Continent wise Analysis of Green Computing Research: A Scientometric Study

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Abstract

This paper attempts to analyse the growth and development of Green Computing, as reflected in publication output covered by Web of Science online database during 1956-2011. Among these 42 countries, Germany has produced 270 (16.24 %) articles and it occupies the first place of European continent. France and Italy have more than 200 articles produced in this field. UK and Spain contributed more than 100 articles. North American countries contributed their output 1317 in total where the USA (33.36%) stands in the highest position among them all, and the reason may be the impact of the advancement of the new and recent technologies applied highly in the USA and followed by Canada, Mexico.

Keywords

Literacy, information and communication technology, University Libraries.

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Introduction

Computing technology plays a crucial role in our day to day activities. Subsequently the associated high volume of energy consumption has become a major concern both economically and environmentally. Green Computing is an emerging applications in computing technology that can reduce energy consumption effectively, which leads to significant CO_2 emission reduction. Green Computing has become an essential component that needs to be considered seriously by the next generation information and communication technology designers. Green Computing is to use computers and related resources in environment friendly ways. Such practices include the implementation of energy-efficient central processing units (CPUs), servers and peripherals as well as finding innovative ways of reducing resource consumption and proper disposal of electronic waste.

Objectives

The major objectives are framed with the exclusive notion of the present study as mentioned below:

- To examine the growth of research productivity of Green Computing research during 1956- 2011.
- To identify the continental with country-wise distribution of publications.
- To identify the country wise Global Citation Scores, Local Citation Scores and h-index

Methodology

The required data was collected from Web of Science database for the period 1956-2011. It can be seen that nearly 3324 bibliographic records of contribution in field of Green Computing over the period of 56 years. The researcher applied the search strings "Green Computing or Green IT" that has used for the data extraction from the database of SCI, SSCI and A&HCI (totally fifty six years) to download the records based on the above strings. A total of 3324 records were downloaded and analyzed by using the Histcite and Bibexcel software applications as per the objectives of the study. The study aims to analyze the thrust areas of research concentration on Green Computing research. It is analytical in nature with the suitable statistical tools applications in strengthening the empirical validity.

Data Analysis and Interpretations

This analysis covers the scientist's research output on Green Computing research publications at continent level. There are seven continents, but here the researcher has taken only six continents because the last continent of Antarctica does not have any contribution to the publications of this area. So for this part of analysis, researcher has selected continents of Europe, North America, Asia, Australia, South America and Africa.

Table 1 indicates that the continent wise distribution of total research output on Green Computing research literature. The European continent stood in the first place with the highest publication of 1663 (40.87 %) on Green Computing output from 44 (48.35 %) countries contributing along with 660 TLCS and 22653 TGCS measured. The North American continent occupies the second position with 1317

Continent Wise Distribution of Green Computing Research Output

publications (32.37 %) from five (5.49 %) countries contributing with 606 TLCS and 23144 TGCS measured. Observed from this analysis Asian continent with 18.26 percent (743) of articles from seventeen (18.68 %) countries along with 245 TLCS and 6193 TGCS measured and it stands in the third position of the research productivity. South American continent has 2.48 percent output during the study period along with 772 total citation scores from seven (7.69 %) countries. Australian continent has 1.67 percent with 897 total citation scores from two (2.20 %) countries. The African continent stands last position with 50 (1.23 %) among the six continents along with 288 total citation scores from sixteen (17.58 %) countries. Apart from these continent publications, unknown articles also found a space of 3.12 percent with 1658 total citation scores. Overall the continent's citation scores are 57116.

Table 1 – Shows Continent Wise Research output of Green Computing

Rank	Continents	Contributing countries	No of Record	Percentage	TLCS	TGCS
1	Europe	44 (48.35)	1663	40.87	660	22653
2	North America	5 (5.49)	1317	32.37	606	23144
3	Asia	17 (18.68)	743	18.26	245	6193
4	South America	7 (7.69)	101	2.48	42	730
5	Australia	2 (2.20)	68	1.67	14	883
6	Africa	16 (17.58)	50	1.23	14	274
Total		**91**	**4069**	**100**	**1640**	**55476**

The Table 1 reveals the continents contribution of the research output on Green Computing during 1956 to 2011 from 91 different countries. At the comprehensive level, taken the duration periods

Europe has the highest research productivity and the lowest research productivity is Africa. Found from this table 4.13, the status of research shows the variation during these year groups

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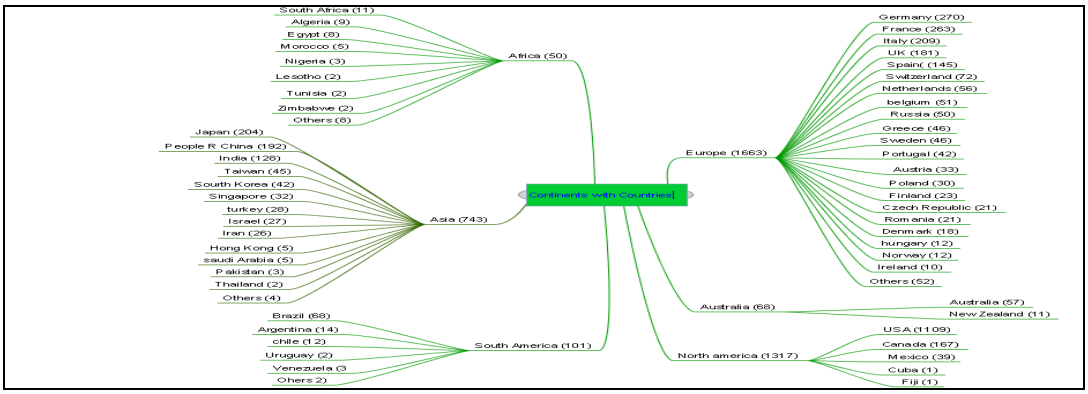

Figure 1 – Shows Continental and Country wise Distribution of Publication

From the above analysis it is derived that European continent has the highest number of publications and the largest total citation scores is by North American continent in the field of Green Computing research output. They dominate in the first and second position, followed by the Asian continent, South America, Australia continent and Africa continents that stood in the position of third, fourth, fifth and sixth respectively with regards to the Green Computing research output .

Table 2 – Shows Performance of Green Computing Research Output in European Countries

S.NO.	Country	Records	TLCS	TGCS	1793%	3324%
1	Germany	270	8	4407	15.06	8.12
2	France	263	49	4724	14.67	7.91
3	Italy	209	22	2584	11.66	6.29
4	UK	181	9	2750	10.09	5.45
5	Spain	145	24	1758	8.09	4.36
6	Unknown	127	34	1599	7.08	3.82
7	Switzerland	72	1	1090	4.02	2.17
8	Netherlands	56	0	918	3.12	1.68
9	Belgium	51	12	698	2.84	1.53
10	Russia	50	0	538	2.79	1.50
11	Greece	46	3	347	2.57	1.38
12	Sweden	46	1	404	2.57	1.38
13	Portugal	42	0	347	2.34	1.26
14	Austria	33	3	286	1.84	0.99
15	Poland	30	0	258	1.67	0.90
16	Finland	23	1	282	1.28	0.69
17	Czech Republic	21	0	141	1.17	0.63
18	Romania	21	0	138	1.17	0.63
19	Denmark	18	0	231	1.00	0.54
20	Hungary	12	0	51	0.67	0.36
21	Norway	12	0	209	0.67	0.36
22	Ireland	10	0	74	0.56	0.30
23	Slovakia	9	0	109	0.50	0.27
24	Ukraine	7	0	30	0.39	0.21
25	Estonia	5	0	26	0.28	0.15
26	Bulgaria	4	0	17	0.22	0.12
27	Czechoslovakia	4	0	89	0.22	0.12
28	Croatia	3	0	7	0.17	0.09
29	Cyprus	3	0	53	0.17	0.09
30	Jordan	3	0	5	0.17	0.09
31	Slovenia	2	0	17	0.11	0.06
32	USSR	2	0	8	0.11	0.06
33	Yugoslavia	2	0	8	0.11	0.06
34	Bermuda	1	0	1	0.06	0.03
35	Bosnia & Herceg	1	2	12	0.06	0.03
36	Burkina Faso	1	0	2	0.06	0.03
37	Byelarus	1	0	0	0.06	0.03
38	Iceland	1	0	23	0.06	0.03
39	Latvia	1	0	5	0.06	0.03
40	Lithuania	1	0	0	0.06	0.03
41	Macedonia	1	0	1	0.06	0.03
42	Montenegro	1	0	1	0.06	0.03
43	Rep of Georgia	1	0	3	0.06	0.03
44	Serbia	1	0	0	0.06	0.03
TOTAL		1793	169	24251	100	53.94

Totally 44 countries were contributing 1663 articles that were published in Green Computing research from European countries. Among these 44 countries, Germany produced 270 (15.06 %) of articles and it occupied the first place of European continent. France and Italy have more than 200 articles produced in this field. UK and Spain were contributing more than 100 articles. Switzerland, Netherlands, Belgium and Russia were contributing each above 50 articles in the field of Green Computing. There are five North American Countries that contributed their output in total 1317 where the USA (33.36%) stands in the highest position among them all, and the reason may be the impact of the advancement of the new and recent technologies applied and followed by Canada, and Mexico. The countries like Cuba and Fiji stand in the last position with (0.3%) output which shows the reason be the lack of facilities and application in Green Computing as shows that follows in the table 3.

Table 3 Performance of Green Computing Research Output by North American Countries

S. No.	Countries	Recs.	TLCS	TGCS	% of 1317	% of 3324
1	USA	1109	502	20747	84.21	33.36
2	Canada	167	58	1916	12.68	5.02
3	Mexico	39	46	460	2.96	1.17
4	Cuba	1	0	14	0.08	0.03
5	Fiji	1	0	7	0.08	0.03
Total		**1317**	**606**	**23144**	100	39.62

Table 4 Research Performance of Green Computing Output by Asian Countries

S. No	Countries	Recs.	TLCS	TGCS	% of 743	% of 3324
1	Japan	204	126	2836	27.46	6.14
2	Peoples R China	192	59	1065	25.84	5.78
3	India	128	20	685	17.23	3.85
4	Taiwan	45	14	365	6.06	1.35
5	South Korea	42	4	354	5.65	1.26
6	Singapore	32	4	217	4.31	0.96
7	Turkey	28	6	132	3.77	0.84
8	Israel	27	4	345	3.63	0.81
9	Iran	26	5	109	3.50	0.78
10	Hong Kong	5	2	58	0.67	0.15
11	Saudi Arabia	5	1	13	0.67	0.15
12	Pakistan	3	0	3	0.40	0.09
13	Thailand	2	0	1	0.27	0.06
14	Kuwait	1	0	0	0.13	0.03
15	Malaysia	1	0	0	0.13	0.03
16	Philippines	1	0	0	0.13	0.03
17	Qatar	1	0	10	0.13	**0.03**
	Total	**743**	**245**	**6193**	**100**	**22.35**

In the case of 17 Asian Countries the top position has been occupied by Japan (6.14%) on the performance of Green Computing output proving its strong technological awareness among them all and this as followed by other countries, where India stands in the Third position (3.85%) and followed by other countries next respective positions. Finally, the last five countries are identified as exhibiting least research performance output in this selected field as per in the above table 4.

Table 5 Research Performance of Australian Countries

S.No	Countries	Recs.	TLCS	TGCS	% of 68	% of 3324
1	Australia	57	9	745	83.82	1.71
2	New Zealand	11	5	138	16.17	0.33
	Total	**68**	**14**	**883**	**100**	**2.04**

The table 5 above shows the performances of research output in the two Australian Countries, in which Australia (1.71%) contributed its output and ranked first and New Zealand (0.33%) occupies the second rank of research output in Green Computing.

Table 6 Research Performance of South American Countries

S.No	Countries	Recs.	TLCS	TGCS	% of 101	% of 3324
1	Brazil	68	36	484	67.33	2.05
2	Argentina	14	0	111	13.86	0.42
3	Chile	12	4	91	11.88	0.36
4	Venezuela	3	2	13	2.97	0.09
5	Uruguay	2	0	22	1.98	0.06
6	Peru	1	0	6	0.99	0.03
7	Trinid & Tobago	1	0	3	0.99	0.03
Total		**101**	**42**	**730**	**100**	**3.04**

In the case of 7 South American Countries in total, in which Brazil (2.05%) performed number one place followed by the other Four countries in the next respective places. The countries like Peru and Trinidad and Tobago occupy the last place in the research output of Green Computing area.

Table 7 Performance of Green Computing Output by African Countries

S. No	Countries	Recs.	TLCS	TGCS	% of 50	% of 3324
1	South Africa	11	0	73	22	0.33
2	Algeria	9	1	18	18	0.27
3	Egypt	8	2	23	16	0.24
4	Morocco	5	6	13	10	0.15
5	Nigeria	3	5	91	6	0.09
6	Lesotho	2	0	0	4	0.06

7	Tunisia	2	0	35	4	0.06
8	Zimbabwe	2	0	6	4	0.06
9	Brunei	1	0	1	2	0.03
10	Burkina Faso	1	0	2	2	0.03
11	Congo Peopl Rep	1	0	5	2	0.03
12	Kenya	1	0	0	**2**	0.03
13	Malagasy Republ	1	0	5	**2**	0.03
14	Senegal	1	0	0	**2**	0.03
15	Sudan	1	0	1	**2**	0.03
16	Tanzania	1	0	1	**2**	0.03
Total		**50**	**14**	**274**	**100**	**1.50**

16 African countries contributed only 50 articles in the subject of Green Computing. Among these 16 countries, South Africa is the leading country followed by Algeria, Egypt and morocco having above five articles. Remaining eleven countries published each below five articles. The productivity of African continent countries takes the last position of world output.

Overall Country wise Distribution of Publications

The table 4.8 below indicates that among the country wise distribution of publications on Green Computing covered by the study the United States of America with 1109(33.4%) publications tops followed by Germany with 270(8.1%), France with 263(7.9%), Italy with 209(6.3%), and Japan with 204(6.1%). India is occupying the 10th position in the world in terms of publications. First place goes to United States of America having total Global Citation Score of 20747 with 1109 publications in terms of Citations Scores and followed by France with 4724 Global Citation Scores, Germany with 4407 Global Citation Scores and remaining contribution by other countries.

H-index and g-index for Top 10 Countries

In the table 4.20 below names of the first 10 countries along with their citations, h-index and g-index are given. It was observed that the first 10 countries had received 86 percent (86.20%) of the total publications and 97 percent (97.38%) of the total Global Citation Scores. USA got the first position in the rank by highest number of citation, h-index and g-index followed by Germany and so on.

Table 8 – h-index and g-index for Top 10 Countries

S.No.	Country	Publications	TGCS	h-index	g-index
1	USA	1109	20747	62	144
2	Germany	270	4407	35	66
3	France	263	4724	35	69
4	Italy	209	2584	27	51
5	Japan	204	2836	26	53
6	Peoples R China	192	1065	17	33
7	UK	181	2750	28	52
8	Canada	167	1916	23	44
9	Spain	145	1758	24	42
10	India	128	685	12	26

Findings and conclusion

Based on the analysis undertaken the present study reveals the following findings:

- Out of 3324 articles, the Indian authors contributing in the area of Green Computing is just 128 (3.9 %) articles. The researcher has found that the publication variation does not differs much from that to the period between the years of 1991 to 2011, very less number of publications as shown in the table below. Indeed, it is below 20 articles. The overall period average citation value is 5.49 measured from 128 articles from Indian authors output of Green Computing. The USA with 1109 (33.4%) publications occupies the first place followed by Germany with 270(8.1%), France with 263(7.9%), Italy with 209(6.3%), Japan with 204(6.1%). India occupies the 10th position in the world in terms of publication. The USA got the first position in the rank by the highest number of citation, h-index and g-index followed by Germany and so on.

- The European continent stood in the first place with the highest publication of 1663 (40.87 %) on Green Computing output from 44 (48.35 %) countries contributing along with 660 TLCS and 22653 TGCS measured. The North American continent occupies the second position with 1317 publications (32.37 %) from five (5.49 %) countries contributing with 606 TLCS and 23144 TGCS measured. Observed from this analysis Asian continent with 18.26 percent (743) of articles from seventeen (18.68 %) countries along with 245 TLCS and 6193 TGCS measured and it stands in the third position of the research productivity. South American continent has 2.48 percent output during the study period along with 772 total citation scores from seven (7.69 %) countries. Australian continent has 1.67 percent with 897 total citation scores from two (2.20 %) countries. The African continent stands last position with 50 (1.23 %) among the six continents along with 288 total citation scores

from sixteen (17.58 %) countries. Apart from these continent publications, unknown articles also found a space of 3.12 percent with 1658 total citation scores. Overall the continent's citation scores are 57116.

- Among these 44 countries, Germany produced 270 (16.24%) articles and it occupies the first place of European continent. France and Italy have more than 200 articles produced in this field. UK and Spain contributed more than 100 articles.

- North American countries were contributed their output 1317 in total where the USA (33.36%) stand in the highest position among them all, and the reason may be the impact of the advancement of the new and recent technologies applied highly in the USA and followed by Canada, Mexico.

- Out of the 17 Asian countries the top position is occupied by Japan (6.14%) on the performance of Green Computing output and has proved its strong technological awareness among them all, followed by other countries, where India stands in the third position (3.85%).

- Among the Australian countries, in which Australia (1.71%) contributed output and ranked first and the New Zealand (0.33%) has picked the second rank of research output in Green Computing.

- Out of the 7 South American countries in total, Brazil performed number one place with (2.05%) and followed by the other four countries in the next respective places.

- All 16 African countries have contributed only 50 articles in the subject of Green Computing. Among these 16 countries, South Africa is the leading country followed by Algeria, Egypt and Morocco having above five articles.

The paradigm shift over the period is a gradual increase in the study period but good response is observed in the year 2007, 2009 and 2010. This study has highlighted quantitatively the contributions made by the researchers during 1956-2011 as reflected in Web of Science database. During 56 years period contributions in terms of number of publications is not significant. A comparison of USA output in relation to the world output may help in understanding the contribution in a better angle. Though the records available in the Web of Science database reveal a small number, it is important to that the Web of Science covers only the peer-reviewed journals. Hence, single author contributions have to be encouraged and this will certainly help for more publications. Since Indian is known for its advancement in Information and Communication Technology an impetus should be given for more publications by single author and multiple authors. Overall, at the global level single author publications should be encouraged.

References

1. Arunachalam, S., & Garg, K. C. (1986). Science on the periphery - a scientometric analysis of science in the Asian countries. *Journal of Information Science*, 12(3), 105-117.

2. Kademani, B S et al. (2008). Scientometric mapping of vacuum research in nuclear science & technology: a global perspective. *Journal of Physics: Conference Series*, 114(1), 1-12.

3. Raja, S. and Balasubramani, R. (2011). Plasmodium falciparum research publication in India: A scientometric analysis. *European Journal of Scientific Research*, 56(3), 294-300.

4. Surulinathi, M., Amsaveni, N., Maheswaran., and Srinivasaragavan, S (2007). Scientometric Dimensions of Knowledge Management Research in India: A Study based on Scopus database, *Sri Lankan Journal of Librarianship and Information Management*, 2(2), 13-24.

5. Balasubramani R and Murugan C(2011) "Mapping of Tapioca (Sago) Research in India: A Scientometric Analysis" *Library Philosophy and Practice, pp 1-12.* http://unllib.unl.edu/LPP/

6. Raja S and Balasubramani R (2011). Plasmodium Falciparum Research Publication in India: A Scientometric Analysis, *European Journal of Scientific Research* 56(3) 294-300.