Research output and scientific impact of global warming research from 1980 -2007: an informetric analysis[1]

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Abstract
The paper considers global warming, and uses both descriptive and evaluative informetric techniques to analyse research in the domain using published literature as indexed and reflected in three key bibliographic databases in the Web of Science, namely the Science Citation Index, Social Sciences Citation Index, and the Arts and Humanities Citation Index from 1980 to 2007. The study covers all the publications on global warming appearing in the selected databases, and analyses them according to country, source, document type, subject, language counts, and publication trends over the period. This paper provides useful information for the development of research policy and evaluation in a burgeoning domain that is likely to benefit, researchers, research policy and information services

Key words: Global Warming; Informetrics; Bibliometrics; Research; Scientific Impact

1. Introduction

Global warming is increasingly becoming an issue and concern that invites theoretical and practical paradigms from a number of different disciplines in national, regional and global academic circles and as witnessed in discussions on its nature, type, causes, consequences, interventions and preventions in popular websites [4] . Formally, it may be defined as the "observed and projected increases in the temperature of Earth's atmosphere and Oceans"(Time for Change: ND)[5]. A more generally held view is that global warming is an ethical

1 . A shorter version of this paper was presented at the Fifteenth Jubilee Crimea Conference 2008, Crimea, Sudak, Ukrain, 7th - 15th June(see http://high.gpntb.ru/win/inter-events/crimea2008/eng/cd/157.pdf)

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4 http://timeforchange.org/definition-for-global-warming-what-is-global-warming and http://www.ucsusa.org/global-warming

5 See http://timeforchange.org/definition-for-global-warming-what-is-global-warming

issue arising from human-induced activities that affect climate change (Brown, 2003). Such would argue that global warming is mainly caused by the "*burning of fossil fuels, such as oil, coal and natural gases, as well as deforestation*" (e.g. Van Reenen, 2007:.4).

Scientifically, the cumulative increase of greenhouse gases leads to solar radiation being trapped within the earth's atmosphere, which in turn enhances the greenhouse effect, warming the earth up. Ultimately, the planet's entire ecosystem, plants, animals and humans alike, are increasingly exposed to danger in a number of ways [6] , such as *"the increase of the temperature on Earth by about 3° to 5° C (34° to 41° Fahrenheit) by the year 2100, and rise of sea levels by at least 25 meters (82 feet) by the year 2100".* It is predicted that nations that are already faced with a myriad of challenges, such as those in Africa, are likely to suffer most from the effects of global warming. Among other reasons, it is believed that these countries would get involved in interventions too little, too late. For example, "*Africa lost over 9% of its trees between 1990 and 2005. This represents over half of global forest loss, despite the fact that the continent accounts for just 16% of global forests*", according to the UN Survey of World Forests (Van Reenen, 2007:.6). Separate reports predict that regional water supplies will decline, livestock and human diseases will increase, flood related diseases will increase, and animal and crop production will decline. Other affected areas will include coastal zones, fisheries and biodiversity. Perhaps it makes sense to adhere to the advise by G8 president Angela Markel (Van Reenen, 2007:.7) who stated that " *we need to work together to get as many countries across the world as possible to undertake to do something about global warming*". Thus information providers and researchers from as many different disciplines as possible should engage in attempts to tackle problem.

According to Lancaster (1991), evaluating research productivity involves three processes, namely: an analysis of the number of publications produced and the quality of the sources in which the published material appears; assessing how much of the work is individual, group or organizational; and determining the quality of the citations of the published works. Informetric research provides an

6 See http://timeforchange.org/effects-of-global-warming

opportunity for research diversification and for the support of global warming research because it presents up-to-date research and publication indicators using multiple variables that include international, regional, national, disciplinary and individual issues, trends and challenges. This study analyzes and evaluates the patterns and trends of global warming research according to publications that appear in the Web of Science database (Science Citation Index-SCI, Social Science Citation Index-SSCI and Arts and Humanities Citation Index-AHCI) from 1980 - 2007 in order to inform research policies, evaluations and decisions on global warming.This paper compares the research output according to several variables and the scientific impact of authors, institutions and countries. The study identifies the most prolific and influential researchers, countries and institutions involved in research on global warming, and compares the productivity and scientific impact of institutions and countries. The paper attempts to answer the following eight research questions: Which countries are involved in global warming research in general and in Africa in particular? Which are the most productive countries in this research domain? Where is research on global warming largely published? Which are the most productive organisations and institutions in global warming research? Who are the most productive authors of global warming research publications? What is each author's scientific influence? Which is the most cited research publication? And what are the trends and patterns of the growth of citations vis-à-vis the papers?

2. Literature review

The term global warming has received significant attention from leading scientists in recent years (Zhang et al., 2006; Omer, 2007; Sautter and Switzer, 2008) as well as criticism from those advancing the theory that increases in the temperatures on Earth are the product of natural forces that have nothing to do with anthropogenic processes (Tao et al. 2006). The focus on climate change has since been used as a scientific platform among atmospheric, natural and social scientists to coin the definition and characteristics of global warming and climate change, such that it is now defined as the increase in the average temperature of the Earth's near-surface air and oceans over the last 900 000 years, particularly in the mid-twentieth century (Hussain and Ansari 2006: 192-193; Ren et al. 2007:890). Nodvin (2008) and Reay (2008) have also voiced their characterization of global warming by distinguishing global warming from climate change. The

authors have separately described global warming as the combined result of the anthropogenic emission of greenhouse gases (carbon dioxide, methane and nitrous oxide) coupled with changes in solar irradiance. Nodvin (2008) views climate change as a product emanating from global warming as evidenced in weather (temperature, precipitation, frequency of heat waves, etc) and other climate system components, such as Arctic sea ice. The authors have warned that the impact of global warming can be characterized according to short-term (seasonal) and periodic (long-term) effects.

There is controversy, however, still dogging agreements on the real **cause** of global warming, with most scientists favouring anthropogenic processes as the main culprit (Tao et al. 2006; Omer 2007; Zhang et al. 2006), and others attributing the cause to natural forces. The increasing consensus is that "*global warming is caused by the emission of greenhouse gases. 72% of the totally emitted greenhouse gases is carbon dioxide (CO2), 18% Methane and 9% Nitrous oxide (NOx). Carbon dioxide emissions therefore are the most important cause of global warming*"[7]. Some scientific results indicate that even if greenhouse gases were stabilized at 2000 levels, a further warming of about 0.50C (0.90F) would still occur (Robick et al. 2003; Berger et al. 2005) justifying the arguments fostered by Earth Science skeptics that global warming is not solely a human affair. Other hypotheses that depart from the main consensus view suggest that most of the increase in temperature is as a result of variations in solar activity. Despite these controversies, there is the possibility of a universal conclusion stemming from the Intergovernmental Panel of Climate Change (IPCC, 2007), adopted recently in Paris, which stated that: "*most of the observed increase in globally averaged temperatures since the mid-20th Century is very likely (90% probability) due to the observed increase in anthropogenic greenhouse gas concentrations…"* (Mathews 2007:1).

There is a lot of research going on that demonstrates the atmospheric and anthropogenic **impact** of greenhouse effects on crop production and water use (Tao et al. 2007:94); climate changes, floods and drought (Zhang et al. 2006); and on the sustainable governance of public resources. The ecological response of organisms to climate change have been noted to show adverse heterogeneity in terms of phonological and physiological characteristics, the variability in species distribution, the composition of and interactions within communities, and the dynamics and structure of the ecosystems (Walther et al. 2002). Some researchers have highlighted the need for energy technologies that address environmental utility and the quality of human live(Sautter and Switzer, 2008). Although the rise in the Earth's temperature is the main cause of global warming and climate change, far reaching socio-economic (low

7 see http://timeforchange.org/CO2-cause-of-global-warming

crop yields, declining food production, cardiological diseases) and environmental (floods, tsunamis, tornados, drought, depletion of coral reefs etc) consequences have been and are being experienced in most parts of the world, and this is what, in our view, has seen the growth of atmospheric related research and the use of modern methodologies to unearth the mystery of global warming.

Walther et al. (2002) have revealed that freeze-free periods in most of the mid-and high-latitude regions are lengthening. Satellite data has revealed a 10% decrease in sun cover and ice extent since the late 1960's, which has also exacerbated the spatial and temporal regime of precipitation affecting organisms with diverse geographical distributions (Walther et al. 2002). Some of the ecological impacts of climate change were revealed in the phonological patterns of and trends of birds, butterflies and wild plants, where, earlier breeding or first singing of birds, earlier arrival of migrant birds and earlier appearance of butterflies are attributed to the early timing of spring activities (Walther et al. 2002). **Invasions** of non-native species from adjacent habitats and a **shift** in community composition (like the recent increase in woody shrub density, extinction of previously common animal species and increases in formerly rare animal species) in the Sororan desert of the southwestern United States have been catalyzed by recent climatic shift (Walther et al. 2002).

In his lamentation on climate change, Mathews (2007) wrote an article on seven steps to **curb global warming,** and he reiterates that all the initiatives aimed at curbing further man-made catastrophes should be focused on driving down greenhouse gas emissions by 2020. This view is also supported by Tim Flannery (cited in Mathews 2007) in his book on global warming ('The Weather Makers'), where he opined that we should reduce our CO_2 emissions by 70% by the year 2050[8]. Some of the steps outlined are as follows:

1. Designing a system that imposes tax on carbon emissions, ratified by a global treaty and enforced by a newly created global authority with preference to the Kyoto model that operates outside the UN system.
2. Monitoring greenhouse gas emissions through global satellite monitoring. This mechanism would ensure that there is honesty in operating hybrid carbon permits and tax systems.
3. Compensating developing countries for preserving a vast area of tropical rainforests that act as an important source of 'carbon sink'.
4. Promoting the development of biofuels as a global alternative and supplement to fossil fuels. This, if implemented by the various governments and industrial agencies, will significantly increase the

8 http://timeforchange.org/CO2-emissions-by-country

use of biofuels by 10% in 2010, and account for 20% by 2020, rising to 50% of (reduced) consumption of transport fuels by 2050.

5. Promoting the production of renewable energy by setting up markets for solar or wind energy and biofuels (vegetable sources, Jatropha, palm oil, soy bean etc.), which have great potential in tropical countries. The development of these sources for alternative electricity and fuel should not be limited to expanding the market but also to the ability to enhance initiatives that remove trade barriers in marketing the alternative and supplementary energy sources (Mathews 2007:4247).

The two most renowned global initiatives currently under the UN convention are the Intergovernmental Panel on Climate Change (IPCC) - mandated with designing a framework where successive scientists report on global warming; and the UN Framework Convention on Climate Change (UNFCCC), adopted in 1992 at Rio Earth summit and agreed upon by the Kyoto protocol which originated from the UN Conference on Climate Change held in Kyoto, Japan, 1997, to directly reduce the emission of CO_2

3. Method and materials

This paper uses both descriptive and evaluative informetric techniques to analyse global warming research using published literature as indexed and reflected in three key bibliographic databases selected from the Web of Science, namely the Science Citation Index, the Social Sciences Citation Index and the Arts and Humanities Citation Index. The Web of Science (SCI, SSCI & A&HCI) indexes the most important, credible and influential research publications, mainly in the form of articles, that are assumed to exhibit a significant impact factor on a given discipline. It consists of over 8,830 titles of records from 230 disciplines with 6,125 active journals and 145 highly cited book series from SCI, 1800 active journal titles and 30 highly cited book series in SSCI and 1,130 active journals and 15 highly cited book series in A&HCI. The study covers all the publications on global warming that appear in the selected databases and all the different types of documents in which the publications appear. The country in which each journal was published was used as an indicator of the origin of global warming research output, and institutional productivity was calculated by counting the frequencies of the institutional occurrences in the authors' address field. The geographic distribution of authors was established in order to determine the author's country of origin and to find the most productive country and geographical region by using authors' addresses. Whereas it was possible to use several related search terms on the subject, such as the greenhouse effect and climatic change, among others, these search terms captured fairly limited records and most of the records were duplicated in the global warming search term. We therefore settled on 'global warming' for the search

term because of its encapsulation of the research theme. Data analysis largely depended on ISI data sets, where relevant data was mined by using the search term 'global warming' and limited to records published between 1980 and 2007, and thereafter presented under the categories featured in Tables 1-6 and Figures one and two below. Further analysis was done by using citation analysis and h-index for impact factor determination. Rousseau (2008:252), defines *citation analysis as that "subfield of bibliometrics where patterns and frequencies of citations, given as well as received are analyzed. Such an analysis is performed on the level of authors, journals, scientific disciplines and any other useful unit or level. Citation analysis further studies relations between cited and citing units (documents, authors, countries etc.)".* As far as h- index is concern it was developed by Jorge Hirsch , 'a physicist at UCSD, as a tool for determining theoretical physicists' relative quality'. It is an "*index that quantifies both the actual scientific productivity and the apparent scientific impact of a scientist. The index is based on the set of the scientist's most cited papers and the number of citations that they have received in other people's publications. The index can also be applied to the productivity and impact of a group of scientists, such as a department or university or country"(h-index 2008)*[9]

3. Results

The results are presented in sections 3.1 to 3.6, and illustrated in Tables 1-7 and in Figures 1 and 2.

3.1. Global warming according to country research productivity

Fifty eight countries are displayed in Table 1. Fifty eight country name value(s) are outside the display option while 1024 records/items do not contain data in the field analysed. Ranking is made by publication/record counts.

Table 1: Global warming publications count by country.

No.	Rank	Country Territory	Record Count	% of 7205	Sum of items cited	Average per item	Average per year	H-Index
1	1	USA	2572	35.70%	48,086	18.69	1717.36	92
2	2	ENGLAND	834	11.58%	15,871	19.03	566.82	61
3	3	JAPAN	546	7.58%	3,546	6.49	197	26
4	4	CANADA	441	6.12%	6,461	14.62	340.05	41
5	5	GERMANY	389	5.40%	6,832	17.56	379.56	39
6	6	AUSTRALIA	278	3.86%	5,861	21.08	293.05	35
7	7	FRANCE	230	3.19%	3,901	16.96	216.72	29
8	8	PEOPLES R CHINA	229	3.18%	1,306	5.7	76.82	18
9	9	NETHERLANDS	193	2.68%	3,297	17.08	183.17	30
10	10	SWEDEN	168	2.33%	2,568	15.29	142.67	23
11	11	NORWAY	134	1.86%	1,661	12.4	92.28	21
12	12	RUSSIA	122	1.69%	1,823	14.94	113.94	21
13	13	INDIA	118	1.64%	959	8.13	50.47	14
14	14	SWITZERLAND	117	1.62%	2,281	19.5	126.72	28

9 . http://en.wikipedia.org/wiki/Hirsch_number#Definition_and_purpose

15	15	ITALY	102	1.42%	1,266	12.41	84.4	17
16	16	DENMARK	96	1.33%	1,793	18.68	112.06	22
17	17	SCOTLAND	90	1.25%	1,653	18.37	91.83	20
18	18	SPAIN	86	1.19%	895	10.41	63.93	16
19	19	SOUTH KOREA	78	1.08%	323	4.14	20.19	10
20	20	AUSTRIA	74	1.03%	711	9.61	41.82	16
21	21	BRAZIL	73	1.01%	1,460	20	73	20
22	22	NEW ZEALAND	71	0.99%	885	12.46	44.25	16
23	23	BELGIUM	67	0.93%	575	8.58	31.94	13
24	24	FINLAND	61	0.85%	869	14.25	54.31	15
25	25	SOUTH AFRICA	46	0.64%	934	20.3	51.89	13
26	26	TAIWAN	39	0.54%	365	9.36	24.33	9
27	27	TURKEY	32	0.44%	142	4.44	10.14	7
28	28	WALES	30	0.42%	461	15.37	25.61	9
29	29	ISRAEL	29	0.40%	521	17.97	34.73	10
30	30	POLAND	26	0.36%	263	10.12	17.53	9
31	31	PORTUGAL	25	0.35%	214	8.56	14.27	7
32	32	ARGENTINA	23	0.32%	255	11.09	17	9
33	32	MEXICO	23	0.32%	150	6.52	10	7
34	34	GREECE	21	0.29%	127	6.05	8.47	6
35	35	CZECH REPUBLIC	20	0.28%	140	7	9.33	7
36	35	IRELAND	20	0.28%	492	14.91	30.75	11
37	35	THAILAND	20	0.28%	193	9.65	10.16	4
38	36	PHILIPPINES	18	0.25%	173	9.61	10.81	6
39	37	HUNGARY	14	0.19%	154	11	11	4
40	37	KENYA	14	0.19%	201	14.36	11.82	7
41	37	NORTH IRELAND	14	0.19%	200	14.29	13.33	9
42	38	SINGAPORE	13	0.18%	47	3.62	4.27	4
43	39	CHILE	12	0.17%	162	13.5	18	4
44	40	ICELAND	10	0.14%	53	5.3	4.82	3
45	40	INDONESIA	10	0.14%	31	3.1	1.72	3
46	40	SAUDI ARABIA	10	0.14%	39	3.9	2.6	2
47	41	ESTONIA	9	0.12%	119	13.22	19.83	4
48	42	BANGLADESH	8	0.11%	61	7.62	4.36	3
49	43	COLOMBIA	7	0.10%	50	7.14	4.17	5
50	43	EGYPT	7	0.10%	18	2.57	1.5	3
51	43	MALAYSIA	7	0.10%	81	11.57	6.23	3
52	44	PANAMA	6	0.08%	499	83.17	55.44	5
53	45	COSTA RICA	5	0.07%	685	137	76.11	4
54	45	SLOVAKIA	5	0.07%	25	5	2.5	2
55	45	SRI LANKA	5	0.07%	14	2.8	1.27	2
56	45	TANZANIA	5	0.07%	155	31	19.38	3
57	45	USSR	5	0.07%	227	45.4	12.61	3
58	45	VENEZUELA	5	0.07%	193	38.6	13.79	4

Sums of items cited(SIC) means the total number of items cited from 1980-2007. Average cites per year(ACY) refers to the total number of citations made to items in a given year while average citations per item(ACI) refers to the number of times an item was cited.

3.2. Sources of Global warming research

A total of 1558 journal titles on global warming were identified during this period of study. 1498 source titles were outside the display option.

Table 2: Global Warming Research Publications by Source

Number	Ranking	Source	Record Count	% of 7205	Sum Cit.	Av. Per Item	Av.Per Year	H-Index
1	1	NATURE	199	0.02762	10138	50.44	362.07	50
2	2	GEOPHYSICAL RESEARCH LETTERS	175	0.024289	2814	16.08	140.7	27
3	3	CLIMATIC CHANGE	161	0.022346	2446	15.19	122.3	27

4	4	SCIENCE	137	0.019015	4560	33.28	228	38
5	5	NEW SCIENTIST	116	0.0161	16	0.14	0.62	2
6	6	ENERGY POLICY	113	0.015684	850	7.52	42.5	16
7	7	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	112	0.015545	2220	19.82	123.33	27
8	8	JOURNAL OF CLIMATE	104	0.014434	2653	25.51	147.39	28
9	9	GLOBAL CHANGE BIOLOGY	97	0.013463	1516	15.63	108.29	25
10	10	CHEMICAL & ENGINEERING NEWS	96	0.013324	38	0.4	1.65	3
11	11	ENERGY CONVERSION AND MANAGEMENT	71	0.009854	299	4.21	17.59	8
12	12	OIL & GAS JOURNAL	61	0.008466	0	0	0	0
13	13	BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY	57	0.007911	1365	23.95	71.84	16
14	13	ENVIRONMENTAL SCIENCE & TECHNOLOGY	57	0.007911	355	6.23	17.75	12
15	14	GLOBAL AND PLANETARY CHANGE	55	0.007634	752	13.67	41.78	16
16	15	CLIMATE DYNAMICS	52	0.007217	2225	42.79	130.88	18
17	16	CLIMATE RESEARCH	50	0.00694	461	9.22	32.93	13
18	17	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	49	0.006801	1487	30.35	87.47	20
19	18	AMBIO	46	0.006384	690	15	30	14
20	19	INTERNATIONAL JOURNAL OF CLIMATOLOGY	44	0.006107	468	10.64	26	13
21	20	ATMOSPHERIC ENVIRONMENT	41	0.00569	425	10.37	28.33	10
22	21	CHEMICAL WEEK	38	0.005274	1	0.03	0.08	1
23	21	INTERNATIONAL JOURNAL OF LIFE CYCLE ASSESSMENT	38	0.005274	122	3.21	15.25	6
24	22	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	36	0.004997	329	9.14	18.28	11
25	22	SCIENCE OF THE TOTAL ENVIRONMENT	36	0.004997	159	4.42	8.83	7
26	23	GLOBAL BIOGEOCHEMICAL CYCLES	35	0.004858	798	22.8	53.2	15
27	24	ENERGY	32	0.004441	148	4.62	8.71	8
28	24	MARINE POLLUTION BULLETIN	32	0.004441	162	5.06	8.53	7
29	25	ECOLOGICAL ECONOMICS	31	0.004303	340	10.97	24.29	11
30	26	CHEMOSPHERE	30	0.004164	347	11.57	19.28	10
31	26	ECOLOGY	30	0.004164	1173	39.1	65.17	15
32	26	PALAEOGEOGRAPHY PALAEOCLIMATOLOGY PALAEOECOLOGY	30	0.004164	450	14.52	26.47	12
33	27	CHINESE SCIENCE BULLETIN	28	0.003886	66	2.36	3.88	4
34	27	FOREST ECOLOGY AND MANAGEMENT	28	0.003886	628	22.43	33.05	12
35	28	JOURNAL OF BIOGEOGRAPHY	27	0.003747	357	13.22	22.31	11
36	28	RENEWABLE ENERGY	27	0.003747	95	3.52	6.33	5
37	29	TCE	26	0.003609	0	0	0	0
38	30	ECOLOGICAL MODELLING	25	0.00347	250	10	13.89	11
39	30	ENVIRONMENTAL HEALTH PERSPECTIVES	25	0.00347	665	26.6	39.12	12
40	30	INTERNATIONAL JOURNAL OF REFRIGERATION-REVUE INTERNATIONALE DU FROID	25	0.00347	105	4.2	6.56	5
41	30	SCIENTIFIC AMERICAN	25	0.00347	112	4.48	5.89	5
42	31	BIOMASS & BIOENERGY	24	0.003331	229	9.54	13.47	9
43	31	GEOLOGY	24	0.003331	653	27.21	36.28	12
44	31	OECOLOGIA	24	0.003331	553	23.04	34.56	11
45	31	WATER AIR AND SOIL POLLUTION	24	0.003331	210	8.75	12.35	10
46	32	ABSTRACTS OF PAPERS OF THE AMERICAN CHEMICAL SOCIETY	23	0.003192	1	0.04	0.05	1
47	32	AGRICULTURAL AND FOREST METEOROLOGY	23	0.003192	186	8.09	10.94	8
48	32	AGRICULTURE ECOSYSTEMS & ENVIRONMENT	23	0.003192	241	10.48	14.18	8
49	32	APPLIED ENERGY	23	0.003192	68	2.96	3.78	6
50	32	JOURNAL OF THE METEOROLOGICAL SOCIETY OF JAPAN	23	0.003192	250	10.87	14.71	9

Table 3: Publications on Global Warming by Document Type
Type in Web of Science 1980-2007

DOCUMENT TYPE	RECORD COUNT	% 0F 7205
ARTICLE	5409	0.750729
EDITORIAL MATERIAL	479	0.066482
REVIEW	436	0.060514
LETTER	336	0.046634
NEWS ITEM	267	0.037058
BOOK REVIEW	158	0.021929
NOTE	43	0.005968
MEETING ABSTRACT	39	0.005413
CORRECTION	22	0.003053
REPRINT	6	0.000833
CORRECTION, ADDITION	4	0.000555
BIOGRAPHICAL-ITEM	2	0.000278
BIBLIOGRAPHY	1	0.000139
DISCUSSION	1	0.000139
ITEM ABOUT AN INDIVIDUAL	1	0.000139
RECORD REVIEW	1	0.000139

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3.3. Institutional Affiliation of Global Warming Publications

Records on the subject could originate from single, multiple or corporate authors who were affiliated to singular or multiple institutions. A total of 3427 institution names or affiliations were noted. 3367 institutional name values were outside display options, while 1062 records (14, 7%) did not contain data in the field being analyzed.

Table 4. Global Warming by Institutional Affiliation in Web of Science 1980-2007

NUMBER	RANKING	INSTITUTIONS	RECORD COUNT	% OF 7205	THE TIMES CITED	AVER. CIT.PER PAPER	AVER.CIT. PER YEAR	h-INDEX
1	1	CHINESE ACAD SCI	123	0.017071	584	4.75	34.35	10
2	2	NASA	90	0.012491	3,885	43.17	185	37
3	3	NATL CTR ATMOSPHER RES	89	0.012353	3,938	44.25	171.2	29
4	3	NOAA	89	0.012353	3225	36.24	153.6	34
5	4	UNIV TOKYO	82	0.011381	737	8.99	40.94	13
6	5	MIT	77	0.010687	1783	23.16	71.32	18
7	6	UNIV CALIF BERKELEY	74	0.010271	1515	20.47	79.74	21
8	7	COLUMBIA UNIV	68	0.009438	2536	37.29	140.9	27
9	8	PENN STATE UNIV	65	0.009022	2140	32.92	107	20
10	8	PRINCETON UNIV	65	0.009022	1675	25.77	93.06	22
11	8	RUSSIAN ACAD SCI	65	0.009022	585	9	36.56	14

12	9	UNIV E ANGLIA	64	0.008883	1569	24.52	56.04	20
13	10	STANFORD UNIV	60	0.008328	2601	43.35	104	21
14	11	UNIV WASHINGTON	58	0.00805	1484	25.15	78.11	17
15	12	UNIV COLORADO	55	0.007634	1292	23.49	71.78	24
16	13	US EPA	53	0.007356	663	12.51	34.89	14
17	14	UNIV READING	51	0.007078	1153	22.61	64.06	16
18	15	UNIV WISCONSIN	50	0.00694	892	17.84	44.6	17
19	16	UNIV TORONTO	47	0.006523	689	14.66	40.53	14
20	17	HARVARD UNIV	45	0.006246	878	19.51	46.21	16
21	18	CSIRO	43	0.005968	1329	30.91	69.95	18
22	18	UNIV CALIF SAN DIEGO	43	0.005968	1291	30.02	67.95	14
23	19	UNIV ILLINOIS	42	0.005829	991	23.6	55.06	16
24	19	UNIV OXFORD	42	0.005829	829	19.74	43.63	14
25	20	MAX PLANCK INST METEOROL	41	0.00569	1314	32.05	73	18
26	21	UNIV COLL LONDON	39	0.005413	528	13.54	29.33	13
27	21	UNIV MARYLAND	39	0.005413	1098	28.15	57.79	16
28	21	UNIV SHEFFIELD	39	0.005413	910	23.33	50.56	15
29	22	CORNELL UNIV	38	0.005274	751	19.76	39.53	12
30	23	COLORADO STATE UNIV	36	0.004997	1104	30.67	61.33	14
31	24	SWEDISH UNIV AGR SCI	35	0.004858	723	20.66	40.17	10
32	25	RUTGERS STATE UNIV	34	0.004719	1287	37.85	67.74	17
33	25	UNIV BRITISH COLUMBIA	34	0.004719	554	16.29	29.16	11
34	25	UNIV MINNESOTA	34	0.004719	822	24.18	45.67	14
35	25	UNIV OSLO	34	0.004719	427	12.56	28.47	10
36	25	UNIV VICTORIA	34	0.004719	866	25.47	54.12	12
37	25	US GEOL SURVEY	34	0.004719	979	28.79	54.39	12
38	26	CNRS	33	0.00458	640	19.39	45.71	13
39	26	HOKKAIDO UNIV	33	0.00458	169	5.12	13	6
40	26	KYOTO UNIV	33	0.00458	231	7	16.5	9
41	26	OHIO STATE UNIV	33	0.00458	1018	30.65	56.56	13
42	26	UNIV ARIZONA	33	0.00458	295	8.94	15.53	10
43	26	UNIV CALIF DAVIS	33	0.00458	851	25.79	47.28	13
44	26	YALE UNIV	33	0.00458	1303	39.48	72.39	16
45	27	NATL INST AGROENVIRONM SCI	30	0.004164	331	11.03	22.07	8
46	27	UNIV BERN	30	0.004164	682	22.73	45.47	14
47	27	UNIV CALIF SANTA BARBARA	30	0.004164	1184	39.47	65.78	16
48	27	UNIV COPENHAGEN	30	0.004164	335	11.17	20.94	10
49	28	UNIV CAMBRIDGE	29	0.004025	370	12.76	21.76	8
50	29	USDA ARS	28	0.003886	469	16.75	26.06	12
51	30	METEOROL OFF	27	0.003747	1927	71.37	91.76	15
52	30	OAK RIDGE NATL LAB	27	0.003747	538	19.93	26.9	9
53	30	UNIV ALBERTA	27	0.003747	686	25.41	38.11	12
54	30	UNIV QUEENSLAND	27	0.003747	1344	49.78	84	9
55	30	UNIV TSUKUBA	27	0.003747	219	8.11	16.85	6
56	30	UNIV UTRECHT	27	0.003747	705	26.11	47	12
57	31	DUKE UNIV	26	0.003609	463	17.81	28.94	10
58	31	UNIV MICHIGAN	26	0.003609	540	20.77	28.42	12
59	32	FORD MOTOR CO	25	0.00347	261	10.44	14.5	7
60	32	LAWRENCE LIVERMORE NATL LAB	25	0.00347	651	26.04	38.29	10

3.4 Author Productivity on Global Warming Literature

'Anon' authors refer to records without author fields. A total of 13573 authors published articles dealing with global warming. It was noted that 13520 author values were outside the display option.

Table 5: Publications count by authors, ISI, 1980-2007

No.	Rank	AUTHORS	RECORD COUNT	% OF 7205	Sum of times cited	Average citation per item	Average citation per year	H-Index
1		[ANON]	200	0.027759				
2	1	PEARCE, F	30	0.004164	9	0.3	0.45	2
3	2	FEARNSIDE, PM	26	0.003609	851	32.73	60.79	16
4	3	HILEMAN, B	23	0.003192	33	1.43	1.57	3
5	4	WALLINGTON, TJ	22	0.003053	255	11.59	18.21	7
6	5	HANSEN, J	20	0.002776	1,330	66.5	78.24	17
7	6	HULME, M	19	0.002637	262	13.79	14.56	7
8	6	SATO, M	19	0.002637	1,266	66.63	74.47	16
9	7	HURLEY, MD	18	0.002498	220	12.22	15.71	6
10	7	KERR, RA	18	0.002498	54	3	2.7	4
11	7	WEAVER, AJ	18	0.002498	350	19.44	21.88	10
12	8	RUEDY, R	17	0.002359	1,241	73	73	16
13	9	JACOBSON, MZ	16	0.002221	608	38	76	8
14	9	SHINE, KP	16	0.002221	267	16.69	19.07	8
15	10	REIF, R	15	0.002082	121	8.07	11	7
16	10	SCHNEIDER, SH	15	0.002082	715	47.67	35.75	7
17	11	HARTE, J	14	0.001943	355	25.36	25.36	9
18	11	MANABE, S	14	0.001943	532	38	35.47	9
19	11	MEEHL, GA	14	0.001943	737	52.64	46.06	11
20	11	ROECKNER, E	14	0.001943	496	35.43	27.56	10
21	12	RIND, D	13	0.001804	400	30.77	23.53	9
22	12	TSURUTA, H	13	0.001804	243	18.69	16.2	6
23	13	WIGLEY, TML	13	0.001804	572	44	20.43	11
24	13	WUEBBLES, DJ	13	0.001804	176	13.54	11.73	9
25	14	KROEZE, C	12	0.001666	67	5.58	3.94	4
26	14	LAL, R	12	0.001666	231	19.25	38.5	6
27	14	MASON, NJ	12	0.001666	80	6.67	11.43	6
28	14	MITCHELL, JFB	12	0.001666	1,505	125.42	83.61	10
29	14	MOSIER, AR	12	0.001666	315	26.25	17.5	8
30	14	WOOD, CM	12	0.001666	143	11.92	10.21	9
31	15	ALDHOUS, P	11	0.001527	16	1.45	0.84	2
32	15	BALLING, RC	11	0.001527	68	6.18	3.58	5
33	15	COX, PM	11	0.001527	860	78.18	95.56	8
34	15	JAIN, AK	11	0.001527	146	13.27	8.11	7
35	15	KARECKI, S	11	0.001527	80	7.27	7.27	6
36	15	SCOTT, A	11	0.001527	14	1.27	1.17	1
37	15	WANG, WC	11	0.001527	272	24.73	14.32	7
38	15	WASHINGTON, WM	11	0.001527	708	64.36	39.33	10
39	15	YAGI, K	11	0.001527	181	16.45	12.07	5
40	15	ZURER, P	11	0.001527	1	0.09	0.05	1
41	16	AERTS, R	10	0.001388	225	22.5	16.07	6
42	16	BRALOWER, TJ	10	0.001388	330	33	27.5	8
43	16	CALDEIRA, K	10	0.001388	191	19.1	10.61	6
44	16	CALLAGHAN, TV	10	0.001388	183	18.3	11.44	5
45	16	HORI, M	10	0.001388	39	3.9	3.9	4
46	16	JOOS, F	10	0.001388	363	36.3	36.3	8
47	16	MENDELSOHN, R	10	0.001388	243	24.3	16.2	7
48	16	NORDHAUS, WD	10	0.001388	583	58.3	34.29	6
49	16	OPPENHEIMER, M	10	0.001388	143	14.3	8.94	6

50	16	PATZ, JA	10	0.001388	223	22.3	17.15	6
51	16	STOCKER, TF	10	0.001388	391	39.1	39.1	9
52	16	YAMASAKI, A	10	0.001388	32	3.2	2.67	3
76	**19**	**Walther,GR**	**5**	**0.00111**	**877**	**175.4**	**125.29**	**4**

3.4. Subject Coverage of Global Warming Research/Publications

A total of 197 subject areas were captured. One hundred and five record values were outside the display option, while three records did not contain data in the field being analyzed.

Table 6: Global Warming by Subject Domain

SUBJECT AREA	RECORD COUNT	% OF 7205	SUBJECT AREA	RECORD COUNT	% OF 7205
ENVIRONMENTAL SCIENCES	1436	0.199306	METALLURGY & METALLURGICAL ENGINEERING	51	0.007078
METEOROLOGY & ATMOSPHERIC SCIENCES	923	0.128105	CONSTRUCTION & BUILDING TECHNOLOGY	45	0.006246
MULTIDISCIPLINARY SCIENCES	729	0.10118	NUCLEAR SCIENCE & TECHNOLOGY	45	0.006246
GEOSCIENCES, MULTIDISCIPLINARY	665	0.092297	PHYSICS, ATOMIC, MOLECULAR & CHEMICAL	45	0.006246
ECOLOGY	612	0.084941	BIOCHEMISTRY & MOLECULAR BIOLOGY	43	0.005968
ENERGY & FUELS	597	0.082859	LIMNOLOGY	41	0.00569
ENGINEERING, CHEMICAL	399	0.055378	EVOLUTIONARY BIOLOGY	38	0.005274
ENVIRONMENTAL STUDIES	376	0.052186	AGRICULTURAL ENGINEERING	37	0.005135
ENGINEERING, ENVIRONMENTAL	314	0.043581	SOCIAL ISSUES	37	0.005135
GEOGRAPHY, PHYSICAL	275	0.038168	SOCIOLOGY	36	0.004997
ECONOMICS	235	0.032616	HUMANITIES, MULTIDISCIPLINARY	35	0.004858
PLANT SCIENCES	202	0.028036	ENTOMOLOGY	34	0.004719
WATER RESOURCES	199	0.02762	SOCIAL SCIENCES, INTERDISCIPLINARY	32	0.004441
CHEMISTRY, MULTIDISCIPLINARY	191	0.026509	LAW	30	0.004164
OCEANOGRAPHY	184	0.025538	PUBLIC ADMINISTRATION	30	0.004164
MARINE & FRESHWATER BIOLOGY	183	0.025399	TRANSPORTATION SCIENCE & TECHNOLOGY	30	0.004164
THERMODYNAMICS	183	0.025399	MATERIALS SCIENCE, COATINGS & FILMS	29	0.004025
SOIL SCIENCE	163	0.022623	MATHEMATICS, INTERDISCIPLINARY APPLICATIONS	29	0.004025
BIODIVERSITY CONSERVATION	159	0.022068	ORNITHOLOGY	29	0.004025
ENGINEERING, MECHANICAL	134	0.018598	ASTRONOMY & ASTROPHYSICS	28	0.003886
FORESTRY	134	0.018598	ENGINEERING, MULTIDISCIPLINARY	28	0.003886
GEOGRAPHY	105	0.014573	POLYMER SCIENCE	28	0.003886
ENGINEERING, CIVIL	104	0.014434	ENGINEERING, AEROSPACE	27	0.003747
AGRONOMY	96	0.013324	GENETICS & HEREDITY	27	0.003747
ENGINEERING, PETROLEUM	92	0.012769	BUSINESS	25	0.00347
GEOCHEMISTRY & GEOPHYSICS	92	0.012769	ELECTROCHEMISTRY	25	0.00347
BIOLOGY	91	0.01263	HISTORY & PHILOSOPHY OF SCIENCE	24	0.003331
MECHANICS	91	0.01263	MICROBIOLOGY	24	0.003331
PHYSICS, APPLIED	84	0.011659	FOOD SCIENCE & TECHNOLOGY	23	0.003192
CHEMISTRY, PHYSICAL	79	0.010965	PHYSICS, CONDENSED MATTER	23	0.003192
PHYSICS, NUCLEAR	77	0.010687	ENGINEERING, INDUSTRIAL	22	0.003053
PUBLIC, ENVIRONMENTAL & OCCUPATIONAL HEALTH	77	0.010687	MANAGEMENT	22	0.003053
PALEONTOLOGY	75	0.010409	PHYSIOLOGY	21	0.002915
ZOOLOGY	73	0.010132	CHEMISTRY, ANALYTICAL	20	0.002776

AGRICULTURE, MULTIDISCIPLINARY	72	0.009993	SOCIAL SCIENCES, MATHEMATICAL METHODS	20	0.002776
ENGINEERING, ELECTRICAL & ELECTRONIC	72	0.009993	AGRICULTURE, DAIRY & ANIMAL SCIENCE	19	0.002637
GEOLOGY	70	0.009715	BUSINESS, FINANCE	19	0.002637
POLITICAL SCIENCE	68	0.009438	INFORMATION SCIENCE & LIBRARY SCIENCE	18	0.002498
BIOTECHNOLOGY & APPLIED MICROBIOLOGY	65	0.009022	TRANSPORTATION	17	0.002359
MATERIALS SCIENCE, MULTIDISCIPLINARY	64	0.008883	BIOPHYSICS	16	0.002221
PLANNING & DEVELOPMENT	59	0.008189	AGRICULTURAL ECONOMICS & POLICY	15	0.002082
MEDICINE, GENERAL & INTERNAL	58	0.00805	COMPUTER SCIENCE, INTERDISCIPLINARY APPLICATIONS	15	0.002082
CHEMISTRY, APPLIED	57	0.007911	COMPUTER SCIENCE, SOFTWARE ENGINEERING	15	0.002082
FISHERIES	52	0.007217	SPECTROSCOPY	15	0.002082
PHYSICS, MULTIDISCIPLINARY	52	0.007217	STATISTICS & PROBABILITY	15	0.002082
INTERNATIONAL RELATIONS	51	0.007078	VETERINARY SCIENCES	15	0.002082

3.5. Language

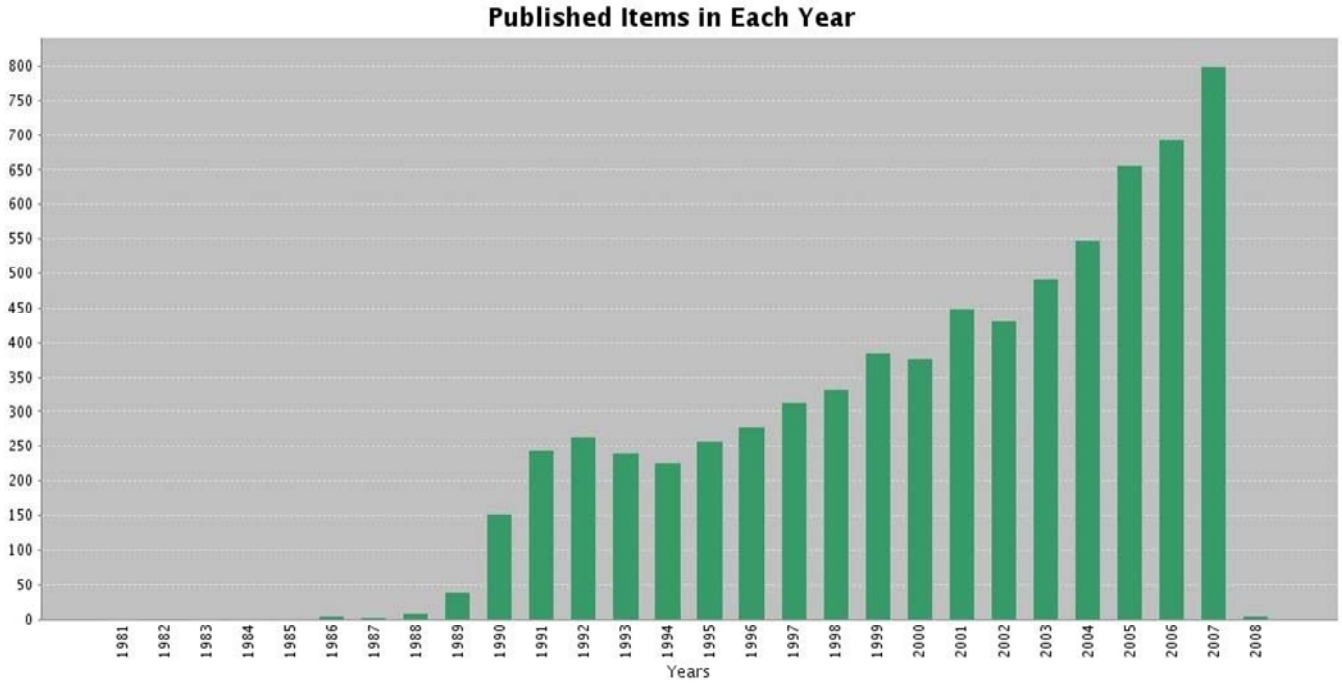
English remained the dominant language used by research publications globally.

Table 7: Global Warming Publications by Language

LANGUAGE	RECORD COUNT	% OF 7205
ENGLISH	7060	97.99%
JAPANESE	42	0.58%
FRENCH	35	0.49%
GERMAN	27	0.37%
RUSSIAN	13	0.18%
SPANISH	9	0.12%
CHINESE	8	0.11%
HUNGARIAN	3	0.04%
PORTUGUESE	3	0.04%
CZECH	2	0.03%
NORWEGIAN	1	0.01%
POLISH	1	0.01%
ROMANIAN	1	0.01%

3.6. Trends and Growth of Global Warming Research and Literature

Fig. One : Published items in each year



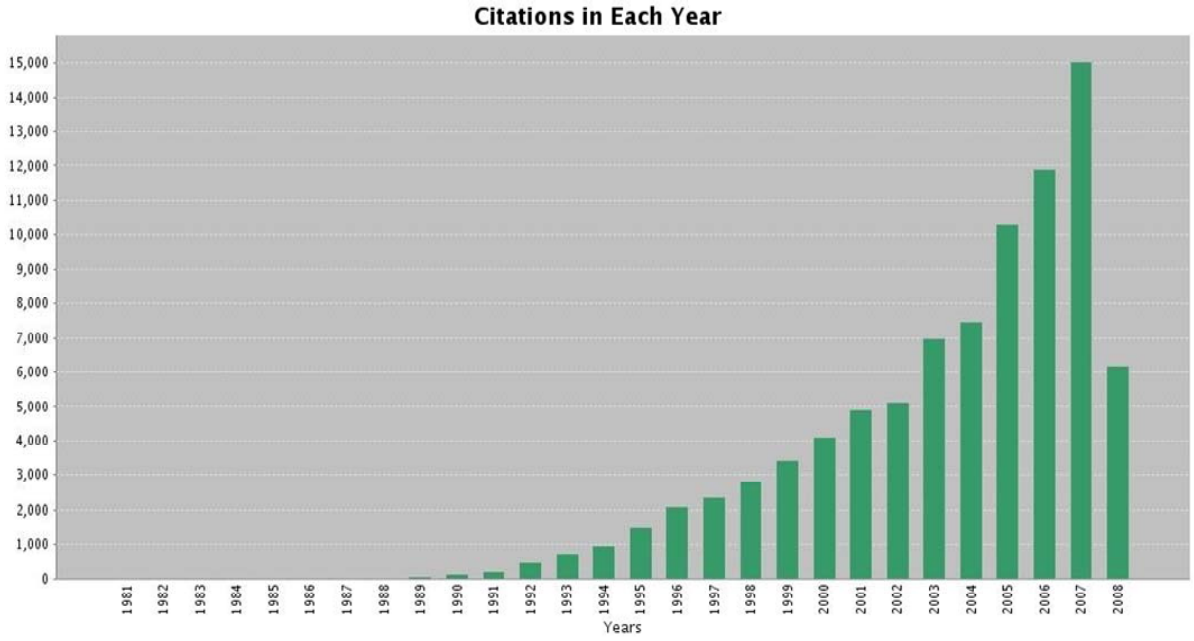


Fig. 2; Citation in Each Year 1980-2007

4. Discussions and Conclusions

Global warming is increasingly becoming a major area of multidisciplinary research right so because of the growing interest and concern of the causes and consequences of the emerging catastrophe that requires proactive intervention before it is too late. This concern has raised scientific latitude among scholars, countries, institutions and information providers on the emerging need to diagnose climate change as a human induced incident. The study found that a total of 116 countries produced one or more publications on global warming, with the USA (2572; 35.7%), England (834; 11.6%) and Japan (546; 7.6%) leading the pack with 3952 (54.85%) publications. In contrast, while the contribution of African countries to global warming research exists, the results indicate that it is insignificant, as noted by the participation of 18 (of 53) countries, with South Africa (46), Kenya (14) and Egypt(7) being among the contributors. It is further noted that an

overwhelming number of journals originate from English speaking countries such as the USA and the UK. The contribution of non-English [first] language speaking countries such as Japan, Germany, France, China, the Netherlands and Sweden was, however, found to be significant, as these six countries were in the list of the world's top ten contributors. English in itself dominates because more countries publish their research using the language. We noted that the number of publications in English is higher in non-English speaking countries and institutions when compared to the publication output in home languages such as Japanese, French, German and Russian. For example, China's country and institutional counts surpass the publication count in Chinese by many folds, suggesting that increasingly, the Chinese could be publishing their research in English. We also believe that the increase of publications in English could also be attributed to an increase in international collaborative research and co-publications, where English becomes the 'compromise' language of publication. Also, the use of the English language increases visibility, accessibility, collaboration and publication in international scholarly research outlets that are both web and print based.

The multidisciplinary nature of global warming research is confirmed by the variety of journals found in the domain. The top five journals, out of a total 1558, were Nature (199; 2.8%), that also accounts for the highest impact factor in the domain, Geophysical Research Letters (175; 2.4%), Climatic Change (161; 2.2%), Science (137; 1.9%) and New Scientist (116; 1.6%). The subject distribution of the records was also diversified, with a strong representation from environmental sciences and studies, meteorology and atmospheric sciences, multidisciplinary sciences, geosciences, ecology, energy and fuels and engineering sciences. The subject coverage was largely in the pure sciences, followed by applied sciences. Records originating from social sciences and humanities appear insignificant.

Most (75%) of the publications are in the form of journal articles. The rest (25%) appear in 15 other document types, with editorial material, reviews, letters, news items and book reviews topping the list with more than 100 records respectively.

Noted further that a large part of Global warming research takes place within the Universities. Although Chinese Academy of Science leads in item/publication counts (see table 4), the number of citations and the h-index scores is lower when compared to those reflected for top institutions (e.g in Table 4). The highest h-index scores are found in the USA institutions suggesting sustained quality research output in the domain. This augurs well for a country known for the highest global warming emissions.

We noted that research on global warming is growing rapidly. For example, the growth of research publications in the domain since 1990 has increased by over 300%, with insignificant rises and falls from 1990 to 2002.and steady growth from 2002 to 2007. Also, that whereas there is a correlation between total cites, average cites per item and per year and the h-index, as reflected on tables 1,2,4 and 5,(e.g on country, source, institution, author) there is no correlation between the four variables and the item counts. It is therefore suggested that more attention be given to citations and h-index for impact factor and item quality judgment for policy decisions.

We conclude, by reflecting on reviewed literature and research on Global warming, that focuses on Global warming characteristics, causes, consequences or effects, preventions, that Global warming is an international, multidisciplinary problem of growing magnitude. It presents major challenges to research, policy, recordal system or documentation, knowledge sharing and interventions of all kinds. Countries and institutions that are currently lagging behind in global warming research such as those in Africa, particularly those that are known for high greenhouse effect emissions should get more involved in active research in the domain. Bibliometric and informetric research provides useful information for the development of political. economic, social and technological policy in general as well as research policy and evaluation, in particular, in a burgeoning domain that is likely to benefit and shape, politics, research, and research policy and information services. We also believe that Library services can benefit from such studies as they would have a positive impact on library collection development, information retrieval and user services. We recommend that information professionals and librarians serving the research and scholarly/academic community should take cognizance of, and be engaged in informetric research in their specialist subject domain to strengthen information retrieval capacity and effective service delivery. In depth research and analysis is ongoing in the highlighted areas under the results section of this paper, including work on collaboration in global warming research

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