Growth of Global Warming Publications: A Scientometric Approach

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Abstract- The aim of this study is to analyse the publication trends on the topic global warming. Journal articles and contents published over a span of decade (2012-2021) utilised as sample. Data was retrieved from Web of Science database. A total of 39149 publications were found on the topic global warming. The data was analyzed using Microsoft excel and it was found that the average number of publications per year was 3915. The highest number 6758 articles were published during the year 2021. Relative Growth Rate (RGR) is found to be in a downward trend from 2013 (0.75) to 2021 (0.19). The doubling time (DT) was found to be in an upward trend from 2013 (0.92) to 2021 (3.65).Among the countries contributed to global warming topic USA published more number of articles 11518 (29.42%) and achieved first rank in publications. China ranked second with 8961 (22.89%) shares of publications followed by England with 3939 (10.021%). Journal of cleaner production has published 1081 (2.76%) articles and achieved an impact factor of 5.84 for the year 2021, followed by this Geophysical research letters has published 944 (2.41%) publications and achieved impact factor of 4.99. This study identified most productive authors and their affiliations institutes from which they publish the papers. Also this study focused on which subject areas where more number of articles being published.

Index Terms- Annual growth rate, Doubling time, Global warming, and Relative growth rate

INTRODUCTION

Global warming is a major environmental problem faced in the earth and its impacts affects the lively hood of all the living beings. Global warming is happening due to the industrialization, and emission of carbon dioxide by human intervention.

Global warming is an increase in the average temperature of the Earth's atmosphere, especially a sustained increase great enough to cause changes in the world climate. The increase in carbon dioxide level is making the Earth's atmosphere hotter. Global warming causes a lot of climate changes in the atmosphere such as changes in weather patterns, changes in air circulation patterns, jet stream, rain without season, melting ice caps, declining ozone layer, the occurrence of heavy storms, cyclones, floods, epidemic diseases, lack of food and so many effects. Its threatening effects are increasing day by day and creating danger for human life. It has become one of the subjects of big social issues which need individual social awareness to a great level. There are many causes of global warming some are natural causes and human-made causes. The most important cause of global warming is greenhouse gases which are generated by some natural processes as well as human activities. So, the global warming change was a large impact on world agricultural productivity in the coming years.

Since global warming is hot topic most of the researcher's, academicians and others concentrate more on this particular topic for their study. Hence this study was initiated to analyse the topic global warming using scientometric tools to know the trends for a decade. Therefore, the present study has been undertaken to know the growth and development of publications in the field of global warming.

REVIEW OF LITERATURE

Sangam and Savitha (2019) presented a methodological approach study emphasis on, Scientometric approach to climate change and global warming literature during 2001-2016 from the Web of science database. The study analysed various parameters such as growth trend, authorship pattern, collaborative index, collaborative co-efficient, degree of collaboration, division of forms, most preferred authors, country-wise distribution and other parameters. The number of publications constantly increased year-wise and single-authored contributions decreased whereas multiple-authored contributions increasing. Both degree of collaboration of multi authors and collaborative co-efficiency have increased.

Rahaman and Joshi (2022) analyzed the research productivity of global warming between 2011 and 2020 based on bibliometrics. A total of 3858 papers have been downloaded from the web of science database and analyzed focused bibliometrics indices, namely annual growth, productive country and organization, prolific author and their pattern of authorship, type of research, most cited reference and research paper, most impactful source, and the theme of research in global warming.

Arijit Das and Sananda Gupta(2021) analysed the growth and development of global warming research in India during 2005-2019. The study analysed 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, and institution-wise contribution.

Issac and Gomathi (2019) analysed the global warming research publication indexed in the web of science database during the period 2008-2017 and retrieved 19969 records. The study analysed the growth of scholarly publications, ranked list of journals, form-wise distribution of records, authorship pattern and researchers' productivity, country-wise productivity, year-wise distribution of records, etc.

OBJECTIVES OF THE STUDY

The objectives of this study are:

- To find total number of contents being published during the year 2012-2021 on the topic global warming
- To find annual growth rate of publications
- To find relative growth rate and doubling time
- To find most creative authors
- To find highly productive institutes
- To find which countries publish more contents
- To find which journal publishes more number of articles with its impact factor
- To analyse which subject area does the authors publish more number of papers.

MATERIALS AND METHODS

The Web of Science database was used for retrieving data on global warming for ten years from 2012 to 2021. A total of 39149 publications were downloaded from Web of Science database. The downloaded data was analysed using the Microsoft excel to achieve the objectives of the study. The Web of Science database allows us to refine the results in terms of publication years, countries, institutes, authors, language, subjects and source titles. Only journal articles and review articles were considered for the analysis.

DATA ANALYSIS AND INTERPRETATIONS

The retrieved data was analysed using simple percentage anslysis, AGR, RGR formula, and ranking tools and presented in this part.

Table 1 Type of Publications

S.No.	Title	Articles	Percentage
1	Articles	35685	91.22
2	Review articles	2774	7.09
3	Editorial materials	391	1.00
4	Book reviews	92	0.24
5	News items	62	0.16
6	Letters	57	0.15
7	Corrections	53	0.14
8	Data papers	21	0.05
9	Retracted Publications	8	0.02
10	Biographical-Items	3	0.01
11	Reprints	2	0.01
12	Retractions	1	0.00
Total		**39149**	**100**

Global warming literature in the world has been published in different forms of publications. Out of the 39149 literatures published, 35985 (91.22%) were Journal articles, 2774(7.09%) were Review articles, 391 (1%) Editorial materials and the remaining 0.74% publications belong to other forms. It was found from the study that publications trend on the topic global warming, researchers have contributed more literatures in the form of journal articles.

GROWTH OF PUBLICATIONS

Table 2 provides the AGR of the number of publications for the period 2012 to 2021.

$$AGR = \frac{\text{End Value - First Value}}{\text{First Value}} \times 100$$

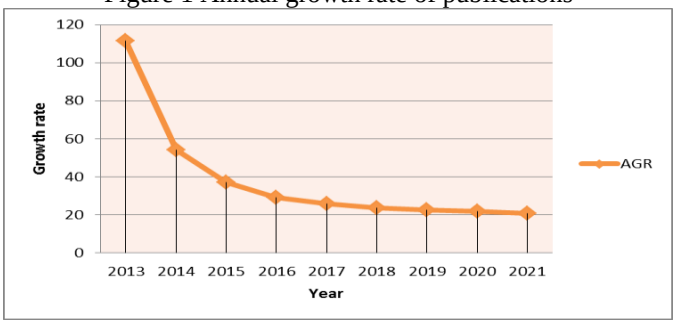
Table 2 AGR of Publications

Year	No. of publications	Cumulative total	Annual growth rate (AGR)
2012	2426	2426	-
2013	2701	5127	111.34
2014	2783	7910	54.28
2015	2937	10847	37.13
2016	3156	14003	29.09
2017	3603	17606	25.73
2018	4139	21745	23.51
2019	4869	26614	22.39
2020	5777	32391	21.71
2021	6758	39149	20.86

A total of 39149 publications were published during the year 2012-2021. The average number of publications per year was 3915. There were only 2426 publications in 2012 and continuous growth of publications was observed during the study period. The highest publications (6758) recorded during the year 2021. It was observed that there was a steady growth in publications from 2012 to 2021.

From table 2 it was found that the annual growth rate (AGR) of the total publications decreasing from 111.34 in 2013 to 20.86 in 2021. This shows that the decreasing trend in the growth rate was found as seen in figure 1.

Figure 1 Annual growth rate of publications



RELATIVE GROWTH RATE (RGR) AND DOUBLING TIME

The Relative Growth Rate (RGR) is the increase in number of articles or pages per unit of time. This definition derived from

the definition of relative growth rates in the study of growth analysis in the field of global warming. The mean relative growth rate (R) over the specific period of interval can be calculated from the following equation.

Relative Growth Rate (RGR)

1 - 2R=Log W2 – Log W1/ T2-T1

Whereas

1-2 R- mean relative growth rate over the specific period of interval

Loge W1 - log of initial number of articles

Loge W2 - log of final number of articles after a specific period of interval

T2-T1- the unit difference between the initial time and the final time

The year can be taken here as the unit of time.

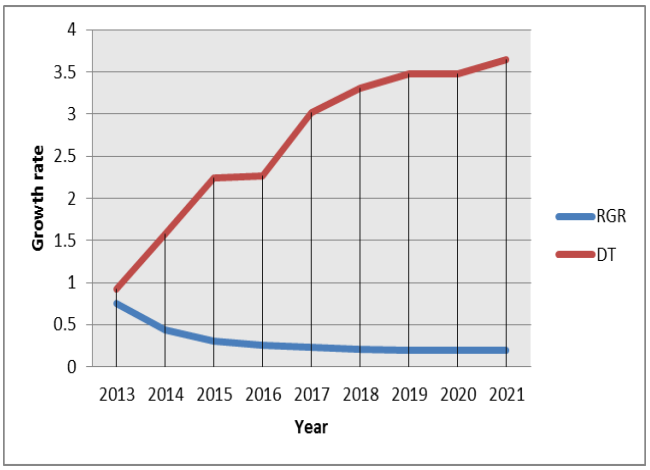
Doubling Time (DT) = 0.693/R

Table 3 Relative growth rate (RGR) and Doubling time (DT) of publications

Year	No. of Publications	Cumulative Total	W1	W2	RGR	DT
2012	2426	2426	-	7.79	-	-
2013	2701	5127	7.79	8.54	0.75	0.92
2014	2783	7910	8.54	8.98	0.44	1.58
2015	2937	10847	8.98	9.29	0.31	2.24
2016	3156	14003	9.29	9.55	0.26	2.27
2017	3603	17606	9.55	9.78	0.23	3.01
2018	4139	21745	9.78	9.99	0.21	3.30
2019	4869	26614	9.99	10.19	0.20	3.47
2020	5777	32391	10.19	10.39	0.20	3.47
2021	6758	39149	10.39	10.58	0.19	3.65

The year-wise Relative Growth Rate (RGR) is found to be in the range of 0.75 to 0.19. It has been observed from Table 3 and figure 2 that RGR is in a downward trend from 2013 (0.75) to 2021 (0.19). The doubling time (DT) was in an upward trend from 2013 (0.92) to 2021 (3.65).

Figure 2 Relative growth rates for research output



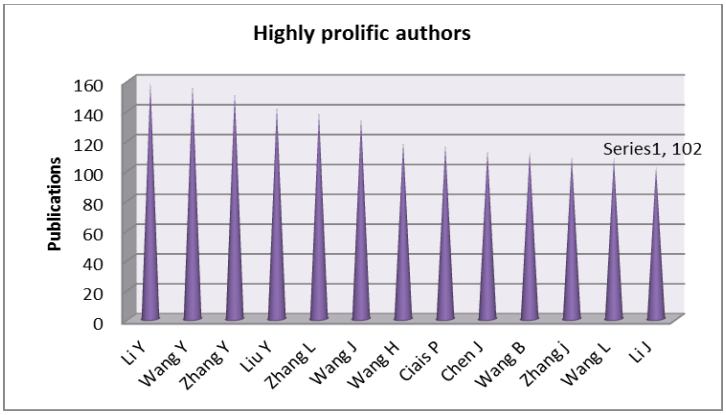
IDENTIFICATION OF MOST CREATIVE AUTHORS

The authors having100-160 or more publications during 2012-2021 are given in Table 4. Li, Y is the most productive author with 159 (0.41%) publications followed by Wang, Y with 157 (0.40%) publications, Zhang, Y with 152 (0.39%) publications, Liu, Y with 143 (0.37%) publications, Zhang, L with 139 (0.36%) publications, Wang, J with 135 (0.35%) publications, Wang, H with 119 (0.30%) publications and Ciais, P with 42 (0.18%) publications respectively. And a total of One lakhs authors have jointly published 38459 articles during the study period.

Table 4 Identification of most creative authors

Rank	Author	No. of publications	Percentage
1	Li Y	159	0.41
2	Wang Y	157	0.40
3	Zhang Y	152	0.39
4	Liu Y	143	0.37
5	Zhang L	139	0.36
6	Wang J	135	0.35
7	Wang H	119	0.30
8	Ciais P	117	0.30
8	Chen J	113	0.29
10	Wang B	112	0.29
11	Zhang j	109	0.28
12	Wang L	108	0.28
13	Li J	102	0.26

Figure 3 Most creative authors



HIGHLY PRODUCTIVE INSTITUTES

Table 5 Highly productive institutes

Rank	Institutions	Country	No. of Publications
1	Chinese Academy of Science	China	3117 (7.97%)
2	University of Chinese Academy of Science	China	1134 (2.90%)
3	National Oceanic and Atmospheric Administration	USA	640 (1.64%)
4	Manjing University of Information Science and Technology	China	575 (1.47%)

5	Columbia University	USA	544 (1.39%)
6	National Centre for Atmospheric Research	USA	526 (1.34%)
7	University of Washington	USA	508 (1.30%)
8	University of Colorado	USA	478 (1.22%)
9	NASA	USA	466 (1.19%)
10	Beijing Normal University	China	430 (1.10%)

Table 5 presents the top ten highly productive institutes that have contributed 430 or more publications on global warming during 2012-2021. A total of 19,416 institutions have contributed entire research output as papers published in various journals. Among the top ten institutions six are from USA and four from China. Chinese Academy of Science, China topped the list with 3117 (7.97%) publications followed by University of Chinese Academy of Science, China with 1134 (2.90%) publications, National Oceanic and Atmospheric Administration, USA with 640 (1.64%) publications, Manjing University of Information Science and Technology, China with 575 (1.47%) publications, Columbia University, USA with 544 (1.39%) publications, National Centre for Atmospheric Research, USA with 526 (1.34%) publications and University of Washington, USA with 308 (1.32%) publications respectively. From the table 5 it was inferred that Chinese academy of science has published 7.97%(3117) papers. Which was found to be the first rank achieved institute that contributes more on global warming topic.

HIGHLY PRODUCTIVE COUNTRIES

Table 6 Highly productive countries

Rank	Country	Total Publications (%)
1	USA	11518 (29.42%)
2	China	8961 (22.89%)
3	England	3939 (10.01%)
4	Germany	3838 (9.80%)
5	Australia	2902 (7.41%)
6	France	2603 (6.65%)
7	Canada	2466 (6.30%)
8	Spain	2196 (5.61%)
9	Japan	2085 (5.33%)
10	Italy	1966 (5.02%)
11	India	1747 (4.46%)
12	Switzerland	1442 (3.68%)
13	South Korea	1351 (3.45%)
14	Sweden	1320 (3.37%)
15	Netherlands	1305 (3.33%)
16	Norway	1189 (3.04%)

In all, there were 191 countries involved in the research in the global warming field and which published at least one publication. The publications share of highly productive countries (≥1000 publications) in global warming varies from 3.04% to 29.42% as seen in table 6 and figure 5. USA ranked first with the highest share 11518 (29.42%) of publications. China ranked second with 8961 (22.89%) share of publications followed by England with 3939 (10.021%) share of publications, Germany with 3838 (9.80%) share of publications, Australia with 2902 (7.41%) share of publications, France with 2603 (6.65%) share of publications, Canada with 2466 (6.65%) share of publications, Spain with 2196 (5.61%) share of publications and Japan with 2085 (5.33%) share of publications, India with 1747 (4.46%) share of publications and the remaining countries are publishing less than 4% of the research output in this study period. However, USA and China together account for 52% of world global warming research publications. India 11th ranks among the countries publishing global warming publications.

LANGUAGE WISE DISTRIBUTION OF PUBLICATIONS

Table 7 Language wise distribution of publications

Rank	Language	No. of Publications (%)
1	English	38990 (99.59%)
2	Chinese	43 (0.11%)
3	French	32 (0.08%)
4	German	22 (0.06%)
5	Spanish	17 (0.04%)
6	Japanese	14 (0.04%)
7	Portuguese	10 (0.03%)
8	Russian	9 (0.02%)
9	Hungarian	4 (0.01%)
10	Polish	4 (0.01%)
11	Norwegian	2 (0.01%)
12	Eskimo	1 (0.00%)
13	Italian	1 (0.00%)

Publications on global warming are spread over 13 languages. The study reveals that the maximum number of publications have been published in English language with 38990 (99.59%) publications, followed by Chinese language with 43 (0.11%) publications, French language ranks third position with 32 (0.08%) publications, German language with 22 (0.06%) publications, Spanish language with 17 (0.04%) publications, Japanese language with 14 (0.04%) publications and Portuguese language with 10 (0.03%) publications. The most predominant language used for communication was English in every year in total productivity on the subject during the study period.

MOST PREFERRED JOURNALS FOR PUBLICATIONS

The scientific literatures retrieved on global warming topic are published in 3339 different web of science indexed journals. Table 8 provides the leading journals each with total number of publications its percentage and impact factors. From the table it was inferred that Journal of Clearner Production published highest number of articles also its impact factor is found to be 5.84 which is highest than the other journals. Followed by this Geophysical research letters with a share of 944 (2.41%) publications and an impact factor is 4.99. Journal of climate occupies the third position with 849

(2.17%) publications and the impact factor is 4.45. The fourth highest source title is Climate dynamics with 752 (1.91%) publications and an impact factor is 4.71, Science of the total environment with 747 (1.75%) publications and an impact factor is 7.96 and Global change biology with 716 (1.83%) publications and the impact factor is 8.44.

Table 8 Most Preferred Journals for Publications

Rank	Journals	No. of Publications	Percentage	Impact Factor
1	Journal of cleaner production	1081	2.76	5.84
2	Geophysical research letters	944	2.41	4.99
3	Journal of climate	849	2.17	4.45
4	Climate dynamics	752	1.92	4.71
5	Science of the total environment	747	1.91	7.96
6	Global change biology	716	1.83	8.44
7	Environmental research letters	697	1.78	3.91
8	Scientific reports	570	1.46	4.38
9	Journal of geophysical research atmospheres	545	1.39	3.32
10	Sustainability	539	1.38	3.25

HIGH PRODUCTIVITY SUBJECT AREAS

Table 9 High productivity subject areas

Rank	Subject	No. of Articles	Percentage
1	Physical Science	12447	31.79
2	Environmental sciences ecology	12347	31.54
3	Engineering	6795	17.36
4	Energy fuels	4162	10.63
5	Science and technology	2150	5.49
6	Geography	1771	4.52
7	Marine freshwater biology	1651	4.22
8	Plant Sciences	1575	4.02
9	Chemistry	1321	3.37
10	Agriculture	1292	3.30
11	Life Sciences Biomedicine	1025	2.62

The scientific literature on global warming is spread over around 96 different subjects. Table 9 shows high productivity subject areas which are contributing more than 1000 articles. It is found that Physical Science subject area has the highest number of articles with 12447 (31.79%) followed by Environmental sciences ecology contributing 12347 (31.54%) articles. Engineering occupies the third position with 6795 (17.36%) articles. The fourth highest number of articles belonged to the subject Energy fuels with 4162 (10.63%), Science and technology with 2150 (5.49%), and Geography with 1771 (4.52%) articles respectively.

CONCLUSIONS

From this study the growth and development of research publications on global warming was dealt and the following conclusions were made. A total of 39149 publications were published during 2012-2021 and the average number of publications per year was 3915. There was a steady growth in publications during the study period. However annual growth rate trend found to be decreasing. USA topped the list with the highest share 11518 (29.42%) of publications. China ranked second with 8961 (22.89%) share of publications followed by England 3939 (10.021%) share of publications, Germany with 3838 (9.80%) share of publications. Chinese Academy of Science, China topped the list with 3117 (7.97%) publications followed by University of Chinese Academy of Science, China with 1134 (2.90%) publications, National Oceanic and Atmospheric Administration, USA with 640 (1.64%) publications, Manjing University of Information Science and Technology, China with 575 (1.47%) publications. The scientific literature on global warming is spread over 96 different subjects. The most prolific authors, highly productive subjects, and also the most preferred journals with impact factors they publish have also been identified.

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