

GLOBAL SCIENTIFIC PRODUCTION ON CLIMATE CHANGE ARTICLES: A BIBLIOMETRICS ANALYSIS

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Abstract: *This research used Bibliometrics and spatial distribution to describe science research productivities in patterns of article types, country, and journal via climate change articles on SCI during 2007-2018. In 25278 articles on climate change field, total research publication and article form is increasingly from 2007 to 2018. Total research productivity increases sharply in 2018 year, gains to 3325 articles and 2800 article forms in 2018 year. Moreover, article form is the highest research production gaining 19917 articles (1st ranking). USA is a country, where has the highest publication outputs in all the article types and in total research productivity (23286 articles with 1st ranking) including 5369 independent articles (23.06%) and 17917 collaborative articles (76.94%). CLIMATIC CHANGE journal has the most research outputs with 1105 articles (4.37%), 1st ranking, and it increases sharply in the last years. NATURE CLIMATE CHANGE journal have not any research output in first years of publication period. This paper found out 163 countries in climate change article publication, whereas Vietnam is ranked the 45th with 159 articles (0.63%) including 33 independent articles (50th ranking, 20.8%) and 126 collaborative articles (44th ranking, 79.2%); and on the world map, Vietnam is performed by light blue color. Additionally, the map also shows that the research productivity is almost revealed on all countries with different research productivity quantities. The countries have high publication, are located highly in USA, Canada, Europe community, and some Asian countries (e.g. China, India, etc.). They are categorized into 5 ranks from low to high amount of publication and be colorized respectively. For example, independent publication is showed from small red round dot to big one, and cooperative publication is performed in different colors, in which USA has the most publications in dark blue and big red do. This paper, therefore, revealed science growth, research publishing trend, and spatial distribution of countries on climate change articles, and it also provides knowledge as well as more understanding about climate change field.*

Keywords: *Climate change, Bibliometrics, Spatial Distribution.*

1. Introduction

The past decade has demonstrated that the global environment has been altered by human activities (CGCR, 1999). Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2007). It is attributed directly or indirectly to human activity that alters the composition

of the global atmosphere such as burning of fossil fuels (CGCR, 1999), land use change and agriculture that are increasing the atmospheric concentrations of greenhouse gases, and aerosols (IPCC, 1995). This change is precisely temperature change, precipitation, humidity, wind patterns (IPCC, 2001) and they make alteration of the energy balance of the climate system lead to increasing risk of vector born diseases, widespread damage of natural ecosystem, loss of biodiversity, increase the frequency of extreme events like droughts, floods (AASA, 2011), typhoon, heat wave,

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wildfire (Ken Ogilvie et al., 2004; Susanne C. Moser et al., 2007). According to the recent Intergovernmental Panel on Climate Change reported, the average global surface temperature has increased by 0.74 C over the last 100 years (1906-2005) (IPCC, 2007), it is caused by the build-up of greenhouse gases in the atmosphere accumulated from continual combustion of fossil fuels (Hatzigeorgiou et al., 2008) and warmer temperatures will lead to a more vigorous hydrological cycle; this translates into prospects for more severe droughts and/or floods in some places and less severe droughts and/or floods in other places (IPCC, 1995) concurrently increasing in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level (IPCC 2007). Consequently, global sea level has risen by between 10 and 25cm over the past 100 years (IPCC, 1995), leads to affect freshwater flows with dramatic adverse effects on biodiversity, people and livelihoods (Jinghai Li et al., 2011). Therefore climate change has become a major scientific, political, economic, and environmental issue during the last decade (Li et al, 2011) and scientific articles on climate change have demonstrated a rapid increase in quantity over the past several decades, a number of papers presenting the latest research achievements have been published in authoritative scientific journals such as Nature and Science (Jinfeng Li et al, 2011). And bibliometric is a research tool, regarded as cannot be absent in investigation of information science field because of its strength in quantitative (Almind and Ingwersen, 1997) and qualitative analysis (Zhang et al, 2010) to improve efficiency rates of information handling process (Ashwini tiwari, 2006) and increase understanding of the information science research (Gayatri mahapatra, 2009). Therefore, in this research based on 25278 articles, which were published on SCI from 2007 to 2028 year to find out a new method as calculation of research publications and spatial distribution of countries on the world map. Particular, the research aim to 1) describe and analyze total research productivity in 2007-2018, research

productivity of article types, journals of climate change articles. 2) Analyze research publication of countries and perform its distribution on the world map. This can be helped authorizes to be easily in envision about climate change scientific productivity on the world.

2. Methodology

The whole data source was download from Science Citation Index (SCI) database from 2007 to 2018 with term "climat* chang*" including "climate changes", "climatic change", "climate change", and "climatic changes". It was used to locate publication containing these words in parts of titles, abstracts or keywords. After that, these 25278 articles were recorded and calculated into spreadsheet Excel with different types as article types, country, journal, and so on.

The common as other bibliometric method, before calculating total research productivities needs to implement some steps as group all the articles originated from England, Scotland, North Ireland, Wales were United Kingdom (UK) heading; the articles are from different States of America are reclassified as United State America (USA). Peoples R China, Taiwan, Hongkong are belonged to be China. Collaborative categories are determined when independent categories are assigned. Independent categories include one or many common authors which are designed researcher. Collaborative categories conclude many different authors from one or multiple countries.

3. Results and discussion

Total 25278 articles were derived from Science Citation Index database to calculate and analyze research publication in period 2007-2018. The results are presented as follow:

3.1. Research productivity in 2007-2018 year

After calculating in total 25278 articles, this research found out total scientific productivity for each year from 2007 to 2018 including alternately as 905 articles (2007); 1214 articles (2008); 1460 articles (2009); 1689 articles (2010); 2035 articles (2011); 1984 articles (2012); 2389 articles (2013); 2325 articles (2014); 2550 articles (2015); 2691 articles (2016); 2711 articles

(2017); and 3325 articles (2018). It indicates annual scientific productivity increases from 2007 to 2018 except for it has a bit decreased in 2012 year and 2014 year, particular in 2012 is less than 2011 year 51 articles, and the article number in 2013 is more than in 2014 year 64 articles - this vision seems contrast with growth rule of research publication on SCI. On the Figure 1 can be seen three growth lines of scientific productivity on total research productivity,

article, and review type, in which next year is almost more published than last year, especially the scientific production increases sharp from 2007 to 2011 (905 articles to 2035 articles) and from 2017 to 2018 (2711 articles to 3325 articles) on climate change articles in article and total research productivity. However, in review type, scientific publication increases from 2007 to 2018, but that increasing is only slowly, approximately 400 articles in 2018.

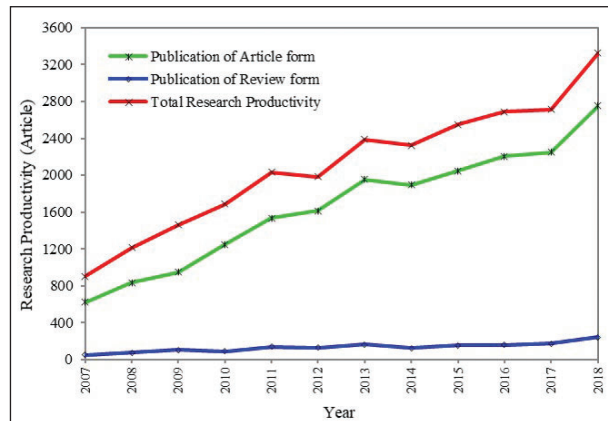


Figure 1. Annual research publication of climate change article

3.2 Article types

Article types are one in many science information categories which can be counted by bibliometric. They include many forms and table 1 is 6 forms with their research productivity attaching by ten countries as United State (USA), United Kingdom (UK), Canada, Germany, China, Australia, France, Spain, Italy, and Netherland. It indicates that Article form has the most publishing output with 19917 articles with the first ranking, following distantly as Editorial Material 1724 articles (2nd), Review 1631 articles (3rd), Proceedings Paper 572 articles (4th), Letter 416 articles (5th), and Correction 258 articles (6th) with the last ranking. Besides, the Article form is popular research production in total countries and it normally occupies the highest publishing output number in total research types. Particular, USA has 4370 articles and occupies 21.94% of total Article form, following as 2079 articles (China, 10.44%); 1493 articles (UK, 7.5%); 1202 articles (Australia, 10.44%); 1110 articles (Germany, 5.57%); 1089 articles

(Canada, 5.47%); 608 articles (France, 3.05%); 589 articles (Spain, 2.96%); 507 articles (Italy, 2.55%); and 441 article belongs to Netherland with 2.21%. Furthermore, research publication of Article form is higher than other forms in big gap. It has 19917 articles in 2007-2018 while other forms only have some hundreds to thousands of research publication.

On the Table 1 can be also seen that USA is a country, which is always has the highest research output about all the Article forms in top ten countries, next is UK (2nd country) in Editorial Material form (202 articles, 11.72%) and Review form (248 articles, 15.21%). But in the Article form, the second ranking in countries is China with 2079 articles (10.44%). In Editorial Material form and Review form, China is ranked the fifth and Australia is ranked in 3rd, Germany and Canada are the fourth ranking about research output. Generally, in the article type has seen that Article form has the highest research publication whereas other forms merely has from some articles to hundreds articles.

Table 1. The distribution of article types by countries in 2007-2018

Type	TP (R)	USA (%)	China (%)	UK (%)	Australia (%)	Germany (%)	Canada (%)	France (%)	Spain (%)	Italy (%)	Netherland (%)
Article	19917 (1)	4370 (21.94)	2079 (10.44)	1493 (7.5)	1202 (6.04)	1110 (5.57)	1089 (5.47)	608 (3.05)	589 (2.96)	507 (2.55)	441 (2.21)
Editorial Material	1724 (2)	439 (25.46)	61 (3.54)	202 (11.72)	109 (6.32)	75 (4.35)	60 (3.48)	30 (1.74)	31 (1.8)	41 (2.38)	24 (1.39)
Review	1631 (3)	434 (26.61)	86 (5.27)	248 (15.21)	172 (10.55)	75 (4.6)	107 (6.56)	50 (3.07)	46 (2.82)	50 (3.07)	37 (2.27)
Proceedings Paper	572 (4)	98 (17.13)	40 (6.99)	49 (8.57)	23 (4.02)	30 (5.24)	22 (3.85)	18 (3.15)	20 (3.5)	20 (3.5)	24 (4.2)
Letter	416 (5)	82 (19.71)	8 (1.92)	54 (12.98)	34 (8.17)	10 (2.4)	19 (4.57)	8 (1.92)	3 (0.72)	3 (0.72)	3 (0.72)
Correction	258 (6)	29 (11.24)	5 (1.94)	23 (8.91)	7 (2.71)	5 (1.94)	5 (1.94)	4 (1.55)	5 (1.94)	6 (2.33)	2 (0.78)

TP Total research productivity; R Ranking;

3.3 Distribution of journal on climate change articles

On the SCI web, each article is published on a journal. Climate change articles can be published on one or many different journals. In the below table is 20 journal names with total the highest research productivity whereas has many famous journals on SCI, such as: CLIMATIC CHANGE journal has 1105 articles (4.37%) and 1st ranking including 49 articles in 2007 year; 61 articles (2008 year); 60 articles (2009); 71 articles (2010); 89 articles (2011); 109 articles (2012); 166 articles (2013); 99 articles (2014); 90 articles (2015); 84 articles (2016); 114 articles (2017); and 113 articles (2018). Following distantly as GLOBAL CHANGE BIOLOGY journal with 518 articles (2nd ranking, 2.05%); PLOS ONE journal with 495 articles (3rd ranking, 1.96%); REGIONAL ENVIRONMENTAL CHANGE journal has 326 articles (4th ranking, 1.29%); SCIENCE OF THE TOTAL ENVIRONMENT journal with 287 articles (5th ranking, 1.14%); NATURE CLIMATE CHANGE journal has 272 articles (6th ranking, 1.08%); GLOBAL ENVIRONMENTAL CHANGE journal has 253 articles (7th ranking, 1%); SCIENCE journal with 244 articles (8th ranking, 0.97%); JOURNAL OF HYDROLOGY journal has 241 articles (9th ranking, 0.95%); and

ENVIRONMENTAL RESEARCH LETTERS journal with 219 articles (10th ranking, 0.87%). Thus, from table 2 shows that CLIMATIC CHANGE journal has the most “climate change” research production in top ten journals on SCI.

Besides, the table 2 can be seen that division of research production in each year in 2007-2018. It indicates some journals grow in publication output and increase sharply in the last years (2017 and 2018 year), such as CLIMATIC CHANGE journal (1st ranking), ENVIRONMENTAL RESEARCH LETTERS journal (10th ranking); and SCIENCE OF THE TOTAL ENVIRONMENT journal (5th ranking). Contrast, there are three journals, which have diminished in the last year as REGIONAL ENVIRONMENTAL CHANGE journal (4th ranking), PLOS ONE journal (3rd ranking), and GLOBAL ENVIRONMENTAL CHANGE journal (7th ranking). Moreover, there are not or very less publication output (0-6 articles in 2007-2010 year) in some journals of climate change articles as REGIONAL ENVIRONMENTAL CHANGE journal, SCIENCE OF THE TOTAL ENVIRONMENT journal, and NATURE CLIMATE CHANGE journal. But they reveal high publication output in many next years. This means climate change field has an important signification on the world and be paid attention by scientists.

Table 2. Distribution of journal in 2007-2018

Journal Type	TP (R)	TP (%)	2007 (%)	2008 (%)	2009 (%)	2010 (%)	2011 (%)	2012 (%)	2013 (%)	2014 (%)	2015 (%)	2016 (%)	2017 (%)	2018 (%)
CLIMATIC CHANGE	1105 (1)	4.37	49 (4.4)	61 (5.4)	60 (5.4)	71 (6.4)	89 (8.1)	109 (9.9)	166 (15.1)	99 (9.0)	90 (8.2)	84 (7.6)	114 (10.3)	113 (10.2)
GLOBAL CHANGE BIOLOGY	518 (2)	2.05	14 (2.7)	21 (4.1)	29 (5.7)	31 (6.0)	50 (9.7)	48 (9.3)	55 (10.5)	54 (10.4)	56 (10.6)	48 (9.3)	52 (10)	60 (11.7)
PLOS ONE	495 (3)	1.96	2 (0.4)	3 (0.6)	11 (2.2)	10 (2.0)	23 (4.7)	34 (6.9)	70 (14.1)	75 (15.2)	73 (14.8)	70 (14.1)	60 (12.1)	64 (12.9)
REGIONAL ENVIRONMENTAL CHANGE	326 (4)	1.29	4 (1.2)	1 (0.3)	3 (0.9)	6 (1.8)	40 (12.3)	16 (4.9)	30 (9.2)	46 (14.1)	51 (15.6)	45 (13.8)	49 (15.1)	35 (10.8)
SCIENCE OF THE TOTAL ENVIRONMENT	287 (5)	1.14	2 (0.7)	2 (0.7)	4 (1.4)	3 (1.1)	8 (2.8)	15 (5.2)	14 (4.9)	16 (5.6)	22 (7.7)	51 (17.7)	48 (16.7)	102 (35.5)
NATURE CLIMATE CHANGE	272 (6)	1.08	0	0	0	0	17 (6.3)	29 (10.6)	37 (13.5)	30 (11.1)	54 (19.8)	40 (14.7)	25 (9.2)	40 (14.8)
GLOBAL ENVIRONMENTAL CHANGE	253 (7)	1	8 (3.2)	6 (2.4)	18 (7.1)	18 (7.1)	32 (12.7)	21 (8.3)	37 (14.6)	32 (12.6)	27 (10.7)	12 (4.7)	17 (6.7)	25 (9.9)
SCIENCE	244 (8)	0.97	43 (17.6)	37 (15.2)	21 (8.6)	19 (7.8)	19 (7.8)	13 (5.3)	13 (5.3)	13 (5.3)	17 (6.9)	18 (7.5)	12 (4.9)	19 (7.8)
JOURNAL OF HYDROLOGY	241 (9)	0.95	6 (2.5)	7 (2.9)	9 (3.7)	10 (4.2)	14 (5.8)	29 (12.0)	32 (13.3)	39 (16.2)	24 (9.9)	25 (10.4)	19 (7.9)	27 (11.2)
ENVIRONMENTAL RESEARCH LETTERS	219 (10)	0.87	5 (2.3)	5 (2.3)	12 (5.5)	9 (4.1)	13 (5.9)	10 (4.6)	23 (10.5)	19 (8.7)	28 (12.8)	28 (12.8)	24 (10.9)	43 (19.6)

TP Total research productivity; R Ranking;

3.4 Distribution of country

In calculation of climate change articles on SCI, country category gives us to be known which countries have independent articles or collaborative articles and its research productivity. Via 25278 articles, this research found out 163 countries published climate change articles in 2007-2018 years. Table 3 includes top 20 countries have the highest publication output and Viet Nam is a country, which is 45th ranking. It indicates that USA is 1st ranking with research output as 23286 articles (24.29%) concluding 5369 independent articles (23.06%) and 17917 collaborative articles (76.94%). The 2nd ranking is China with 8782 articles (9.16%), whereas has 2241 independent articles (25.52%) and 6541 collaborative article (74.48%). United Kingdom is ranked the third with 8051 articles (8.4%), in which 2023 independent articles (25.13%) and 6028 collaborative articles (74.87%). The ranking list is followed by Australia 6153 articles (4th ranking

with 6.42%); Germany 5079 articles (5th ranking, 5.3%); Canada (6th ranking with 5.07%); France 3365 articles (7th ranking, 3.51%); Spain 2701 articles (8th ranking, 2.82%); Italy 2473 articles (9th ranking, 2.58%); Netherlands 2164 articles (10th ranking, 2.26%); India; Switzerland; Japan; Sweden; Brazil; Norway; South Korea; Denmark; South Africa; and Finland have research productivity from 974 articles (1.02%) to 2105 articles (2.2%) at the 11th-20th ranking. Finally in the below ranking table is Vietnam with 159 articles (45th ranking, 0.63%) including 33 independent articles (50th ranking, 20.8%) and 126 collaborative articles (44th ranking, 79.2%).

Besides, in the Table 2 can be seen clearly that 8 countries are always top ranking in total research production, independent article and collaborative article as USA, China, UK, Australia, Germany, Canada, France, and Spain. Next is Italy (9th ranking), it has independent article number (10th ranking) less than India. Although India is the 9th ranking in independent articles,

but it is ranked the 11th in collaborative article and total publication output categories. More over, Japan and Sweden often exchange ranking with each other (13th and 14th ranking) in all three kinds of research output. This exchange ranking also happens in research productivity of Norway, South Korea, and Denmark (16th, 17th, 18th ranking). Some countries

have not any ranked changing about research outputs as Switzerland, Brazil, South Africa, and Finland (12th, 15th, 19th, and 20th ranking). Thus, distribution of research productivity by countries demonstrated that USA where had the highest research publication and ranking in all three kinds of research output; Viet Nam ranks the 45th with 159 articles (Table 3).

Table 3. Distribution of country in 2007-2018

Country name	Research productivity		Independent article		Collaborative article	
	TP (R)	TP/TA (%)	P (R)	P/TP (%)	P (R)	P/TP (%)
USA	23286(1)	24.29	5369(1)	23.06	17917(1)	76.94
China	8782(2)	9.16	2241(2)	25.52	6541(2)	74.48
UK	8051(3)	8.40	2023(3)	25.13	6028(3)	74.87
Australia	6153(4)	6.42	1530(4)	24.87	4623(4)	75.13
Germany	5079(5)	5.30	1276(6)	25.12	3803(5)	74.88
Canada	4859(6)	5.07	1284(5)	26.43	3575(6)	73.57
France	3365(7)	3.51	702(7)	20.86	2663(7)	79.14
Spain	2701(8)	2.82	674(8)	24.95	2027(8)	75.05
Italy	2473(9)	2.58	609(10)	24.63	1864(9)	75.37
Netherlands	2164(10)	2.26	509(11)	23.52	1655(10)	76.48
India	2105(11)	2.20	666(9)	31.64	1439(11)	68.36
Switzerland	1644(12)	1.72	377(12)	22.93	1267(12)	77.07
Japan	1626(13)	1.70	367(14)	22.57	1259(13)	77.43
Sweden	1545(14)	1.61	376(13)	24.34	1169(14)	75.66
Brazil	1432(15)	1.49	339(15)	23.67	1093(15)	76.33
Norway	1115(16)	1.16	258(17)	23.14	857(16)	76.86
South Korea	1093(17)	1.14	306(16)	28.00	787(18)	72.00
Denmark	1073(18)	1.12	246(18)	22.93	827(17)	77.07
South Africa	1024(19)	1.07	242(19)	23.63	782(19)	76.37
Finland	974(20)	1.02	237(20)	24.33	737(20)	75.67
Viet Nam	159(45)	0.63	33(50)	20.8	126(44)	79.2

TP Total research productivity; P research publication; R Ranking; TA Total publishing article number

And below Figure 2 presents spatial distribution of independent and collaborative articles via countries on the world shows that research productivity is almost published on all the countries. Which country has big red round dot, it means the scientific productivity in that country is a lot, where as USA has the most research publication. Contrast, which country has small red round dot, it means that country

has a few research publication, even there are some countries have very few research output. On the world map shows the countries, which have a lot of research publication almost belongs to USA and Europe country community; a few ones are in Asia countries. Left ones are low research publication. Moreover, the Figure 2 also shows the independent article number and cooperative article number belong to USA

in big red round dot and dark blue color. The countries have few research output is revealed by small red round dot and light blue color (0-309 articles in cooperated output and 0-119 article in independent output). The countries are second ranked after USA belongs to China, Australia, Canada, etc. India has 1439 cooperative articles, is performed by light pink color on the world map. Thus, spatial distribution of research publication is divided by 5 classes. In

independent publication, 0-119 articles is 1st class, 120-377 articles is 2nd class, 378-702 articles is 3rd class, 703-2241 articles is 4th class, and the last class includes 2242-5369 articles, the class has the most research publication. In cooperative publication has 5 classes as well and is distributed by 5 color kinds, from light blue, yellow, light pink, green, and dark blue, in which the dark blue has the most research publication on climate change articles from 2007 to 2018 year.

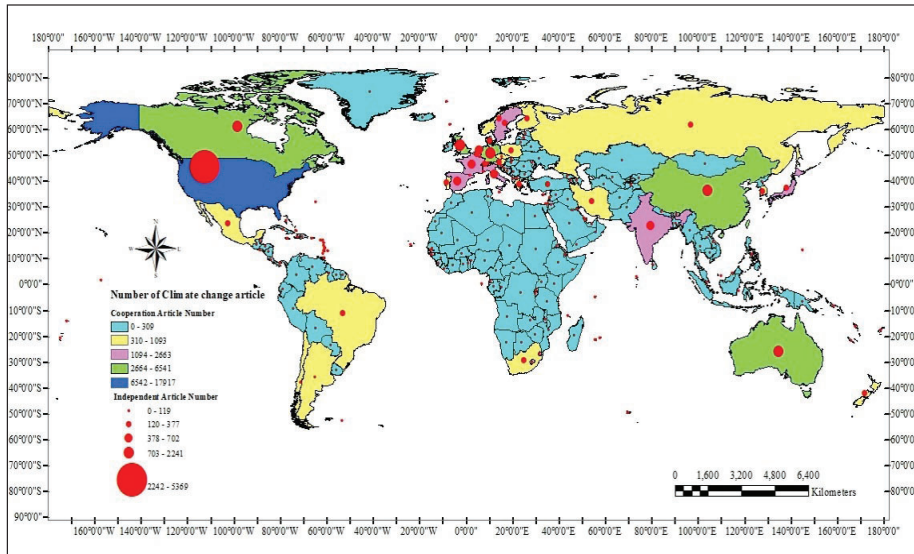


Figure 2. Distribution of independent and cooperative article on the world

4. Conclusion

From 25278 articles published on SCI during 2007-2018, analysis of research productivity provided to be more understanding about climate change field, knowledge deeply of calculation in publication output in many years, some significant points in this research are drawn following as:

Total research productivity increases in yearly and increases sharply in 2018 year, gains to 3325 articles, in which Article form also grows continuously to 2018 year and achieves about 2800 articles in 2018. Moreover, Article form is the highest research production as well with 19917 articles (1st ranking). USA is a country, where has the highest publication output in all the article types and in total research productivity (23286 articles with 1st ranking). It includes 5369 independent articles (23.06%)

and 17917 collaborative articles (76.94%).

CLIMATIC CHANGE journal has the most research output with 1105 articles (4.37%), 1st ranking, and it increases sharply in the last years. NATURE CLIMATE CHANGE journal have not any research output in first years of publication period, but its publication grows highly in next year. Besides, there are 163 countries are found in climate change article publication and spatial distribution of research productivity is performed on the world map. The research productivity is almost revealed on all the countries with different scientific productivity quantities; they are classed 5 kinds from low to high publication. Particular, Independent publication is showed from small red round dot to big one, and cooperative publication is perform in different colors, in which USA has the most publication in dark blue and big red dot.

Moreover, the countries have high publication most belong to USA, Canada, Europe country community, and some Asia countries as China, India. Viet Nam is performed by light blue

color with 159 articles in total research publication (45th ranking, 0.63%), concluding 33 independent articles (50th ranking, 20.8%) and 126 collaborative articles (44th ranking, 79.2%).

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