

A SCIENTOMETRIC ANALYSIS AND VISUALIZATION OF GLOBAL WARMING RESEARCH IN INDIA, 2005-2019

- Arijit Das

- Sananda Gupta

Mr. Arijit Das

Research Scholar,

Department of Library and

Information Science

Jadavpur University, Kolkata -

700032

Email:

arijitdas.lis.rs@jadavpuruniversity.in

Corresponding Author

Ms. Sananda Gupta

Library Assistant,

The Heritage College,

Kolkata- 700 107

Email:

sananda.gupta1005@gmail.com

This paper analyses the growth and development of global warming related research in India during 2005-2019. The main focus of this study is to provide an overview of research activities carried out in the country on the subject for a span of 15 years, describing various aspects of research productivity. The Scopus international multidisciplinary bibliographical database has been used to identify the Indian contributions in the field of global warming. The study analyses the performance based on several quantitative and qualitative indicators, such as annual growth rate of the country, authorship pattern, national publication output and impact in terms of average citation per paper, international collaboration, institution wise contribution etc. The study further use the visualization tool, i.e. VOSviewer to map the different aspects related to co-authorship pattern, word occurrences etc.

Keywords: Global Warming; Scientometrics; Degree of Collaboration; Scopus; India; Authorship Pattern

INTRODUCTION

Scientometric study concerned with the analysis of scientific publications. The concept of scientometrics study developed in the 21st century and this can be applied to any discipline irrespective of their period of evolution. In recent time, many scientometric techniques are evolved and now the studies not only limited to traditional resources but also depends on web and digital resources. Now-a-days global warming is a burning problem and it is a threat to the population and native as well. Global warming is the talk of the day throughout the world. People are curious about the global warming factors like increasing of emissions of green house gases. They are eager to know what it is, why it happens, what measures to be taken to cope up with the problems of global warming. As a result, an explosive growth of literature about the global warming has taken place. The number of scientists working in this field is increasing day by day. The horizon of the knowledge about global warming is widening. Periodicals are the indicator of the literature growth of any field of knowledge.

The main aim of this study is to find out the research trend in the field of global warming throughout the world. Very few literatures are available on global warming with the help of scientometric analysis. The present study attempted to undergo scientometric study based on the research articles referring to global warming published for the last 15 years, i.e., from 2005 to 2019 from a popular bibliographic database and also to analyse those data. The present study could be very useful to the policy makers, decision makers who works on different environmental issues nationally as well as globally and suggests them about the present scenario of research in India and help to take necessary steps for the growth and developments in the field of global warming literature and related areas like effects of greenhouse gases, climate changing factors, mitigating the carbon emissions were also included. All the literatures available related to global warming whether it analysis the causes, effects or its solutions were need to be identified and by the best use of these literatures necessary initiatives can be taken by the policy makers, environmental agencies for the betterment of the society.

LITERATURE REVIEW

In this section an attempt has been taken to highlight the previous works done to analyse the global warming and related literature based on different parameters set by the bibliometric and scientometric analysis and also concludes the importance of these previous studies in respect to the present study. These works are arranged by the latest time of publishare as follows –

Zhang et al. (2021) have conducted a bibliometric analysis from a country perspective on the development of Bioenergy research which will be treated to be a key component for the replacement of energy demands and also mitigating the effects of global warming. The study found the USA, UK and Germany were the leading countries in terms of total publications and also in terms of h-index. The study also highlights that developing countries lagged behind compared to the developed countries in terms of production of such research. The study concluded that developing countries should perform better in research of sustainable energy resources that could strengthen the efforts of mitigation global warming. Santos (2021) carried out a comparative study of global publications trend from 1910 to 2020 on climate related literature and global warming/ climate change/ climate emergency related literature. The data source of the study was based on Web of Science and based on the data present study has analysed different factors related to growth of literature. In terms of publication ratio the last decade noted the most expanding decade in the field of research chosen for the study.

Hamidi and Ramavandi (2020) performed a scientometric study of researches on air pollution in developing countries. This work provides a quantitative, visual, and large-scale review of the majority of publications on ‘air pollution in developing countries’. Based on the search in ISI Web of Science database, 25,363 documents were retrieved for air pollution research in developing countries. The documents were analyzed for co-authorship, countries collaboration, ISI Web of

Science categories co-occurrence, keyword co-occurrence, and institutional collaboration. The data showed that the published studies had an upward trend over the years. Li et al. (2020) have analysed the impacts of climate change on water quality helps to better formulate water quality strategies under the challenge of an uncertain future. This study reviewed 2998 related articles extracted from the Science Citation Index-Expanded database from 1998 to 2018 to analyse and visualize historical trend evolution, current research hotspots, and promising ideas for future research by combining a traditional literature review, bibliometric analysis, and scientific knowledge mapping.

Yue et al. (2020) performed a bibliometric study on research trends related to global carbon footprint. They collected 3698 papers from Web of Science database. The study reveals that from 2007 to 2018, the number of papers published on Carbon Footprint research has shown an upward trend. This area gradually received more attention from researchers. The study also showed that the country and Institute associated with the publications and also they analysed the hot topic in this area. Abeydeera et al. (2019) have conducted a study based on research carried out on major greenhouse gases like carbon dioxide which noted to be the prime climate change factor. This study highlights the research publications in the field from several perspectives which further aims to reduce such types of factors. Major research countries were identified through the study and it gives a clear idea to policymakers, academicians about the future directions of research on the field of carbon emissions and its reductions.

Alexandre-Tudo et al. (2019) carried out a bibliometric analyses on current trends in scientific research on Global Warming. They evaluated 1672 articles from 2005 to 2014. The bibliographic database, i.e. Web of Science was used to gather data. The result shows that the number of research papers reported from 2005 (3%) to 2014 (18%). This growth clearly indicates that Global Warming is now a hot topic and becoming important in our society. Moreover, the study highlights on the high impact factor journals concerned with this topic global warming and also noticed the frequently used keywords from the most cited papers. Newton and Gomathi (2019) focused on global warming research output during the period 2008-17. The research data was obtained from the Web of Science. The study emphasized on the growth of scholarly publications, ranked list of journals, form wise distribution of records, authorship pattern and researcher productivity, country-wise productivity, year wise distribution of records etc. Sangam and Savitha (2019) shows that the number of publications on climate change and global warming are increasing year-wise and single authored contribution decreased, whereas, multiple authored contributions increasing. The Relative Growth Rate also increases gradually from 2001 to 2016 and the doubling time during this period was 0.98 and 4.36 respectively.

Ajitha and Vasudevan (2018) analyse the publication trend of global warming literature during 2012-2017. The study focuses on year wise growth, document wise growth, language of publication, authorship pattern, most published journals, institution wise distribution and country

wise distribution. The data was retrieved from the Web of Science database. The study revealed that the yearly output showed an increasing trend, English is the most preferred language. Majority of the publications are articles, followed by review and book chapter, *the Journal of Climate* is the core journal and the USA is the top among the countries. Mohanathan and Rajendran (2018) studied scientometrics analysis of the papers published on Greenhouse effect in India during the period 2001 - 2017. A total of 568 data retrieved from the Scopus database. The research reveals that in the category of individual authors Tiwari, G. N. published highest number of papers, i.e. 21(3.70%), document-wise distribution shows that the most number of documents are of the type of article totaling to 395 (69.54%) publications. Foreign countries contribution in India shows that the United States of America (USA) has the top rate of involvement with 60 (31.91%) publications.

Shabahat and Muzamil (2015) carried out a scientometric study on global warming literature. They choose a short span of time period, i.e. 5 years. Their sources of data used for the study was Web of science. The study shows that the published data were highest in the year 2013 that is 4788 number of publications, and the lowest was that of the year 2009 that is 2238 publications. The highest number of publications was produced from USA, followed by England. The articles were the most widely used document forms, followed by reviews. The prolific journals were Climate Change and Global Change Biology. Saravanan et al. (2014) have attempted to highlight the quantitative growth and

development of climate change literature in terms of publication output as per Web of science from 1991 to 2012. The focus of this analysis leads to study the literature on climate change published from five developing countries namely Argentina, Brazil, China, India and Mexico. They retrieved 7065 records and Institution wise topper is Academy of Science, China (1843 records). Subject-wise maximum publication is Geosciences (22.4%). English language occupies the first place with 6882 out of 7065 records.

Venkatesan et al. (2013) conducted a scientometric analysis on climate change research productions using online database of Web of science. There were 94756 records contributed worldwide over a period, i.e. 1999-2012. The results shows that there is an increasing trend in research publications through worldwide and majority of the researches have been concentrated in Environmental Science and Ecology and Geology. The developed countries have contributed more in climate change research. Manigandan and Jayaraman (2012) focused in their paper on the research trends in global warming for the past 18 years. The maximum number of articles (6206) appeared in the year 2010. Among the journal-wise publication, *Energy policy* (Impact factor 2.614) is in the top of the list with 1485 articles, out of which, 837 articles were selected and analysed. Majority of articles, i.e. 285 (34.05%) have the length between 6 to 9 pages and maximum number of articles, i.e. 277 (33.09%) were contributed by two authors.

Most of these studies have been done on the current literature available in reputed research

journals of different fields on global warming and related areas within it. These studies help to understand the overall research performance scenario of world on the field and highlight the major concern areas carried out, for instance, top performed countries of the world, data sources used, year wise growth of literature, identified related areas with global warming, major subject areas associated with such research and so on. These all together helps to identify the indicators to show in the study taken for and assess the research performance of India in the field of Global Warming literature and conclude the scenario during the time period of the study, so that the decision makers, academicians, environment related associations can take necessary steps for the development of the field and establish the country globally as a major source of literature in the field.

OBJECTIVES OF THE STUDY

- to find out the year wise growth pattern of publications in global warming literature in India;
- to analyse the authorship pattern and the research performance of individual authors in terms of documents published, citations received and their link strength of association with other authors;
- to find out the major institution in India conducting global warming research;
- to find out the major subject fields carried out research in global warming in India;
- to find out the most productive collaborative countries of global warming research with India;

- to find out the citation pattern of global warming research publications in India.

METHODOLOGY

The study focused on the scientometric analysis of research publications in the field of global warming research in India. Firstly, the data were collected from the international multi-disciplinary bibliographic database, i.e. Scopus. The collected data was then analysed by the aid of scientometric indicators and VOSviewer visualization tool. A total of 2062 records were identified in the field of global warming literature in India for the period from 2005 to 2019. Microsoft Excel was used to classify the collected data. Analysis was made on the basis of different parameters like year wise growth pattern of literature, authorship collaboration, visualization of authorship association in terms of link strength, item wise authorship density visualization, and subject and Indian institution wise distribution of global warming literature.

DATA ANALYSIS AND DISCUSSION

Year wise growth of publications and citation pattern of global warming literature in India

The growth pattern (Table 1) of global warming research in the number of articles published over the last fifteen years period reveals that maximum number of documents published in the year of 2019 with 381 articles and minimum number in the year of 2006 with only 20 articles. A gradual growth rate of publications has been noted during the period in the field of global warming research in India. During this span of fifteen years period of time a total of 2062 research publications has been published from

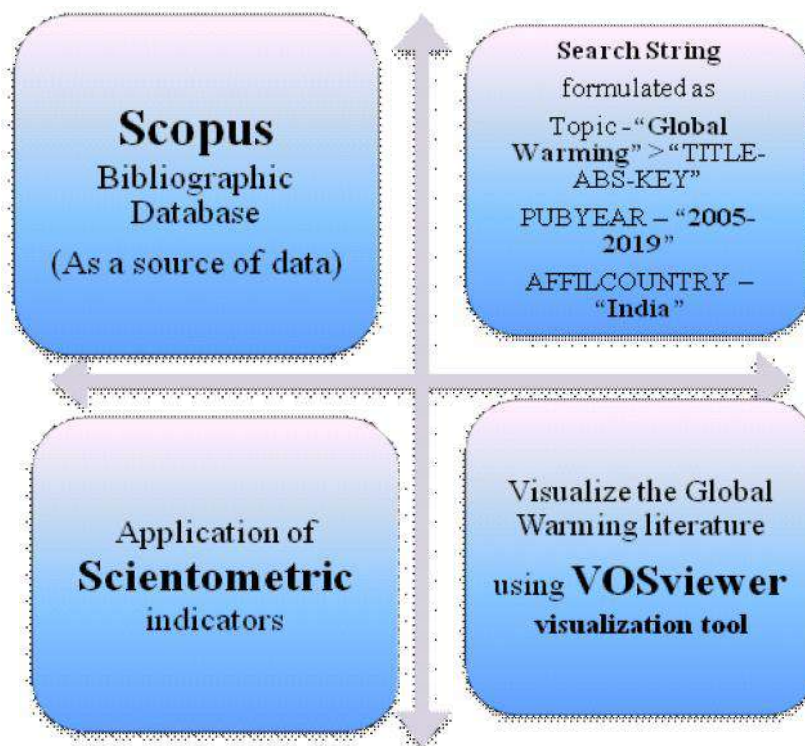


Fig1: Methodological framework of the study

India at an average of 137 papers each year. From 2013 the rate of publications increased over the average number of papers which indicates that

with the change of global environment Indian institutions also increase the rate of research to give more attention in the concerned areas.

Table 1: Year wise distribution of articles and citations

	2005	2006	2007	2008	2009	2010	2011	2012
Total Publications (TP)	23	20	30	44	84	97	128	113
Total Citations (TC)	2120	3608	4863	1495	2574	3682	3200	2517
Average Citations per Paper (CPP) (CPP=TC/TP)	92.17	180.4	162.1	33.98	30.64	37.96	25	22.27
	2013	2014	2015	2016	2017	2018	2019	Total
Total Publications (TP)	158	153	169	192	215	255	381	2062
Total Citations (TC)	6687	2593	2267	2003	1599	1222	414	40,844
Average Citations per Paper (CPP) (CPP=TC/TP)	42.32	16.95	13.41	10.43	7.44	4.79	1.09	19.81

Year wise average citation (Table 1) indicates the productivity of publications of a particular year. From 2005 to 2019 Indian institutions contributed 2062 research papers in the field of global warming related research and these papers together receives 40, 844 citations altogether. The average citation over the fifteen years is noted as 19.81 per paper. Most productive year in terms of average citation received per paper identified in the year 2006, 20 papers published and received 3608 citations at an average of 180.4 citations per paper which is identified above of the total average. Other most productive years noted as 2007 (162.1 citations/paper) and 2005 (92.17 citations/paper). A decreasing rate of average citations was also noted from the year 2008.

Citation impact of global warming publications in India

Citation analysis has been done based on the impact of the papers which measured by the number of citations received by each of the papers published during the study period. The table 2 shows five different categories, which was done on the basis of the citations received by individual papers. There were 592 papers (28.71%) out of 2062 have received 0 citations which categorized

under impact less papers. The most number of papers (892) with 41.71% found under the category of low impact papers which receives 1 to 10 citations, followed by moderate impact papers, receives 11 to 50 citations and the number of papers noted was 444 (21.53%). The last two categories were high impacted papers (110 papers) which receives 51 to 100 citations each and very high impacted papers (56 papers) which receives more than 100 citations. Citation analysis indicates that there are more than half of the papers i.e. 70.42% (1452 papers) belong to impact less and low impacted categories, whereas, only 8.05% (166 papers) of the total papers have more than 50 citations which belongs to high and very high impacted category.

AUTHORSHIP PATTERN AND CO-AUTHORSHIP VISUALIZATION

Authorship pattern

The table 3 presents the predominance of number of multiple authored articles over single authored articles in the field of global warming research in India. This table also shows the year wise distribution of single and multiple authored articles. It is accounted that only 186 articles which means only 9.02% out of total 2062

Table 2: Citation impact of global warming publications in India

Citation Impact	Number of Citations	Number of Papers	% of Papers
Impact less papers	0	592	28.71
Low impact papers	1-10	860	41.71
Moderate impact papers	11-50	444	21.53
High impact papers	51-100	110	5.33
Very high impact papers	>100	56	2.72
Total		2062	100

articles written by single authorship and remaining 1876 articles, i.e. 90.98% written by multiple authorship. Among the four categories from table 3, more than three authored papers accounted most of 41.71% (860 papers), then two authored papers accounted 26.38% (544 papers), followed

by three authored papers of 22.89% (472 papers) and single authored papers of 9.02% (186 papers). Most number of single authored papers (21 papers) and most number of multiple authored papers (360 papers) both noted in the year 2019.

Table 3: Authorship Pattern & Year wise Degree of Collaboration

Year	No. of Single Authored Articles (Ns)	No. of Two Authored Articles (N2)	No. of Three Authored Articles (N3)	No. of More Than Three Authored Articles (N>3)	No. of Total Multiple Authored Articles (Nm) [Nm= N2+N3+N>3]	Degree of Collaboration
2005	2	8	5	8	21	0.91
2006	4	3	3	10	16	0.80
2007	2	12	4	12	28	0.93
2008	8	13	12	11	36	0.81
2009	15	15	18	36	69	0.82
2010	14	22	25	36	83	0.86
2011	13	27	35	53	115	0.90
2012	13	27	20	53	100	0.88
2013	15	44	26	73	143	0.91
2014	15	43	39	56	138	0.90
2015	12	42	48	67	157	0.93
2016	16	44	46	86	176	0.92
2017	18	60	46	91	197	0.92
2018	18	65	62	110	237	0.93
2019	21	119	83	158	360	0.94
Total / %	186 / 9.02%	544 / 26.38%	472 / 22.89%	860 / 41.71%	1876 / 90.98%	0.91

Degree of Collaboration

To measure the Degree of Collaboration (ratio of number of collaborative papers to the

total numbers of paper in a specific period), formula suggested by Subramanyam (1983) is used.

The Formula (Subramanyam, 1983) for calculation of Degree of Collaboration is,

$$C = \frac{Nm}{Nm+Ns}$$

[Where,

C= Degree of Collaboration

Nm = Total number of multi-authored articles

Ns = Total number of single authored articles]

Here, Nm = 1876, Ns = 186, thus the degree of collaboration for the overall fifteen years from 2005 to 2019 of global warming research in India is -

$$\begin{aligned} C &= Nm/Nm+Ns \\ &= 1876/1876+186 \\ &= 0.91 \end{aligned}$$

It is observed from the table 3 that the Degree of Collaboration during all the year was on the higher side and it has been increasing from year by year. The whole Degree of Collaboration accounted 0.91 in the concerned field of research

in India. The lowest three years rate of Degree of Collaboration identified in the year of 2006 (0.80), 2008 (0.81) and 2009 (0.82), whereas, the highest rate identified in the year of 2019 with 0.94, 2018, 2015 and 2007 with 0.93. Out of total fifteen years of study 8 individual years found equal or more than equal rate of Degree of Collaboration of overall 0.91.

Co-authorship Visualization

A total of 5446 authors have been counted by the VOSviewer tool during a span of 15 years time of global warming research in India. For analysis of co-authorship association and item wise authorship density full counting method and authors as a unit of analysis has been chosen from the tool. Other fields used were minimum number of documents of an author was 5 and minimum number of citations taken as 0. As a result, out of 5446 authors 123 met the threshold, each of these authors having at least 5 documents and 5 citations. Based on the total link strength

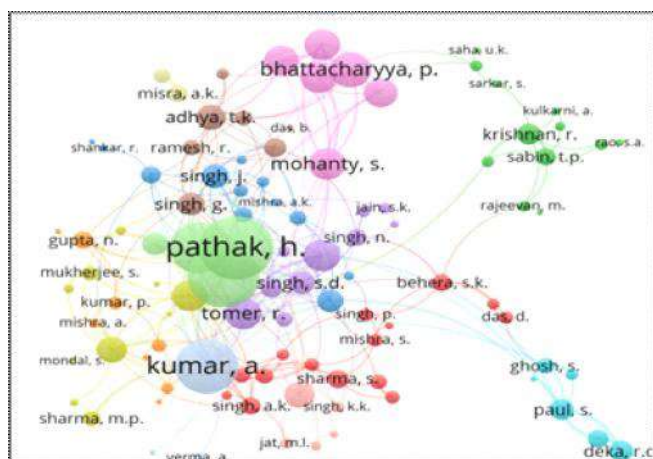


Fig 2: Association of co-authors based on total link strength

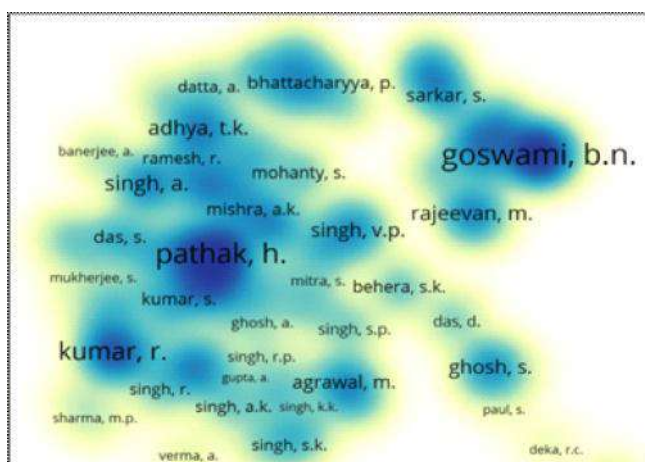


Fig 3: Citation wise authorship density visualization

The figure 3 shows authors density visualization according to their total citations received and total link strength. Authors having higher number of citations have noted more density than other authors. Goswami, B. N. received 1097 citations for his 7 documents published, Pathak, H. receives 981 citations for 26 documents and Kumar, R. receives 745 citations for 32 documents published during the study period. From the above analysis Pathak, H. has performed better among all the authors based on both the parameters whether it is total link strength or citations received. On the other hand Goswami, B. N. has got the highest number of citations for only 7 documents he published but he has only 4 link strength which indicates that he was not much associated with other authors but he has high impact papers.

Contributions on global warming research of Indian Institutions

During the study period for a span of 15 years, a total of 2062 research articles have been identified. All these articles were contributed by Indian affiliated institutions. Among all the institutions, 19 institutions contributed more than 20 articles in the field of global warming research. Top 4 institutions contributed more than 50 articles each, Indian Institute of Tropical Meteorology (89 publications) noted the highest producing global warming research related literature, followed by Indian Institute of Science, Bengaluru (78 publications), ICAR - Indian Agricultural Research Institute, New Delhi (55 publications) and Indian Institute of Technology Delhi (54 publications) respectively. Together these four institutions contributed 276 research papers which are 13.39% of total outputs in India.

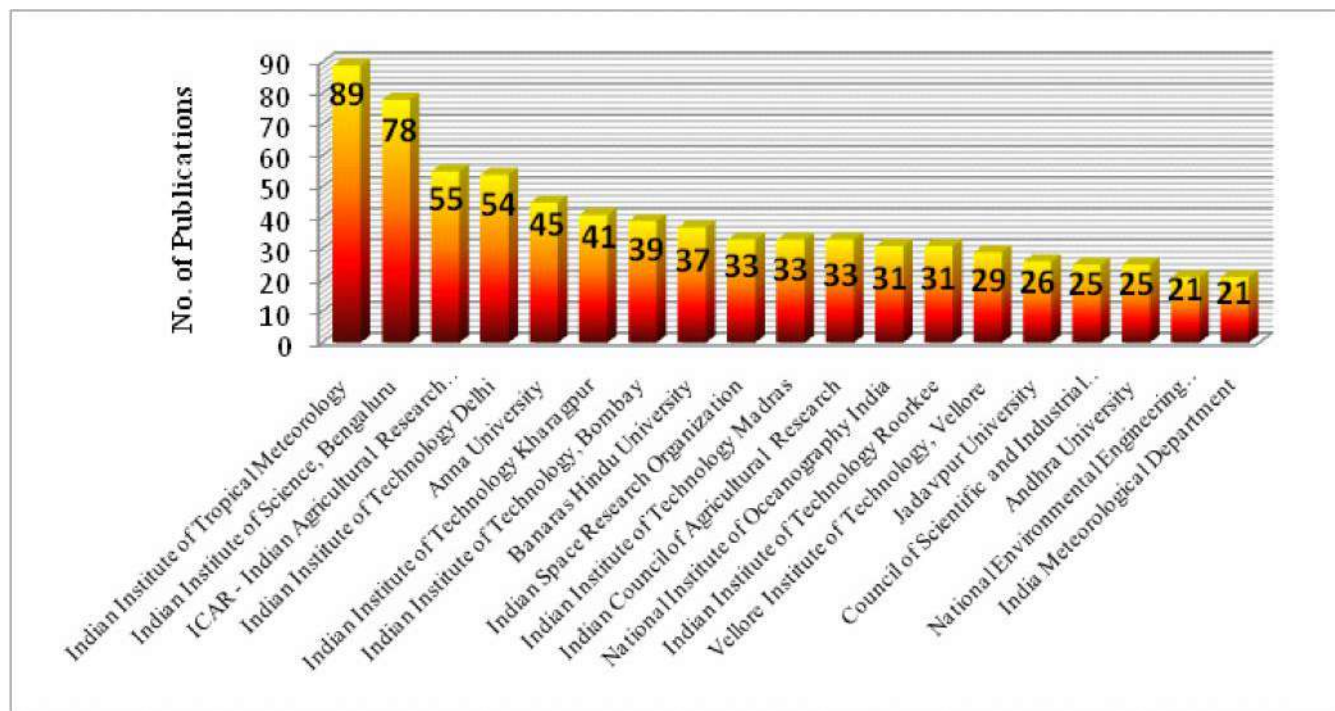


Fig 4: Institution wise distribution of research outputs

Subject wise distribution of global warming research in India

The global warming research publications grouped based on several subject domains and the same is shown in the table 4. The highest number of publications (>100) noted to 5 domains: Environmental Science (654) identified as the top contributed domain, followed by Earth and Planetary Sciences (422), Agriculture (222), Energy (192) and Social Sciences (125). Top two

subject fields, i.e. Environmental Science and Earth and Planetary Sciences contributed more than half (52.19%) of the total publications in the field of global warming research. The contribution of publications in the concerned field has also spread in various other disciplines too. Among them Material Science, Physics and Astronomy, Biochemistry and Molecular Biology are contributed considerable number of papers in the field of global warming research.

Table 4: Subject wise distribution

Sl. No.	Subject Area	Number of Publications	%	Cumulative	Cumulative %
1	Environmental Science	654	31.72	654	31.72
2	Earth and Planetary Sciences	422	20.47	1076	52.18
3	Agriculture	222	10.77	1298	62.95
4	Energy	192	9.31	1490	72.26
5	Social Sciences	125	6.06	1615	78.32
6	Materials Science	86	4.17	1701	82.49
7	Physics and Astronomy	76	3.69	1777	86.18
8	Biochemistry, Genetics and Molecular Biology	75	3.63	1852	89.82
9	Multidisciplinary	60	2.91	1912	92.73
10	Chemistry	35	1.70	1947	94.42
11	Decision Sciences	24	1.16	1971	95.59
12	Economics and Finance	21	1.02	1992	96.61
13	Pharmacology, Toxicology and Pharmaceutics	20	0.97	2012	97.58
14	Arts and Humanities	11	0.53	2023	98.11
15	Others	39	1.89	2062	100.00
Total		2062	100		

Mapping the keyword occurrences of global warming research in India

During a span of 15 years started from 2005 to 2019 as the study period, a total of 2062 research publications have been identified in the field of global warming literature published from Indian institutions. VOSviewer visualization tool

has been used to extract the terms from title field of the articles and a full counting method has also been applied during extracting the terms. Minimum occurrences of a term chosen as 8, as a result, 108 meet the threshold out of the 5762 terms identified by the software tool. For each of these 108 terms VOSviewer calculated a

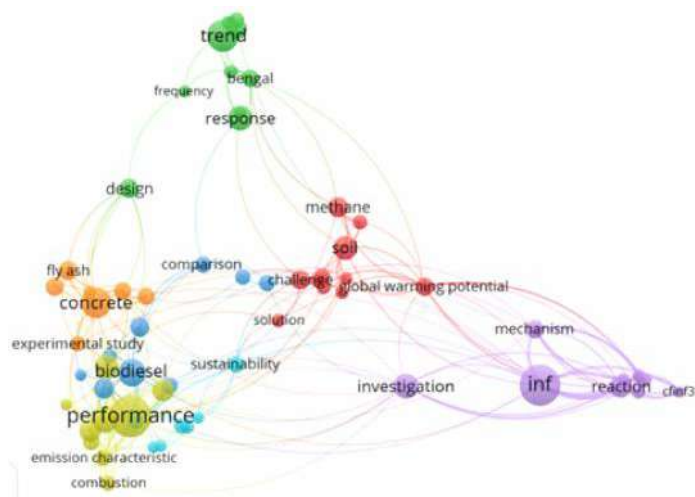


Fig 5: Word occurrences extracted from title field
relevance score and 60% most relevant terms are to be selected to mapping. As a result, 64 terms selected out of these 108 terms based on the relevance score. Some of these terms are not connected to each other, the figure5 showing only the largest set of connected items only. Some of the terms from the figure easily identifiable which

are large set of connection to each other, these are performance, biodiesel, sustainability, solution, global warming potential, fly ash, soil, concrete, trend, methane, reaction, investigation etc. The figure denotes that most of the works are carried out by using such terms and these have a large set of connection to each other in the field of global warming research in India.

International Collaboration

Indian institutions contributed 2062 research papers during a period of fifteen years starting from 2005 to 2019. Out of all these publications India also published 1369 papers i.e. 66.39% of the total publications collaboratively with 119 countries. Among all these collaborative countries 12 countries (Fig 6) identified publishing 25 or more articles with collaboration to India. These top 12 countries published a total of 734 articles out of total 1369 collaborative

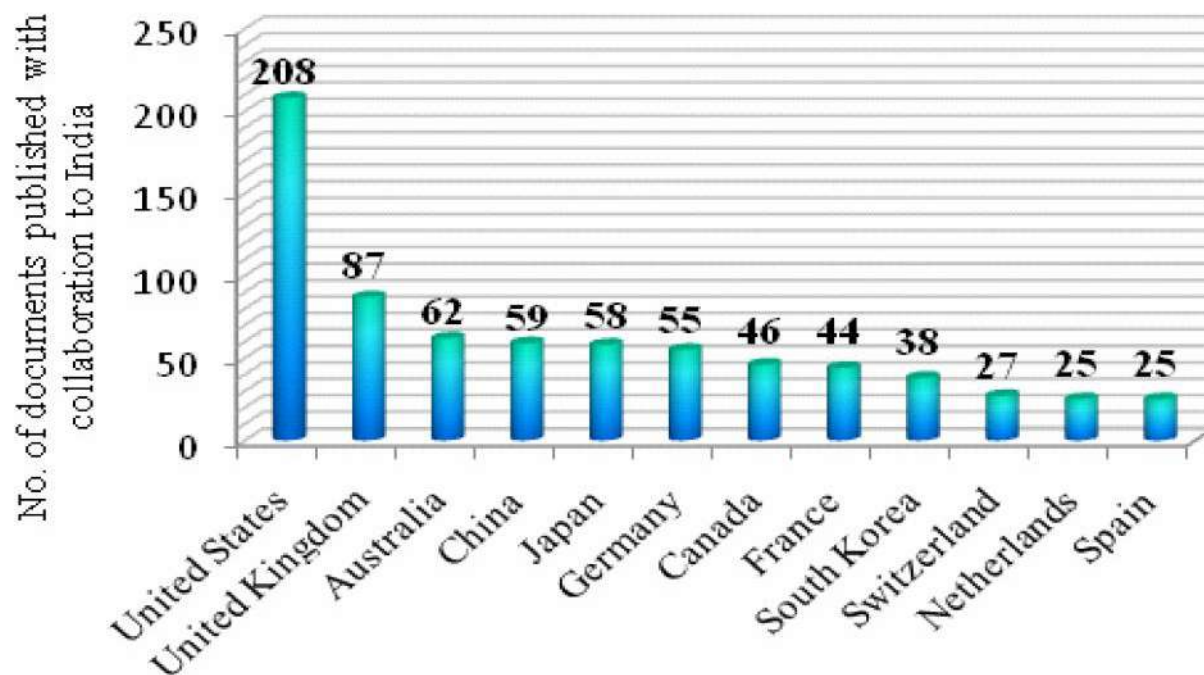


Fig 6: Top Collaborative Countries

articles i.e. 53.62% of total collaborative publications. The United States of America noted as the top collaboration with 208 publications, followed by United Kingdom, Australia, China, Japan and Germany with 87, 62, 59, 58 and 55 publications respectively.

CONCLUSION

This analysis was conducted on global warming literature published in India within the time duration of 15 years starting from 2005 to 2019. During this time, 2019 found as the peak year of number of articles production, i.e. 381. In the category of authorship pattern single authored contribution decreased, whereas, multiple authored contribution increasing constantly. Among the institutions, the Indian Institute of Tropical Meteorology and the Indian Institute of Science, Bengaluru identified as top producing institutes in India. Environmental Science and Earth and Planetary Sciences identified as the most dominated subject domains conducting research on global warming related issues. The United States of America, UK, Germany were among the top international collaboration with Indian authors. Citation analysis indicates that there are more than half of the papers i.e. 70.42% has received less than 10 citations each and categorized as impact less and low impacted articles, whereas only 8.05% of the total papers have received more than 50 citations which categorized as the high and very high impacted papers. It can be concluded by mentioning that the impact of citation analysis indicates that India should look to increase their level of research activities by producing more

quality papers rather publishing more quantity of papers in the field of global warming and related research.

REFERENCES

1. Abeydeera, L. H. U. W., Mesthrige, J. W., & Samarasinghalage, T. I. (2019). Global research on carbon emissions: a scientometric review. *Sustainability*, 11, 3972. <https://doi.org/10.3390/su11143972>
2. Ajitha A., & Vasudevan T M (2018). A scientometric analysis of global warming literature during 2012-2017. *International Journal of Library and Information Studies*, 8(1), 488-494.
3. Alexandre-Tudo, J. L. et al. (2019). Current trends in scientific research on global warming: a bibliometric analysis. *International Journal of Global Warming*, 17(2), 142-169.
- climate research: History and bibliometric trends of publications (1910-2020).
4. Hamidi, A., & Ramavandi, B. (2020). Evaluation and scientometric analysis of researches on air pollution in developing countries from 1952 to 2018. *Air Quality, Atmosphere & Health*, 13, 797-806.
5. Li, X., Li, Y., & Li, G. A. (2020). Scientometric review of the research on the impacts of climate change on water quality during 1998–2018. *Environmental Science and Pollution Research*, 27(13), 14322–14341.
6. Manigandan, I., & Jayaraman, S. (2012). Global warming: a bibliometric study. *Asian Journal*

- of Information Science and Technology*, 2(2), 16-21
7. Mohanathan, P., & Rajendran, N. (2018). Research output of greenhouse effect in India: a scientometric Analysis. *Library Philosophy and Practice (e-journal)*. <http://digitalcommons.unl.edu/libphilprac/2027>
 8. Newton, I., & Gomathi, P. (2019). Research output on global warming: a scientometric analysis. *Journal of Engineering and Applied Sciences*, 14(6), 2022-2031.
 9. Sangam, S. L. & Savitha, K. S. (2019). Climate change and global warming: A scientometric study. *COLLNET Journal of Scientometrics and Information Management*, 13(1), 1-14
 10. Santos, R. M. (2021). *Climate change/global warming/climate emergency versus general climate research: History and bibliometric trends of publications (1910-2020)*.
 11. Saravanan, G. et al. (2014). Climate change research (1991–2012): comparative scientometric study of Argentina, Brazil, China, India and Mexico. *Library Philosophy and Practice (e-journal)*. <http://digitalcommons.unl.edu/libphilprac/1134>
 12. Shabahat, H., & Muzamil, M. (2015). Research assessment of climate change data: a scientometric construct. *Qualitative and Quantitative Methods in Libraries (QQML) Special Issue Bibliometrics and Scientometrics*, 183-194.
 13. Subramanyam, K. (1983). Bibliometric studies of research collaboration: a review. *Journal of Information Science*, 6, 33-38. <https://doi.org/10.1177/016555158300600105>
 14. Venkatesan, M., Gopalakrishnan, S., & Gnanasekaran, D. (2013). Growth of literature on climate change research: a scientometric study. *Journal of Advances in Library and Information Science*, 2(4), 236-242.
 15. Yue, T. et al. (2020). Research trends and hotspots related to global carbon footprint based on bibliometric analysis: 2007–2018. *Environmental Science and Pollution Research*, 27, 17671–17691. <https://doi.org/10.1007/s11356-020-08158-9>
 16. Zhang, Y., Yu, Q., & Li, J. (2021). Bioenergy research under climate change: a bibliometric analysis from a country perspective. *Environmental Science and Pollution Research*, 1-14. <https://doi.org/10.1007/s11356-021-12448-1>.

