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Climate Change Research literature in India: A Scientometric Analysis during 1991 – 2018

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Abstract

Climate change research was assessed in India by Scientometric analysis between the period 1991 to 2018. Data were downloaded from Web of Science (Science Citation Index). The twenty-eight years of study from 1991 to 2018 were used to study the increase in research on climate change. The search string used to search the database was "Climate Change" Search string used in the "Subject" field and the period 1991-2018 were limited and the country of India was refined to download climate change records. A total of 5360 records were identified and downloaded. The records were analyzed to study the year wise distribution, collaborated countries, document wise distribution, productive institution/organization, prominent research area, journal wise distribution, and most productive authors in Climate Change research.

Keywords: *Bibliometrics, Scientometrics, Indian publications, Climate change Research*

1. Introduction

Climate Change refers to alterations in the global weather patterns over past six or seven decades, resulting in adverse changes in ambient temperature, precipitation, wind velocity, carbon-di-oxide levels, ground water table, ocean levels, solar ultra violet radiations and forest cover. These long-term changes affect the global population of microbes, plants, animals and human-beings through perceptible modifications in their physiology, beyond the threshold magnitude.

Global as well as regional climate change patterns show danger signals and their cumulative effect is likely to make this earth uninhabitable maybe over a very long period of time from now. Already certain regions of the globe have started giving signs of failure to support life. The ground water table is exhausted in many regions desertification is a major problem. Urbanization

has resulted in the loss of forest cover and many habitats in the loss have become unavailable to invertebrates, birds and mammals.

Some parts of India are suffering under the scorching sun, while some other parts are in deluge. These disparities are also due to human-induced climate changes. Emission from industries and other types of human activities are making India warmer, disrupting precipitation patterns and increasing the frequency of events connected with extreme weather conditions. Though no country immune to these weather conditions, India is much more vulnerable. This study assessed Climate change research publications in India by Scientometric analysis between the period 1991 to 2018.

2.Review of Literature

Literature review offers a new way to solve the selected problem. This is a summary of the article's evaluation for the selected topic. The following literature was reviewed to gather an idea for the study.

Kumar and Alex (2019) analyzed to identify the research output on marine biology publications period of 1999-2017. They studied the distribution of publications was based on the year of publication, country, language and document type. Relative growth rate of the publications and doubling time was calculated.

Sangam, Shivappa and Savitha (2019) represented a methodological approach focused on climate change and global warming studies as a Scientometric approach. The data obtained from Web of Science during 2001-2016. They analyzed the various objectives of the study, such as publication growth, pattern of authors, collaborating index, degree of collaborations, prominent authors. Publications increased yearly. Single author contribution decreased and collaborative study increased.

Issac Newton and Gomathi (2018) focused on scientometric analysis of global warming during 2008-2010. Scientometric methods are still used to determine individual scientific indicators, promoting scientific results, choosing library journals, and even determining the potential of a chosen field. Recognition for the adaptation of scientometric analysis in different disciplines

increases the ubiquitous growth of literature on scientometrics and related fields. Research data was obtained from Web of Science. The results of studies on global warming were analyzed through Bibliographic details of this study, such as copyright, language, document type were analyzed with Bibxel software tool.

Lukwale, Sophia and Sife, Alfred (2017) assessed research trends on climate change literature in Tanzania between 2006 and 2016. The study analyzed the growth, collaboration between authors and distribution of subject categories on climate change. They analyzed identified citations to publication trends, and analyzed the performance of individual researchers. The findings shows that there were 319 scholarly publications during the past 10-years, gives an average of about 32 publications per year.

Haunschild *et al.* (2016) has studied climate change research publications, it aims to display relevant literature in terms of bibliometrics and presents a number of quantitative data. An increase in the total volume of production of a publication, output of some major sub-areas contributing to journals and countries and their citation are studied.

Ali, Hydar and Adithyakumari (2015) analyzed the results of studies in the field of biodiversity conducted from period from 2003 to 2012, with various parameters, including citation impact, international collaboration, subject field contributions, productivity of leading Indian institutions and most productive authors. The Web of Science database has been used to obtain data for ten years.

Saravanan *et al.* (2014) analyzed climate change research in five scientific networks in developing countries, namely Argentina, Brazil, China, India and Mexico. The study was a comparative study of annual growth, document types, the most prolific authors, relevant journal, language and institutional wise distributions.

Venkatesan *et al.* (2013) analyzed the climate change research using Web of Science database between 1999 and 2012, there were 94,756 records published worldwide. The publications were based on year-wise growth, country, language and type of document. Relative growth rates of publications and doubling times were analyzed. The organizations and funding agencies were

also studied. The results show that there was a growing trend in the world of research, and most research has focused on environmental science, ecology and geology.

Nabout, Joao *et al* (2012) conducted a scientometric analysis of the global climate change (GCC) literature to identify the patterns, trends and biases in this research field. The analysis was based on papers published in all periods available in Thomson ISI database. For each document, the publication year, publication journal, geographic scope, approach used, environment, atmosphere, seawater, taxonomic groups or geophysical variables, and keywords were described.

Jinfeng Li *et al.* (2011) evaluated the global scientific results of climate change research for the past 18 years. They characterized the research methods and research trends. The data are taken from the Science Citation Index, which was extended from 1992 to 2009. Articles on climate change were analyzed according to country, organization, title, and word distribution. According to their study in the 21st century on climate change, “model”, “monitoring”, and “remote sensing” will continue to be cutting-edge research methods. A new method phylogeography is likely to be applicable in the near future.

Alex, P and PreedipBalaji (2010) analyzed results of climate change studies in India over the five years 2005-2009 based on the ISI Science Citation Index. The research emphasis the growth in the field of climate change for five years. There are 25,081 publications worldwide; of these the Indian subcontinent has published 391 articles in more than 101 journals. The purpose of this article is limited to the study of the growth of Indian Publications for five years.

Stanhill, Gerald (2001) analyzed the growth of climate change science as a scientometric study. The annual summaries of scientific publications on climate change, published in the Bulletin of the American Meteorological Society were an indicator of its growth. A growing number of subject headings covering have many aspects of climate change.

3.Objectives

The prime objective of this study is to examine the current state of Indian research productivity in the field of climate change, which was identified in the results of the country’s research studies in the period 1991-2018. The following objectives are structured for the purposes of the present study.

1. To identify the year wise distribution of publications in Climate Change research
2. To find out the collaborated countries with India for publishing Climate Change research.
3. To assess the document wise distribution of research productivity in Climate Change research.
4. To measure the most productive Institution/organization in Climate Change research.
5. To analyze the most productive research areas in Climate Change research.
6. To determine journal wise distribution in Climate Change research.
7. To analyze the most productive authors in Climate Change research.

4.Methodology

The study is on Indian climate change research between 1991 and 2018. This study analyzed the results of research publications on climate change. The data needed for the study of climate change research publications retrieved from the Science Citation Index (SCI) on the Web of Science (WoS). WoS is a research platform provided by Thomson Reuters (Thomson Scientific emerged from Institute for Scientific Information (ISI)). The SCI database is one of the most comprehensive databases covering all areas of science. The raw data was downloaded from the Web of Science. The twenty eight years of study from 1991 to 2018 was used to study the increase in research on climate change. The search string used to search the database was "Climate Change" in the "Subject" field and the period between 1991-2018 were limited and the country of India was refined to download climate change records. Totally 5360 of records were identified and downloaded and these records were analyzed according to the aim of the study. Microsoft Excel was also used to analyze the data.

5.Limitation of the Study

This study is limited to the publications indexed in the Science Citation Index Database. Top 20 results were identified from the distribution of publications. The year limited to 1991-2018.

6.Tools and Techniques used:

6.1.Relative Growth Rate (RGR)

The relative growth rate is increased in the number of publications or pages per unit of time. Relative growth rate and doubling the calculated time for publications. This model was

developed by Mahapatra (1985) and applied to study the growth rate of climate change research publications. The average relative growth rate $R_{(1-2)}$ over a given time period can be calculated from the following equation:

$$\bar{R}_{(1-2)} = \frac{W_2 - W_1}{T_2 - T_1}$$

Where, $R_{(1-2)}$ is mean relative growth rate over the specified period of interval.

$W_1 = \text{Log } W_1$: (Natural log of initial number of publications/pages).

$W_2 = \text{Log } W_2$: (Natural log of final number of publications/pages).

$T_2 - T_1$ = The unit difference between the initial time and final time.

6.2. Doubling Time (Dt)

From the calculation it is known that there is a direct equivalence between RGR and Dt. If the number of entries in the item is doubled over a given period then the difference between the logarithms of the beginning and end of the period must be the logarithm of number 2. If one use natural logarithm, this means that the difference has a value of 0.693 Nutan Gaud et al. (2019). The corresponding doubling time for publications can be calculated by using the following formula:

$$\text{Doubling time (Dt)} = 0.693 / R$$

6.3. Annual Growth Rate (AGR)

The annual growth rate is calculated on the formula given by Kumar and Kaliyaperumal (2015) and it is mentioned below:

$$\text{AGR} = (\text{End Value} - \text{First Value}) / (\text{First Value}) \times 100$$

7. Data Analysis and Interpretation

Scientometric analysis was conducted to evaluate the quantitative and qualitative development of scientific subjects. This article attempts to evaluate qualitative and quantitative research on climate change research based on the distribution of publications from India.

Table 1: RGR and Doubling Time of Publications

S. No	Years	No. of Publications	Cumulative Publications	W1	W2	RGR	dt
1	1991	8	8	---	2.079442	0	0
2	1992	8	16	2.079442	2.772589	0.693147	0.999788
3	1993	12	28	2.772589	3.332205	0.559616	1.23835
4	1994	13	41	3.332205	3.713572	0.381368	1.817145
5	1995	13	54	3.713572	3.988984	0.275412	2.51623
6	1996	16	70	3.988984	4.248495	0.259511	2.670405
7	1997	22	92	4.248495	4.521789	0.273293	2.535737
8	1998	24	116	4.521789	4.75359	0.231802	2.989625
9	1999	27	143	4.75359	4.962845	0.209254	3.311758
10	2000	30	173	4.962845	5.153292	0.190447	3.638808
11	2001	24	197	5.153292	5.283204	0.129912	5.334375
12	2002	38	235	5.283204	5.459586	0.176382	3.928977
13	2003	41	276	5.459586	5.620401	0.160815	4.30929
14	2004	49	325	5.620401	5.783825	0.163424	4.240495
15	2005	71	396	5.783825	5.981414	0.197589	3.50728
16	2006	77	473	5.981414	6.159095	0.177681	3.900244
17	2007	117	590	6.159095	6.380123	0.221027	3.135361
18	2008	125	715	6.380123	6.572283	0.19216	3.60637
19	2009	153	868	6.572283	6.766192	0.193909	3.573838
20	2010	196	1064	6.766192	6.969791	0.203599	3.40375
21	2011	300	1364	6.969791	7.218177	0.248386	2.79001
22	2012	328	1692	7.218177	7.433667	0.21549	3.215931
23	2013	410	2102	7.433667	7.650645	0.216978	3.193872
24	2014	484	2586	7.650645	7.857868	0.207223	3.344223
25	2015	559	3145	7.857868	8.053569	0.195702	3.541105
26	2016	641	3786	8.053569	8.239065	0.185496	3.735926
27	2017	697	4483	8.239065	8.408048	0.168982	4.101019

28	2018	877	5360	8.408048	8.586719	0.178672	3.878626
	Total	5360					

Table 1 show that research results in the period from 1991 to 2018. A total of 5360 scientific articles published throughout India for 28 years. The highest percentage of papers was published in 2018. The above table shows that relative growth rates for Climate Change research is increased to 0.693147 in the year 1992, and it decreased to 0.160815 RGR in 2003. And the doubling time for publications of Climate Change in 2001 has increased to 5.334375 and it is low in the year 1992.

Table 2: Annual Growth Rate (AGR) of Publications

S. No	Years	No. of Publications	Cumulative Sum	% of 5360	AGR
1	1991	8	8	0.149	0
2	1992	8	16	0.149	0
3	1993	12	28	0.224	50
4	1994	13	41	0.243	8.333333
5	1995	13	54	0.243	0
6	1996	16	70	0.299	23.07692
7	1997	22	92	0.41	37.5
8	1998	24	116	0.448	9.090909
9	1999	27	143	0.504	12.5
10	2000	30	173	0.56	11.11111
11	2001	24	197	0.448	-20
12	2002	38	235	0.709	58.33333
13	2003	41	276	0.765	7.894737
14	2004	49	325	0.914	19.5122
15	2005	71	396	1.325	44.89796
16	2006	77	473	1.437	8.450704
17	2007	117	590	2.183	51.94805

18	2008	125	715	2.332	6.837607
19	2009	153	868	2.854	22.4
20	2010	196	1064	3.657	28.10458
21	2011	300	1364	5.597	53.06122
22	2012	328	1692	6.119	9.333333
23	2013	410	2102	7.649	25
24	2014	484	2586	9.03	18.04878
25	2015	559	3145	10.429	15.49587
26	2016	641	3786	11.959	14.66905
27	2017	697	4483	13.004	8.736349
28	2018	877	5360	16.362	25.82496
	Total	5360		100	

Table 2 shows that the Annual Growth Rate (AGR) of Publication during 1991-2018. The highest annual growth rate was 58.33333 in 2002 and the lowest growth rate is -20 in 2001.

Fig 1: Year wise Publication Growth

It shows the year wise publication growth of documents in Climate Change research.

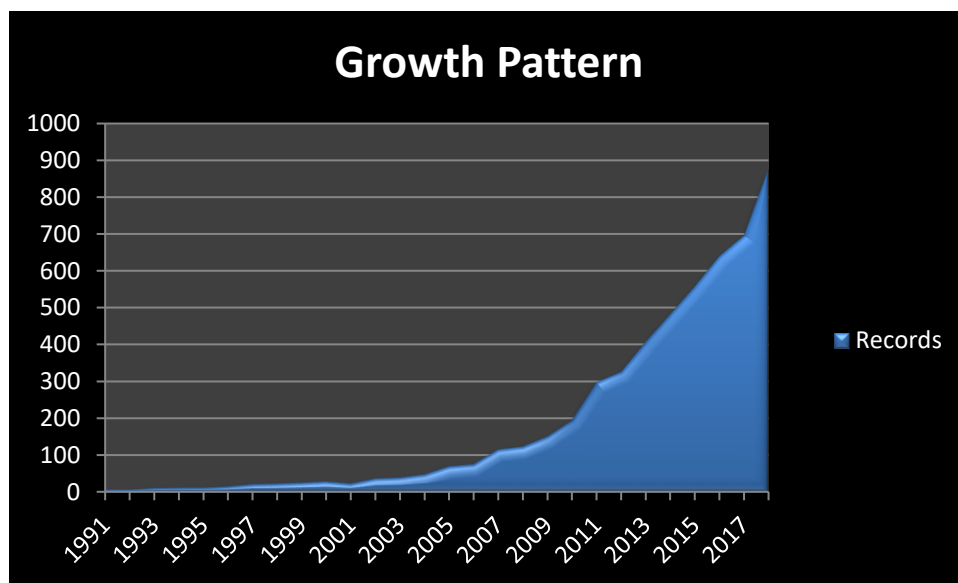


Table 3: Distribution of India's International Collaborative Papers in Climate Change Research

S. No.	Countries/Regions	Records	% of 5360
1	USA	869	16.213
2	England	368	6.866
3	Germany	308	5.746
4	Australia	262	4.888
5	France	246	4.59
6	Peoples R China	218	4.067
7	Canada	193	3.601
8	Japan	158	2.948
9	Netherlands	149	2.78
10	Italy	130	2.425
11	Sweden	126	2.351
12	Switzerland	104	1.94
13	Spain	90	1.679
14	Brazil	88	1.642
15	South Africa	87	1.623
16	Nepal	80	1.493
17	Mexico	76	1.418
18	Scotland	76	1.418
19	Norway	75	1.399
20	Austria	68	1.269

Top 20 countries are listed above in the table 3 shows the Distribution of India's International Collaborative Papers in Climate Change research and the highest number of publication is made by the United States with 290 articles; Norway and Austria are least with 75 and 68 publications for each respectively.

Table 4: Documents type distribution of publications

S. No	Document Types	Records	% of 5360
1	Article	4693	87.556
2	Review	509	9.496
3	Proceedings Paper	125	2.332
4	Editorial Material	95	1.772
5	Letter	38	0.709
6	Book Chapter	37	0.69
7	Meeting Abstract	10	0.187
8	News Item	6	0.112
9	Correction	5	0.093
10	Note	4	0.075
11	Data Paper	2	0.037

The table 4 shows that the document type distribution of the publications. In this category article is most preferred document i.e. Article 4693, 509 review, 125 Proceedings Paper, Editorial Material 95. In this category Data Paper was only 2 it is the least amount used in this document types.

Table 5: Distribution of Publications by Organizations

S. No	Organizations	Records	% of 5360
1	Indian Institute of Technology	524	9.776
2	Indian Institute of Science	293	5.466
3	Indian Institute of Tropical Meteorology	224	4.179
4	Banaras Hindu University	158	2.948
5	Physical Research Laboratory	144	2.687
6	Indian Agricultural Research Institute	138	2.575
7	International Crops Research Institute for the Semi-Arid Tropics	123	2.295
8	Birbal Sahni Institute of Paleobotany	117	2.183
9	National Institute of Oceanography	116	2.164
10	Wadia Institute Himalayan Geology	108	2.015

11	University of Delhi	104	1.94
12	Jawaharlal Nehru University	97	1.81
13	Council of Scientific & Industrial Research	89	1.66
14	Indian Meteorological Department	86	1.604
15	Chinese Academy Science	79	1.474
16	National Institute of Hydrology	77	1.437
17	Indian Space Research Organisation	68	1.269
18	Punjab Agricultural University	67	1.25
19	Anna University	66	1.231
20	Indian Institute of Technology, Delhi	62	1.157

Table 5 shows the publications by distribution of Organizations. Indian Institute of Technology produces more on Climate Change research with 524 publications followed by Indian Institute of Science with 293 publications.

Table 6: Distribution of Publications in the Research Areas

S. No	Research Areas	Records	% of 5360
1	Environmental Sciences Ecology	1421	26.511
2	Geology	1040	19.403
3	Meteorology Atmospheric Sciences	954	17.799
4	Science Technology other Topics	877	16.362
5	Agriculture	657	12.257
6	Water Resources	503	9.384
7	Physical Geography	393	7.332
8	Engineering	373	6.959
9	Plant Sciences	260	4.851
10	Energy Fuels	184	3.433
11	Remote Sensing	119	2.22
12	Oceanography	114	2.127
13	Biodiversity Conservation	112	2.09

14	Geochemistry Geophysics	108	2.015
15	Paleontology	106	1.978
16	Marine Freshwater Biology	99	1.847
17	Forestry	75	1.399
18	Chemistry	66	1.231
19	Imaging Science Photographic Technology	63	1.175
20	Biotechnology Applied Microbiology	62	1.157

Table 6 shows that top 20 research areas of Climate Change research. Most of the Researchers published their research in Climate Change research in the area of Environmental Sciences Ecology with 1421 articles, followed by Geology with 1040 publications.

Table 7: List of Most Productive Journals in Climate Change research

S. No	Source Titles	Records	% of 5360
1	Current Science	423	7.892
2	Journal of Agrometeorology	99	1.847
3	Quaternary International	89	1.66
4	Journal of The Geological Society of India	79	1.474
5	Climate Dynamics	76	1.418
6	Mausam	75	1.399
7	International Journal of Climatology	73	1.362
8	Theoretical and Applied Climatology	71	1.325
9	Climatic Change	66	1.231
10	Scientific Reports	64	1.194
11	Environmental Monitoring and Assessment	63	1.175
12	Journal of Geophysical Research Atmospheres	62	1.157
13	Geophysical Research Letters	61	1.138
14	Journal of Earth System Science	60	1.119
15	Palaeogeography Palaeoclimatology Palaeoecology	59	1.101
16	Indian Journal of Agricultural Sciences	57	1.063

17	Renewable Sustainable Energy Reviews	56	1.045
18	Natural Hazards	55	1.026
19	Atmospheric Environment	50	0.933
20	Global and Planetary Change	48	0.896

Table 7 indicates the top 20 journals which are used for publishing the research papers in the area of Climate Change research. Maximum (423) papers are published in Current Science followed by Journal of Agrometeorology with 99 publications. Quaternary International Published 89 publications. Least articles are published in Global and Planetary Change with 48 articles.

Table 8: Top Indian Authors productivity to Climate Change Research

S. NO	Authors	Records	% of 5360	Rank
1	Kumar, A	90	1.679	1
2	Kumar, S	79	1.474	2
3	Ghosh, S	75	1.399	3
4	Kumar, R	71	1.325	4
5	Singh, S	67	1.25	5
6	Singh, A.K	61	1.138	6
7	Singh, R	55	1.026	7
8	Srivastava, P	54	1.007	8
9	Gupta, A.K	53	0.989	9
10	Singh, P	52	0.97	10
11	Bala, G	51	0.951	11
12	Kumar, P	49	0.914	12
13	Aggarwal, P.K	47	0.877	13
14	Singh, A	45	0.84	14
15	Ravindranath, N.H	44	0.821	15
16	Sharma, A	43	0.802	16
17	Ramesh, R	38	0.709	17

18	Kumar, V	35	0.653	18
19	Sarkar, S	34	0.634	19
20	Joshi, P.K	33	0.616	20

Table 8 indicates the ranking of top twenty authors by the number of publications in Climate Change research during the period 1991-2018. It is clearly seen from the table that Kumar, A has published the highest number of publications with 90 records, followed by Kumar, S with 79 records and Ghosh, S with 75 records , It is also noted that Joshi, P.K has scored the least with 33 publications.

8.Major Findings and Conclusion

The study reveals 5360 scientific articles published throughout India for 28 years during 1991 to 2018. The highest percentage of papers was published in 2018. The relative growth rate (RGR) for Climate Change research during the period it is increased to 0.693147 in the year 1992, and it is decreased to 0.160815 RGR in 2003. And the doubling time for publications of Climate Change in 2001 has increased to 5.334375 and it is low in the year 1992. The highest annual growth rate was 58.33333 in 2002 and the lowest growth rate is -20 in 2001. The highest number of India's International Collaborative Papers in Climate Change research is made by the United States with 290 articles. The study reveals that Articles, Reviews, and proceedings papers are the major document types chosen by the researchers to publish. Indian Institute of Technology produces more on Climate Change research with 524 publications followed by Indian Institute of Science with 293 publications. Most of the Researchers published their research in Climate Change research in the area of Environmental Sciences Ecology with 1421 articles, followed by Geology with 1040 publications. Maximum 423 papers are published in Current Science followed by Journal of Agrometeorology with 99 publications and Quaternary International Published 89 publications. Least articles are published in Global and Planetary Change with 48 articles. Kumar, A has published the highest number of publications with 90 records. As Indians, we are supposed to be concerned about any minor climate-related events in any region of our country. The small step taken by us will be a large leap towards saving our environment for the prosperity. We must adopt novel methods to handle domestic solid wastes, plastics and other industrial refuse etc. When these kind of small innovations are consolidated, the climate change

in India could be delayed. This Scientometric study on Climate Change research can lead the researchers to take the research into further level in relevant areas of climate change.

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