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Scientometric Discovery of Research Contributions of the Journal "Nature Climate Change" During 2011-2020

TAPAS KUMAR DAS*
MUKESH BEHERA**
JIGNESH MAKWANA***
AKHANDANAND SHUKLA1****

The study looks at the scientometric traits of the Nature Climate Change (NCC) journal and the papers that were extracted from the Scopus database between 2011 and 2020.The analysis and visualisations for the study were done using RStudio and VOSviewer. The analysis indicated an upward trend in the number of publications in NCC from 2011 to 2020; carbon emissions, climate change, global warming, greenhouse gases, and carbon dioxide were the key research topics; the top authors were from the United States and the United Kingdom.Since the study depends on information obtained from the Scopus database, any database limitations may have an impact on the results of the study.

Keywords: *Bibliographic Coupling, Citation Analysis, Country Collaboration, Co-authorshipPattern, Co-citation, Keyword Co-occurrence, RStudio, Scopus, Scientometrics, VOSviewer.*

1 INTRODUCTION

Climate is one of the most seminal points of debate in the contemporary socio-political scenario. Climate change, according to United Nations[1], "refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, such as through variations in the solar cycle. But since the 1800s,

* Research ScholarPG Department of Library & Information ScienceSardar Patel University, Anand SLIA, IIT GandhinagarEmail: tapaskumar.mu@gmail.com

** Library Professional TraineeIIT GandhinagarEmail: mukeshbehera25@gmail.com

*** Assistant ProfessorPG Department of Library & Information ScienceSardar Patel University, AnandEmail: jignesh.makwana2182@gmail.com

**** Associate ProfessorDepartment of Library & Information ScienceCentral University of Tamil Nadu, ThiruvarurEmail: akhandanandshukla@gmail.com

human activities have been the main driver of climate change, primarily due to burning fossil fuels like coal, oil and gas". The inevitable progress of industrial modernity and the technological advancements caused by this epochal transformation has been subjected to various studies, reports and works. There have been various crucial/prophetic interventions regarding this highly alarming condition from the past decades.

The 1992 United Nations Rio Declaration[2-3], which remarks that "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation", was one such crucial intervention. According to Nancy Fraser[4], the term "eco-politics" has spread widely. She expands by remarking that it is "no longer the exclusive property of stand-alone environmental movements, climate change now appears as a pressing matter on which every political actor must take a stand".

Therefore, it becomes crucial to study the contemporary dynamics and developments in the sphere of change in climate. From this premise, this paper concentrates on the journal *Nature Climate Change*. It is a decade-old high-impact transformative journal founded in the field of "global warming" and current "climate change" in April 2011 as the continuation of *Nature Reports Climate Change* (established in 2007). It aims at "understanding the Earth's changing climate, and its consequences, is a scientific challenge of enormous importance to society"[5]. The journal is indexed in all the major databases, including Web of Science and Scopus. In the Journal Citation Reports (JCR) of the Web of Science, in the 2021 edition, it has an impact factor of 20.893.The journal focuses on issues relating to the most important and cutting-edge top-tier novel research in the natural and social sciences and attempts to integrate multidisciplinary study.Through a peer-reviewing process, it is committed to publishing in all fields connected to climate change and upholds the criteria for high-quality science.

2 REVIEW OF LITERATURE

For reviewing the diverse publications related to the topic under study, some significant literature is reviewed. According to data gathered from the Scopus database, Raza et al.[6] conducted a study on carbon footprint of buildings from 1971 to 2021. Since 2002, the research on carbon footprint has risen and major contributions in English have primarily come from China and the United States. Yue et al.[7] performed a bibliometric analysis of 12 years' worth of works on carbon footprinting. The total number of publications (3698) was obtained as study samples from the Web of Science database (from 2007 to 2018) and analyzed using CiteSpace, VOSviewer, Sci2, CoPalRed, IN-SPIRE, Vantage Point, Bibexcel, and other tools.The four major components discovered using

keyword clustering include: Carbon footprint calculation methods, research scales, energy, and Agriculture; three prominent countries identified in this field of research, such as the USA, China, and the UK.The "Chinese Academy of Sciences" holds the most research, according to the study's spatial analysis from the viewpoint of publishing institutions. Li & Li[8] carried out a scientometrics study on risk governance and sustainability and their relationships from 1998 to 2021. After searching the Web of Science Core Collection for pertinent articles published in scholarly journals, 1156 papers were retrieved and examined for the study. This study sheds light on the diversity of risk governance, sustainability, and other related fields of study. Kaur & Sood[9] studied disaster management and ICT papers published between 2009 and 2019. The study looked at papers published in the last ten years on the use of ICT in various disasters. Data were taken from Scopus to assess the rise in publishing output annually, identify related subject areas, and establish productivity analysis criteria.

From the country's perspective, Zhang et al.[10] conducted a bibliometric study and network analysis of bioenergy research in relation to climate change. The study was based on journal articles from Scopus published between 1999 and 2018. A total of 3050 papers have been evaluated for the research since 1999. According to the study, developed nations like the USA, Canada, and some European nations have high rates of reading and publishing. Due to linguistic and cultural differences, academic collaboration between Asian and African countries is still minimal. A "Carbon Capture Technology"related research from 1998 to 2018 by Omoregbe et al.[11] revealed that the UK was the most productive nation while South America and Africa were the least fertile continents. The study used the total number of 1020 publications using the keywords "post-combustion" and "oxy-fuel combustion" from all conference papers and articles related to carbon capture. Alcayde et al.[12] provided an innovative technique for assessing renewable energy articles and scientific collaboration networks utilizing community detection. The Scopus Database API Interface was used to acquire bibliographic data from scientific publications for the analysis. By the end of 2017, a search for "renewable energy" in Scopus produced 24,152 entries for papers co-authored by 46,741 researchers from 23,092 affiliations across 156 countries.

In order to determine the scientific agreement on whether humans are causing global warming, Myers et al.[13] examined the articles on climate change published between 2015 and 2019. Out of 153 independently verified climate experts, 98.7% stated that human activities, such as burning fossil fuels, are the main causes of the Earth's warming. Herlihy et al.[14]detailed the steps for carrying out a scoping review of the peer-reviewed literature on climate change and health using PubMed and WoS with explicit inclusion and exclusion. The range of publication dates and key terms were discovered for the search

strategy.A bibliometric analysis of research papers on halogenated gases (CHGs) that are subject to international convention control from 1999 to 2018 was done by Wang et al.[15]The results showed that the most productive countries like the USA, UK and China, Institutions like "National Oceanic and Atmospheric Administration" had contributed the most to environmental science. Additionally, studies on biological toxicity and compounds that deplete the ozone layer reveal a tendency toward an ever-increasing environmental effect.

3 SCOPE AND LIMITATION

The scope of the study is confined to research publications inthe journal *Nature Climate Change*(NCC). The study period is limited to 10 years, i.e., from 2011 to 2020.

4 MATERIAL AND METHOD

Data were extracted from the Scopus database using Advanced Search Strategy.The search string used for extraction of data was: SRCTITLE ("Nature Climate Change") AND (LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR,2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR,2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR,2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR,2011))

Conference papers, journal articles, conference reviews, articles in press, editorials, short surveys, notes, book chapters, letters, books, erratum, and other types of information are included in the data retrieved from Scopus.We performed bibliometric, network, and cluster analyses using the Bibliometrix-R package and VOSviewer.

5 RESULTS AND DISCUSSION

5.1 PUBLICATIONS, CITATIONSAND H-INDEX

The journal NCC published 2769publications during the period with169659 citations, as evident from Table 1. The table shows the journal's year-wise publication, citation, and h-index performance. The journal covers a variety of documents like Articles, Articles in Press, Conference Paper, Editorials, Erratum, Letter, Note, Review and Short Survey under its publication coverage. The highest number of documents published under Article (1135),

followed by Notes (639), Letter (283), Review (247), Short Survey (183), Erratum (139), Editorial (133), Article in Press (6) and Conference Paper (4). Out of total publications inNCC, more than 40% documents belong to Article. The citations to the published documents are displayed in Table 1, which shows the highest citations to Articles (114849) followed by Review (32922), Note (13340), Letter (6406), Short Survey (1476), Article in Press (257), Conference Paper (154), Erratum (144), and Editorial (111). Regarding citation counts, more than 67% citations belong to Articles, followed by 19.4% for Review documents. On average, NCC published 276.9 articles with 16965.9 citations per year and thus received 61.27 citations per document. The year-wise h-index is calculated in Table 1, which displays the highest h-index (h=98) in 2013. Higher citations lead to higher h-index values.

5.2 PROLIFIC AND INFLUENTIAL AUTHORS

Table 2 lists the top 10 prolific and influential authors in terms of the highest number of publications, citations and h-index. Amongst the category of prolific authors, Petherick, A. and Van Renssen, S. have published the highest number of research papers (38 each) followed by Ciais, P. (30), Wake, B. (27) etc. In terms of finding influential authors, total NCC citations and NCC h-index have been chosen as parameters. Ciais, P. has received the highest number of citations (4911), thus considered the most influential author followed by Canadell, J. G. (4547) etc. The top 10 authors have individually received more than 3000 citations each in the NCC journal. Similarly, as per the h-index, Ciais, P. has the highest h-index (h=24) value based on his NCC citations followed by Canadell, J. G. (h=18). Among the top 10 prolific and influential authors, two (Ciais, P. and Canadell, J. G.) appeared in all categories, i.e., publications, citations and h-index. Similarly, five authors (Rogelj, J.; Riahi, K.; Friedlingstein, P.; Knutti, R.; and Peters, G. P.) appeared in any of the two categories. On analysis of Table 2, it is evident that Ciais, P. is the most influential and prolific author amongst all authors in the *NCC* journal.

Table 1: Publications, Citations and h-index

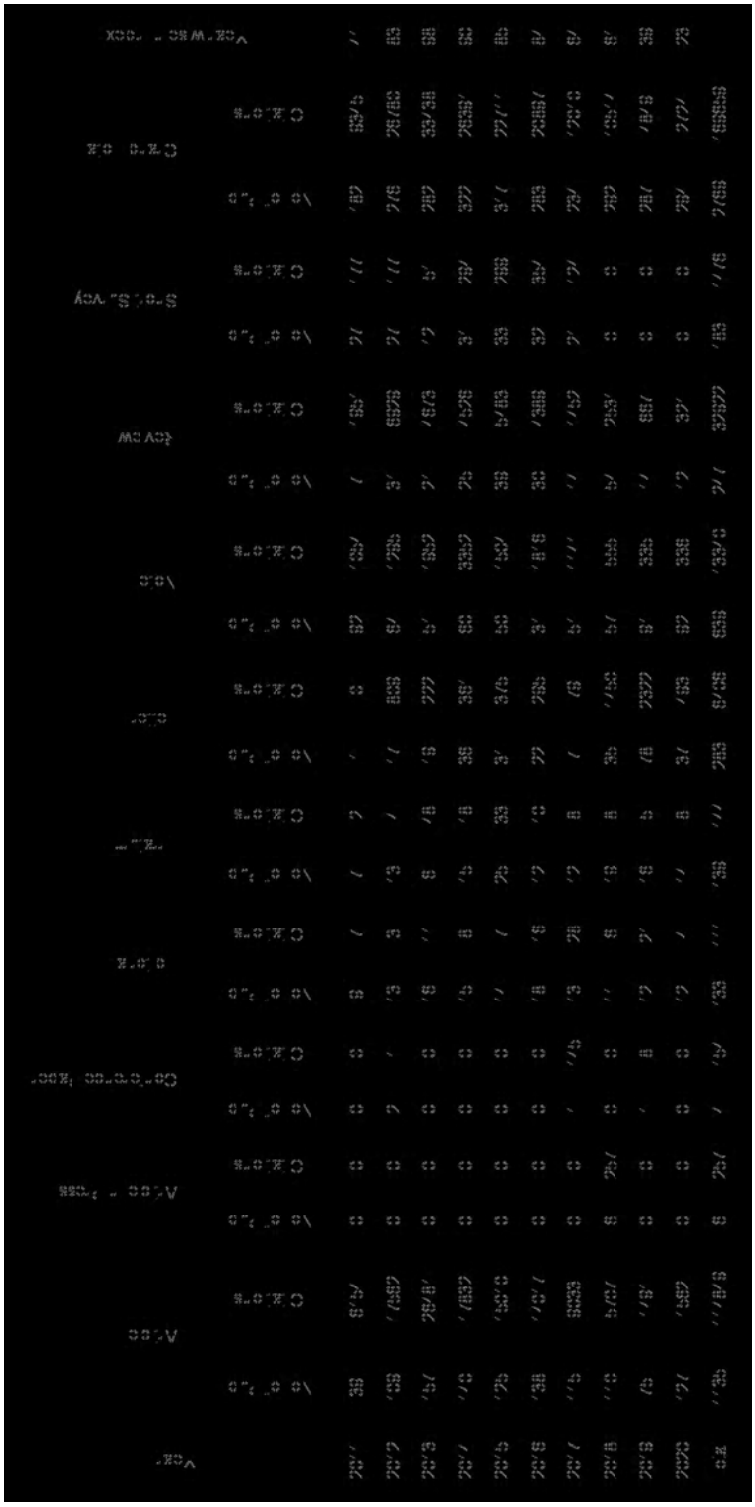


Table 2: Prolific and Influential Authors

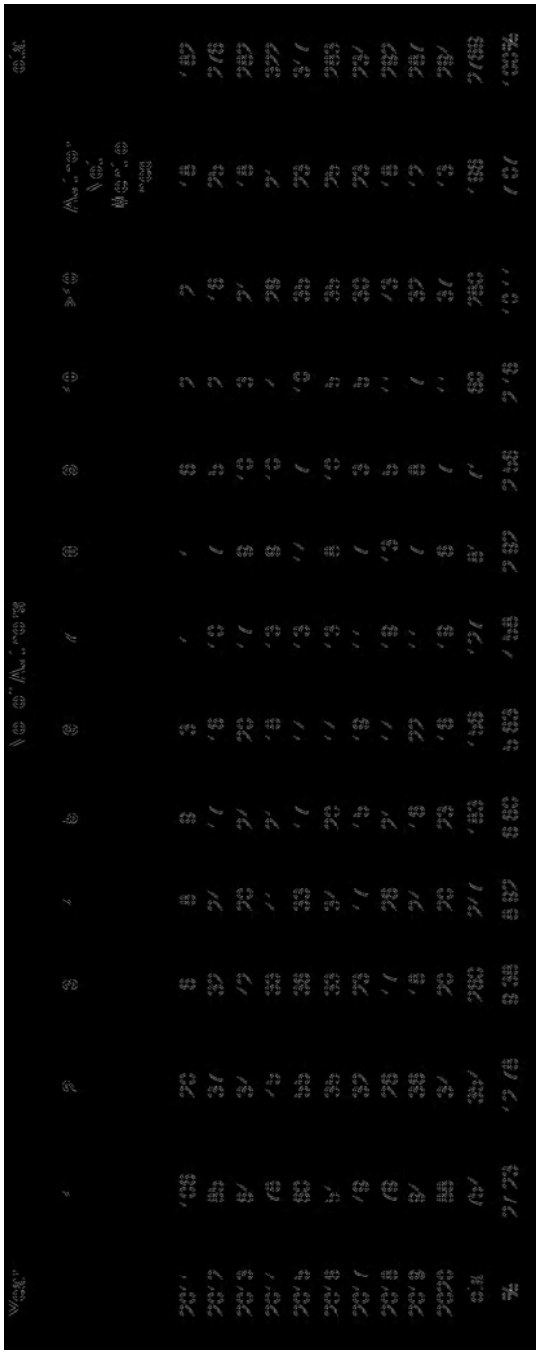
Prolific Authors		Most Influential Authors			
Authors	**TP**	**Authors**	**TC**	**Authors**	**h-index**
Petherick, A.	38	Ciais, P.	4911	Ciais, P.	24
Van renssen, S.	38	Canadell, J. G.	4547	Canadell, J. G.	18
Ciais, P.	30	Dai, A.	3801	Friedlingstein, P.	18
Wake, B.	27	Knutti, R.	3782	Peters, G. P.	16
Rogelj, J.	23	Lobell, D. B.	3675	Riahi, K.	16
Yeeles, A.	21	Cai, W.	3510	Rogelj, J.	16
Langenbrunner, B.	20	Timmermann, A.	3406	Knutti, R.	15
Canadell, J. G.	19	Wu, L.	3378	Van Vuuren, D. P.	15
Riahi, K.	19	Peters, G. P.	3196	Hawkins, E.	14
Friedlingstein, P.	18	England, M. H.	3189	Fischer, E. M.	13

(TP=Total Publications, TC=Total Citations)

5.3 AUTHORSHIP PATTERNS

The authorship pattern in research publications of the NCC journal has been analyzed year-wise in Table 3. More thanten authors in a research publication are also observed, while few research publications (7%) have not mentioned any authors. The highest number of research publications belonged to single-authored (27.23%) followed by two authored (12.78%) and >10 authored (10.11%). Amongst all authorship patterns, single-authored publications are more (27.23%), while 65.7% of publications are published in multiple authorship patterns. Multiple authorship patterns are prevalent amongst authors and thus found strong collaboration.

Table 3: Authorship Patterns



5.4 HIGHLY CITED PUBLICATIONS

Table 4 represents the top 10 highly cited publications in the *NCC* journal. Dai, A. (2013) published the most cited research publication (2037 citations) with an average of 226.44 citations per year followed by Trenberth, K. E. et al. (2014) with 1228 citations (153.75 citations per year) etc. Each of the top 10 highly cited publications has more than 900 citations while receiving a minimum of 98 citations per year.

Table 4: Top 10 Highly Cited Publications

Publication Details	Year	Citation	CPY
"Dai, A. (2013). Increasing drought under global warming in observations and models. *Nature Climate Change*, 3(1), 52–58."	2013	2037	226.44
"Trenberth, K. E., et al. (2014). Global warming and changes in drought. *Nature Climate Change*, 4(1), 17–22."	2014	1228	153.75
"Yao, T., et al. (2012). Different glacier status with atmospheric circulations in Tibetan Plateau and surroundings. *Nature Climate Change*, 2(9), 663–667."	2012	1196	119.7
"Coumou, D., &Rahmstorf, S. (2012). A decade of weather extremes. Nature Climate Change, 2(7), 491–496."	2012	1088	108.9
"Park Williams, et al. (2013). Temperature as a potent driver of regional forest drought stress and tree mortality. *Nature Climate Change*, 3(3), 292–297."	2013	1008	112.22
"Cai, W., et al. (2014). Increasing frequency of extreme El Niño events due to greenhouse warming. *Nature Climate Change*, 4(2), 111–116."	2014	992	124.25
"Nykvist, B., & Nilsson, M. (2015). Rapidly falling costs of battery packs for electric vehicles. *Nature Climate Change*, 5(4), 329–332."	2015	989	141.57
"Hirabayashi, Y., et al. (2013). Global flood risk under climate change. *Nature Climate Change*, 3(9), 816–821."	2013	981	109.33
"Kahan, D. M., et al. (2012). The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Climate Change*, 2(10), 732–735."	2012	981	98.3
"Poloczanska, E. S., et. al. (2013). Global imprint of climate change on marine life. *Nature Climate Change*, 3(10), 919–925."	2013	953	106

5.5 MOST INFLUENTIAL COUNTRIES IN NCC

Table 5 represents a list of the top 10 countries as per the highest number of publications in the NCC journal. Authors from the United States havepublished the highest number of publications (1255 publications with 47494 citations) followed by the United Kingdom (729 publications, 19152 citations) and Australia (406 publications, 15020 citations). Countries like Germany, Canada, France, Netherlands, China, Switzerland, and Norway have contributed significantly. The Citations per Publications (CPP) are higher for Switzerland (139.5) and China (122.2) than the United States which has the highest publications and citations. Similarly, Table 6represents the most influential countries based on CPP and found that the United States has received the highest number of citations (47494) but hasthe second lowest CPP (72.8) amongst the top 10 influential countries. Austria has contributed 106 research publications having a total of 3734 citations and topped with the highest CPP (169.7) followed by Switzerland (139.5) and China (122.2). The United Kingdom has the second highest number of publications and citations but the CPP ratio is least among the top 10 countries. Rests of the countries (like Australia, France, Netherlands, Canada and Germany) have higher CPP than the United States of America.

Table 5: Top 10 Countries (based on publications)

Country	Publications	Citations	CPP
United States	1255	47494	72.8
United Kingdom	729	19152	61.8
Australia	406	15020	88.9
Germany	352	6577	75.6
Canada	203	5263	77.4
France	200	2906	78.5
Netherlands	194	3904	78.1
China	169	6353	122.2
Switzerland	167	7112	139.5
Norway	128	2232	85.8

Table 6: Top 10 Influential Countries (based on CPP)

Country	Citations	Publications	CPP
Austria	3734	106	169.7
Switzerland	7112	167	139.5
China	6353	169	122.2
Australia	15020	406	88.9
France	2906	200	78.5
Netherlands	3904	194	78.1
Canada	5263	203	77.4
Germany	6577	352	75.6
United States of America	47494	1255	72.8
United Kingdom	19152	729	61.8

(Citation per Publication)

5.6 MOST FREQUENT KEYWORDS

Figure 1displays the top 10 keyword occurrences in research papers published in the NCC journal. It shows how the keywords in the relevant area are distributed. The study shows the crucial keywords in the area, including climate change, global warming, carbon dioxide, climate modeling, greenhouse gas, environmental policy, etc. The keyword “climate change” has occurred 793 times followed by the term “global warming”, “carbon dioxide”, “climate modeling”, “climate effect”, etc. It is evident from the study that the NCC journal published research around “climate change” or its related area and thus contributed significant research on climate change.

5.7 KEYWORD CO-OCCURRENCE

Figure 2 demonstrates the co-occurrence of all keywords. The analysis found that the essential keywords are Climate Change, Global Warming, Climate Modeling, Carbon Dioxide, Biodiversity, Rainfall, Policy Making, Acidification, Decision Making, Arctic, Cooling, Fossil Fuel, Deforestation, Extreme Event etc. There are 606 items in all, divided into 8 clusters: Cluster 1 (Red Colour) has 148 items, Cluster 2 (Green Colour) has 132 items, Cluster 3 (Blue Colour) has 128 items, Cluster 4 (Yellow Colour) has 81 items, Cluster 5 (Purple) has 62 items, Cluster 6 (Cyan Colour) has 48 items, Cluster 7 (Orange Colour) has 6 items, and Cluster 8 (Brown Colour) has only one item.

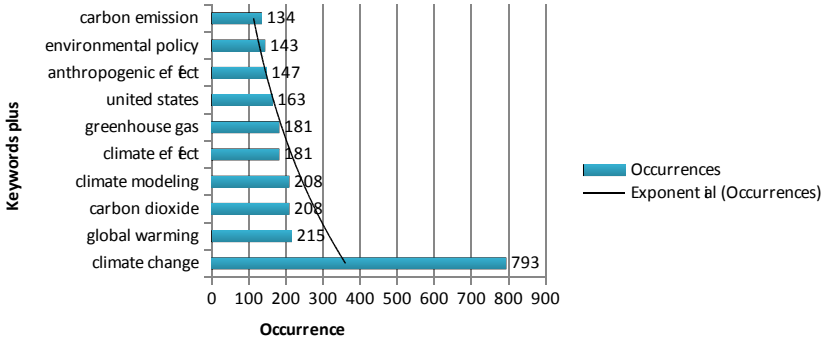


Fig: 1. Most Frequent Keywords (Field: Keywords Plus)

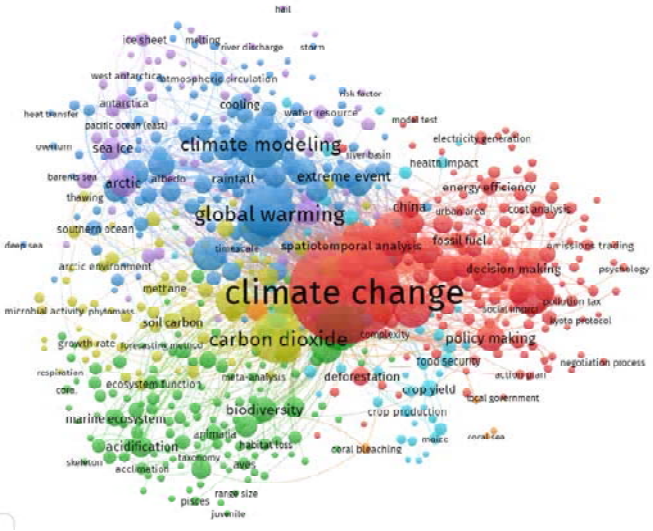


Fig: 2. Co-occurrence of Keywords

5.8 COUNTRY COLLABORATION

The network graph (Fig. 3) shows the relationship between units, with the units representing nodes of circles and the relationships representing a link between two nodes. The bibliometric network maps for country collaboration were created using VOSviewer. There are 49 countries in all, divided into 5 clusters: Cluster 1 (Red Colour) has 17 countries, Cluster 2 (Green Colour) has 10 countries, Cluster 3 (Blue Colour) has 9 countries, Cluster 4 (Yellow Colour) has 7 countries, and Cluster 5 (Purple Colour) has 6 countries. The Cluster 1 countries have higher collaboration (association), followed by Cluster 2 and Cluster 3. The United States has the highest amount of collaboration with other countries followed by the United Kingdom, Japan, France, Switzerland, China, Austria, Italy etc.

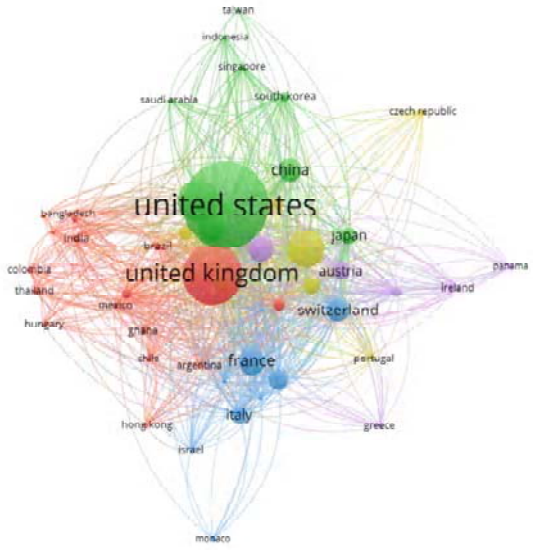


Fig. 3: Country Collaboration

5.9 CO-AUTHORSHIP NETWORK

The number of co-authorship clusters established amongst authors is displayed in Figure 4 by the relationship between authorship and colour variations. According to cluster analysis, the co-authorship network has 13 clusters. There are a total of 13 authorship clusters and 208 authors. Cluster 1 has 32 authors, Cluster 2 has 28 authors, Cluster 3 has 26 authors, Cluster 4 has 23 authors, Cluster 5 has 22 authors, Cluster 6 has 18 authors, Cluster 7 has 14 authors, Clusters 8 and 9 have 11 authors each, Cluster 10 has 7 authors, Cluster 11 has 6 authors, Cluster 12 has 6 authors, and Cluster 13 has 4 authors.

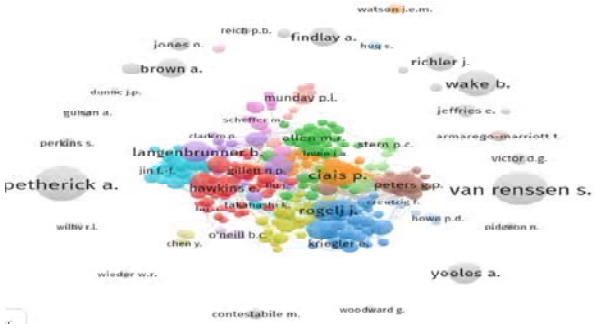


Fig. 4: Co-Authorship Network

5.10 CLUSTERING OF BIBLIOGRAPHIC COUPLING

Figure 5 shows the cluster range, documents, cluster frequency, and normalized local citation score for the most productive documents in a cluster of bibliographic coupling analysis. There are four clusters visible in Fig. 5. The map depicts the most productive documents, while the links show how they are linked. Cluster 1 has 57 documents. The highest normalized local citation score is 7.21 (SCHLEUSSNER CF, 2016, NAT CLIM CHANGE) and the lowest is 0.54 (JOHNSTON A, 2013, NAT CLIM CHANGE). Cluster 2 has 66 documents. The highest normalized local citation score is 5.97 (KNUTTI R, 2013, NAT CLIM CHANGE) and the lowest is 0.54 (RIIHEL A, 2013, NAT CLIM CHANGE). Cluster 3 has 110 documents. The highest normalized local citation score is 2.9 (QI D, 2017, NAT CLIM CHANGE) and the lowest is 0.54 (WEBSTER M, 2013, NAT CLIM CHANGE). Cluster 4 has 17 documents. The highest normalized local citation score is 3.25 (WILLIAMS AP, 2013, NAT CLIM CHANGE) and the lowest is 0.54 (RAFFEL TR, 2013, NAT CLIM CHANGE).

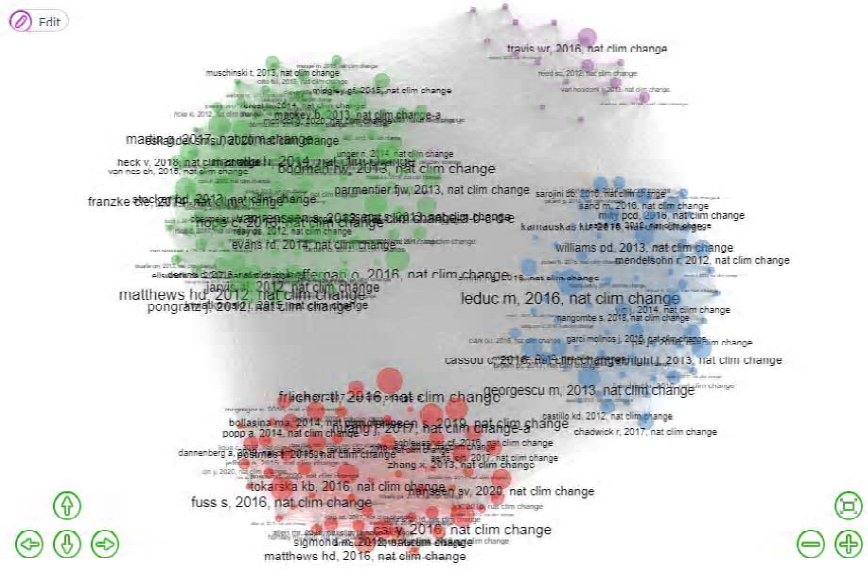


Fig.5: Clustering of Bibliographic Coupling

5.11 AUTHOR CO-CITATION NETWORK

Figure 6 shows the author's co-citation network where nodes with a similar colourrepresent a cluster. The first cluster is in red having 10 authors. The first cluster is most important in terms of Betweenness, Closeness and Page Ranks, emphasizing mainly the group of authors formed by Taylor (93.77 Betweenness,

0.016 Closeness and 0.019 Page Rank), Meehl (20.56 Betweenness, 0.015 Closeness and 0.019 Page Rank), Hansen (43.46 Betweenness, 0.017 Closeness and 0.019 Page Rank) etc. The second cluster in bluehas16 authors. The Betweenness, Closeness and Page Ranks for the group of authors (in the second cluster) formed by Smith (91.16 Betweenness, 0.015 Closeness and 0.020 Page Rank), Rogelj (4.50 Betweenness, 0.014 Closeness and 0.020 Page Rank), Allen (22.89 Betweenness, 0.015 Closeness and 0.020 Page Rank) etc. The third cluster is in green colour with 23 authors. The Betweenness, Closeness and Page Ranks for the group of authors (in the third cluster) formed by Zhang (14.50 Betweenness, 0.014 Closeness and 0.020 Page Rank), Wang (10.56 Betweenness, 0.014 Closeness and 0.021 Page Rank), Liu (13.72 Betweenness, 0.014 Closeness and 0.020 Page Rank) and so on.

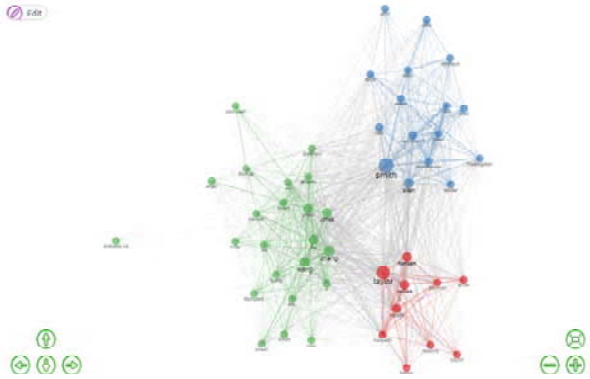


Fig.6:Author Co-CitationNetwork

6 CONCLUSION

Climate change has become one of the most popular buzzwords recently. It has been recurring in various engagements in diverse spheres. This study, which aimed to determine the trends of published literature in *Nature Climate Change* (NCC) for the period of a crucial decade, i.e., 2011-2020, has yielded significant outputs. It is found that most articles published were research articles followed by notes, letters, reviews, short surveys, erratum and editorials etc. Out of all categories, *the NCC* published more than 40% research articles, receiving more than 67% citations of the total. “Reviews” were the second most published research document with more than 19% citations. Petherick, A. and Van Renssen, S. were the top contributors to the NCC, while Ciais, P. was the most influential author in terms of citations and h-index. The study found that multiple authorships are prevalent in *NCC* with high collaboration among authors. Global warming related studies have a high impact in *NCC*

and thus receive the highest citations per year. The United States, United Kingdom and Australia have produced much scientific literature on climate change, as observed in *NCC*. Keyword plus based study of *NCC* indicated that "climate change" topic is core of the research concern followed by "global warming", and "climate modelling" etc. The collaborative research found most in the countries like the United States and the United Kingdom.

Further study visualized the co-authorship network, clustering of bibliographic coupling and author co-citation network. Insights on climate change research and its other aspects, as stated in NCC journal papers, are provided by this study.The study's significant contributions are the discoveries made on scientific productivity, important and prolific academics, influential nations in climate change research, highly cited research, keyword analysis, and networks of author and country collaboration.

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