. In Sustainability (Switzerland) (Vol. 7, Issue 6, pp. 7833–7865). MDPI. https://doi.org/10.3390/su7067833

What is sustainable agriculture Agricultural Sustainability Institute". asi.ucdavis.edu. 11 December 2018. (Retrieved on 20 January 2022)

Yuan, B.-Z., & Sun, J., (2021). Bibliometric Analysis of Rice And Climate Change Publications Based On Web of Science. https://doi.org/10.21203/rs.3.rs-683332/v1

Zhang Y, Yu Q, Li J., (2021). Bioenergy research under climate change: a bibliometric analysis from a country

Zhang, C., Fang, Y., Chen, X., & Congshan, T., (2019). Bibliometric analysis of trends in global sustainable livelihood research. In Sustainability (Switzerland) (Vol. 11, Issue 4). MDPI. https://doi.org/10.3390/su11041150

Zhang, W., Yuan, H., (2019). A Bibliometric analysis of energy performance contracting research from 2008 to 2018. Sustainability 11 (13), 1–23.

Zyoud SH, Fuchs-Hanusch D., (2020). Mapping of climate change research in the Arab world: a bibliometric analysis. Envi- ron Sci Pollut R 27:3523–3540. https://doi.org/10.1007/ s11356-019-07100-y