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CLIMATE CHANGE ON BIODIVERSITY: A SCIENTOMETRIC STUDY

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Abstract:

The present study is an attempt to analyze the dataset obtained from the Web of Science database scientometrically in the field of Climate Change on Biodiversity literature published from 2011 to 2021. The present study, suitably entitled "**Climate Change on Biodiversity: A Scientometric Study"**

Keywords:

Climate, Climate Change, Biodiversity, Scientometrics,

Introduction:

Scientometrics is the quantitative study of science, communication in science, and science policy. What started as Eugene Garfield's idea of an index to improve information retrieval in the 1960s and resulted in the creation of the Science Citation Index (SCI) (Garfield, 1979; Wouters, 1999) was soon recognized as a novel instrument in the empirical study of the sciences (e.g., Price, 1965; Cole & Cole,1973). The availability of output indicators (such as databases of publications and patents) complemented ongoing efforts by the Organization of Economic Cooperation and Development (OECD) in Paris to standardize input statistics of the scientific enterprise (OECD, 1963, 1976). Based on these data, the National Science Board of the U.S.A. initiated the biannual series of Science Indicators in 1972.2 The new journal Scientometrics was launched in 1978 and in that same year leading historians, philosophers of science, and social scientists—among them Robert K. Merton—published an edited volume entitled Toward a Metric of Science: The Advent of Science Indicators, in which they reflected on the new perspectives (Elkana et al., 1978). The historian Derek J. de Solla Price published a number of books and articles in the 1960s and '70s which laid the foundations for the newly emerging field of quantitative science studies (e.g., Price, 1961, 1963, 1965), culminating in a full-fledged research program (Price, 1976). The sociology of science, however, during the 1980s turned increasingly towards micro-analysis focusing on the behavior of scientists in laboratories (e.g., Latour & Woolgar, 1979). From this perspective, the quantitative analysis of scientific literature at the macro (e.g., disciplinary) level was not considered useful to explain scientific practices (Edge, 1979). Rather, with its 2 The series was renamed into Science and Engineering Indicators in 1987 (National Science Board, 2012). 3 focus on scientific communications—as a unit of analysis potentially different from scientists as authors—scientometrics developed at arm's length from the sociology of science and closer to the library and information sciences. At the same time, the value of scientometric indicators for informing science policies and research management became manifest (Irvine & Martin, 1984). Under these diverging pressures, the field of science & technology studies increasingly bifurcated during the period 1985-2000 into qualitative "sociology of scientific knowledge," on the one side, and the quantitative study of scientometrics and science indicators, on the other. Additionally, a third line of research emerged that published articles that use insights from the quantitative study of science and technology for evaluation and policy purposes. Such research appeared in journals such as Research Policy, Research Evaluation, Technology Analysis & Strategic Management (Leydesdorff & Van den Besselaar, 1997). During the 2000s, attention to evaluation and ranking was further enhanced after the publication of the first Academic Ranking of World Universities (ARWU) of the Shanghai Jiao Tong University in 2004 (Shin et al., 2011). The use of impact factors of journals for evaluative purposes has pervaded the academic environment, even to the level of individual tenure decisions, which increasingly are based on quantitative measures of publications and citations. Another popular indicator, the h-index (Hirsch, 2005), provides a simple impact metric for individual authors that can readily be used in online searching, for example, with Google Scholar, but is also incorporated in the major citation databases such as the Web-of-Science and Scopus. Computer programs (e.g., Publish or Perish at http://www.harzing.com/pop.htm) can freely be downloaded from the Internet and allow for 4 measuring numbers of publications, citations, h-index, g-index (Egghe, 2006), etc., at the level of individuals, journals, and institutions without

much prior knowledge of the scientometrics involved. In the meantime, the production and improvement of these indicators have become organized in university departments, spin-offs, and relevant companies such as Elsevier and Thomson-Reuters. The increased access to large datasets through the Internet led to the development of the network sciences as part of computing and applied physics during the first decade of this century (e.g., Newman, 2010). A number of these studies used co-authorship and citation data for modeling the network dynamics. Although these efforts to model the evolution of the sciences statistically (e.g., Scharnhorst et al., 2012) often do not aim at contributing to social-scientific understanding and theorizing, the new methods (e.g., visualization techniques) developed by these researchers are partly derived from and have also been adopted by scientometricians. Such interdisciplinary exchanges make scientometrics an active research specialty that in the 2000s has been experiencing spectacular growth in its literature. More recently, the specialty can increasingly be considered a "research front" in terms of the turnover of the referencing patterns (Milojević & Leydesdorff, 2013; Wouters & Leydesdorff, 1994).

Importance of Scientometrics

Scientometrics is the field of study which concerns itself with measuring and analyzing scholarly literature. Scientometrics is a sub-field of bibliometrics. Major research issues include measuring the impact of research papers and academic journals, understanding scientific citations, and using such measurements in policy and management contexts.[1] In practice, there is a significant overlap between Scientometrics and other scientific fields such as information systems, information science,the science of science policy, sociology of science, and metascience. Critics have argued that over-reliance on Scientometrics has created a system of perverse incentives, producing a publish or perish environment that leads to low-quality research.

According to Tague-Sutcliffe (1992): "Scientometrics is the study of the quantitative aspects of science as a discipline or economic activity. It is part of the sociology of science and has application to science policymaking. It involves

quantitative studies of scientific activities, including, among others, publication, and so overlaps bibliometrics to some extent".

Objectives of the study

The main objective of the study is to analyze the publications in the area of climate change on biodiversity as reflected in the Web of Science database in 2011. In brief the objectives of the study are listed below:

- To analyze records in chronological order.
- To analyze the Relative growth rate of climate change on biodiversity research publications from 2011 to 2021.
- To study the collaborative index in climate change on biodiversity.
- To compute the year-wise growth of publications and citations.
- To find the core periodicals from the set of data.
- To find the collaborative research trend and authorship pattern.
- To test for applicability of Bradford and Lotka laws

Climate Change and Biodiversity

Meaning of Climate: "The conditions prevailing in an area in general or over a long period".

Climate change

Climate change includes both global warming driven by human-induced emissions of greenhouse gases and the resulting large-scale shifts in weather patterns.

Biodiversity: "The variety of plant and animal life in the world or in a particular habitat, a high level of which is usually considered to be important and desirable".

Meaning of climate change on biodiversity: Climate change is affecting the habitats of several species, which must either adapt or migrate to areas with more favorable conditions. or the interconnected nature of ecosystems means that the loss of species can have knock-on effects upon a range of ecosystem functions.

What is the effect of climate change on biodiversity?

The link between climate change and biodiversity has long been established. Although throughout Earth's history the climate has always changed with ecosystems and species coming and going, rapid climate change affects ecosystems and species ability to adapt and so biodiversity loss increases.

Is there a relationship between biodiversity and climate?

Climate change is considered to be a critical threat to many components of biodiversity and is generally expected to have an increased impact on biodiversity, in the future. Numerous examples from scientific studies have shown complex relationships between climate change and biodiversity.

Importance of Climate Change on Biodiversity

- The two most important factors in the climate of an area are temperature and precipitation. The yearly average temperature of the area is obviously important, but the yearly range in temperature is also important.
- Climate, especially temperature, affects the distribution and health of coastal ecosystems, and the productivity of industries that depend on those ecosystems, such as fisheries.
- Biodiversity is important to humans for many reasons. ... Ecological life support— biodiversity provides functioning ecosystems that supply oxygen, clean air and water, pollination of plants, pest control, wastewater treatment and many ecosystem services.

Impact of Climate Change on Biodiversity

- Only a small change in pattern of climate has severe impact on the biodiversity, altering the habitats of the species and presenting a threat for their survival, making them vulnerable to extinction. Millennium Ecosystem Assessment (MEA) predicts climate change to be the principal threat to the biological diversity (Anonymous, 2007).Due to increase in temperature several plant species like Berberisa siatica, Taraxacum officinale, Jasminum officinale etc.have shifted towards higher altitude in Nainital. Teak dominated forests are predicted to replace the Sal trees in central India and also the conifers may be replaced by the deciduous types. According to Gates (1990) 3°C increase in temperature may leads to the forest movement of 2.50 km/year which is ten times the rate of natural forest movement.

- Anonymous (2009) reported that changes in climate affects the normal life cycle of plant. He also reported that invasive species (Lantana, Parthenium and Agera).

Methodology

The Data for the study is obtained from 'Web of Knowledge' database currently maintained by Clarivate Analytics. The Query was designed to refer to various topics in 'Climate Change on Biodiversity' (CCB). The data (22,121 records) was downloaded in August 26th, 2021, in Tab-delimited-Win format. From the obtained dataset on Climate Change on Biodiversity (CCB) literature published world-wide between 2011-2021, all bibliographic details are transferred to spreadsheets and then the data is analyzed from the help of software HistCite, and MS Excel advanced functionalities, and formulae related to Scientometric analysis have been used to evaluate the preferred results as per the objectives of the study.

Scope and Limitations of the study

The present study is the scientometric analysis on the *Climate Change on Biodiversity* literature. The study is confined towards the *Effects of Climate Change on Biodiversity* research published worldwide during 2011-2021 data collected from Web of Science (WoS) database.

Data analysis and Interpretation:

Publication Productivity

The following table shows the year-wise growth of publications, citations and cited references to the articles in field of CCB during the field of study. A total of 22121 research articles published worldwide in the field of Climate Change on Biodiversity during 2011 to 2021. The highest number of papers 3200 (14.47%) published in the year 2020, with an average number of publications per year was 2011. This is evident that there is steady and gradual increase in number of publications starting from the year 2011 till 2021.

A total of 528114 citations received from all the publications of CCB during 2011 to 2021, with an average citation per paper per year is 48010. The highest number of citations 74498 (14.11%)

received in the year 2011, followed by 69180 (13.10%) citations notified in the year 2014. It is observed that there is gradual decrease in the number of citations starting from the year 2011 to 2021 except in the year 2014 with 69180 (13.10%) citations. It is quite obvious that the latest papers will take time to gather cations and make an impact of their ideas.

Cited references play an important role in the justifying and provide the evidence for the previous research works caried out by the researchers in the field of study. In the preset study, a total of 96973 cited references cited in the 22121 papers with an average of 8815 cited references per year per paper. The highest cited references 16687 (17.21%) observed in the publications published in the year 2021, followed by in the year 2012 with 9417 (9.71%) cited references.

Table – 1 Year-wise growth of Publications, Citations and Cited References.

Sl. No.	Year	Papers	% of Papers	Citations	% of Citations	Cited Refs	% of Cited Ref
1	2011	1031	4.66	74498	14.11	7676	7.92
2	2012	1202	5.43	65586	12.42	9417	9.71
3	2013	1363	6.16	65994	12.50	8233	8.49
4	2014	1579	7.14	69180	13.10	7066	7.29
5	2015	1789	8.09	64227	12.16	8932	9.21
6	2016	1979	8.95	53883	10.20	8607	8.88
7	2017	2195	9.92	48757	9.23	7300	7.53
8	2018	2442	11.04	38300	7.25	7930	8.18
9	2019	2772	12.53	29676	5.62	7338	7.57
10	2020	3200	14.47	15880	3.01	7787	8.03
11	2021	2569	11.61	2133	0.40	16687	17.21
	Total	**22121**	100	**528114**	100	**96973**	100
	Avg	**2011**		**48010**		**8815**	

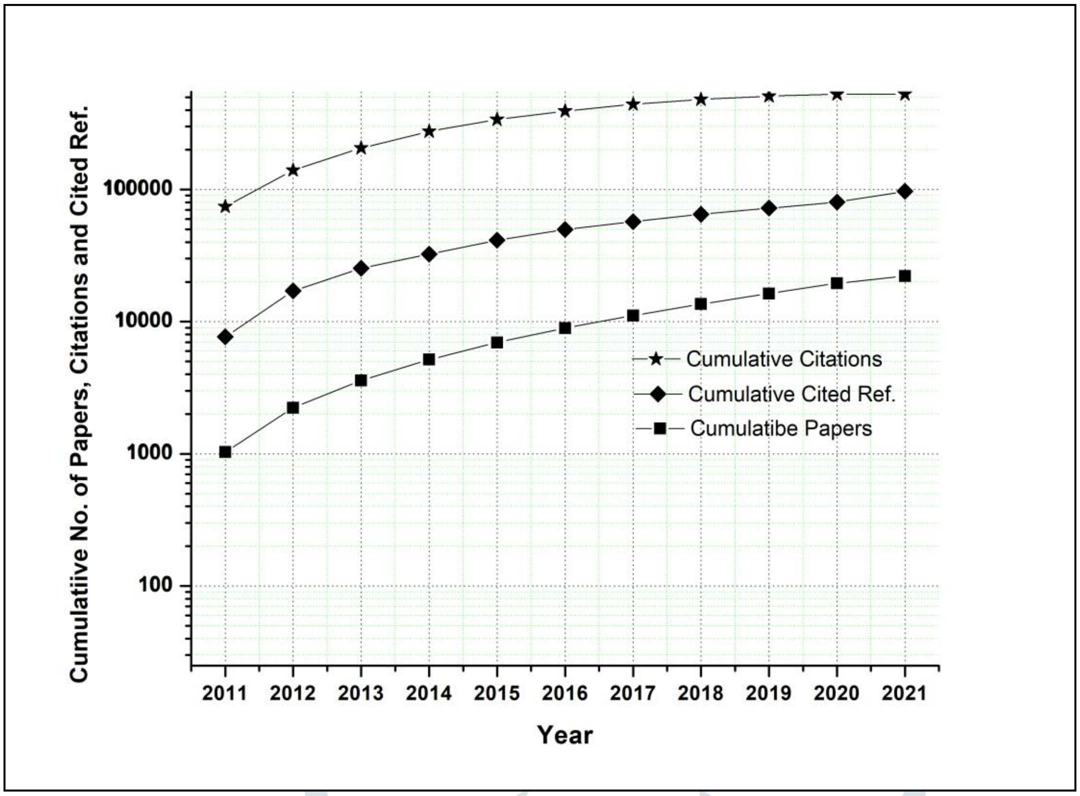

Figure – 1. Year-wise growth of papers, citations and cited references.

Document Types

Table – 2. Publications according to different Document types

Sl. No	Document Type	No. of Publications	% of Publications	No. Of Citations	% of Citations
1	Article	18962	85.72	49711	78.10
2	Review	2033	9.19	11433	17.96
3	Editorial Material	352	1.59	868	1.36
4	Article; Early Access	290	1.31	0	0.00
5	Article; Proceedings Paper	202	0.91	289	0.45
6	Review; Book Chapter	92	0.42	862	1.35
7	Article; Data Paper	48	0.22	51	0.08
8	Letter	34	0.15	229	0.36
9	Article; Book Chapter	31	0.14	199	0.31

10	Review; Early Access	27	0.12	0	0.00
11	Correction	17	0.08	5	0.01
12	Meeting Abstract	9	0.04	0	0.00
13	News Item	7	0.03	6	0.01
14	Book Review	6	0.03	0	0.00
15	Editorial Material; Early Access	4	0.02	0	0.00
16	Editorial Material; Book Chapter	3	0.01	0	0.00
17	Article; Retracted Publication	2	0.01	0	0.00
18	Chronology	1	0.00	0	0.00
19	Letter; Early Access	1	0.00	0	0.00
	Total	**22121**	**Total**	**63653**	

Table 2 explains the publications according to document types. Total no of documents are 22121, total no of citations are 63,653. All document types show citing percentage of documents. highest document types are articles 18962 (85.72%) and lowest document type is chronology and Letter; Early Access 1(0%). highest publications citations value is 79711(78.10%), and lowest percentage is 5(0.01%).

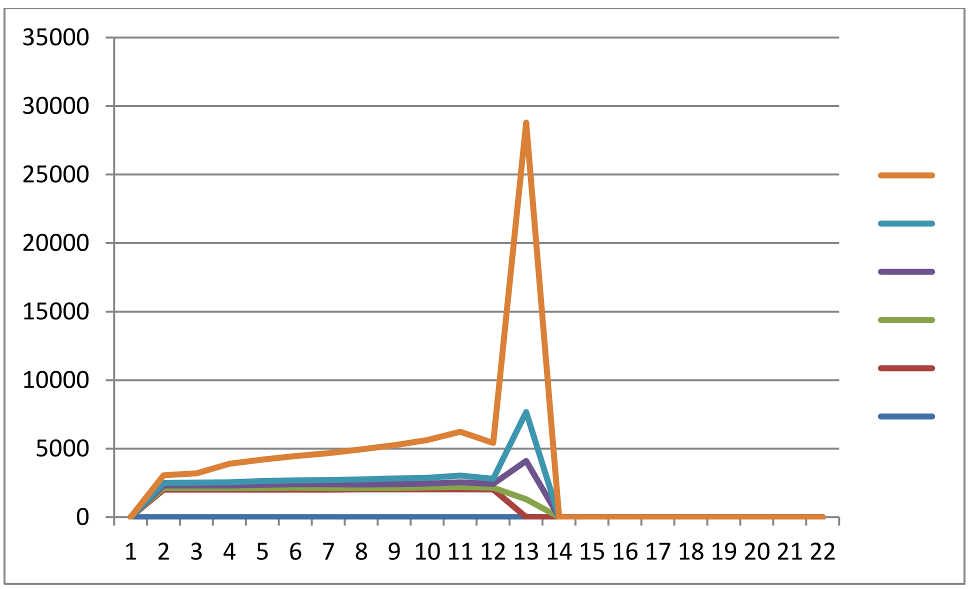

Figure-2. Publications according to different Document types

Language-wise distribution of articles

Table-3. Language-wise distribution of publications

Sl. No	Language	No. of Publications	% of Publications	No. of Citations	% of Citations
1	English	21951	99.2	63611	99.93
2	Spanish	75	0.3	20	0.03
3	French	33	0.1	5	0.01
4	German	27	0.1	3	0.00
5	Portuguese	9	0	7	0.01
6	Croatian	8	0	3	0.00
7	Polish	7	0	0	0.00
8	Russian	3	0	1	0.00
9	Afrikaans	2	0	0	0.00
10	Chinese	2	0	0	0.00
11	Czech	2	0	0	0.00
12	Serbian	1	0	3	0.00
13	Unspecified	1	0	0	0.00
	Total	**22121**	**63653**		

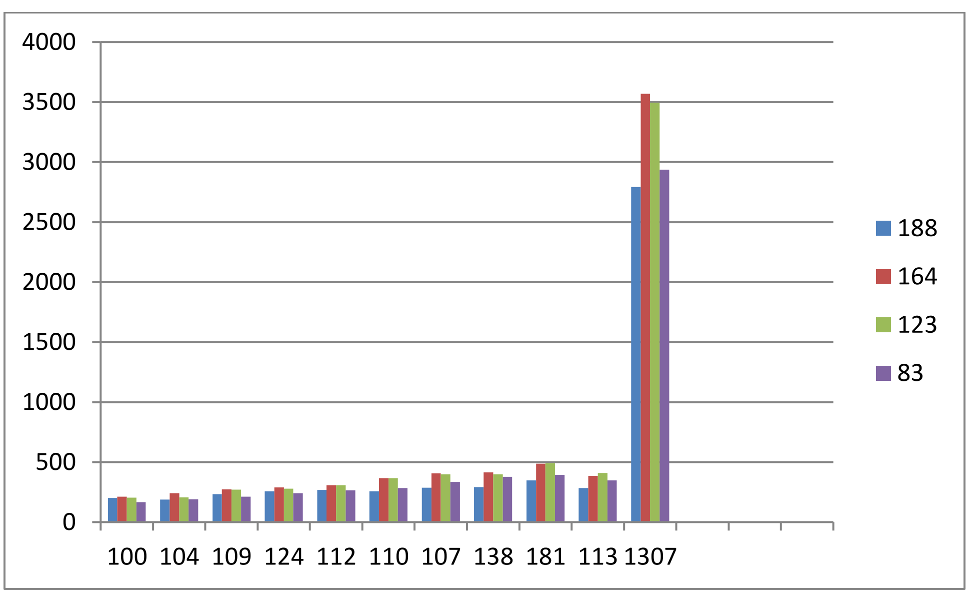

Figure-3. Language-wise distribution of publications

Table 3 shows the language-wise distribution of publications in which almost all publications are published in English language. The total no. of publications published in English language are 21951(99.2%) and the lowest no. of publication published in Serbian & Unspecified language (1).

Relative Growth Rate and Doubling Time of RCUB publications

Relative Growth Rate (RGR): The mean relative growth rate R (1-2) over a specified period of the interval can be calculated from the following equation suggested by Mahapatra,M (1985).

$$R(1-2) = \frac{w_2 - w_1}{T_2 - T_1}$$

R = Mean relative growth rate over the specific period of the interval;
W1 = log w1 (Natural log of initial number of publications/pages);
W2 = log w2 (Natural log of initial number of publications/pages);
T2-T1 = Unit difference between the initial time and final time. Therefore,
R (a) = Relative growth rate per unit of publications per unit of time (year)
R (p) = Relative growth rate per unit of pages per unit of time (year).

Doubling Time (DT): Not only is the time to double the no. of publications of one subject matter for a during but then the difference between the number of logarithms by the beginning and end of the during must be the number 2 logrithms has a value of (0.693).

Thus, the corresponding doubling time for publications can be calculated with the following formula:

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

Therefore,

$$\text{Doubling time for publication } Dt(a) = \frac{0.693}{R(a)}$$

Table – 4. Relative Growth Rate and Doubling Time of Publications

Year	No. of Publications	Cumulative Publications	RGR	Mean RGR	DT	Mean DT
2011	1031	1031	-	1.91	-	1.65
2012	1202	2233	0.77		0.90	
2013	1363	3596	0.48		1.45	
2014	1579	5175	0.36		1.90	
2015	1789	6964	0.30		2.33	

2016	1979	8943	0.25	1.16	2.77	3.78
2017	2195	11138	0.22		3.16	
2018	2442	13580	0.20		3.50	
2019	2772	16352	0.19		3.73	
2020	3200	19552	0.18		3.88	
2021	2569	22121	0.12		5.61	
	22121		**3.07**	**0.31**	**29.23**	**2.72**

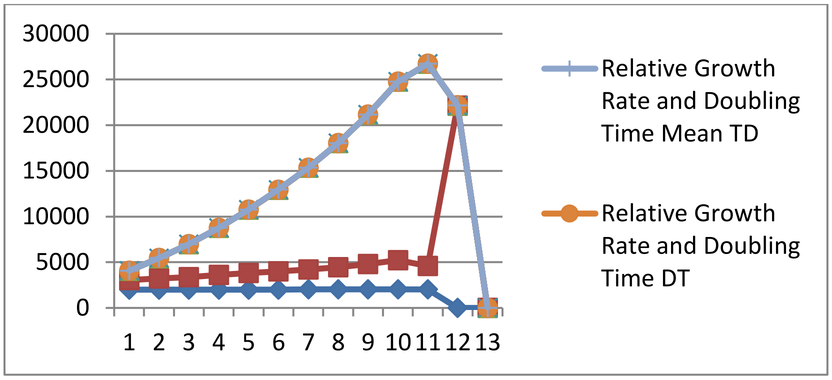

Figure-4. Relative Growth Rate and Doubling Time of Publications

The Table-4 shows the relative growth rate and doubling time of CCB literature published between 2011 to 2021. The relative growth rate of publications output decreases gradually from 2011 to 2021. The highest relative growth rate 0.77 was found in the 2012 and the lowest (0.12) was found in the year 2021. The mean RGR was 0.31.

The doubling time (DT) of the publication during 2011-2021, increased gradually from 0.90 in the year 2011 to and 5.61 in the year 2021. The highest doubling time was found 5.61 in the year 2021. The Mean DT was 2.72.

Authorship pattern and Collaboration studies

Collaboration is an intense form of interaction, that allows for effective communication as well as the sharing of competence and other resources (Melin and Persson 1996). However, the complex nature of human interaction that takes place between collaborators and the magnitude of their collaboration are not easily captured by quantitative tools. For example, the precise relationship between quantifiable activities (e.g. data analysis) and intangible contributions (e.g. ideas) and their weightage in the final product of the collaboration (e.g. a research paper) is extremely difficult to determine. Science indicators, however, provide additional quantitative information of a more direct and objective nature to be geographical patterns of cooperation among scientific institutions (Gupta et al. 1997).

Table -5. Authorship pattern and Collaboration study

Year	Authorship pattern							Multi-authored papers	Total papers	CC	MCC
	Single-Aut	2-Aut	3-Aut	4-Aut	5-Aut	6-10 Aut	11-19 Aut				
2011	109	182	188	164	123	197	61	915	1031	0.65	0.65
2012	100	201	213	204	166	241	61	1086	1202	0.67	0.67
2013	104	188	240	206	191	343	75	1243	1363	0.69	0.69
2014	109	232	273	271	213	376	85	1450	1579	0.69	0.69
2015	124	256	289	278	241	446	118	1628	1789	0.7	0.7
2016	112	268	309	307	265	524	144	1817	1979	0.71	0.71
2017	110	257	366	366	284	624	162	2059	2195	0.72	0.72
2018	107	286	406	398	335	666	194	2285	2442	0.73	0.73
2019	138	291	414	399	377	852	243	2576	2772	0.73	0.73
2020	181	347	487	492	394	930	288	2938	3200	0.73	0.73
2021	113	284	385	409	348	788	247	2461	2569	0.74	0.74
Total	**1307**	**2792**	**3570**	**3494**	**2937**	5987	**1678**	20458	22121	**0.71**	**0.71**

Aut = author (s), CC = Collaborative Coefficient, and MCC = Modified Collaborative Coefficient.

Year-wise trends in publications such as the single-authored, multi-authored, cumulative number of papers and collaboration pattern such as CC and MCC are shown in Table-7. Out of 22121 publications, 1307 (5.9%) were single-authored and 20458 (92.48%) were multi-authored papers. This data clearly indicates that there is collaboration trend among researchers in the field of CCB. It is quite evident from the above table that, the Collaborative Co-efficient (CC) (Ajiferuke et al. 1988) value varies between 0.65 and 0.74 with an average collaboration value 0.71 which is very high. The Modified Collaborative Coefficient (MCC) (Savanur & Srikanth, 2010) values also support CC values.

Out of 22121 total papers, 2792 (12.62) papers were double-authored, 3570 (16.14 %) papers were publications written by three authors, 3495 (15.8%) of papers were four-authored and 1678 (7.59%) papers of authors more than eleven. Years 2020, and 2019 are the most productive years with 3200 (14.47 %), and 2772 (12.53%) papers respectively.

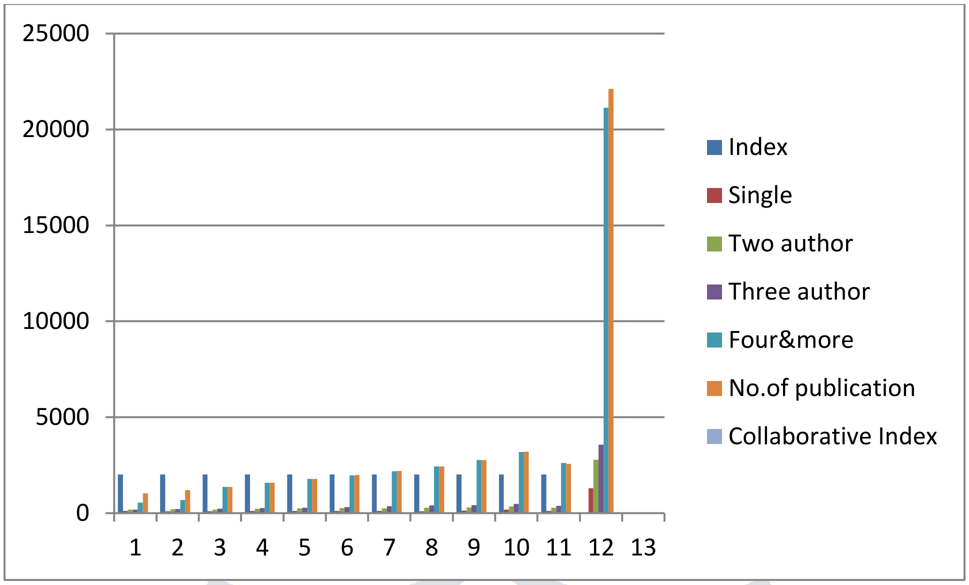

Figure-5. Authorship pattern

Channels of Communication

A total of 22121 research output in the field of world CCB literature appeared during 2011-2021 has been published in 1967 different peer reviewed national and international source journals and these papers received 528114 citations in the subject field.

Table – 6. Journal-wise distribution of publications in the field of CCB

Sl. No	Name of the Journal	No. of Articles	% of Articles	No. of Citations	% of Citations	ACPP
1	PLOS One	772	3.49	22698	4.30	29.40
2	Global Change Biology	520	2.35	22275	4.22	42.84
3	Biological Conservation	418	1.89	13930	2.64	33.33
4	Science Of the Total Environment	408	1.84	5590	1.06	13.70
5	Ecology And Evolution	338	1.53	4587	0.87	13.57
6	Diversity And Distributions	322	1.46	6141	1.16	19.07
7	Scientific Reports	316	1.43	4980	0.94	15.76
8	Ecological Indicators	304	1.37	5353	1.01	17.61
9	Sustainability	296	1.34	2301	0.44	7.77
10	Forest Ecology and Management	284	1.28	4874	0.92	17.16
11	Global Ecology and Biogeography	284	1.28	10036	1.90	35.34
12	Biodiversity and Conservation	282	1.27	4643	0.88	16.46
13	Journal Of Biogeography	269	1.22	7668	1.45	28.51
14	Proceedings of the National Academy of Sciences of the United States of America	215	0.97	20921	3.96	97.31

15	Forests	186	0.84	1425	0.27	7.66
16	Ecography	185	0.84	4314	0.82	23.32
17	Journal of Applied Ecology	173	0.78	6816	1.29	39.40
18	Ecosphere	171	0.77	2942	0.56	17.20
19	Global Ecology and Conservation	158	0.71	1416	0.27	8.96
46	27 Journals Having Publications Between 101-150	3302	14.93	95360	18.06	28.88
97	51 Journals (within the range of 51-100)	3481	15.74	122465	23.19	35.18
1967	1870 Journals (within the range of 1-50)	9437	42.66	157379	29.80	16.68
	TOTAL	22121		528114		

Table-6 shows the frequency distribution of CCB papers and their citation counts in various journals. The top two journals in terms of the highest publications and citations were: PLOS One with 772 (3.49%) papers with 22698 (4.3%) citations and Global Change Biology with 520 (2.35%) papers with 22275 (4.22%) citations. The top 46 journals published more than 100 articles contributed 9203 (41.6%) papers and these articles received 248270 (47%) of total citations. The majority 1921 (97.6%) of periodical published 12918 (58%) of papers which received 53% of total citations. The journal *"Proceedings of the National Academy of Sciences of the United States of America"* published 215 papers and received 20921 (3.96%) of citations is having the highest Average Citation Per Paper rate i.e. 97.31.

Bradford's Law of Scattering

Identifying the journals in a subject field is an important aspect of scientometric studies especially Bradford's law of scattering, has its application in the acquisition policy of journals in libraries and information centres.

Bradford law of scattering describes how the literature on a particular subject is scattered or distributed in various journals, and he formulated that, "if scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same number of articles as the nucleus. When the number of periodicals in the nucleus in the and succeeding zones will be as "1: n : n2" where n is a multiplier (Bradford, 1934, p.86).

For testing of the verbal formulation of Bradford's law, the frequency of journal articles arranged in decreasing order of the articles, and the 1967 journal titles were divided into three zones. The distribution of journals and a corresponding number of

articles in the three zones along with the value of Bradford multiplier are shown in Table-7.

In the present dataset, the first 30 journals publishing 7404 articles, followed by 127 journals containing 7380 articles and next 1810 journals containing 7337 articles. It can be noticed that the three zones are almost exactly the 1/3rd of the total articles as suggested by Bradford.

Table-7. Scattering of journals and articles over Bradford Zone

Zone	No. of Journals	No. of Articles	Bradford Mutiplier
1st	30	7404	--
2nd	127	7380	4.23
3rd	1810	7337	14.25
Total	1967	22121	9.24 (Avg)

The identified zones arranged in the geometric series in the form of 1: n: n^2 as given by Bradford. We found that the relationship of each zone in the present study is 30 : 277 : 2561.

Here, 30 journals found in the nucleus zone and the mean value of Bradford's multiplier is n = 9.24.
Therefore, 30 : (30 x 9.24) : (30 x 9.242) :: 1 : n : n2
42: 168: 672
Since the percentage of error is 0.45 negligible, we can infer that the dataset of 22121 research articles in the field of CCB published in 1967 journals fits well Bradford's law.

Lotka's law of authorship distribution.

(Lotka, 1926) "Published his pioneering study on the frequency distribution of scientific productivity determined from a decennial index (1907- 1916) of Chemical Abstracts Lotka's Law". Latka law is a traditional method used to test the limits of the scientific literature's publication activity. You describe the frequency of authors publishing in a given field. It says 1 / n^2 of the no. of authors making N contributions, and all contributors account for at least (60%) of the same contribution. That is, in all the authors of a particular field, only (60%) of people have presently one publication (15%) have two publications (1 / 2^2 times 60) (7%) have three publications (1 / 3^2 times 60), and so 10-13. These laws can be expressed as:

"The general formula for the relation thus found to exist between the frequency Y of persons making X contributions is". (Russell C. Coil, 1978) see p.642.

Lotka's law is tested for the author's productivity of all the BRICS countries for the year 2001-2016. The procedure and variables calculated are as follows:
The general formula of the Lotka's law is:

$$x^n y = c$$

"where*y* is the number of Authors with *x* articles, the exponent *n* and constant *c* are parameters to be estimate from a given set of authors productivity".

The value of exponent *n* is calculated by the least-squares method described by Pao in 1985 using the following formula:

$$n = \frac{N \sum XY - \sum X \sum Y}{N \sum X^2 - (\sum X)^2}$$

N= number of pairs of data X = logarithm of x, i.e. number of articles Y = logarithm of y, i.e. number of authors The value of constant c is calculated using the following formula:

$$c = \frac{1}{\sum_1^{P-1} \frac{1}{x^n} + {}^1/_{(n-1)(P^{n-1})} + {}^1/_{2 * P^n} + {}^n/_{24 * (P-1)^{n+1}}}$$

$$\sum_1^{P-1} \frac{1}{x^n} = \textit{is obtained by summing the first 19 terms of } \frac{1}{x^n}$$

where X = 1, 2, 3, . . . 19

Here, P = 20; n = value obtained using formula (2); x = number of articles

Table - 8: Observed and theoretical cumulative frequency of authors when n=2 and when n= -2.847

No. of Articles (x)	No. of Authors (y)	log(x) X	log(y) Y	XY	XX	When n = 2			When n = -2.847		
						Observed cumulative frequency of authors	Theoretical cumulative frequency of authors	Difference	Observed cumulative frequency of authors	Theoretical cumulative frequency of authors	Differenc e
1	50456	0.0000	10.8289	0.0000	0.0000	0.6991	0.6079	0.0912	0.6991	0.8095	-0.1103
2	10893	0.6931	9.2959	6.4434	0.4805	0.8501	0.7599	0.0902	0.8501	0.9220	-0.0719
3	4328	1.0986	8.3729	9.1985	1.2069	0.9100	0.8274	0.0826	0.9100	0.9574	-0.0474
4	2266	1.3863	7.7258	10.7102	1.9218	0.9414	0.8654	0.0760	0.9414	0.9731	-0.0316
5	1204	1.6094	7.0934	11.4164	2.5903	0.9581	0.8897	0.0684	0.9581	0.9813	-0.0232
6	837	1.7918	6.7298	12.0582	3.2104	0.9697	0.9066	0.0631	0.9697	0.9863	-0.0165
7	555	1.9459	6.3190	12.2961	3.7866	0.9774	0.9190	0.0584	0.9774	0.9894	-0.0120
8	339	2.0794	5.8260	12.1148	4.3241	0.9821	0.9285	0.0536	0.9821	0.9916	-0.0095
9	267	2.1972	5.5872	12.2764	4.8278	0.9858	0.9360	0.0498	0.9858	0.9932	-0.0074
10	210	2.3026	5.3471	12.3122	5.3019	0.9887	0.9421	0.0466	0.9887	0.9943	-0.0056
11	154	2.3979	5.0370	12.0781	5.7499	0.9909	0.9471	0.0437	0.9909	0.9952	-0.0043
12	126	2.4849	4.8363	12.0177	6.1748	0.9926	0.9513	0.0413	0.9926	0.9959	-0.0033
13	80	2.5649	4.3820	11.2397	6.5790	0.9937	0.9549	0.0388	0.9937	0.9964	-0.0027
14	64	2.6391	4.1589	10.9755	6.9646	0.9946	0.9580	0.0365	0.9946	0.9969	-0.0023
15	68	2.7081	4.2195	11.4266	7.3335	0.9955	0.9607	0.0348	0.9955	0.9972	-0.0017
16	49	2.7726	3.8918	10.7904	7.6872	0.9962	0.9631	0.0331	0.9962	0.9975	-0.0013
17	35	2.8332	3.5553	10.0731	8.0271	0.9967	0.9652	0.0315	0.9967	0.9978	-0.0011
18	23	2.8904	3.1355	9.0627	8.3542	0.9970	0.9671	0.0299	0.9970	0.9980	-0.0010
19	33	2.9444	3.4965	10.2953	8.6697	0.9975	0.9688	0.0287	0.9975	0.9982	-0.0007
20	21	2.9957	3.0445	9.1206	8.9744	0.9978	0.9703	0.0275	0.9978	0.9983	-0.0006
21	24	3.0445	3.1781	9.6757	9.2691	0.9981	0.9717	0.0264	0.9981	0.9985	-0.0004
22	17	3.0910	2.8332	8.7576	9.5545	0.9983	0.9729	0.0254	0.9983	0.9986	-0.0003
23	14	3.1355	2.6391	8.2747	9.8313	0.9985	0.9741	0.0244	0.9985	0.9987	-0.0002
24	10	3.1781	2.3026	7.3177	10.1000	0.9987	0.9751	0.0235	0.9987	0.9988	-0.0001
25	21	3.2189	3.0445	9.7999	10.3612	0.9990	0.9761	0.0228	0.9990	0.9989	0.0001
26	5	3.2581	1.6094	5.2437	10.6152	0.9990	0.9770	0.0220	0.9990	0.9990	0.0001
27	3	3.2958	1.0986	3.6208	10.8625	0.9991	0.9779	0.0212	0.9991	0.9990	0.0000

28	18	3.3322	2.8904	9.6313	11.1036	0.9993	0.9786	0.0207	0.9993	0.9991	0.0002
29	5	3.3673	1.6094	5.4195	11.3387	0.9994	0.9794	0.0200	0.9994	0.9992	0.0002
30	4	3.4012	1.3863	4.7151	11.5681	0.9994	0.9800	0.0194	0.9994	0.9992	0.0002
31	1	3.4340	0.0000	0.0000	11.7923	0.9995	0.9807	0.0188	0.9995	0.9993	0.0002
32	7	3.4657	1.9459	6.7440	12.0113	0.9996	0.9813	0.0183	0.9996	0.9993	0.0003
33	3	3.4965	1.0986	3.8413	12.2256	0.9996	0.9818	0.0178	0.9996	0.9993	0.0003
34	6	3.5264	1.7918	6.3184	12.4352	0.9997	0.9823	0.0173	0.9997	0.9994	0.0003
36	2	3.5835	0.6931	2.4839	12.8416	0.9997	0.9828	0.0169	0.9997	0.9994	0.0003
37	5	3.6109	1.6094	5.8115	13.0387	0.9998	0.9832	0.0165	0.9998	0.9994	0.0004
38	1	3.6376	0.0000	0.0000	13.2320	0.9998	0.9837	0.0161	0.9998	0.9995	0.0003
40	2	3.6889	0.6931	2.5569	13.6078	0.9998	0.9841	0.0158	0.9998	0.9995	0.0003
41	2	3.7136	0.6931	2.5741	13.7906	0.9998	0.9844	0.0154	0.9998	0.9995	0.0004
43	1	3.7612	0.0000	0.0000	14.1466	0.9999	0.9847	0.0151	0.9999	0.9995	0.0003
46	1	3.8286	0.0000	0.0000	14.6585	0.9999	0.9850	0.0148	0.9999	0.9995	0.0003
47	1	3.8501	0.0000	0.0000	14.8236	0.9999	0.9853	0.0146	0.9999	0.9995	0.0003
49	3	3.8918	1.0986	4.2756	15.1463	0.9999	0.9856	0.0144	0.9999	0.9996	0.0004
51	1	3.9318	0.0000	0.0000	15.4593	0.9999	0.9858	0.0142	0.9999	0.9996	0.0004
55	1	4.0073	0.0000	0.0000	16.0587	1.0000	0.9860	0.0140	1.0000	0.9996	0.0004
60	1	4.0943	0.0000	0.0000	16.7637	1.0000	0.9862	0.0138	1.0000	0.9996	0.0004
81	1	4.3944	0.0000	0.0000	19.3112	1.0000	0.9863	0.0137	1.0000	0.9996	0.0004
94	1	4.5433	0.0000	0.0000	20.6415	1.0000	0.9863	0.0137	1.0000	0.9996	0.0004
		143.12	145.10	312.97	468.75	0.6991	0.6079	0.0912	0.6991	0.8095	-0.1103

n	c	C – linear eqn
-2.847	0.809	11.512

Result: *LS n = 2*				Result: *n* = -2.847		
Max Diff	Critical Value	Lotka Test		Max Diff	Critical Value	Lotka Test
0.0912	0.0051	FALSE		0.0004	0.0051	TRUE

The maximum difference D_{max} for *n* =2, is 0.0912 and is larger than the Critical Value of Kolmogorov-Smirnov (K-V) Test at the level of significance 5% is 0.0051 and therefore does not supports for the consideration of Lotka's law i.e., the observed authorship current data set doesn't confirm the applicability of Lotka's Law in the field of CCB research. Therefore, Lotka's Law for the CCB literature is not accepted for the Authorship distribution when *n* = 2.

The maximum difference Dmax for *n* = -2.847, is 0.0004 and the Critical Value is 0.0051. The critical value is larger than the maximum difference of Kolmogorov-Smirnov (K-V) Test at the level of significance 5% is 0.0051. Therefore, Lotka's Law is applicable to CCB research literature for the Authorship distribution when *n* = -2.847

Therefore, concluded that the dataset does follow Lotka's generalized inverse square law.

Major findings

1. A total of 22121 research articles published worldwide in the field of Climate Change on Biodiversity during 2011 to 2021.
2. The highest number of papers 3200 (14.47%) published in the year 2020, with an average number of publications per year was 2011.
3. There is steady and gradual increase in number of publications starting from the year 2011 till 2021.
4. A total of 528114 citations received from all the publications of CCB during 2011 to 2021, with an average citation per paper per year is 48010.
5. The highest number of citations 74498 (14.11%) received in the year 2011, followed by 69180 (13.10%) citations notified in the year 2014.
6. In the preset study, a total of 96973 cited references cited in the 22121 papers with an average of 8815 cited references per year per paper.
7. The highest cited references 16687 (17.21%) observed in the publications published in the year 2021, followed by in the year 2012 with 9417 (9.71%) cited references.
8. Among many document types majority of 85.72% them are journal articles.

9. English language predominates with 99.2% of articles published in the field of CCB.
10. The highest relative growth rate 0.77 was found in the 2012 and the lowest (0.12) was found in the year 2021. The mean RGR was 0.31.
11. The highest doubling time was found 5.61 in the year 2021. The Mean DT was 2.72.
12. Out of 22121 publications, 1307 (5.9%) were single-authored and 20458 (92.48%) were multi-authored papers.
13. This data clearly indicates that there is a collaboration trend among researchers in the field of CCB.
14. The Collaborative Co-efficient (CC) value varies between 0.65 and 0.74 with an average collaboration value 0.71 which is very high.
15. Out of 22121 total papers, 2792 (12.62) papers were double-authored, 3570 (16.14 %) papers were publications written by three authors, 3495 (15.8%) of papers were four-authored and 1678 (7.59%) papers of authors more than eleven.
16. A total of 22121 research output published in 1967 different peer reviewed national and international source journals and these papers received 528114 citations in the subject field.
17. PLOS One with 772 (3.49%) papers with 22698 (4.3%) citations and Global Change Biology with 520 (2.35%) papers with 22275 (4.22%) citations.
18. The journal "Proceedings of the National Academy of Sciences of the United States of America" published 215 papers and received 20921 (3.96%) of citations is having the highest Average Citation Per Paper rate i.e., 97.31.
19. The dataset of 22121 research articles in the field of CCB published in 1967 journals with average Bradford Multiplier 9.24 fits well Bradford's law.
20. Lotka's Law for the CCB literature with D_{max}=0.0912 and Critical value=0.0051 does not accepted for the Authorship distribution when n = 2.
21. Lotka's Law is applicable to CCB research literature with D_{max}=0.0004 and Critical value=0.0051 for the Authorship distribution when n = -2.847

Conclusion

Scientometric studies using the various bibliometric and economic indicators and techniques highlights the research contribution, performance, and evaluation of various countries, institutions. The secondary dataset obtained from Web of Science database on the world literature on Climate Change on Biodiversity field (22121 research output with 48010 average citations per paper, published during 2011 to 2021) highlights there is urgent need to take precautionary measures against the adverse effects of Climate Change on biodiversity. The study observed that there is a collaboration trend among researchers in the field of CCB with collaboration coefficient of 0.71.

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