

Authorship Pattern of Green Computing Research: The Global Perspective

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Abstract

The study scrutinized research performance of global scientists in the field of Green Computing. The purpose of this study is to present the preliminary results of a research in progress regarding the subject of Green Computing. The period of study was from 1956 to 2011. A total of 3324 records were obtained and analyzed along with a number of publications by Global Green Computing scientists covered in the Web of Science Database have been taken up for this study. The search strings "Green Computing" and "Green IT" are used for the data from the database of SCI, SSCI and ACHI from 1956 to 2011 (a total of 56 years). A total of 3324 records were downloaded and analyzed using the Histcite software application as per the objectives of the study. The study covers the measure of types of publications preferred by Scientists, Authorship Pattern, Authorship Productivity Lotka's Law. A total of 3324 recorded with 44640 Global Citation Scores and 414 Local Citation Scores of Green Computing research. It means on an average every year 3324 articles are published each article has 13.43 citation scores. In our study period 80 h-index values. The European continent has taken the first place with 1663(22653 Global citation Scores). Out of 1091 journals, "PHYSICAL REVIEW B" has published the highest number articles. Among the 7831, "Cederbaum, LM" has published the highest number of articles. Collaborative author's productivity is more than a single contribution. The degree of collaboration $C = 0.84$ represents 84 percent of collaborative authors articles that were published during the study periods. Totally 2145 institutions contributed to the 3324 research articles in the field of Green Computing. The total word count is 6404 and its Grand Total is LCS 414, GCS 44640. The findings end with suitable suggestions.

Keywords: Green computing, Green IT

1. 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 CO₂ 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. Many IT manufacturers and vendors continuously invest in designing energy efficient computing devices, reducing the use of dangerous materials, and encouraging the recyclability of digital

devices and printing paper. Green Computing practices were primarily introduced by the Environmental Protection Agency in 1992 with the launch of the Energy Star program.

2. OBJECTIVES AND HYPOTHESES

The major objectives and hypotheses were framed with the exclusive notion of the present study as mentioned below:

- To determine the authorship pattern and the nature of collaboration and co-authorship pattern and determine the degree of collaboration in Green Computing research.
- To identify the h-index, g-index and gh-index.
- To identify the rage of citation of Indian scientist during 1991-2011.
- The implication of Lotka's law related with author productivity in Green Computing research output is scrutinized.

- The scientific productivity of authors in the discipline of Green Computing research conforms to Lotka's (n – value) inverse square law of scientific productivity.

3. 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, VOSviewer 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.

4. ANALYSIS AND INTERPRETATIONS

4.1 Prolific Authors

In this analytical period, 7831 scientists have produced 3324 paper contributions scattered over 1091 journals. In accordance to this the researcher has given the ranks according to their highest publication in the field of Green Computing research at up to till 13th rank for top 100 published authors. The first 100 (1.28 %) of authors are identified as per the highest contributors of Green Computing research output. The research shows the total local citation score and total global citation score

and total citation scores. Hence, the hypothesis is proved from the analysis above (the authors are ranked on the basis of their published papers on their maximum number of publications).

The analysis depicts the productivity of authors during the period of study. LS Cederbaum is the most productive author who published 34 papers with 44 TLCS and 652 TGCS with first place, out of 7831 authors and the below table shows only top 10 authors. A. Tadeu with 23(75 TGCS) articles comes second place, “Tarantelli, F” with 20(40 TLCS and 454 TGCS) articles comes third place. The author “Uzunoglu NK” has published the articles which is calculated to 15 articles (0.5 %); 3 TLCS and 92 TGCS with fourth place and the authors of “Kumar R” and “Pozrikidis C” has published only 14 articles TLCS and it stands on the fifth rank of research output in the field of Green Computing research output.

The author “Bard PY” and “Sanchez-Sesma FJ” published 12 articles (0.4 %) stood with sixth rank. Selected five authors contributed each 11 articles with seventh rank. Author of “Wang Y” contributed only ten articles in the area of Green Computing with the eighth rank. Another group of seven selected authors contributed each nine articles with ninth rank. Ten authors contributed each eight articles with tenth rank. Another ten authors were contributed each seven articles with eleventh rank. Another twenty eight authors contributed each six articles with twelfth rank. Thirty one authors contributed their publications in the field of Green Computing each five article with thirteenth rank. Remaining 7731 authors contributed below five articles only.

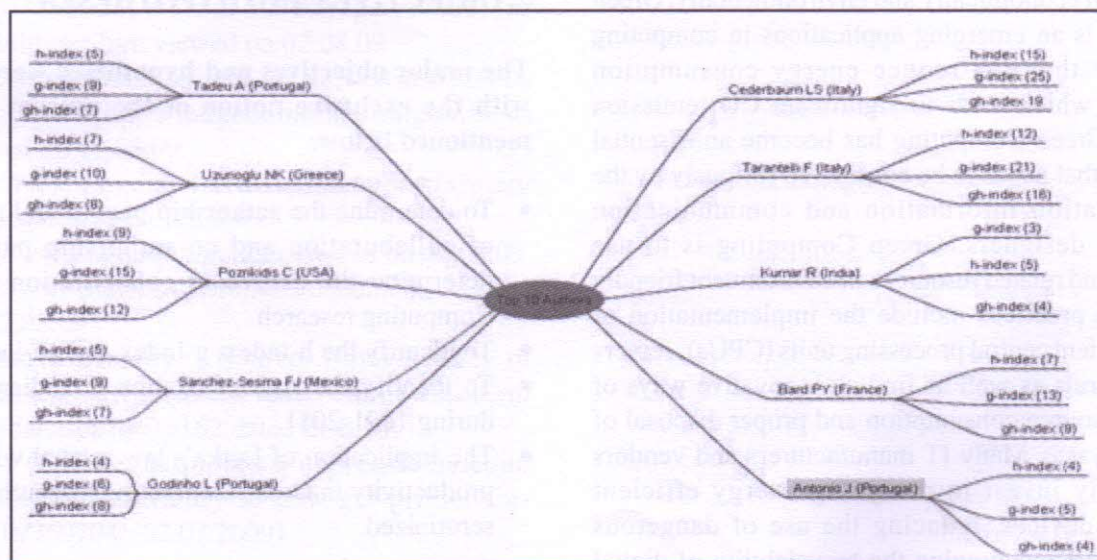


Fig.1h-index of Top 10 ranked authors

It is concluded from the above analysis, out of 7831 authors, the mentioned authors contributed "LS Cederbaum"; "A. Tadeu"; "F. Tarantelli"; "Uzunoglu NK" "Kumar R" and "Pozrikidis C" the highest number

of publications. The authors of "Cederbaum LS" and "Campillo M" has the highest TGCS measured. "Cederbaum LS" and "Tarantelli F" are having the highest TLCR.

Table 4.1 h-index values and g-index

Sl.No.	Author	Country	Recs.	TCS	h-index	g-index	gh-index	CPP	TLCR
1	Cederbaum LS	Italy	34	696	15	25	19	19.18	41
2	Tadeu A	Portugal	23	75	5	9	7	3.26	2
3	Tarantelli F	Italy	20	495	12	21	16	22.7	38
4	Uzunoglu NK	Greece	15	187	7	10	8	6.13	2
5	Kumar R	India	14	27	3	5	4	1.93	0
6	Pozrikidis C	USA	14	218	9	15	12	15.36	4
7	Bard PY	France	12	170	7	13	9	14.17	16
8	Sanchez-Sesma FJ	Mexico	12	80	5	9	7	6.67	14
9	Antonio J	Portugal	11	32	4	5	4	2.91	1
10	Godinho L	Portugal	11	41	4	6	8	3.73	1

The author of "Cederbaum LS" from Italy has produced 34 articles with 696 TCS and its h – index value is 15, g – index value is 25, gh – index value is 19 and CPP value is 19.18 and 41 times cited the mentioned authors' articles. The author of "Tadeu A" from Portugal has produced 23 articles with 75 TCS and its h – index value is 5, g – index value is 9, gh – index value is 7 and CPP value is 3.26 and only 2 times cited the mentioned authors' articles. "Tarantelli F" from Italy has produced 20 articles with 495 TCS and its h – index value is 12, g – index value is 21, gh – index value is 16 and CPP value is 22.7 and only 38 times cited the mentioned authors' articles. "Uzunoglu NK" from Greece has produced 15 articles with 187 TCS and its h – index value is 7, g – index value is 10, gh – index value is 8 and CPP value is 6.13 and only 2 times cited the mentioned authors' articles. "Kumar R" from India has produced 14 articles with 27 TCS and its h – index value is 3, g – index value is 5, gh – index value is 4 and CPP value is 1.93 and there is no cited articles. "Pozrikidis C" from USA has produced 14 articles with 218 TCS and its h – index value is 9, g – index value is 15, gh – index value is 12 and CPP value is 15.36 and only 4 times cited the mentioned authors' articles. "Bard PY" from France has produced 12 articles with 170 TCS and its h – index value is 7, g – index value is 13, gh – index value is 9 and CPP value is 14.17 and only 16 times cited the mentioned authors' articles. "Sanchez-Sesma FJ" from Mexico has produced 12 articles with 80 TCS and its h – index value is 5, g – index value is 9, gh –

index value is 7 and CPP value is 6.67 and only 14 times cited the mentioned authors' articles. "Antonio J" from Portugal has produced 11 articles with 32 TCS and its h – index value is 4, g – index value is 5, gh – index value is 4 and CPP value is 2.91 and only one time cited the mentioned authors' articles. "Godinho L" from Portugal has produced 11 articles with 41 TCS and its h – index value is 4, g – index value is 6, gh – index value is 8 and CPP value is 3.73 and that one time cited the mentioned authors' articles. It is concluded from this analysis that the author of "Cederbaum LS" (Italy) is identified as the active author of Green Computing publications; the scored high values for h-index, g-index, gh – index and CPP values and number of cited the articles.

From the analysis above, it is found that the authorship pattern of year wise, till 1987 is that only one article was published each year from 1956, seven single authors' contributions and one double authored articles and one triple authored articles. Overall single authored articles published was 4.95 percent, 19.8 percentage of authors contributed at three authors group, 25.6 percent of authors contributed at four authored group respectively. Among this authorship pattern, three authored collaboration output has been leading, followed by two authored collaboration and four authored collaboration output is high level. Six, seven, eight and nine authored group of authored collaboration output is very low.

The research has identified the factor; the three or two authored team is leading their research work and is

very successful at every year output in the subject of Green Computing.

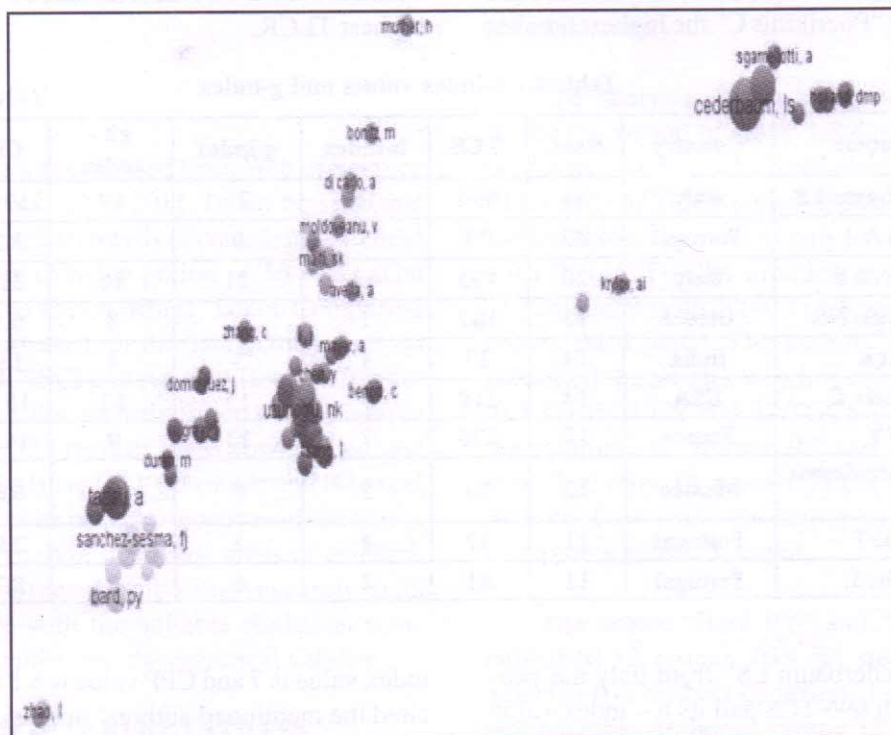


Fig.2 Shows bibliographic coupling of authors

4.2 Lotka's Law of Author Productivity

Lotka's law is one of the three major laws of bibliometrics that mainly explains the literature distribution of various authors' productivity in a given field (Lotka, 1926). It finds that most articles are being contributed by a few researchers, with a large proportion of researchers contributing just one publication. Therefore, Lotka summarizes the logarithmic relation between researchers and publication quantities. It states that "the number (of authors) making n contributions is about $1/n^2$ of those making one publication; and the proportion of all contributors, that make a single contribution, is about 60 percent" (Lotka, 1926), as cited in Potter (1988).

The general formula is $XY = C$, where X is the number of publications, Y is the relative frequency of authors with X publications, and n and C are constants, depending on the specific field. In brief, the author who publishes two articles accounts, on average, for $1/4$ of the total number of publications. The authors who publish three articles account for about $1/9$ of the total number of publications, and so on. Therefore, authors

who publish one article account for 60% of all the publications. That is to say, authors who publish n publications will be $1/n^2$ of the proportion of total publications. This formula is also called the Inverse Square Law (Tsay, 2003).

P = Number of x items in table = 17
 N = Sum of contributors = 10341
 N : Observed value

$$n = \frac{N \sum XY - \sum X \sum Y}{N \sum X^2 - (\sum X)^2} = \frac{17(216.598) - (42.17)(34.9)}{17(42.17) - (42.17)(42.17)} = 2.083$$

$$C = \frac{1}{\sum_{i=1}^p \frac{1}{X^2} + \frac{1}{(n-1)(p^2)} + \frac{1}{2p^2} + \frac{n}{24(p-1)^{n-1}}}, p=17, x=1, 2, 3, \dots, 17$$

$$= \frac{1}{\sum_{i=1}^{17} \frac{1}{X^2} + \frac{1}{(2.4292-1)(65^{2.4292-1})} + \frac{1}{2(65)^{2.4292}} + \frac{2.4292}{24(65-1)^{2.4292-1}}}$$

Table 4.2 Authorship Patterns in the Area of Green Computing Research Output

Year	Single Author	Double Authors	Three Authors	Four Authors	Five Authors	Six Authors	Seven Authors	Eight Authors	Nine Authors	10 & above	Total
1956	1	-	-	-	-	-	-	-	-	-	1
1967	1	-	-	-	-	-	-	-	-	-	1
1968	-	1	-	-	-	-	-	-	-	-	1
1971	1	-	-	-	-	-	-	-	-	-	1
1973	1	-	-	-	-	-	-	-	-	-	1
1975	1	-	-	-	-	-	-	-	-	-	1
1978	2	-	-	-	-	-	-	-	-	-	2
1980	1	-	-	-	-	-	-	-	-	-	1
1985	1	-	-	-	-	-	-	-	-	-	1
1986	-	-	1	-	-	-	-	-	-	-	1
1987	-	-	1	-	-	-	-	-	-	-	1
1990	3	3	2	-	-	-	-	-	-	-	8
1991	17	24	20	7	3	1	1	-	-	-	32
1992	50	72	58	2	10	6	-	-	-	2	78
1993	18	39	24	8	3	1	-	1	-	1	38
1994	14	51	33	9	1	3	-	1	-	-	47
1995	21	35	31	8	5	1	-	2	1	-	48
1996	17	35	36	4	-	4	3	2	-	-	49
1997	24	36	26	11	6	3	1	2	-	-	49
1998	27	47	35	15	4	3	2	1	-	-	60
1999	28	43	32	12	11	5	2	2	9	-	73
2000	19	48	51	10	5	8	2	1	-	2	79
2001	32	43	29	13	8	2	3	2	2	2	61
2002	14	40	49	24	12	4	2	1	-	1	93
2003	15	56	29	24	10	5	1	2	4	2	77
2004	20	54	49	26	9	7	1	2	1	3	98
2005	22	70	61	25	13	6	3	-	-	2	110
2006	27	63	57	27	9	4	5	1	1	3	107
2007	22	72	62	41	18	10	7	4	-	2	144
2008	27	55	52	38	22	12	4	3	1	3	135
2009	34	58	67	44	29	11	3	5	6	2	167
2010	25	66	67	47	26	10	8	3	4	7	172
2011	27	49	41	26	20	13	7	5	5	6	123
Total	512 (4.95)	2046 (19.8)	2649 (25.6)	1684 (16.28)	1100 (10.64)	684 (6.61)	371 (3.59)	312 (3.02)	234 (2.26)	749 (7.24)	10341

Table 4.3 Lotka's law of Author Productivity in Green Computing

No. of Contributors	No. of Contributions	No. of Authors	$\Sigma X = \log x$	$\Sigma Y = \log y$	$\Sigma X+Y$	$\Sigma X \cdot X$
1	34	6750	0	3.52	0	0
1	23	1682	0	3.13	0	0
1	20	750	0	2.99	0	0
1	15	344	0	2.70	0	0
2	14	225	0.69	2.63	1.81	0.48
2	12	168	0.69	2.48	1.71	0.48
5	11	70	1.61	2.39	3.85	2.59
1	10	80	0	2.30	0	0
7	9	63	1.94	2.19	4.25	3.76
10	8	10	2.30	2.08	4.78	5.29
10	7	55	2.30	1.94	4.46	5.29
28	6	24	3.33	1.79	5.96	11.09
45	5	28	3.80	1.60	6.08	14.44
86	4	15	4.45	1.38	6.14	19.80
250	3	20	5.52	1.09	6.02	30.47
841	2	23	6.73	0.69	4.64	45.29
6750	1	34	8.81	0	0	77.62
8041	8041	10341	42.17	34.9	49.71	216.598

Totally 10341 authors have contributed in the subject of Green Computing. It emphasizes the fact that the more number of publications by a researcher in any field requires high degree of inquisitiveness, competency, efficiency, insistence, and exposure to literatures. That is why majority of authors have contributed more number of papers. Further, the nature of the institutions in which the researchers are working, the research area of specialization, and availability of infrastructure facilities influence the author's productivity.

In other words, for every 100 authors making one contribution each, there would be 25 others contributing 25 articles each ($100/22 = 25$) and about 11 contributing three articles each ($100/33 = 11.1$) about 6 contributing four articles each ($100/44 = 6.25$), and so on.

Lotka's law can be expressed by the equation: $a_n = a_1/n^2$, $n = 1, 2, 3, \dots$

Where, a_n is the number of authors contributing n papers each and a_1 is the number of authors contributing one paper each.

Table 4.3 indicates that the application of Lotka's law with respect to author productivity of Green Computing research output. It could be seen clearly from the table

that proportion of all contribution that makes a single contribution is 14.68 percentage. It means that the collaborative authors' contribution is very high.

Further, Lotka's Chi square model confirms the source trend. It explains the fact that the tabulated value shows that observed authors value is more than expected value. Thus the present analysis clearly invalidates the Lotka's findings. In the present analysis, productivity is attributed to several factors. If a complete publication detail of an author is taken, the Lotka's law testing may present a different picture. Hence, the fifth hypothesis is proved (The scientific productivity of authors in the discipline of Green Computing research conforms to Lotka's ($n - \text{value}$) inverse square law of scientific productivity).

4.3 Price's Square Root Law

In order to validate whether the distribution status of authors fulfill Price's Square root law and the calculation is based on

$$N = 10341$$

$$PSQ = \sqrt{N} = 101.69$$

Based on table 4.4, the contribution percentage of 114 (Nearly closed square root value of 10341) contributors is located at 7.88% of publications. It means 114 authors contribute the output of just above two

percentage of articles. The value is far away from 50% (half of the literature on a subject); so this result is not in compliance with Price's Square Root Law.

Table 4.4 Applicable of Price's Square Root Law

No. of Contribution A	Number of Contributors B	Percentage of 8041	Total no. of Contributors A * B	Cumulated A *B	Accumulated % of A * B
34	1	0.01	34	34	0.33
23	1	0.01	23	57	0.22
20	1	0.01	20	77	0.19
15	1	0.01	15	92	0.15
14	2	0.02	28	120	0.27
12	2	0.02	24	144	0.23
11	5	0.06	55	199	0.53
10	1	0.01	10	209	0.10
9	7	0.09	63	272	0.61
8	10	0.12	80	352	0.77
7	10	0.12	70	422	0.68
6	28	0.35	168	590	1.62
5	45 (114)	0.56 (7.88)	225	815	2.18 (7.88)
4	86	1.07	344	1159	3.33
3	250 (450)	3.11	750 (1909)	1909	7.25 (18.46)
2	841	10.46	1682	3591	16.27
1	6750 (7591)	83.94	6750 (8432)	10341	65.27 (81.53)
8041		100	10341		100

4.4 Price Principle (80X20 Rule)

Table 4.4 is analyzed to validate Pareto Principle and to test whether 80 percentages of contributions have come from 20 percentage of authors. Since the total number of authors is 10341, the 20 percentage of total authors is in 1909 only.

Based on table 4.4, the value of "Accumulated % of A*B" is 18.46 percentage once the "Accumulated Contributors" is 1909. In 80X20 rule view, the value should not be close to 80 percentage. Hence it is conclude that this result is not in compliance with Pareto Principles.

4.5 Single Vs Multi Authors

It is found from the study that multiple authors' contribution is 85.32 in Green Computing research and the remaining 14.68 publications by single authors.

Table 4.5 Single Vs Multi Authors

Sl. No.	Authorship Pattern	Publications	%
1	Single Author	512	15.40
2	Multiple Authors	2812	84.59
Total		3324	100

4.6 Degree of Collaboration

To determine degree of collaboration in quantitative terms, the formula given by K. Subramanyam (1983) was used.

The formula is $C = \frac{NM}{NM + NS}$

Where

C = Degree of collaboration
 NM = Number of multi authored papers
 NS = Number of single authored papers

$$C = \frac{2812}{2812+512}$$

In the present study the value of C is

$$C=0.845$$

As a result, the degree of collaboration in the Green Computing research is 0.845 which clearly indicates its dominance upon multiple authors' contribution. A study of data from the below table 4.11 indicates the degree of

collaboration in research output of Green Computing. The degree of collaboration is 0.84 during the study period 1956 to 2011. i.e., out of the total 3324 literature published, 84 percentage of them are published under joint venture of publication in Green Computing research. It is identified that till 1987 there was no significant study on the collaborative values. After 1990 the degree of collaboration value has been identified between 0.62 and above.

Table 4.6 Single Vs Multi-Authored and Degree of Collaboration

Year	Single Authors (N _s)		Multi Authored (N _m)		Total	Degrees of Collaboration
	No. of Output	%	No. of Output	%		
1956	1	0.20	0	0.00	1	0
1967	1	0.20	0	0.00	1	0
1968	-	0	1	0.03	1	1
1971	1	0.20	0	0.00	1	0
1973	1	0.20	0	0.00	1	0
1975	1	0.20	0	0.00	1	0
1978	2	0.39	0	0.00	2	0
1980	1	0.20	0	0.00	1	0
1985	1	0.20	0	0.00	1	0
1986	0	0.00	1	0.04	1	0
1987	0	0.00	1	0.04	1	0
1990	3	0.59	5	0.18	8	0.62
1991	17	3.32	56	1.99	73	0.77
1992	50	9.77	150	1.81	200	0.75
1993	18	3.52	77	2.74	95	0.81
1994	14	2.73	98	3.49	112	0.88
1995	21	4.10	83	2.92	104	0.79
1996	17	3.32	84	3.49	101	0.83
1997	24	4.69	85	3.02	109	0.77
1998	27	5.27	107	3.81	134	0.79
1999	28	5.47	116	3.91	144	0.81
2000	19	3.71	127	4.52	146	0.86
2001	32	6.25	104	3.70	136	0.76
2002	14	2.72	133	4.73	147	0.90
2003	15	2.93	133	4.73	148	0.89
2004	20	3.90	152	5.41	172	0.88
2005	22	4.30	180	6.40	202	0.89
2006	27	5.27	170	6.05	197	0.86
2007	22	4.30	217	7.68	238	0.91
2008	27	5.27	191	6.79	217	0.88
2009	34	6.64	225	8.00	259	0.86
2010	25	4.87	239	8.46	263	0.90
2011	27	5.27	172	6.12	199	0.86
	512(15.40)	100	2812(84.59)	100	3324	19.27 (0.845)

Among the entire sample duration period, the years of 2007 and 2010 has the highest collaboration (0.91 and 0.90). Overall the average degree of collaboration of the whole sample year is 0.84. Further it is identified that 84 percentage of authors were contributing their research output worked as a team or joint venture. It could be seen clearly from the discussion above that the degree of collaboration in producing research output on Green Computing research has shown the fluctuation trend during the study period, because the researcher has identified the selection area of Green Computing as a new discipline. Based on this study, the result of the degree of collaboration $C = 0.84$. i.e, 84 percent of collaborative authors' articles published during the study periods.

4.7 Authorship Pattern

Table 4.7 explicates the authorship pattern of contributions. Out of 3324 articles, a single author has contributed 15.40 percent, 30.78 percent of articles were published with two authors (2046), 26.56 percent of articles were published by three authors (2649), 12.67 % of the contributions were published by four authors (1684), 6.62 percent of the contributions were published by five authors (1100), 3.43 per cent of the contributions were published by six authors (684), 1.59 percent of articles were produced by seven authors (371) group, 1.17 percent of articles were from eight authors (312) group, 0.78 percent of articles were contributed by nine authors (234) group and 0.99 percent of articles were published from more than ten authors (749) group respectively.

Table 4.7 Authorship Pattern of Publications on Green Computing

Sl. No.	Authorship Pattern	Publications	%	No. of Authors	%
1	Single Author	512	15.40	512	4.95
2	Double Authors	1023	30.78	2046	19.79
3	Three Authors	883	26.56	2649	25.62
4	Four Authors	421	12.67	1684	16.28
5	Five Authors	220	6.62	1100	10.64
6	Six Authors	114	3.43	684	6.61
7	Seven Authors	53	1.59	371	3.59
8	Eight Authors	39	1.17	312	3.02
9	Nine Authors	26	0.78	234	2.26
10	Ten & Above Authors	33	0.99	749	7.24
Total		3324	100	10341	100

A significant note of the study is that the majority of the articles are contributed by multiple authors. Especially triple authors' contribution is highest among the other collaborative productivity. It indicates that the single authored work is less than that of the multiple authored contributions. The objective of the study of authorship pattern is to bring out the research pattern in a discipline. The extent of research contribution by the researchers is explained in the analysis of authorship pattern. Hence it is considered to be an important aspect in Bibliometric analysis. It aims at analyzing the performance of scientists in contributing research output either individually or collectively. Many studies have analysed the characteristics of the subject literature and have focused their attention on the quality and rate at which authors published in their fields. It has received adequate attention in the present research. In identifying the individual research performance in any area of

science, it is essential to analyze the author productivity. The author productivity is determined based on the scientists in a field. Generally, research activity carried out by a scientist or a group of scientists, depends on the nature and aim of research. It also depends on the ability and efficiency of scientists. This is based on their skills and talents. The analysis of author productivity examines the prevailing trend in understanding research process in any discipline of science.

4.8 Rate of Citations of Indian during 1991-2011

Out of the total 3324 number of articles, the contributions of Indian authors to the area of Green Computing is just 128 (3.9%) articles. Before 1991, there is no awareness or no familiarity in this subject of Green Computing, because this field is found emerging out in the field of information technology. The researcher has

found that the publication variation does not differs much between the years of 1991 to 2011 and is shown in table 4.7. Further it is identified that the publications during the set period is below 20 articles. The rate of citation of Indian authors' publications at global level is the highest in the year of 2003 (130 times cited from just 7 articles) and 2007 (107 times cited from 8 articles only). The values of average of citation per paper, the year of 2003 and follow the year 2000 were having the highest values. The overall periods average citation value is 5.49 measured from 128 articles from Indian output of Green Computing.

Table 4.8 Rate of Citation of Indian Authors

Year	No. of Indian Author Articles	Number of Citations	Number of CPP
1991	1	2	2.00
1992	2	16	8.00
1993	5	22	4.40
1994	3	23	7.67
1995	1	3	3.00
1996	2	0	0.00
1997	2	11	5.50
1998	5	26	5.20
1999	5	12	2.40
2000	3	49	16.33
2001	1	4	4.00
2002	4	17	4.25
2003	7	130	18.57
2004	6	38	6.33
2005	9	27	3.00
2006	6	23	3.83
2007	8	107	13.38
2008	19	53	2.79
2009	15	62	4.13
2010	17	9	0.56
2011	7	0	0.00
Total	128	634	115.34 (5.49)

Note: CPP – Citation per paper

5. FINDINGS AND CONCLUSION

- Out of 7831 authors, the mentioned authors were contributed "LS Cederbaum"; "A. Tadeu"; "F. Tarantelli"; "Uzunoglu NK" "Kumar R" and "Pozrikidis C" highest number of publications. The authors of "Cederbaum LS" and "Campillo M" have the highest TGCS measured. "Cederbaum LS" and

"Tarantelli F" have the highest TLCCR. The author of "Cederbaum LS" (Italy) is identified the active author of Green Computing publications; he scored high values for h-index, g-index, gh – index and cpp values and number of cited the articles.

- The majority of the articles are contributed by multiple authors. Especially triple authors' contribution is the highest among the other collaborative productivity. It indicates that the single authored work is less than that of the multiple authored contributions. The researched has identified the factor; the three or two authored team has been leading their research work to a winning triumph in the every year output in Green Computing.
- Out of the total 10341 authors subjected to this analyses in the subject of Green Computing. Single authored contribution is 14.68 percentage. It means that the collaborative authors' contribution is very high.
- Square root of 10341 is 101.69. this analysis reveals that 114 authors contributes the output of just above two percentage of articles. The value is far away from 50% (half of the literature on a subject); so this result is not in compliance with Price's Square Root Law.
- 80 percentage of contributions does come from 20 percentage of contributors. Since total authors number is 10341, the mean of the 20 percentage of total author number is 1909. In 80 X 20 rule view, the value should not be close to 80 percentage. We can conclude that this result is not in compliance with Pareto Principles.
- The research output on Green Computing research has shown the fluctuation trend during the study period, because the researcher has identified the selection area of Green Computing as a new discipline. Single authors' contribution is 512 (15.4 %). Based on this study, the result of the degree of collaboration $C = 0.84$. i.e, 84 percent of collaborative authors' articles were published during the study periods.
- 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 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.

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