Bibliometric Analysis of Rice And Climate Change Publications Based On Web of Science

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Abstract

To clarify the current situation, hotspots, and development trends, in the field of rice and climate change topic research, a massive literature dataset were analysed from the Web of Science database by bibliometric method. The research theme was chosen given the continuous increase of studies related to climatic changes and their consequences to rice. Based on the Web of Science core database, this study analyzed 3377 papers in the field of rice and climate change topic research from 1990 to 2021, which include 67 highly cited papers. Papers were mainly written in English (3,366, 99.674 %), from 12,655 authors, 3,259 organizations and 113 countries/territories, published in 761 journals and seven book series. The top five Journals are *Science of the Total Environment* (97, 2.872 %), *Climatic Change* (71, 2.102 %), *Agricultural and Forest Meteorology* (66, 1.954 %), *Global Change Biology* (65, 1.925 %) and *Sustainability* (64, 1.895 %), each published more than 64 papers. Top five countries and regions were Peoples R China, USA, India, Australia and Japan. Top five organizations of Chinese Acad Sci, Nanjing Agr Univ, Int Rice Res Inst (IRRI), Chinese Acad Agr Sci, and Univ Chinese Acad Sci were popular based on contribution of articles more than 116 papers each. Among the all authors, top five authors were Tao Fulu, Pan Genxing, Zhang Zhao, Hasegawa Toshihiro, Jagadish Krishna S.V., each published more than thirty papers. All keywords were separated seven clusters for different research topic. Visualizations offer exploratory information on the current state in a scientific field or discipline as well as indicate possible developments in the future. The results will help researchers clarify the current situation in rice and climate change adaptation science but also provide guidance for future research. This work is also useful for student identifying graduate schools and researchers selecting journals.

Introduction

In recent years, climate change has had a more significant impact on earth's ecosystem and its human socio-economic system. In response to climate change, countries all over the world have enacted various policy measures to reduce greenhouse gas emissions to reduce the further rise in global average temperatures, and reduce the risks and losses of climate change. Climate change adversely impacts our agriculture and will force agricultural production to adapt to the altered environmental conditions. Increase in climatic variations and extreme weather events in the recent past have exerted significant effect on crop productivity over different regions on earth. The consequences of climate change are drastically impacting field crop production; it is an immense prerequisite to attribute resilience through crop improvement. Rice (*Oryza sativa* L.) is the staple food for half the world's population. Climate change has been an increasingly significant factor behind fluctuations in the yield and quality of rice (Murphy et al., 2013; Morita et al., 2016; Zafar et al., 2018; Kingra et al., 2019; Schneider and Asch, 2020; Senguttuvel et al., 2020). In the last years, increased interests in climate change research by scholars have been witnessed. These interests are accompanied by spectacular rise in the amount of scientific output in this topic of research.

Bibliometric analysis, as an important quantitative analysis tool, can effectively describe the overall trend of the development of a subject or field, and it has been widely used in various fields. In recent years, the

bibliometric method is more and more frequently used in climate change research. Li et al. (2011) used it to evaluate the academic output, trends, features, and research methods in climate change literature from 1992 to 2009, and proposed a key innovative clustering analysis method. Wang et al. (2014) explored the development trend of the literature in the cognate area of climate change vulnerability through quantitative analysis, pointing out that health problems in the socio-economic system, food safety problems in agriculture, and water resources management problem were the most frequently discussed in the field of vulnerability research at present. Based on SCI-E and SSCI database, Wei et al. (2015) reviewed research hotspots and model methods used in the field of climate policy modelling with a bibliometric method. A bibliometric analysis of climate change adaptation was completed based on massive research literature data (Wang et al. 2018). There are others bibliometric analysis publications, such as peer-reviewed literature on climate change and human health with an emphasis on infectious diseases (Sweileh 2020), scientific production on coastal communities' social vulnerability to climate change (Lima & Bonetti, 2020), bioenergy research under climate change (Zhang et al. 2021), carbon capture technologies for climate change mitigation (Omoregbe et al., 2020), climate change and carbon sink (Huang et al., 2020), disaster and climate change resilience (Rana, 2020), soil and water conservation in the Loess Tableland-Gully Region of China (Wang et al., 2019), advances in water use efficiency in agriculture and sustainable water use in agriculture (Velasco-Muñoz et al., 2018a, b).

Bibliometrics analysis technique has been adopted related with agronomy or crop research such as, perennial staple crops (Kane et al., 2016), Japanese rice (Morooka et al., 2014), rice physiology and management in China (Peng, 2017), global rice research during 1985–2014 (Liu et al., 2017), genetically modified maize (Santillán-Fernández et al., 2021), transgenic maize (Li et al., 2018), fiber crops (Bartol and Mackiewicz-Talarczyk, 2015), climate change in agriculture (Aleixandre-Benavent et al., 2017), plant defense against biotic stresses as improvement for sustainable agriculture (Gimenez et al., 2018), soil nutrient research between 1992 and 2020 (Pan et al., 2021), planthopper (Hu and Cao, 2018), etc. Sun and Yuan have analyzed rice with fertilizer based on Citespace (Sun and Yuan, 2019), rice with irrigation (Sun and Yuan, 2020a), the top papers in world rice research (Sun and Yuan, 2020b), Library and Information Science (Sun and Yuan, 2020c), water Resources (Sun and Yuan, 2020d), Agronomy category (Sun and Yuan, 2021), green and sustainable science and technology (Yuan and Sun, 2019), scientific research on maize or corn (Yuan and Sun, 2020a, b), muskmelon (Yuan et al., 2021), strawberry (*Fragaria × ananassa* Duch.) research publications from Horticulture category (Yuan and Sun, 2021a) and cotton research from Plant Sciences category based on Web of Science (Yuan and Sun, 2021b), etc. However, no bibliometric research papers were published on climate change and rice topic research.

The purpose of this paper was to use bibliometric methods to analyze the publications of rice and “climate change” topic research through publication year, category, author, affiliations, country, journals, all keywords and other key features, according to the Clarivate Analytics's Web of Science (WoS) core database. Co-authorship network visualization of author, organizations and countries, co-occurrence network visualization of all keywords were done by VOSviewer.

Materials And Methods

2.1 Web of Science and Essential Science Indicators (ESI)

Clarivate Analytics's WoS is the world's leading scientific citation search and analytical information platform, and the one of the world's largest and most comprehensive academic information resources covering more than 12,000 core academic journals. The publication counts from the WoS Core Collection were derived from the following databases: The Science Citation Index—Expanded (SCIE)—1900-present, Social Science Citation Index (SSCI)—1900-present, Conference Proceeding Citation Index-Science (CPCI-S)—2015-present, Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH)—2015-present, Current Chemical Reactions (CCR-EXPANDED)—1985-present, Index Chemicus (IC)—1993-present.

2.2 Data collection

This study surveyed papers in WoS Core Collection (1900-present), and the data collection was completed on the single day on June 13, 2021 to avoid the bias. We used the keywords as rice and "climate change" in the topic (TS). The query as following: TS = rice and "climate change".

Then the results were refined by document types of Article or Review. So, there are 3,377 papers on rice and "climate change" topic research from WoS Core Collection. Full record and cited references of the included papers were extracted and imported into VOSviewer (Leiden University, Leiden, the Netherlands) for further citation analysis. The impact factors (IF 2020 and IF 5year) were taken from the Journal Citation Report (JCR 2020) published in 2021, which had the latest data available.

2.3 VOSviewer

Visualizations (network and overlay) using program VOSviewer are conducted on WoS data in order to determine co-occurrence and clusters of connected publications, country input and author collaboration (co-authorship) as well as clusters of interrelated research topics (text data). VOSviewer (1.6.16 version, 2020) is a free bibliometric visualizer with an intuitive and user-friendly interface. It was chosen because it can work with large sets of data and offer a range of analysis and investigation options, creating intuitive images that aid in evaluating data (Van Eck and Waltman, 2010). In this work, we used VOSviewer to show the international collaboration between the authors, organizations, countries and the research trends through all keywords. VOSviewer (version 1.6.16; van Eck and Waltman, 2020) were used to conduct bibliometric analysis, network analysis, and cluster analysis. In this paper, default parameters values of the VOSviewer are usually used in the analysis. Items are represented by a label and a circle. The size of circles reflects the weight of an item. Some items are not displayed in avoidance of overlapping. The colors in network visualization (text maps) represent clusters of similar items as calculated by the program. Distance between the items indicates the strength of relationships.

Results And Discussion

3.1 Document type and language of publication.

Based on Clarivate Analytics's WoS Index, there were total 3,377 papers of the rice and climate change topic research during 1990–2021. All the publications were identified in SCIE (3,207), SSCI (636), CPCI-S (74), Arts and Humanities Citation Index (23), Book Citation Index–Science (21), and CPCI-SSH (3). The document types of all papers were articles (3,028, 89.665 %) and reviews (349, 10.335 %), and also including proceedings papers (77, 2.28 %), early access (55, 1.629 %), book Chap. (21, 0.622 %), and data paper (5, 0.148 %), etc.

Among the all 3,377 papers, there are 67 highly cited papers. All of the papers were almost published in English (3,366, 99.674 %), and then others were Portuguese (4, 0.118 %), Spanish (3, 0.089 %), French (2, 0.059 %), German (1, 0.03 %) and Japanese (1, 0.03 %). The English was dominating language from the WoS, and scholars tend to publish their articles in English as they want them to be widely accepted. Moreover, most of the published documents were in the form of original research articles written in English language (Khan, et al., 2020).

3.2 Publication Output.

The number of published academic papers is an important indicator to measure the development trend of certain scientific research. Figure 1 shows the publications of rice and climate change topic research between 1990 and 2021. The highest value was 562 in 2020. The number of citations to a paper is considered a good quantitative measure of a paper's impact. In general, the quantity of rice and climate change topic research publications presents a fast growth tendency after 2008. There are 62, 214, 2,328, 773 papers during the period of 1990–1999, 2000–2009, 2010–2019, 2020–2021, respectively. These trends reflect the increasing attention devoted to this area during the past decade.

The quality of publications was measured by the number of citations and *h*-index. The *h*-index was initially proposed as a measure of a researcher's scientific output based on counting the number of publications (*N*) by that researcher cited *N* or more times (Hirsch, 2005). For the total 3,377 papers, the *h*-index is 123, the total number of citations was 88,264 over the period and the average citation per item is 26.14. The first paper on the rice and climate change topic titled of "Potential rice yields in future weather conditions in different parts of Asia" written by Jansen DM was published in 1990 in Netherlands Journal of Agricultural Science (38(4):661–680).

3.3 Web of Science Categories and research areas

There are total 111 WoS subject categories and 75 research areas for rice and climate change topic research. Table 1 showed the top 21 WoS categories and research areas for rice and climate change topic research during 1990–2021. Among these, the top five categories include Environmental Sciences (1,079 papers, 31.951 % of 3,377 papers), Agronomy (568, 16.82 %), Meteorology Atmospheric Sciences (476, 14.095 %), Plant Sciences (404, 11.963 %), and Agriculture Multidisciplinary (301, 8.913 %). The top five research areas include Environmental Sciences Ecology (1,278 papers, 37.844 % of 3,377 papers), Agriculture (1,045, 30.945 %), Meteorology Atmospheric Sciences (476, 14.095 %), Plant Sciences (404,

11.963 %), and Science Technology Other Topics (382, 11.312 %). Journals or papers may be classified in two or more categories in the WoS, shows the multidisciplinary character of this research field (Elango & Ho, 2018). Documents are also mapped to one or several research areas in WoS. In WoS, publications are mapped to WoS categories which are more detailed than research areas (Stopar et al., 2021).

Table 1

Top 21WoS categories and research areas for rice and climate change topic research after 1990.

Rank	WoS categories			Research areas		
	Categories	No. papers	% Total papers	Areas	No. papers	% Total papers
1	Environmental Sciences	1079	31.951	Environmental Sciences Ecology	1278	37.844
2	Agronomy	568	16.82	Agriculture	1045	30.945
3	Meteorology Atmospheric Sciences	476	14.095	Meteorology Atmospheric Sciences	476	14.095
4	Plant Sciences	404	11.963	Plant Sciences	404	11.963
5	Agriculture Multidisciplinary	301	8.913	Science Technology Other Topics	382	11.312
6	Ecology	255	7.551	Water Resources	235	6.959
7	Environmental Studies	254	7.521	Geology	224	6.633
8	Water Resources	235	6.959	Engineering	180	5.33
9	Geosciences Multidisciplinary	221	6.544	Biodiversity Conservation	103	3.05
10	Multidisciplinary Sciences	196	5.804	Business Economics	94	2.784
11	Green Sustainable Science Technology	186	5.508	Food Science Technology	87	2.576
12	Soil Science	157	4.649	Forestry	69	2.043
13	Engineering Environmental	113	3.346	Physical Geography	68	2.014
14	Biodiversity Conservation	103	3.05	Energy Fuels	61	1.806
15	Economics	92	2.724	Remote Sensing	60	1.777
16	Food Science Technology	87	2.576	Chemistry	53	1.569
17	Forestry	69	2.043	Biotechnology Applied Microbiology	51	1.51
18	Geography Physical	68	2.014	Biochemistry Molecular Biology	48	1.421

Rank	WoS categories			Research areas		
	Categories	No. papers	% Total papers	Areas	No. papers	% Total papers
19	Agricultural Engineering	61	1.806	Imaging Science Photographic Technology	48	1.421
20	Energy Fuels	61	1.806	Genetics Heredity	44	1.303
21	Remote Sensing	60	1.777	Development Studies	41	1.214

3.4 Core Journals.

All the 3,377 publications were published in 761 journals and seven book series. The five book series are Advances in Agronomy (16), Annual Review of Phytopathology (2), Advances in Biochemical Engineering Biotechnology (1), Advances in Ecological Research (1), Advances in Parasitology (1), Biotechnology Genetic Engineering Reviews (1) and World Review of Nutrition and Dietetics (1). The top 20 core journals were displayed in the Table 2 with total articles each more than 30 papers, Journal impact factor as IF 2020 and IF 5 year, Quartile rank in Category, etc.

Table 2
Top 20 core Journals on rice and climate change topic research indexed in the WoS.

Rank	Journal	TP	Ratio	IF 2019	IF 5year	QC
1	Science of the Total Environment	97	2.872	7.963	7.842	Q1
2	Climatic Change	71	2.102	4.743	5.633	Q1
3	Agricultural and Forest Meteorology	66	1.954	5.734	5.964	Q1
4	Global Change Biology	65	1.925	10.863	11.716	Q1
5	Sustainability	64	1.895	3.251	3.473	Q2
6	Field Crops Research	58	1.718	5.224	6.19	Q1
7	Agriculture Ecosystems Environment	57	1.688	5.567	6.604	Q1
8	Journal of Cleaner Production	54	1.599	9.297	9.444	Q1
9	Agricultural Water Management	45	1.333	4.516	5.12	Q1
10	Frontiers in Plant Science	45	1.333	5.753	6.612	Q1
11	Agricultural Systems	44	1.303	5.37	5.622	Q1
12	Plos One	44	1.303	3.24	3.788	Q2
13	Scientific Reports	44	1.303	4.379	5.133	Q1
14	Paddy and Water Environment	42	1.244	1.517	1.754	Q3
15	Agronomy Basel	41	1.214	3.417	3.64	Q1
16	European Journal of Agronomy	41	1.214	5.124	5.567	Q1
17	Environmental Research Letters	40	1.184	6.793	7.801	Q1
18	Environmental Science and Pollution Research	35	1.036	4.223	4.306	Q2
19	Journal of Agrometeorology	30	0.888	0.557	0.651	Q4
20	Theoretical and Applied Climatology	30	0.888	3.179	3.375	Q2
Note: TP: Total publications; Ratio: Ratio of 3,377 (%); IF 2020: journal impact factor in 2020; IF5 year: journal impact factor of 5 years; QC: Quartile in Category.						

The top 5 journals, top 10 journals, top 15 journals and top 20 journals published about 10.748 %, 18.419 %, 24.786 % and 29.996 % of the total papers, respectively. The top five Journals are *Science of the Total Environment* (97, 2.872 %), *Climatic Change* (71, 2.102 %), *Agricultural and Forest Meteorology* (66, 1.954 %), *Global Change Biology* (65, 1.925 %) and *Sustainability* (64, 1.895 %), each published more than 64 papers. Based on results of Table 2, among top 20 journals, fourteen journals were in Quartile 1, four journals were in Quartile 2, one journal was in Quartile 3, and one journal was in Quartile 4. White-Gibson

et al (2019) have also demonstrated the importance of publishing articles in the English language in a high IF journals. Journals in the Q1 rank are considered to have the highest impact.

Journal co-citation analysis refers to the phenomenon that occurs when two journals are cited by the same document. Cocitation of journals reflects correlations between various journals and disciplines. The intellectual base of a research field can also be obtained through journal co-citation analysis. According to the publication data in the citation of 761 journals, there were 156 journals meet the thresholds of five publications, which 155 journals were connected to each other. The network of citation in the field of rice and climate change topic research based on WoS was shown eleven clusters with different colors in Fig. 2, the size of circles reflects a total number of journal publication records.

3.5 Authors co-authorship analysis

Authors and their social relationships are the core elements of a research field, as well as an important embodiment of the research power of the field. Those researchers with high academic productivity usually dominate the development tendencies of research field. A total of 12,655 authors have 3,377 publications, and among these, 314 authors met the thresholds of five publications, but only 257 authors were connected with each other. The network has a large number of participants as well as a wide range of collaborations. The network of authorship in the field of rice and climate change topic research based on WoS represented in Fig. 3, the size of circles reflects a total number of records. Authors in the same cluster usually suggested that they studied in a similar field or worked at same institute or had close cooperation with each other.

Table 3 provided the top twenty-two author information published articles in the field of rice and climate change topic research from 1990 to 2021 along with citation, average citations, organization-enhenced and countries, and published more than sixteen papers. Though we combined the some same author with the different spell, but the total number of authors were also calculated separately. Among the all authors, top five authors were Tao Fulu, Pan Genxing, Zhang Zhao, Hasegawa Toshihiro, Jagadish Krishna S.V. (Jagadish, S.V. Krishna; Jagadish, S.V.K), each published more than thirty papers.

Table 3

The top 22 most prolific authors published papers in the field of rice and climate change topic research from 1990 to 2021.

Rank	Author	Papers	Citations	Average citations	Organizations	Country
1	Tao, Fulu	43	2050	47.67	Chinese Acad Sci	China
2	Pan, Genxing	39	3087	79.15	Nanjing Agr Univ	China
3	Zhang, Zhao	36	1824	50.67	Beijing Normal Univ	China
4	Hasegawa, Toshihiro	32	746	23.31	Natl Agr & Food Res Org NARO	Japan
5	Jagadish, Krishna S.V. (Jagadish, S.V. Krishna; Jagadish, S.V.K)	30	1479	49.30	Kansas State University	USA
6	Iizumi, Toshichika	25	763	30.52	Natl Agr & Food Res Org NARO	Japan
7	Jat, M. L.	24	480	20.00	Int Maize & Wheat Improvement Ctr CIMMYT	India
8	Li, Lianqing	23	1121	48.74	Nanjing Agr Univ	China
9	Zhang, Xuhui	22	805	36.59	Nanjing Agr Univ	China
10	Zhang, Weijian	21	518	24.67	Chinese Acad Agr Sci	China
11	Zhu, Yan	21	568	27.05	Nanjing Agr Univ	China
12	Lal, Rattan	20	554	27.70	Ohio State Univ	USA
13	Tang, Liang	19	530	27.89	Nanjing Agr Univ	China
14	Liu, Xiaoyu	18	578	32.11	Nanjing Agr Univ	China
15	Zhang, Hai-Lin (Zhang, Hailin)	18	376	20.89	China Agr Univ	China

Rank	Author	Papers	Citations	Average citations	Organizations	Country
16	Zhu, Jianguo	18	349	19.39	Chinese Acad Sci	China
17	Cao, Weixing	17	270	15.88	Nanjing Agr Univ	China
18	Liu, Leilei	17	327	19.24	Nanjing Agr Univ	China
19	Smith, Pete	17	2074	122.00	Univ Aberdeen	Scotland
20	Cheng, Kun	16	299	18.69	Nanjing Agr Univ	China
21	Confalonieri, Roberto (Confalonieri, R.)	16	426	26.63	Univ Milan	Italy
22	Mueller, Christoph	16	712	44.50	Leibniz Assoc, Potsdam Inst Climate Impact Res PIK	Germany

The organization of the author is the latest institute based on the latest publications. Among the twenty-two authors, there were fourteen authors from China, the organizations were Chinese Acad Sci, Nanjing Agr Univ, Beijing Normal Univ, Chinese Acad Agr Sci, China Agr Univ; two authors are from Kansas State University and Ohio State Univ of USA; two authors are from Natl Agr & Food Res Org NARO of Japan; one author is from Int Maize & Wheat Improvement Ctr CIMMYT of India; one author is from Univ Aberdeen of Scotland; one author is from the Univ Milan of Italy; one author is from Leibniz Assoc, Potsdam Inst Climate Impact Res PIK of Germany. The five authors with the higher average citations per paper were Smith, Pete; Pan, Genxing; Zhang, Zhao; Jagadish, Krishna S.V. (Jagadish, S.V. Krishna; Jagadish, S.V.K); Li, Lianqing; and the average citations per paper was more than 48.74 times.

3.6 Countries/regions co-authorship analysis

There were 113 countries or regions that contributed 3,377 papers in the field of rice and climate change topic research from 1990 to 2021. Table 4 represent the list of the top 21 countries or regions that published more than 52 papers, and also shows the cluster, total link strength, citations and average citations. Among the 21 countries or regions, Peoples R China, USA, India, Australia and Japan were the five major article contributors. In case of average citations, Scotland, Canada, Austria, USA and Netherlands showed the higher citations per paper. The strength of international research collaboration was presented as Total Link Strength (TLS) which is automatically given by VOSviewer upon mapping research activity of selected countries. The TLS is proportional to the extent of international research collaboration where higher TLS value indicates greater collaboration.

Table 4
Top 21 countries/regions publishing papers in the field of rice and climate change topic research from 1990 to 2021.

Rank	Countries/Regions	Records	Cluster	Total link strength	Citations	Average citations
1	Peoples R China	1066	3	954	25427	23.85
2	USA	768	6	1129	35673	46.45
3	India	516	5	441	11593	22.47
4	Australia	320	2	618	11384	35.58
5	Japan	311	2	311	7217	23.21
6	England	250	1	581	9830	39.32
7	Germany	221	4	587	9994	45.22
8	Philippines	161	7	328	7121	44.23
9	Netherlands	128	4	307	5795	45.27
10	South Korea	127	3	118	1613	12.70
11	Bangladesh	123	2	190	1763	14.33
12	Italy	114	1	252	3973	34.85
13	France	109	4	335	3792	34.79
14	Canada	103	2	203	6838	66.39
15	Pakistan	103	3	128	2039	19.80
16	Vietnam	98	2	126	1431	14.60
17	Thailand	87	2	128	2634	30.28
18	Spain	78	1	194	2757	35.35
19	Brazil	54	1	128	743	13.76
20	Austria	53	3	182	2733	51.57
21	Scotland	52	1	212	4185	80.48

We developed the co-authorship network map using VOSviewer (Fig. 4). There are 71 countries or regions that met the requirement threshold as five. The size of circles in Fig. 4 reflects a total number of records and the distance between the countries indicate the strength of relationships. The VOSviewer divided these circles into seven clusters. The different colors group represent the different clusters formed by sets of countries. Distance between the countries indicates the strength of relationships. Importance of

countries/regions is represented by their centrality in the network. Bigger circles represent more publications by a country. Thicker lines indicate more and closer cooperation between countries

According to number of publications from high to low among each cluster in Fig. 4, the first cluster consisted of twenty-one countries or regions (red colour) including England, Italy, Spain, Brazil, Scotland, Switzerland, Sweden, South Africa, Kenya, Norway, Colombia, Denmark, Portugal, Ireland, Argentina, Tanzania, Poland, Hungary, Uganda, Costa Rica and Peru. The second cluster consisted of fourteen countries or regions (green colour) including Australia, Japan, Bangladesh, Canada, Vietnam, Thailand, Malaysia, New Zealand, Indonesia, Finland, Sri Lanka, Singapore, Laos and Bhutan. The third cluster consisted of fourteen countries (blue colour) including Peoples R China, South Korea, Pakistan, Austria, Iran, Belgium, Saudi Arabia, Turkey, Wales, Egypt, Czech Republic, Slovakia, Oman and Greece. The fourth cluster consisted of twelve countries and regions (yellow colour) including Germany, Netherlands, France, Taiwan, Nigeria, Ghana, Russia, Benin, Madagascar, Cote Ivoire, Senegal and Uruguay. The fifth cluster consisted of six countries and regions (violet) including India, Mexico, Nepal, Cambodia, Ethiopia and Afghanistan. The sixth cluster (shallow blue) is including two countries of USA and Israel. The seventh cluster (crown) is including two countries of Philippines and Myanmar. Taiwan, as a region of China, shows the stronger research ability in the field of rice and climate change topic research. More cooperation could bring more advanced achievements in scientific research. Nowadays, increasing concept of international exchanges have promoted academic communications (Tang et al., 2018).

3.7 Organizations co-authorship analysis.

The analysis of research institution will give us the information that which organizations stand on the frontier of this research. According to the publication data, it was revealed that a total of 3,259 organizations have 3,377 publications. Table 5 represents the top 19 organizations and institutions ranked by the number of total publications (more than 41 papers), the total link strength, citations, average citations and country.

Table 5

Top 19 organizations publishing papers in the field of rice and climate change topic research from 1990 to 2021.

Rank	Organizations	Records	Total link strength	Citations	Average citations	Country
1	Chinese Acad Sci	346	600	10328	29.85	China
2	Nanjing Agr Univ	136	233	5846	42.99	China
3	Int Rice Res Inst (IRRI)	133	282	6821	51.29	Philippines
4	Chinese Acad Agr Sci	119	286	3812	32.03	China
5	Univ Chinese Acad Sci	116	214	1490	12.84	China
6	Beijing Normal Univ	80	139	1952	24.40	China
7	China Agr Univ	80	146	1502	18.78	China
8	Int Maize & Wheat Improvement Ctr Cimmyt (Cimmyt)	63	115	1960	31.11	Mexico
9	USDA ARS (USDA, ARS)	61	133	2958	48.49	USA
10	Natl Agr & Food Res Org (NARO)	55	123	956	17.38	Japan
11	Univ Florida	54	188	2197	40.69	USA
12	Huazhong Agr Univ	48	86	2037	42.44	China
13	Natl Inst Agroenvironm Sci	47	84	2719	57.85	Japan
14	Nanjing Univ Informat Sci & Technol	45	71	419	9.31	China
15	Univ Queensland	44	66	793	18.02	Australia
16	Univ Tokyo	44	110	1388	31.55	Japan
17	Wageningen Univ	42	91	2035	48.45	Netherlands
18	Indian Agr Res Inst	41	42	1395	34.02	India
19	Univ Calif Davis	41	72	2914	71.07	USA

These 19 organizations were mainly based in China (eight organizations), USA (three organizations), Japan (three organizations), Philippines (one organization), Mexico (one organization), Australia (four organization), Netherlands (one organization) and India (one organization). Furthermore, top five organizations of Chinese Acad Sci, Nanjing Agr Univ, Int Rice Res Inst (IRRI), Chinese Acad Agr Sci, and Univ Chinese Acad Sci were popular based on contribution of articles more than 116 papers each. Similarly in case of citation, the top five organizations of Univ Calif Davis, Natl Inst Agroenvironm Sci, Int

Rice Res Inst (IRRI), USDA ARS (USDA, ARS) and Wageningen Univ showed the higher average citations more than 48.45 times per paper.

Among the total 3,259 organizations, there were 373 organizations met the minimum thresholds of five, and 371 organizations were connected to each other (Fig. 5). The VOSviewer software divided these 371 institutes into sixteen clusters with different colors. Geographical localization is an important factor for partnership and joint venture.

3.8 All Keywords co-occurrence analysis

Among all 12,577 keywords, only 856 keywords met the threshold level of more than seven times included in the map. Figure 6 shows the network map that links the all keywords to the entire sample of the articles analyzed. There are six main clusters that represent different viewpoints on rice and climate change topic research (Fig. 6). Each node in the figure represents a keyword. The larger the node, the higher the frequency of keyword occurrence; the more lines, the higher the frequency of keyword co-occurrence; additionally, the thickness of the connecting line is proportional to the closeness of the connection. The top twenty-two co-occurrence keywords more than 159 times were climate-change, climate change, rice, temperature, yield, agriculture, impacts, growth, adaptation, food security, wheat, impact, management, model, responses, China, variability, productivity, elevated CO₂, trends, carbon-dioxide, maize, etc.

The same data were then arranged by a period of rice and climate change topic research as overlay map (Fig. 7). Blue colour indicate earlier research topics, whereas, yellow and green colours indicate the more recent topics of interest. The blue coloured topics do not indicate no longer research work on that topics, it usually indicates that, on average, this topic was intensely investigated earlier and now more attention has shifted towards other topics. Perhaps, these terms are now so general, therefore, no longer extensively used as keywords. Yellow and green circles present those research fronts. For example, the keywords of carbon-dioxide in Fig. 7 can be observed with blue circles showing the older topic research, the keywords of adoption, famers, footprint, sustainability, climate change and management in Fig. 7 can be observed with yellow or shallow green circles showing the front research.

Visualizations conducted on large datasets (big data) offer exploratory information on the current state in a scientific field or discipline as well as indicate possible developments in the future. Here, the twenty keywords or so were list and ranked in each cluster based on Fig. 6. Nodes with similar color represent a cluster of related terms.

The first cluster (Red) is focused on rice growth and yield responses to elevated CO₂, and includes keywords as rice, yield, growth, responses, elevated CO₂, carbon-dioxide, drought, grain-yield, photosynthesis, stress, plants, tolerance, high-temperature, *oryza-sativa* L., global warming, *oryza sativa*, atmospheric CO₂, cultivars, heat stress, heat-stress, night temperature, spikelet fertility, etc.

The second cluster (Green) represents the soil management and greenhouse-gas emissions, and including keywords as management, soil, nitrogen, greenhouse-gas emissions, CO₂, nitrous-oxide emissions, methane, dynamics, carbon, emissions, use efficiency, methane emission, N₂O emissions, carbon sequestration, biomass, performance, quality, methane emissions, mitigation, rice fields, cropping systems, etc.

The third cluster (blue) is focused on crop models under climate change, and include keywords as climate change, temperature, impacts, wheat, model, China, variability, trends, maize, simulation, irrigation, crop yield, rice production, rice yield, winter-wheat, yields, precipitation, uncertainty, phenology, resources, crop, models, etc.

The fourth cluster (yellow) represents agriculture adaptation and food security, and keywords include as agriculture, adaptation, food security, impact, productivity, water, vulnerability, systems, crop production, India, land-use, Bangladesh, food, sustainability, system, risk, farmers, strategies, adoption, conservation, land, climate change adaptation, etc.

The fifth cluster (violet) is focused on rice yields response to climate change, and keywords include as climate-change, rice yields, climate, rainfall, irrigated rice, sensitivity, climate-change impacts, weather, environment, wheat yields, united-states, Holocene, radiation, monsoon, cultivation, environmental-change, extreme heat, land use, ozone, high-resolution, rice cultivation, etc.

The sixth cluster (shallow blue) is focused on challenges to climate change, and keywords include as challenges, climate change impacts, pests, losses, crop simulation, dynamic simulation-model, infocrop, tropical environments, agroecosystems, coastal zone, progress, etc.

3.9 The most frequently cited articles

Although a great many articles have been published, a relatively small number of individuals account for a large proportion of the citations within the period. The annual citations of the eight papers showed an increasing trend after year of publication (Fig. 8). The eight papers were written by Lobell et al (2011), Smith et al (2008), Peng et al (2004), Ruddiman (2003), Challinor et al (2014), Weaver and Reisen (2010), Ray et al (2012) and O'Brien et al (2004), etc. Here, the total citations for the most frequently cited articles were more than 638 times. The time dependence of a single paper is called its history. In the beginning year (zero year here), generally the articles have lower citation because of same year of publication. From the publication year to 2021, the average citation per year of the most citation eight papers were 155.82, 87.57, 68.11, 42.58, 98.38, 63.17, 63.8 and 35.44 times, etc. From Fig. 8, it can be found that the citation per year of the papers increased till to 2020, but the increase rate was different each year. Among eight articles, the highest average citation per year (155.82- blue colour) was observed for article of Lobell et al (2011) published in *Science* (Fig. 8).

Conclusions

Based on the Web of Science core database, a detailed analysis was conducted of rice and climate change topic research from 1990 to 2021 through use of a bibliometric method. This study analyzed 3,377 papers in the field of rice and climate change topic research from 1990 to 2021, including 67 highly cited papers. Papers were mainly written in English, from 12,655 authors, 3,259 organizations and 113 countries/territories, published in 761 journals and seven book series. The top five Journals are *Science of the Total Environment*, *Climatic Change*, *Agricultural and Forest Meteorology*, *Global Change Biology* and *Sustainability*. Top five countries and regions were Peoples R China, USA, India, Australia and Japan. Top five organizations were Chinese Acad Sci, Nanjing Agr Univ, Int Rice Res Inst (IRRI), Chinese Acad Agr Sci, and Univ Chinese Acad Sci. Top five authors were Tao Fulu, Pan Genxing, Zhang Zhao, Hasegawa Toshihiro, Jagadish Krishna S.V. All keywords were separated seven clusters for different research topic. The results will help researchers clarify the current situation in rice and climate change adaptation science but also provide guidance for future research.

Declarations

Supplementary Information The online version contains supplementary material available at

Availability of data and material Applicable

Author contribution Conceptualization: Bao-Zhong Yuan and Jie Sun; methodology: Bao-Zhong Yuan and Jie Sun; formal analysis and investigation: Bao-Zhong Yuan and Jie Sun; writing – original draft preparation: Jie Sun; writing – review and editing: Bao-Zhong Yuan. All authors have read and agreed to the published version of the manuscript.

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References

1. Aleixandre-Benavent R, Aleixandre-Tudo JL, Castello-Cogollos L, Aleixandre JL (2017) Trends in scientific research on climate change in agriculture and forestry subject areas (2005–2014). *J Clean Prod* 147:406–418. <https://doi.org/10.1016/j.jclepro.2017.01.112>

2. Bartol T, Mackiewicz-Talarczyk M (2015) Bibliometric analysis of publishing trends in fiber crops in Google Scholar, Scopus, and Web of Science. *J Nat Fibers* 12(6):531–541.
<https://doi.org/10.1080/15440478.2014.972000>
3. Challinor AJ, Watson J, Lobell DB, Howden SM, Smith DR, Chhetri N (2014) A meta-analysis of crop yield under climate change and adaptation. *Nature Climate Change* 4(4):287–291.
<https://doi.org/10.1038/NCLIMATE2153>
4. Elango B, Ho YS (2018) Top-cited articles in the field of tribology: A bibliometric analysis. *COLLNET Journal of Scientometrics Information Management* 12(2):289–307.
<https://doi.org/10.1080/09737766.2018.1529125>
5. Gimenez E, Salinas M, Manzano-Agugliaro F (2018) Worldwide research on plant defense against biotic stresses as improvement for sustainable agriculture. *Sustainability* 10(2):391.
<https://doi.org/10.3390/su10020391>
6. Hirsch JE (2005) An index to quantify an individual's scientific research output. *Proc. Natl. Acad. Sci. U. S. A.* 102(46): 16569–16572. <https://doi.org/10.1073/pnas.0507655102>
7. Hu CX, Cao LZ (2018) Bibliometric and visual analysis of planthopper research between 1980 and 2017. *Curr Sci* 114(12):2445–2452. <https://doi.org/10.18520/cs/v114/i12/2445-2452>
8. Huang L, Chen K, Zhou M (2020) Climate change and carbon sink: a bibliometric analysis. *Environ Sci Pollut Res* 27(8):8740–8758. <https://doi.org/10.1007/s11356-019-07489-6>
9. Jansen DM (1990) Potential rice yields in future weather conditions in different parts of Asia. *Neth J Agric Sci* 38(4):661–680
10. Kane DA, Rogé P, Snapp SS (2016) A systematic review of perennial staple crops literature using topic modeling and bibliometric analysis. *PLoS ONE* 11(5):e0155788.
<https://doi.org/10.1371/journal.pone.0155788>
11. Khan A, Khan D, Akbar F (2020) Bibliometric analysis of publications on research into cotton leaf curl disease. *Discoveries* 8(2):e109. <https://doi.org/10.15190/d.2020.6>
12. Kingra PK, Kaur R, Kaur S (2019) Climate change impacts on rice (*Oryza sativa*) productivity and strategies for its sustainable management. *Indian J Agric Sci* 89(2):171–180
13. Li JF, Wang MH, Ho YS (2011) Trends in research on global climate change: a Science Citation Index Expanded-based analysis. *Global Planet Change* 77(1–2):13–20.
<https://doi.org/10.1016/j.gloplacha.2011.02.005>
14. Li XT, Mao DH, Cheng JM (2018) Study on map knowledge domains of transgenic maize based on Citespace. *American Journal of Agriculture Forestry* 6(3):44–49.
<https://doi.org/10.11648/j.ajaf.20180603.12>
15. Lima CO, Bonetti J (2020) Bibliometric analysis of the scientific production on coastal communities' social vulnerability to climate change and to the impact of extreme events. *Nat Hazards* 102(3):1589–1610. <https://doi.org/10.1007/s11069-020-03974-1>
16. Liu B, Zhang L, Wang XW (2017) Scientometric profile of global rice research during 1985–2014. *Curr Sci* 112(5):1003–1011. <https://doi.org/10.18520/cs/v112/i05/1003-1011>

17. Lobell DB, Schlenker W, Costa-Roberts J (2011) Climate trends and global crop production since 1980. *Science* 333(6042):616–620. <https://doi.org/10.1126/science.1204531>
18. Morita S, Wada H, Matsue Y (2016) Countermeasures for heat damage in rice grain quality under climate change. *Plant Production Science* 19(1):1–11. <http://dx.doi.org/10.1080/1343943X.2015.1128114>
19. Morooka K, Ramos MM, Nathaniel FN (2014) A bibliometric approach to interdisciplinarity in Japanese rice research and technology development. *Scientometrics* 98(1):73–98. <https://doi.org/10.1007/s11192-013-1119-0>
20. Murphy T, Irvine K, Sampson M (2013) The stress of climate change on water management in Cambodia with a focus on rice production. *Climate Dev* 5(1):77–92. <https://doi.org/10.1080/17565529.2013.771570>
21. O'Brien K, Leichenko R, Kelkar U, Venema H, Aandahl G, Tompkins H, Javed A, Bhadwal S, Barg S, Nygaard L, West J (2004) Mapping vulnerability to multiple stressors: climate change and globalization in India. *Global Environmental Change-Human Policy Dimensions* 14(4):303–313. <https://doi.org/10.1016/j.gloenvcha.2004.01.001>
22. Omoregbe O, Mustapha AN, Steinberger-Wilckens R, El-Kharouf A, Onyeaka H (2020) Carbon capture technologies for climate change mitigation: A bibliometric analysis of the scientific discourse during 1998–2018. *Energy Reports* 6:1200–1212. <https://doi.org/10.1016/j.egyr.2020.05.003>
23. Pan XY, Lv JL, Dyck M, He HL (2021) Bibliometric analysis of soil nutrient research between 1992 and 2020. *Agriculture-Basel* 11(3):223. <https://doi.org/10.3390/agriculture11030223>
24. Peng SB (2017) Booming research on rice physiology and management in China: A bibliometric analysis based on three major agronomic journals. *Journal of Integrative Agriculture* 16(12):2726–2735. [https://doi.org/10.1016/S2095-3119\(17\)61804-5](https://doi.org/10.1016/S2095-3119(17)61804-5)
25. Peng SB, Huang JL, Sheehy JE, Laza RC, Visperas RM, Zhong XH, Centeno GS, Khush GS, Cassman KG (2004) Rice yields decline with higher night temperature from global warming. *Proc Natl Acad Sci USA* 101(27):9971–9975. <https://doi.org/10.1073/pnas.0403720101>
26. Rana IA (2020) Disaster and climate change resilience: A bibliometric analysis. *International Journal of Disaster Risk Reduction* 50:101839. <https://doi.org/10.1016/j.ijdr.2020.101839>
27. Ray DK, Ramankutty N, Mueller ND, West PC, Foley JA (2012) Recent patterns of crop yield growth and stagnation. *Nat Commun* 3:1293. <https://doi.org/10.1038/ncomms2296>
28. Ruddiman WF (2003) The anthropogenic greenhouse era began thousands of years ago. *Clim Change* 61(3):261–293. <https://doi.org/10.1023/B:CLIM.0000004577.17928.fa>
29. Santillán-Fernández A, Salinas-Moreno Y, Valdez-Lazalde JR, Pereira-Lorenzo S (2021) Spatial-temporal evolution of scientific production about genetically modified maize. *Agriculture-Basel* 11(3):246. <https://doi.org/10.3390/agriculture11030246>
30. Schneider P, Asch F (2020) Rice production and food security in Asian Mega deltas—A review on characteristics, vulnerabilities and agricultural adaptation options to cope with climate change. *J Agron Crop Sci* 206(4):491–503. <https://doi.org/10.1111/jac.12415>

31. Senguttuvel P, Jaldhani V, Raju NS, Balakrishnan D, Beulah P, Bhadhana VP, Mangrauthia SK, Neeraja CN, Subrahmanyam D, Rao PR, Hariprasad AS, Voleti SR (2020) Breeding rice for heat tolerance and climate change scenario; possibilities and way forward. A review. Arch Agron Soil Sci. <https://doi.org/10.1080/03650340.2020.1826041>
32. Smith P, Martino D, Cai ZC, Gwary D, Janzen H, Kumar P, McCarl B, Ogle S, O'Mara F, Rice C, Scholes B, Sirotenko O, Howden M, McAllister T, Pan GX, Romanenkov V, Schneider U, Towprayoon S, Wattenbach M, Smith J (2008) Greenhouse gas mitigation in agriculture. Philosophical Transactions of the Royal Society B-Biological Sciences 363(1492):789–813. <https://doi.org/10.1098/rstb.2007.2184>
33. Stopar K, Mackiewicz-Talarczyk M, Bartol T (2021) Cotton fiber in web of science and scopus: mapping and visualization of research topics and publishing patterns. J Nat Fibers 18(4):547–558. <https://doi.org/10.1080/15440478.2019.1636742>
34. Sun J, Yuan BZ (2019) Visualization analysis of research on rice with fertilizer from the 'agronomy' category based on CiteSpace. Curr Sci 117(9):1449–1458. <https://doi.org/10.18520/cs/v117/i9/1449-1458>
35. Sun J, Yuan BZ (2020a) A bibliometric analysis of research on rice and irrigation from the 'Agronomy' category based on the Web of Science. Curr Sci 119(3):438–446. <https://doi.org/10.18520/cs/v119/i3/438-446>
36. Sun J, Yuan BZ (2020b) Mapping of the world rice research: A bibliometric analysis of top papers during 2008–2018. Ann Libr Inform Stud 67(1):56–66
37. Sun J, Yuan BZ (2020c) Bibliometric mapping of top papers in Library and Information Science based on the Essential Science Indicators Database. Malaysian Journal of Library Information Science 25(2): 61–76. <https://doi.org/10.22452/mjlis.vol25no2.4>
38. Sun J, Yuan BZ (2020d) Mapping of top papers in the subject category of Water Resources based on the Essential Science Indicators. Ann Libr Inform Stud 67(2):90–102
39. Sun J, Yuan BZ (2021) Trend and research status of Agronomy based on the Essential Science Indicators during 2009–2019. Agron J 113(2):2184–2194. <https://doi.org/10.1002/agj220628.20628>
40. Sweileh WM (2020) Bibliometric analysis of peer-reviewed literature on climate change and human health with an emphasis on infectious diseases. Globalization Health 16(1):44. <https://doi.org/10.1186/s12992-020-00576-1>
41. Tang M, Liao HC, Wan ZJ, Herrera-Viedma E, Rosen MA (2018) Ten years of Sustainability (2009 to 2018): a bibliometric overview. Sustainability 10(5):1655. <https://doi.org/10.3390/su10051655>
42. van Eck NJ, Waltman L (2010) Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics 84(2):523–538. <https://doi.org/10.1007/s11192-009-0146-3>
43. Van Eck NJ, Waltman L (2020) Manual for VOSviewer version 1.6.16. Univeristeit Leiden, Leiden
44. Velasco-Muñoz JF, Aznar-Sánchez JA, Belmonte-Ureña LJ, López-Serrano MJ (2018a) Advances in water use efficiency in agriculture: a bibliometric analysis. Water 10(4):377.

<https://doi.org/10.3390/w10040377>

45. Velasco-Muñoz JF, Aznar-Sánchez JA, Belmonte-Ureña LJ, and I.M. Román-Sánchez (2018b) Sustainable water use in agriculture: a review of worldwide research. *Sustainability* 10(4):1084. <https://doi.org/10.3390/su10041084>
46. Wang B, Pan SY, Ke RY, Wang K, Wei YM (2014) An overview of climate change vulnerability: a bibliometric analysis based on Web of Science database. *Nat Hazards* 74(3):1649–1666. <https://doi.org/10.1007/s11069-014-1260-y>
47. Wang ZH, Zhao YD, Wang B (2018) A bibliometric analysis of climate change adaptation based on massive research literature data. *J Clean Prod* 199:1072–1082. <https://doi.org/10.1016/j.jclepro.2018.06.183>
48. Wang YP, Liu WZ, Li G, Yan WM, Gao GY (2019) A bibliometric analysis of soil and water conservation in the loess tableland-gully region of China. *Water* 11:20. <https://doi.org/10.3390/w11010020>
49. Weaver SC, Reisen WK (2010) Present and future arboviral threats. *Antiviral Res* 85(2):328–345. <https://doi.org/10.1016/j.antiviral.2009.10.008>
50. Wei YM, Mi ZF, Huang ZM (2015) Climate policy modeling: an online SCI-E and SSCI based literature review. *Omega-International Journal of Management Science* 57(SI): 70–84. <https://doi.org/10.1016/j.omega.2014.10.011>
51. White-Gibson A, O'Neill B, Cooper D, Leonard M, O'Daly B (2019) Levels of evidence in pelvic trauma: a bibliometric analysis of the top 50 cited papers. *Ir J Med Sci* 188:155–159. <https://doi.org/10.1007/s11845-018-1818-x>
52. Yuan BZ, Sun J (2019) Bibliometric and mapping of top papers in the subject category of green and sustainable science and technology based on ESI. *COLLNET Journal of Scientometrics Information Management* 13(2):269–289. <https://doi.org/10.1080/09737766.2020.1716643>
53. Yuan BZ, Sun J (2020a) Bibliometric analysis of research on the maize based on top papers during 2009–2019. *COLLNET Journal of Scientometrics Information Management* 14(1):75–92. <https://doi.org/10.1080/09737766.2020.1787110>
54. Yuan BZ, Sun J (2020b) Mapping the scientific research on maize or corn: a bibliometric analysis of top papers during 2008–2018. *Maydica* 65(2):M17
55. Yuan BZ, Sun J (2021a) Bibliometric analysis of Strawberry (*Fragaria × ananassa* Duch.) research publications from Horticulture category based on Web of Science. *Journal of Berry Research*
56. Yuan BZ, Sun J (2021b) Bibliometric analysis of cotton research from Plant Sciences category based on Web of Science. *J Nat Fibers*. <https://doi.org/10.1080/15440478.2021.1952139>
57. Yuan BZ, Bie Z, Sun J (2021) Bibliometric analysis of global research on muskmelon (*Cucumis melo* L.) based on Web of Science. *HortScience*, <https://doi.org/10.21273/HORTSCI15827-21>
58. Zafar SA, Hameed A, Nawaz MA, Wei MA, Noor MA, Hussain M, Mehboob-ur-Rahman (2018) Mechanisms and molecular approaches for heat tolerance in rice (*Oryza sativa* L.) under climate

change scenario. *Journal of Integrative Agriculture* 17(4):726–738. [https://doi.org/10.1016/S2095-3119\(17\)61718-0](https://doi.org/10.1016/S2095-3119(17)61718-0)

59. Zhang YJ, Yu Q, Li J (2021) Bioenergy research under climate change: a bibliometric analysis from a country perspective. *Environ Sci Pollut Res* 28(21):26427–26440. <https://doi.org/10.1007/s11356-021-12448-1>

Figures

Figure 1

Trends in the quantity of published papers of rice and climate change research from 1990 to 2021.

Network visualization maps of citation journals with minimum of 5 publications in the field of rice and climate change topic research based on WoS with 155 circles and 11 clusters.

Figure 3

Network visualization map of top authors in rice and climate change topic research from 1990 to 2021. Cooperation based on co-authorship between authors. Network visualization map of authors with minimum productivity of five publications in the studied field and exist within a collaborative research group.

Figure 4

The country co-authorship network of rice and climate change research related publications from 1990 to 2021. The country co-authorship network map with 71 circles and 7 clusters, the bigger circles represented the more influential countries in this field. The distance and thickness of links represented the degree of cooperation among countries. Clusters are shown by different colors. Importance of countries/regions is represented by their centrality in the network. Bigger circles represent more publications by a country. Thicker lines indicate more and closer cooperation between countries.

Figure 5

The organizations co-authorship network of rice and climate change topic research related publications from 1990 to 2021. The institutions co-authorship network map with 371 nodes and 16 clusters, the bigger nodes represented the more influential institution in this field. The distance and thickness of links represented the degree of cooperation among organizations.

Figure 6

VOSviewer co-occurrence network visualization mapping of most frequent all keywords (minimum of 7 occurrences) on rice and climate change topic research. Co-occurrence network of all keywords including author keywords and keywords plus. Of the all 12,577 keywords, there were only 856 keywords meet the threshold more than 7 times included in the map. After keywords analysis, there are six main clusters that represent six different viewpoints on rice and climate change topic. Nodes with similar color represent a cluster of related terms.

Figure 7

VOSviewer co-occurrence overlay visualization mapping of most frequent all keywords (minimum of seven occurrences) on rice and climate change topic research from 1990 to 2021. The years in which specific keywords frequently occur are shown by different colors. Importance of keywords is represented by their centrality in the network. More occurrences of keywords are shown with bigger circles. More co-occurrences of keywords are shown with thicker lines.

Figure 8

Comparison of the citations per year of the most eight papers related to rice and climate change topic research from their initial publications to June 13, 2021.