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GLOBAL RESEARCH TRENDS IN AGRICULTURAL EDUCATION AND AGRICULTURAL TECHNOLOGY: A SCIENTOMETRIC STUDY

Shivam Pachauri*, Shivi Dwivedi**

Abstract *The study examines the landscape of agriculture research, with a focus on agricultural technology and agricultural education, utilizing Scopus-indexed publications between 1965 and 2025. The data was retrieved from the Scopus database on December 04, 2025 and total of 2,321 publications were analyzed. A bibliometric analysis was conducted using descriptive and network techniques to evaluate research productivity, trends, and collaborations. Key findings reveal that citations for agricultural technology, with agricultural education research have shown sustained growth, reflecting the rise of digital platforms. Co-authorship analysis highlights strong international collaborations, with significant contributions from scholars like Cosby, A., Manning, J. and, Harreveld, B. and leading research hubs in the U.S.A, China, and India. Keyword co-occurrence identified critical themes such as Agriculture, Education, and Food Technology. Emerging clusters in agriculture professional training and agri farm highlight underexplored domains that require further investigation. Future research should address machine learning technology in agriculture sector and its impacts and develop innovative methodologies to mitigate its evolving challenges in diverse settings.*

Keywords: *Agriculture, Agriculture Technology, Agriculture Education, Bibliometrics, Scientometrics*

INTRODUCTION

A review of research trends in global agricultural education and agricultural technology revealed that much of the research was inclined towards scientometric analysis of the agricultural science publications as opposed to the actual focus on the areas. Expanding research between 1993–2012, rate of citation, and distribution of research across the disciplines got the limelight whereas special aspects of agricultural education or agricultural technology were breached sporadically (Sagar et al., 2013). In addition, agronomy was emphasized to contribute to the rise of agricultural production on the basis of applicable knowledge and scientific methods (Salmerón-Manzano & Manzano-Agugliaro, 2021). Special attention was given to smart agriculture and the influence information and communication technologies (ICT) have on the processes in agriculture. Research indicates that intelligent technologies can help solve the problems of contemporary agriculture with real-time information, production enhancers, and remote observation (Bala & Kaur, 2024). The United States and China were the most mentioned countries in terms of research in the field of agricultural big data, and the greatest number of publications about the use of the artificial intelligence in agriculture was found in China, the United States, India, and Australia (Trivedi, 2019; Vazquez et al., 2021). The same applies to the top research institutions, which were the Chinese Academy of Sciences, the National Agricultural Research Institute, and Northwest A&F University, and the largest funding organization, which was the Indian Council of Agricultural Research, with 104 publications (Ding et al., 2023; Sankar & Prema, 2022).

Regarding agricultural education, it is also stated in the research that application of ESD principles in education is important to address the requirements of global sustainability and the United Nations Sustainable Development Goals (SDGs). It will not only satisfy the need of future workforce, but also foster sustainable agriculture throughout the world (Foster et al., 2024). This significance is also added by the fact that it influences the visibility and reputation of agricultural journals

* Assistant Librarian, Sanskriti University, Mathura, Uttar Pradesh, India. Email: shivampachauri27@gmail.com; ORCiD: https://orcid.org/0009-0003-1049-6070

** Assistant Professor, DLIS, Dr. B.R. Ambedkar University, Agra, Uttar Pradesh, India. Email: shvdwivedi6214@gmail.com; ORCiD: https://orcid.org/0009-0009-8293-6120

and researchers within the global scientific community (Lindner et al., 2020).

Moreover, the recent studies on agri-food shelf-life extension technologies, their classification into five groups of concepts, and the prevailing but local market-based patenting approach of China were also mentioned (Thavorn et al., 2021). A bibliometric survey conducted at a global level regarding the adoption and innovation of the agricultural processing technologies revealed the presence of seven major research areas, powerful authors, and 10 highly cited studies. The study presents valuable information to policy makers, scientists, and other industry stakeholders in order to enhance agricultural productivity and to enhance sustainable agricultural production (Indriyani et al., 2023). This research aims to determine the primary trends in the evolution of "Agricultural Education" and "Agricultural Technology" content, along with their effects on evaluating annual publication output, citations, and alterations in the authorship's organizational structure. Additionally, co-authorship network analysis will be employed to illustrate the evolving nature of research collaboration, especially highlighting the growing importance of multi-institutional and international research partnerships (Tripathi & Garg, 2016).

METHODOLOGY

The bibliometric approach consists of three phases: the initial phase involves selecting, identifying, and acquiring the database. Drawing from previous studies and findings, Scopus (the database from Elsevier) was selected as it is a significant and extensive resource covering multiple fields, offering essential data for both qualitative and quantitative evaluations (Jenkins, 2017). The finalized search string for "Articles, abstract, and keywords" was utilized, ensuring that if the keywords appeared in the document, relevant documents would be displayed in the output. The utilized data sources comprise relevant scholarly articles found via advance search terms (TITLE-ABS-KEY (Agriculture Technology) AND TITLE-ABS-KEY (Agricultural Education)) AND PUBYEAR > 1964 AND PUBYEAR < 2026. The data analysis involved evaluating yearly publication totals, national input, global collaborations, academic fields, researcher teamwork, citations, institutional ties, and cited literature. This research employs second tools: MS-Excel and VOSviewer, to examine author collaboration, co-authorship networks of countries and, widely referenced papers utilizing various filtering methods in MS Excel. The extraction of articles from the Scopus database occurs in several stages.

The final component is the examination and depiction of extensively cited documents. To examine trends in the dataset, the fundamental descriptive analysis generates various tables and graphs. Using the initial charts and tables, trends in the conceptual area were recognized, which were incorporated into the analysis of yearly publication counts, citations, leading five countries, journals, authors, and the development of keywords. Subsequently, keyword analysis and development were conducted through VOSviewer, which was employed to dynamically assess the most impactful papers, journals, authors, and countries based on their publications and citations.

RESULTS AND DISCUSSION

Publication Trends

Table 1 has examined the annual distribution of articles between 1965 and 2025, included a total of 2321 articles. The greatest amount of articles, 305, which accounts for 13.14% of all publications, appeared in 2024. The starting year of publication recorded the lowest articles ever, totaling 0.04% each of all publications years from 1965-1979.

Table 1: Publication Trends Year-Wise

Sr. No.	Year	No. of Documents	Percentage
1	2025	293	12.61
2	2024	305	13.14
3	2023	213	9.17
4	2022	178	7.66
5	2021	190	8.18
6	2020	187	8.05
7	2019	112	4.82
8	2018	78	3.36
9	2017	63	2.71
10	2016	48	2.07
11	2015	52	2.24
12	2014	56	2.41
13	2013	50	2.15
14	2012	42	1.81
15	2011	55	2.37
16	2010	38	1.64
17	2009	31	1.33
18	2008	30	1.29
19	2007	35	1.51
20	2006	36	1.55
21	2005	19	0.82
22	2004	16	0.69
23	2003	11	0.49
24	2002	19	0.82
25	2001	20	0.88
26	2000	11	0.47
27	1999	19	0.84

Sr. No.	Year	No. of Documents	Percentage
28	1998	5	0.22
29	1997	10	0.43
30	1996	8	0.34
31	1995	7	0.30
32	1994	12	0.54
33	1993	7	0.30
34	1992	3	0.13
35	1991	11	0.47
36	1990	8	0.34
37	1989	4	0.17
38	1988	4	0.17
39	1987	5	0.22
40	1986	3	0.13
41	1985	5	0.22
42	1984	2	0.09
43	1983	3	0.13
44	1982	2	0.13
45	1981	3	0.04
46	1980	3	0.09
47	1979	1	0.04
48	1978	2	0.04
49	1976	1	0.04
50	1975	1	0.04
51	1970	1	0.04
52	1969	1	0.04
53	1967	1	0.04
54	1965	1	0.04
Total		2321	100

Most Productive Sources

This table indicates the quantity of papers donated by various sources of publication and its proportion. On the list, sustainability Switzerland (57 publications) and IOP Conference Series Earth and Environmental Science (43 publications) are ranked first and second with a share of 2.45 and 1.85 respectively. After that, ASEE Annual Conference and Exposition and Agriculture Switzerland are the next significant sources, with 1.12% and 1.03 contributions, respectively. Other sources, including Lecture notes on Networks and Systems, Frontiers in Sustainable Food Systems, Plos One, and the Journal of Physics conference series make significant contributions albeit less than 1%. Lastly, there are a total of 282 publications in the list which in itself contribute to an overall percentage of 12.14 meaning that these sources make a good percentage contribution to the research output.

Table 2: Top 10 Productive Sources

Rank	Source Name	No. of Publication	Percentage
1	Sustainability Switzerland	57	2.45
2	IOP Conference Series Earth and Environmental Science	43	1.85
3	ASEE Annual Conference and Exposition Conference Proceedings	26	1.12
4	Agriculture Switzerland	24	1.03
5	Lecture Notes in Networks and Systems	23	0.99
6	Frontiers in Sustainable Food Systems	21	0.90
7	E3s Web of Conferences	20	0.86
8	Plos One	19	0.81
9	Journal of Physics Conference Series	17	0.73
10	Acta Horticulturae	16	0.68
10	Precision Agriculture	16	0.68
	Total	282	12.14%

Documents by Type

The Table 3 lists 2,321 documents published between 1965 and 2025 in the following categories: As can be seen, the largest numbers of papers published are articles, at 1273, accounting for 54.84% of the total. This implies that researchers write their research in the genre of a general research article (journal article). Furthermore, 589 are conference paper (25.37%), indicating that researchers sometimes provide in-depth reviews of previously published literature. Only 198 (8.53%) are book chapter, on a specific topic. Only 163 (7.02) review papers were presented and, Lowest publication under category- retracted and data paper carry 2-2 publication with (0.08%) a clear indication that retracted and data paper-based publications contributed little to this study. Throughout this period, the analysis was conducted using research articles as the primary publication medium, while other types of documents were published in very small numbers.

Table 3: Documents Type

Sr. No.	Document Type	No. of Documents	Percentage
1	Article	1273	54.84
2	Conference Paper	589	25.37
3	Book Chapter	198	8.53
4	Review Paper	163	7.02
5	Book	58	2.49
6	Note	9	0.38
7	Conference Review	9	0.38
8	Erratum	7	0.30
9	Short Survey	4	0.18
10	Editorial	4	0.18
11	Letter	3	0.12
12	Retracted	2	0.08
13	Data Paper	2	0.08
	Total	2321	100

Top Cited Publication

The Table 4 presents data on the top 10 highly cited research papers published within the time frame of the study, in order of the number of Citations received. The most cited paper in 2018 is "Machine learning in agriculture: A review" with 2267 citations to date which is the highest in this list then comes "Plant-microbe interactions promoting plant growth and health: Perspectives for controlled use of microorganisms in agriculture", which was published in 2009 and received 1340 citations. The research area is very wide and covers agricultural education and agricultural technology. The table indicates the kinds of research topics that have made more impact in the scientific community and which studies have been cited more frequently. This table is an important means of assessing the quality and effectiveness of research at this institute.

Table 4: Top Cited Publication

Sr. No.	Year	Publication	Citation	Document Type
1.	2018	"Machine learning in agriculture: A review"	2267	Review Paper
2.	2009	"Plant-microbe interactions promoting plant growth and health: Perspectives for controlled use of microorganisms in agriculture"	1340	Short Survey
3.	1995	"Participatory learning for sustainable agriculture"	1109	Article
4.	2001	"History, current status, and collaborative research projects for Bemisia Tabaci"	670	Review Paper
5.	2020	"Computer vision technology in agricultural automation —A review"	638	Review Paper
6.	2022	"Towards leveraging the role of machine learning and artificial intelligence in precision agriculture and smart farming"	604	Review Paper
7.	2020	"Enabling technologies and sustainable smart cities"	506	Article
8.	2011	"Consumption risk, technology adoption and poverty traps: Evidence from Ethiopia"	483	Article
9.	2017	"The Socio-Technical Dynamics of Low-Carbon Transitions"	474	Review Paper
10.	2014	"Nanotechnology in agriculture: Prospects and constraints"	409	Review Paper

NETWORK ANALYSIS

The network illustrates keywords that create clusters (Fig. 2), with nodes and connections linking graphs that represent the relationships among words. The node sizes, representing the keywords, are linked to the frequency of the keywords' occurrence in the documents; a larger node indicates a higher frequency (and vice versa). The linkages, or edges, illustrate the connections between two nodes. The width of the link reflects the strength of this connection; a broader link signifies a more robust relationship (Van Eck & Waltman, 2010). The lowest count of keyword repetitions was set at 3. Just 495 of the 5797 author keywords met the criteria and were displayed. The simultaneous presence of author keywords results in 104 clusters, 3650 connections, and 4830 overall link strengths. Each cluster color signifies a unique cluster, with cluster 1 containing 11 items, cluster 2 also having 11 items, cluster 3 with 11 items, cluster 4 with 10 items, cluster 5 comprising 9 items, cluster 6 holding 9 items, cluster 7 encompassing 9 items, cluster 8 featuring 9 items, cluster 9 with 8 items, and cluster 10 containing 8 items. The keywords based solely on occurrences include the top five selected keywords: the first is "Agriculture" with 252 occurrences, 625 total link strength, and 271 links; the second is "Education" with 86 occurrences, 232 total link strength, and 119 links; the third is "food security" with 74 occurrences, 201 total link strength, and 126 links; the fourth is "technology" with 51 occurrences, 192 total link strength, and 111 links; and the fifth is "climate change" with 73 occurrences, 189 total link strength, and 104 links. The minimum frequency of the author's documents was set at 3. Out of the overall 7378 author co-authorship instances, merely 79 reached the threshold and were displayed. The co-authorship of the author, derived from documents, results in 79 items, 53 clusters, 49 links, and 152 link strengths. Each color of the cluster denotes a distinct cluster, and this study takes into account the top three in total. Cluster 1 comprises 4 items, while cluster 2 includes 3 items, cluster 3 has 3 items, cluster 4 contains 3 items, cluster 5 features 3 items, cluster 6 also has 3 items, cluster 7 hosts 3 items, clusters 8 through 18 each have 2 items, and cluster 10 includes 2 items. According to total link strength, the five authors identified are: the first author (Cosby, A. and Manning, J.) with a total link strength of 23, the second author (Harreveld, B.) with a total link strength of 20, the third author (Mitra, M. and Nagchaudhuri, A.) with a total link strength of 16, the fourth author (Fogarty, E.S.) with a total link strength of 15, and the fifth author (Pandya, J.R.) with a total link strength of 10. According to the citations, the five leading authors were chosen, with the first author being (Wang, T.) having a total of 638 citations, followed by the second author (Tripathi, G.) with 506 citations, the third author (Zhang, Z.) with 388 citations, the fourth author (Waquil, P.D.) with 297 citations, and the fifth author (Vanek, S.J.) with 240 citations.

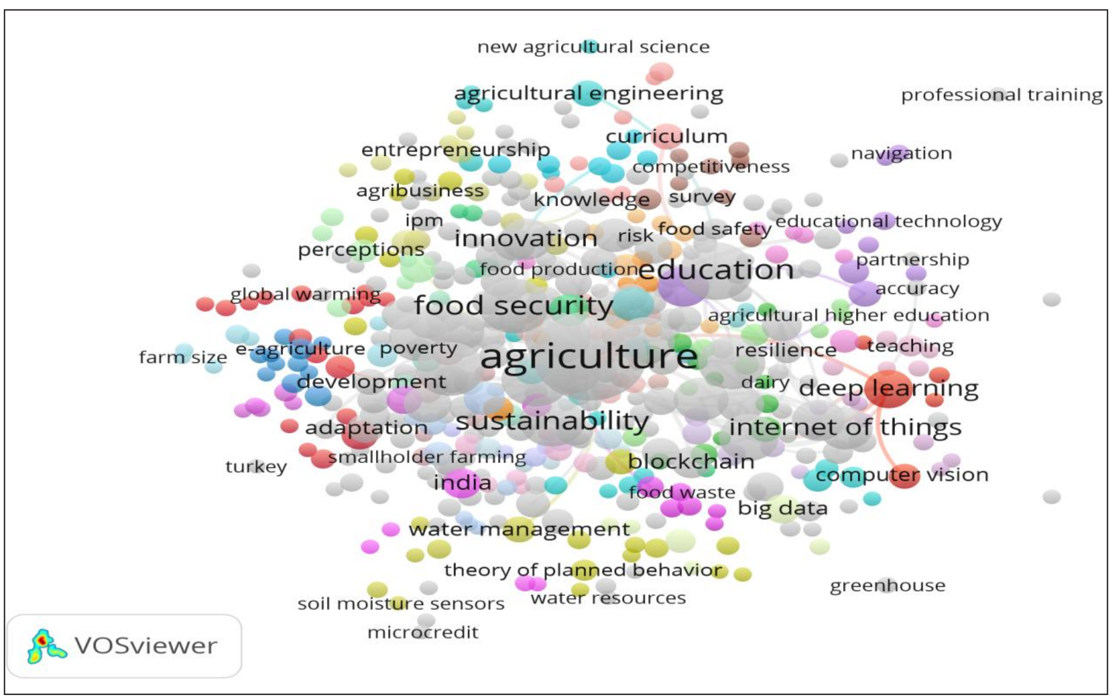

Fig. 1: Author Keywords Co-Occurrence Network

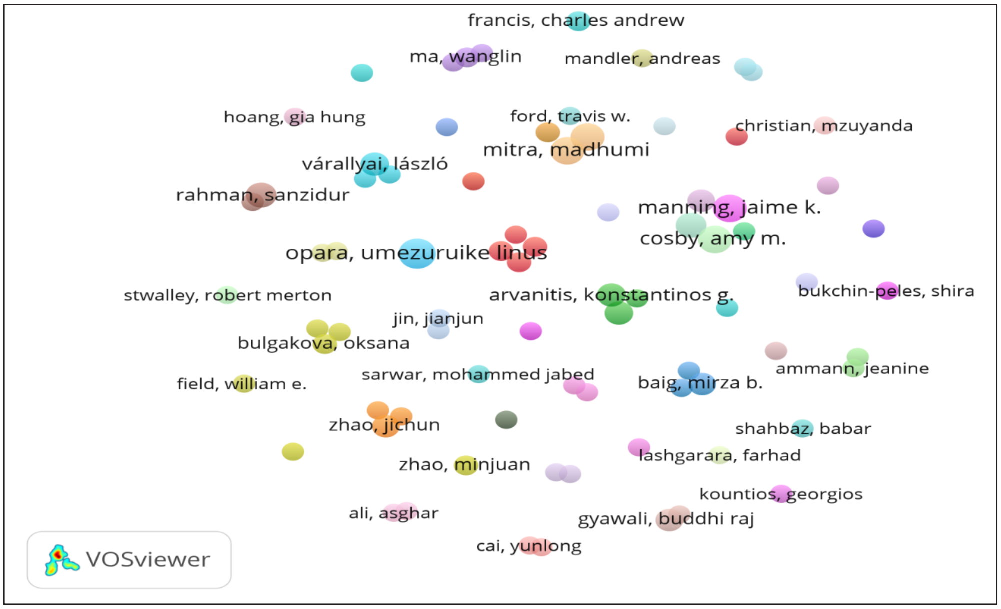

Fig. 2: Co-Authorship Networks

We conduct a co-authorship analysis at the country/region and author level to illustrate the publication collaboration link across various countries and regions from 1965 to 2026. The lowest number of times the author's documents were required was established at 1. Out of the total countries of authors, 134 were mapped. According to documents, the author's countries generate 124 items, 61 clusters, 697 connections, and 1165 link strengths. Each color of the cluster signifies a distinct cluster, with the study focusing on the top ten overall. Cluster 1 contains 5 items, followed by cluster 2 with 4 items, cluster 3 with 4 items, cluster 4 with 3 items, cluster 5 with 3 items, cluster 6 with 3 items, cluster 7 with 3 items, cluster 8 with 3 items, cluster 9 with 3 items, and cluster 10 with 3 items. According to documents, citations, and overall link strength, the top five countries identified are as follows: the first country is the (United States) with 436 documents, 9727 citations, and 214 total link strength; the second country is (China) with 334 documents, 5217 citations, and 142 total link strength; the third country is (India) with 329 documents, 5206 citations, and 94 total link strength; the fourth country is not specified in the database and is labeled as "undefined," with 105 documents and 494 citations. The fifth nation is the United Kingdom, featuring 99 documents, 6544 citations, and a total link strength of 137.

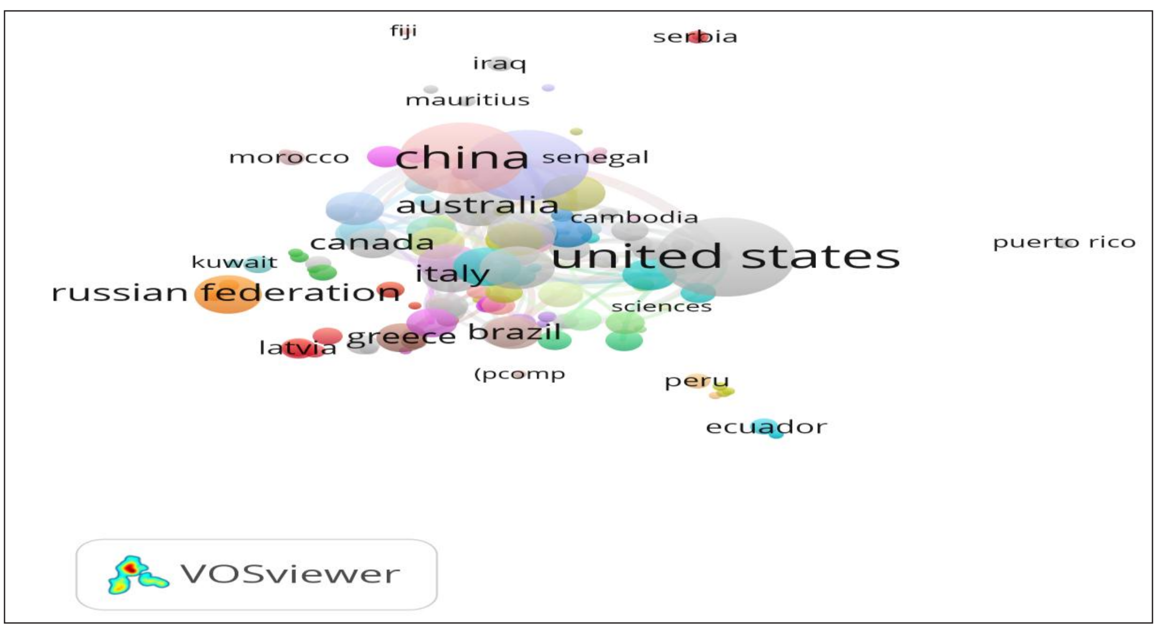

Fig. 3: Co-Authorship and Countries Networks

CONCLUSION

The analysis above makes it clear that the number of publications regarding agricultural, educational, and technological research grew significantly within the period between 1965 and 2025, and the output of the research has become more effective and efficient over time. An analysis of the trend of publications shows that the number of publications is 2,321 in total, and the most recent year is 2024, where 305 articles were published, which takes 13.14 percent of the overall amount. This is the sign of growing activity and interest of scientific community in this field. Conversely, the years of the early years (1965-1979) showed a very low number of publications, which implies that, the awareness and resources of the agricultural and technological research were gradually rising.

The evaluation of the most fruitful sources shows that such authoritative journals as Sustainability Switzerland and IOP Conference Series Earth and Environmental Science served as the major factors that predetermined the line of research. The contribution of these two sources was 2.45 and 1.85, respectively. Other sources like the ASEE Annual Conference and Exposition, Agriculture Switzerland, Lecture Notes in Networks and Systems, Frontiers in Sustainable Food Systems and PLOS One also contributed to research output in significant but comparative lesser contributions. In general, this set of 282 publications can be considered a contribution of 12.14 percent that means that the input of various sources has increased the quality and range of research.

Document type analysis will show that researchers mostly choose to provide their work in the form of journal articles. Among the total 2321 documents, 1273 were articles (54.84%), 589 were conference papers (25.37%). This means that scientists are not just writing regular articles of research but also doing an extensive discussion and debate by forums through conferences. Moreover, the value of book chapter, review paper, and data paper contribution was very low implying that the research activity in such categories is minimal. The fact that the retracted and the data papers are only 2 each depicts that there are very low levels of research errors and this adds to the overall research quality.

Based on the study of highly cited publications, it is possible to note that the topics of machine learning, plant-microbial interactions, and agricultural technology are one of the most influential ones in agriculture. The fact that there were 2,267 citations of the article titled Machine Learning in Agriculture: A Review suggests that the problem of applying modern technologies to agriculture has become one of the research topics of the vital importance. Equally, other studies that have been cited heavily have had an immense influence to the scientific world.

The network analysis demonstrated the scope of thematic relationships in the research. The 104 clusters that are based on 495 keywords reveal that the number of subfields in which the topics of research are split is quite large, and the keywords that occur most of the time include: “Agriculture,” “Education,” “Food Security,” “Technology,” and “Climate Change” which further points at the direction that research takes at the moment. The co-authorship network also shows that there are major authors, like Cosby, Manning, Harreveld, Mitra, etc., who were very effective in collaborative research. They have been ranked to the top five on the basis of a number of documents, total number of citations and total strength of links. Out of five, U.S.A. leads in the list of countries with 436 documents, 9727 citations and total link strength of 214 due to the impact of its research and worldwide cooperation. China occupies the second position with 334 documents, 5217 citations and total link strength is 142 which is a testimony of the fast emerging Chinese research center in this area. India has the third highest number of documents of 329, 5206 citations and strength of the link of 94, which testifies to the high level of research activity in India.

Overall, the given work represents a detailed and thorough overview of the agricultural, educational, and technological research development revealing major themes, valuable sources, significant authors, and network models. This study can be useful in terms of the structuring of future studies, the determination of new priorities, and the improvement of research quality.

DECLARATION

Ethics Approval: The research utilized scientometric analysis, employing the Scopus database, adhering to specific inclusion and exclusion criteria.

Conflict of Interest: The authors explain that this was research that was not done with any commercial or financial ties which can be interpreted as conflict of interest.

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