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Climate change research (1991–2012): comparative scientometric study of Argentina, Brazil, China, India and Mexico

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Climate change research (1991–2012): comparative scientometric study of Argentina, Brazil, China, India and Mexico

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ABSTRACT

This paper attempts to highlight quantitatively the growth and development of climate change literature in terms of publication output as per Web of Science® (1991–2012, September).The focus of this analysis is to study the literature on climate change published from five developing countries namely Argentina, Brazil, China, India and Mexico. This paper is a comparative study on year wise, document type, most productive authors, subject wise, journal wise, institution wise, and language wise distributions.

7065 records have been retrieved for climate change for the studies countries. Country-wise climate change records and most prolific authors for the five countries have been identified. Authorship and collaboration trend was towards multi-authored papers. Institution-wise climate change records for these countries have also been generated. The topper here is Chinese Academy of Science, China (1843 records). We have grouped the listed publications from Web of Science® under "climate change" into six broad subjects among which "Geosciences (multidisciplinary)" has recorded maximum publications (22.4%) followed by "Environmental Sciences" (21.6%) while "Meteorology and atmospheric sciences" has recorded the least (9.3%). English language occupies the first place with 6882 out of 7065 records for the studied countries.

KEYWORD: Climate change literature, Scientometric analysis, Developing countries, Argentina, Brazil, China, India, Mexico

1. INTRODUCTION

Climate is a component of the natural environment within which and against whose bounds human civilization has developed and prospered [1]. Climate change is one of the most

significant challenges to global economic development. Every country contributes to growing greenhouse gas emissions, and every country will bear the socioeconomic and ecological consequences of global warming. Global air and ocean temperatures have risen as also the percentage of carbon dioxide in the atmosphere. Oceans have become more acidic and sea level has gone up (Gopal Raj, N. in *The Hindu*, Chennai Edition dated 16 November 2012, p.11). The Asia and Pacific region is more vulnerable to these risks than other regions, given its dependence on the natural resources and agriculture sectors, densely populated coastal areas, week institutions, and the poverty of a considerable proportion of its populations. The average annual surface air temperature of India has increased by 0.5°C in the past century. The consequences of certain levels of climate change are well understood and widely accepted. However, climate change is likely to include greater variations in climate phenomena, including droughts and floods, as well as more frequent and severe weather events, such as cyclones and storms, and greater seasonal variability from mild and severe winters to dry and very wet summers [2].

Scientometrics is the study dealing with the quantification of written communication which helps in the measurement of the published knowledge by analyzing literature, inter-relationship among different branches of knowledge, productivity, authorship pattern, degree of collaboration, pattern of collection building, and their use [3].

A scientometric study on climatic change literature was conducted by Li et al (2011) [4] who analysed the research trends in this field through Science Citation Index for 18 years (1992 to 2009). They also compared the growth of climate change literature from seven developed countries. We have here compared and studied the climate change literature from 5 developing countries.

This study has been undertaken with the purpose of finding out the comparative growth and characteristics of climate change literature of 5 developing countries namely Argentina, Brazil, China, India and Mexico from Web of Science®. The rationale for the choice of the countries is that these countries have high population density on coastal areas, and face severe pressure on natural resources mainly due to economic and demographic patterns; hence any major climatic fluctuations will impact them. The publications from these countries may also focus on such aspects that will aid in better management strategies for the future.

2. OBJECTIVES

This study compares the growth of literature on climate change in the 5 studied countries and makes a quantitative assessment of status of the research by way of analyzing the following features of research outputs:-

- Annual growth of publications
- Document types used by the scientists
- Most prolific authors of five countries along with degree of collaboration
- Subject wise distribution
- Journal wise distribution
- Organizational distribution
- Language wise distribution
- Highly cited papers and h-index of 5 developing countries

3. MATERIALS AND METHODS

Documents used in this study were based on the online database Web of Science®. Period of study is 1991 to September 2012 (21 years). The present study has used the topic search "climate change" within the specified time span. A total of 7065 records on climate change for 5 developing countries were retrieved. The search included the three citation databases namely Science Citation Index, Social Sciences Citation Indices and Arts and Humanities Citation Indices. Once a marked list of papers has been created, the resulting export file is processed by HistCite™ (Bibliometric Analysis and Visualization Software developed by Garfield and colleagues).

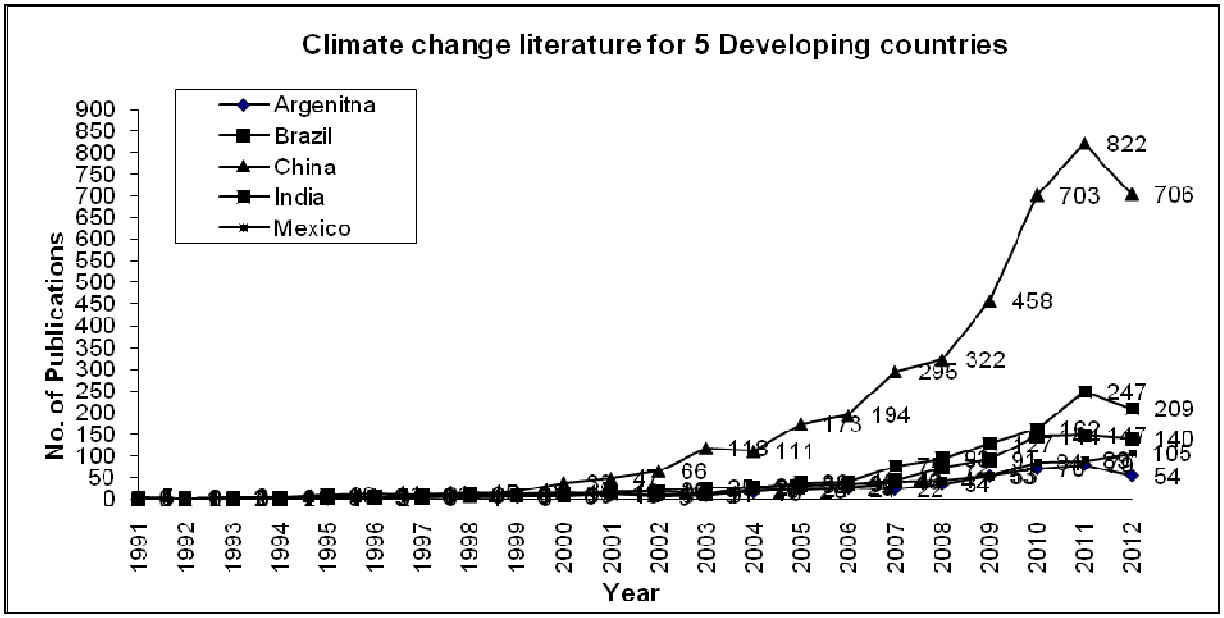
4. RESULTS

4.1. Growth of Climate change literature

A graphical analysis (Figure 1) of the growth in the number of articles over the twenty one year-period reveals that the maximum records have originated from China (4121) and the minimum

from Argentina (443). The dip in records in the year 2012 for all the countries is because the period of study concludes with September 2012.

Figure 1 Comparison of Growth of Climate change literature, 1991-2012



4.2. Source wise distribution of Climate change literature

14 document types were researched (Table 1) for this study yielding a total of 7065 records during the 21 year study period. The productivity of climate change literature spreads over a variety of publication media. It is noteworthy that Argentina, which contributed minimum by way of number of publications, has topped the percentage of records (81.04%) in the form of articles in listed journals while highly productive countries like India (75.24%) and China (78.65%) have produced the least number of publications in journals.

Table 1 Source wise distribution of Climate change literature for 5 developing countries

Document Type	Argentina (%)	Brazil (%)	China (%)	India (%)	Mexico (%)
Article	359 (81.04)	654 (79.85)	3241 (78.65)	863 (75.24)	433 (80.93)
Article; Proceedings Paper	26 (5.87)	35 (4.27)	152 (3.69)	43 (3.75)	27 (5.05)

Book Review	0	3 (0.37)	3 (0.07)	3 (0.26)	1 (0.19)
Chronology	0	0	4 (0.10)	0	0
Correction	0	0	2 (0.05)	2 (0.17)	0
Editorial Material	5 (1.13)	18 (2.20)	39 (0.95)	41 (3.57)	11 (2.06)
Letter	2 (0.45)	5 (0.61)	11 (0.27)	18 (1.57)	4 (0.75)
Meeting Abstract	1 (0.23)	5 (0.61)	5 (0.12)	6 (0.52)	5 (0.93)
News Item	0	0	0	3 (0.26)	0
Note	0	0	0	2 (0.17)	0
Proceedings Paper	11 (2.48)	23 (2.81)	510 (12.38)	52 (4.53)	8 (1.50)
Proceedings Paper; Book Chapter	0	0	1 (0.02)	1 (0.09)	0
Review	39 (8.80)	74 (9.04)	146 (3.54)	108 (9.42)	45 (8.41)
Review; Book Chapter	0	2 (0.24)	7 (0.17)	5 (0.44)	1 (0.19)
Total	443 (100.00)	819 (100.00)	4121 (100.00)	1147 (100.00)	535 (100.00)

4.3. Author wise distribution of Climate change literature

Table 2 gives the contributions of individual authors during the study period. The authors may have sole-authored or co-authored the papers. The most prolific author during the period is Wang (53 contributions) from China. The number of contributing authors was also maximum from China (9952 authors contributed 4121 publications).

Table 2 Most prolific authors for Climate change literature for 5 developing countries

Top Ten Authors for 5 Developing countries				
Argentina (Records)	**Brazil (Records)**	**China (Records)**	**India (Records)**	**Mexico (Records)**
Sala OE (16)	Marengo JA (20)	Wang Y (53)	Ravindranath NH (28)	Peterson AT (20)

Diaz S (11)	Fearnside PM (18)	Li Y (44)	Aggarwal PK (18)	Martinez-Meyer E (18)
Kitzberger T (11)	Cerri CC (15)	Zhang Y (43)	Bala G (18)	Conde C (11)
Villalba R (11)	Diniz JAF (15)	Chen X (38)	Lal M (16)	Saenz-Romero C (11)
Menendez CG (10)	Laurance WF (15)	Zhang Q (38)	Ghosh S (15)	Gay C (9)
Nunez MN (9)	Malhi Y (15)	Wang HJ (37)	Mujumdar PP (14)	Iglesias-Prieto R (9)
Caldwell MM (8)	Nepstad DC (15)	Zhang L (37)	Singh R (14)	Navarro-Siguenza AG (8)
Flint SD (8)	Artaxo P (14)	Chen J (36)	Kumar A (13)	Estrada F (7)
Rusticucci M (8)	Costa MH (14)	Fang JY (34)	Kumar S (13)	Parra-Olea G (7)
Ballare CL (7)	Nepstad D (14)	Liu JY (34)	Kumar R (12)	Rehfeldt GE (7)

4.4. Degree of Collaboration

As regards authorship pattern of the literature, single author contribution is low when compared to multi authored papers.

The Degree of collaboration is formulated with the help of Subramanyan (1983) formula:-

C = Nm/Nm + Ns

Where C = Degree of Collaboration

Nm = Number of multi authored papers

Ns = Number of single authored papers

The results of the degree of collaboration are presented in Table 3.

Table 3 Degree of Collaboration

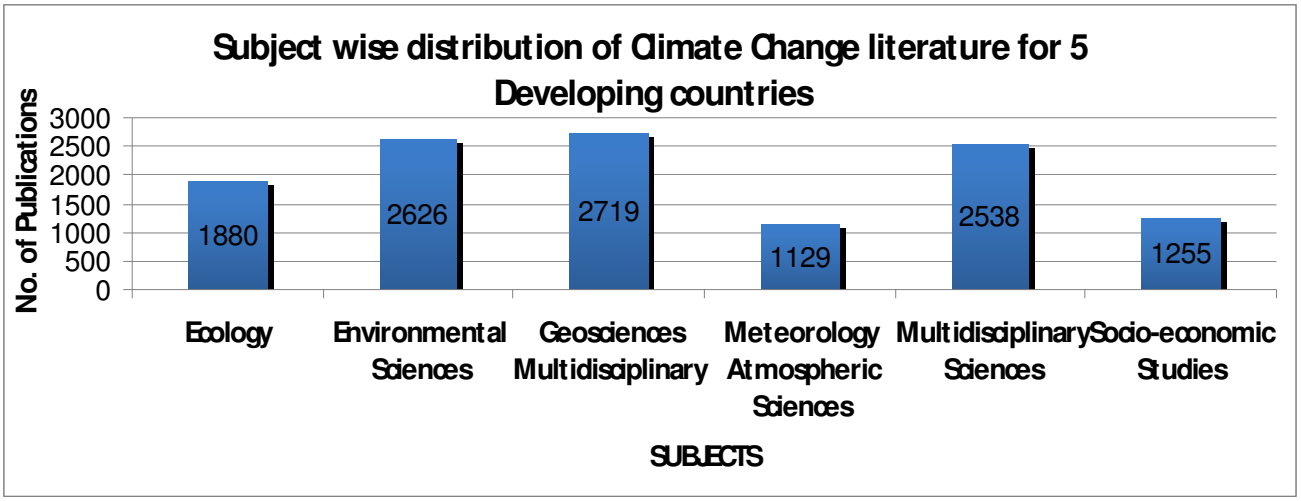
Countries	Degree of Collaboration
Argentina	0.95
Brazil	0.92
China	0.96
India	0.85
Mexico	0.96

4.5. Subject wise distribution of Climate change literature

According to Web of Science® subject categorization, the publications of climate change during the study period scattered over 141 subjects for the studied countries. These scattered subjects are regrouped in to 6 broad subjects.

Figure 2 shows that "Geosciences (multidisciplinary)" has recorded maximum publications (22.4%) followed by "Environmental Sciences" (21.6%) while "Meteorology and atmospheric sciences" has recorded the least (9.3%).

Figure 2 Subject wise distribution of Climate change literature



4.6. Journal wise distribution of Climate change literature

By way of journal wise distribution of publications, highest records, among publications from all countries, are from the Journal *Chinese Science Bulletin* with 165 records while Indian journal *Current Science* is close behind with 153 records. The top 10 journals for each of the countries are provided in Table 4.

Table 4 Top ten journals for Climate change literature for 5 developing countries

Argentina (Records)	Brazil (Records)	China (Records)	India (Records)	Mexico (Records)
Palaeogeography Palaeoclimatology Palaeoecology (14)	Global Change Biology (21)	Chinese Science Bulletin (165)	Current Science (153)	Atmosfera (22)
Climatic Change (13)	Science (16)	Advances in Atmospheric Sciences (81)	Journal of Agrometeorology (30)	Global Change Biology (12)
Climate Dynamics (10)	Geophysical Research Letters	Science in China Series D-Earth	Climatic Change (20)	Interciencia (12)

	(15)	Sciences (77)		
Forest Ecology and Management (8)	Journal of Climate (14)	Journal of Geophysical Research-Atmospheres (63)	International Journal of Climatology (18)	Science (12)
International Journal of Climatology (7)	Climatic Change (13)	Climatic Change (59)	Mitigation and Adaptation Strategies for Global Change (18)	Biodiversity and Conservation (10)
Journal of Climate (7)	Energy Policy (13)	Quaternary International (59)	Energy Policy (16)	Journal of Biogeography (9)
Quaternary International (7)	Forest Ecology and Management (13)	Palaeogeography Palaeoclimatology Palaeoecology (57)	Hydrological Processes (15)	Plos One (9)
Global Change Biology (6)	Plos One (12)	Geophysical Research Letters (56)	Journal of Geophysical Research-Atmospheres (15)	Biological Conservation (8)
Journal of Biogeography (6)	Journal of Biogeography (11)	Journal of Geographical Sciences (56)	Journal of The Geological Society of India (15)	Climatic Change (7)
Journal of Hydrology (6)	Pesquisa Agropecuaria Brasileira (11)	Global Change Biology (53)	Mausam (14)	Forest Ecology and Management (7)

4.7. Institution wise distribution of Climate change literature

Table 5 Top ten Institutions for Climate change literature for 5 Developing countries

Argentina (Records)	Brazil (Records)	China (Records)	India (Records)	Mexico (Records)
Univ Buenos Aires (103)	Univ Sao Paulo (143)	Chinese Acad Sci (1843)	Indian Inst Technol (116)	Univ Nacl Autonoma Mexico (232)
Consejo Nacl Invest Cient & Tecn (82)	Univ Fed Rio de Janeiro (53)	Peking Univ (233)	Indian Inst Sci (84)	Univ Kansas (26)
Univ Nacl Cordoba (34)	Univ Fed Vicosa (42)	Beijing Normal Univ (222)	Indian Inst Trop Meteorol (38)	Univ Autonoma Baja California (15)
Univ Nacl Comahue (29)	Woods Hole Res Ctr (40)	Lanzhou Univ (212)	Indian Agr Res Inst (34)	Univ Calif Berkeley (15)
Inst Antartico Argentino (17)	Univ Fed Minas Gerais (33)	Nanjing Univ (145)	Phys Res Lab (32)	Ctr Invest Cient & Educ Super Ensenada (14)
INTA (12)	Univ Oxford (33)	China Meteorol Adm (144)	Banaras Hindu Univ (29)	Inst Politecn Nacl (14)
Univ Austral Chile (12)	Inst Nacl Pesquisas Espaciais (30)	CAS (103)	Natl Inst Hydrol (25)	CIMMYT (13)
Univ Colorado (11)	Univ Brasilia (27)	Chinese Acad Meteorol Sci (80)	Univ Delhi (25)	Inst Ecol AC (13)
Univ Nacl Tucuman (11)	Univ Fed Goias (27)	Tsinghua Univ (76)	Int Crops Res Inst Semi Arid Trop (24)	NOAA (13)
CSIC (10)	Univ Fed Rio Grande do Sul (26)	Chinese Acad Agr Sci (75)	Natl Inst Oceanog (24)	CSIC (12)

An analysis of the institutions involved in publications reveals that there were 8039 institutions involved in publications in the field of climate change sharing 7065 articles during the study period in Table 7. The Chinese Academy of Science stands first with 1843 records.

4.8. Language wise distribution of Climate change literature

It is also important to identify the languages of publication (Table 6). As we expected, English is the predominant language of publications. Out of the 7065 records retrieved, English occupies the first position with 6882 records.

Table 6 Language wise distribution on Climate change for 5 developing countries

Country	Language							Total
	Chinese	English	French	German	Portuguese	Russian	Spanish	
Argentina	0	430	0	0	0	0	13	443
Brazil	0	772	2	0	43	0	2	819
China	87	4031	0	1	1	1	0	4121
India	0	1147	0	0	0	0	0	1147
Mexico	0	502	1	0	0	0	32	535
Total	87	6882	3	1	44	1	47	7065

4.9. Highly Cited Papers

List of the top 5 most highly cited papers in climate change; 1991-2012 from 5 developing countries is given below in the Table 7.

Table 7 Highly Cited Papers on Climate change for 5 developing countries

Country	Title/Source	Times cited (WoS)
ARGENTINA	Title: Biodiversity - Global biodiversity scenarios for the year 2100 Author(s): Sala, OE; Chapin, FS; Armesto, JJ; et al. Source: SCIENCE Volume: **287** Issue: **5459** Pages: **1770-1774** DOI: **10.1126/science.287.5459.1770** Published: **MAR 10 2000**	1719
	Title: Consequences of changing biodiversity Author(s): Chapin, FS; Zavaleta, ES; Eviner, VT; et al. Source: NATURE Volume: **405** Issue: **6783** Pages: **234-242** DOI: **10.1038/35012241** Published: **MAY 11 2000**	906
	Title: Biotic control over the functioning of ecosystems Author(s): Chapin, FS; Walker, BH; Hobbs, RJ; et al. Source: SCIENCE Volume: **277** Issue: **5325** Pages: **500-504** DOI: **10.1126/science.277.5325.500** Published: **JUL 25 1997**	409
	Title: Global observed changes in daily climate extremes of temperature and precipitation Author(s): Alexander, LV; Zhang, X; Peterson, TC; et al.	329

	Source: JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES Volume: **111** Issue: **D5** Article Number: **D05109** DOI: **10.1029/2005JD006290** Published: **MAR 15 2006**	
	Title: Plant functional types and ecosystem function in relation to global change Author(s): Diaz, S; Cabido, M Source: JOURNAL OF VEGETATION SCIENCE Volume: **8** Issue: **4** Pages: **463-474** DOI: **10.2307/3237198** Published: **SEP 1997**	272
BRAZIL	Title: Extinction risk from climate change Author(s): Thomas, CD; Cameron, A; Green, RE; et al. Source: NATURE Volume: **427** Issue: **6970** Pages: **145-148** DOI: **10.1038/nature02121** Published: **JAN 8 2004**	1641
	Title: Novel methods improve prediction of species' distributions from occurrence data Author(s): Elith, J; Graham, CH; Anderson, RP; et al. Source: ECOGRAPHY Volume: **29** Issue: **2** Pages: **129-151** DOI: **10.1111/j.2006.0906-7590.04596.x** Published: **APR 2006**	1311
	Title: Large-scale impoverishment of Amazonian forests by logging and fire Author(s): Nepstad, DC; Verissimo, A; Alencar, A; et al. Source: NATURE Volume: **398** Issue: **6727** Pages: **505-508** DOI: **10.1038/19066** Published: **APR 8 1999**	558
	Title: THE ROLE OF DEEP ROOTS IN THE HYDROLOGICAL AND CARBON CYCLES OF AMAZONIAN FORESTS AND PASTURES Author(s): NEPSTAD, DC; DECARVALHO, CR; DAVIDSON, EA; et al. Source: NATURE Volume: **372** Issue: **6507** Pages: **666-669** DOI: **10.1038/372666a0** Published: **DEC 15 1994**	485
	Title: Ecosystem decay of Amazonian forest fragments: A 22-year investigation Author(s): Laurance, WF; Lovejoy, TE; Vasconcelos, HL; et al. Source: CONSERVATION BIOLOGY Volume: **16** Issue: **3** Pages: **605-618** DOI: **10.1046/j.1523-1739.2002.01025.x** Published: **JUN 2002**	420
CHINA	Title: Global observed changes in daily climate extremes of temperature and precipitation Author(s): Alexander, LV; Zhang, X; Peterson, TC; et al. Source: JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES Volume: **111** Issue: **D5** Article Number: **D05109** DOI: **10.1029/2005JD006290** Published: **MAR 15 2006**	329
	Title: The Global Soil Moisture Data Bank Author(s): Robock, A; Vinnikov, KY; Srinivasan, G; et al. Source: BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY Volume: **81** Issue: **6** Pages: **1281-1299** DOI: **10.1175/1520-0477(2000)081<1281:TGSMDB>2.3.CO;2** Published: **JUN 2000**	308
	Title: The history and variability of the East Asian paleomonsoon climate Author(s): An, ZS Conference: **1st PAGES Open Science Meeting** Location: **UNIV LONDON, LONDON, ENGLAND** Date: **APR 19-23, 1998** Source: QUATERNARY SCIENCE REVIEWS Volume: **19** Issue: **1-5** Pages: **171-187** DOI: **10.1016/S0277-3791(99)00060-8** Published: **JAN 2000**	294
	Title: Millennial- and orbital-scale changes in the East Asian monsoon over the past 224,000 years Author(s): Wang, Yongjin; Cheng, Hai; Edwards, R. Lawrence; et al. Source: NATURE Volume: **451** Issue: **7182** Pages: **1090-1093** DOI: **10.1038/nature06692** Published: **FEB 28 2008**	279
	Title: Attributing physical and biological impacts to anthropogenic climate change Author(s): Rosenzweig, Cynthia; Karoly, David; Vicarelli, Marta; et al. Source: NATURE Volume: **453** Issue: **7193** Pages: **353-U20** DOI:	273

	10.1038/nature06937 Published: **MAY 15 2008**	
INDIA	Title: Global observed changes in daily climate extremes of temperature and precipitation Author(s): Alexander, LV; Zhang, X; Peterson, TC; et al. Source: JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES Volume: **111** Issue: **D5** Article Number: **D05109** DOI: **10.1029/2005JD006290** Published: **MAR 15 2006**	334
	Title: Global Biodiversity: Indicators of Recent Declines Author(s): Butchart, Stuart H. M.; Walpole, Matt; Collen, Ben; et al. Source: SCIENCE Volume: **328** Issue: **5982** Pages: **1164-1168** DOI: **10.1126/science.1187512** Published: **MAY 28 2010**	245
	Title: EFFECTS OF INCREASED SOLAR ULTRAVIOLET-RADIATION ON TERRESTRIAL PLANTS Author(s): CALDWELL, M; TERAMURA, AH; TEVINI, M; et al. Source: AMBIO Volume: **24** Issue: **3** Pages: **166-173** Published: **MAY 1995**	187
	Title: Greenhouse gas mitigation in agriculture Author(s): Smith, Pete; Martino, Daniel; Cai, Zucong; et al. Source: PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B-BIOLOGICAL SCIENCES Volume: **363** Issue: **1492** Pages: **789-813** DOI: **10.1098/rstb.2007.2184** Published: **FEB 27 2008**	186
	Title: Tropical cyclones and climate change Author(s): Knutson, Thomas R.; McBride, John L.; Chan, Johnny; et al. Source: NATURE GEOSCIENCE Volume: **3** Issue: **3** Pages: **157-163** DOI: **10.1038/NGEO779** Published: **MAR**	149
MEXICO	Title: Biodiversity - Global biodiversity scenarios for the year 2100 Author(s): Sala, OE; Chapin, FS; Armesto, JJ; et al. Source: SCIENCE Volume: **287** Issue: **5459** Pages: **1770-1774** DOI: **10.1126/science.287.5459.1770** Published: **MAR 10 2000**	1719
	Title: Extinction risk from climate change Author(s): Thomas, CD; Cameron, A; Green, RE; et al. Source: NATURE Volume: **427** Issue: **6970** Pages: **145-148** DOI: **10.1038/nature02121** Published: **JAN 8 2004**	1641
	Title: Novel methods improve prediction of species' distributions from occurrence data Author(s): Elith, J; Graham, CH; Anderson, RP; et al. Source: ECOGRAPHY Volume: **29** Issue: **2** Pages: **129-151** DOI: **10.1111/j.2006.0906-7590.04596.x** Published: **APR 2006**	1311
	Title: Coral reefs under rapid climate change and ocean acidification Author(s): Hoegh-Guldberg, O.; Mumby, P. J.; Hooten, A. J.; et al. Source: SCIENCE Volume: **318** Issue: **5857** Pages: **1737-1742** DOI: **10.1126/science.1152509** Published: **DEC 14 2007**	662
	Title: Observation and modeling of biomass and soil organic-matter dynamics for the grassland and biome worldwide Author(s): PARTON, WJ; SCURLOCK, JMO; OJIMA, DS; et al. Source: GLOBAL BIOGEOCHEMICAL CYCLES Volume: **7** Issue: **4** Pages: **785-809** DOI: **10.1029/93GB02042** Published: **DEC 1993**	511

4.10. General observations on Climate change literature

The general observations on climate change literature from 1991 to 2012 through Web of Science® are listed in Table 8.

Table 8 General observations on Climate change literature, 1991-2012

Countries	Results found	Sum of Times Cited	Sum of Times Cited without self-citations	Citing Articles	Citing Articles without self-citations	Average Citations per Item	h-index
Argentina	443	10393	10088	9033	8859	23.46	45
Brazil	819	17606	16521	13463	13066	1.5	65
China	4123	35514	29279	23064	20950	8.61	73
India	1142	9430	8330	7602	7141	8.26	44
Mexico	535	12844	12387	10551	10326	24.01	43

DISCUSSION AND CONCLUSION

The quality and quantity of scientific works is often judged by the outputs mainly in the form of publications. Our work attempts to capture these outputs in five developing countries. It is not in the purview of this study to get in to the finer aspects of these publications like the quality of the journals/ books, impact factors and citations, to name a few.

Our results clearly show that China and India are the countries that produce the maximum outputs quantitatively. One handicap for the other countries could be the language barrier as English is not the main medium for communication; but China has proved to be an exception in this issue with more outputs in English than India. But it will be unfair to draw any further inferences as the economic conditions and the prevailing environmental conditions to focus on climate change research are totally different between these countries. For example, Argentina and India may not face similar comparable climate-related issues that may prompt research in the field culminating in publications.

It will be interesting to find out how the scientific outputs from these developing countries compare with countries that have better academic and economic facilities. This may be an issue to be analysed in detail by researchers in scientometrics.

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