MAPPING THE RESEARCH PRODUCTIVITY OF GREEN COMPUTING: A SCIENTOMETRIC STUDY

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Abstract
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.

As an emerging topic in IT management, “Green IT” practices are drawing high interest among IT organizations as well as suppliers, manufacturers and service providers. With the rapid run up of energy costs and a broadening awareness of the impact of global climate change, IT organizations are looking for strategies to offset rising costs and use technology in ways that reduce their environmental impact. By keeping this view in mind, the researcher intends to undertake the study on “Mapping the Research Productivity of Green Computing: A Scientometric Study”. This study attempts to analyse the performance of researcher working in the field of Green Computing in terms of growth rate, areas of research concentration, authorship pattern, scattering of articles in different sources, and Institution wise distribution.

The research design is analytical that adopts detailed analysis of secondary data using a range of bibliometric and scientometric tools, techniques and formula along with standard statistical techniques. The major objectives are framed with the exclusive notion of the present study as mentioned below: (i) To examine the growth of research productivity of Green Computing research during 1956-2011. (ii) To identify the Document type and Journal wise distribution of publications in Green Computing. (iii) To study the subject-wise breakup of publications. (iv) To determine the authorship pattern and the nature of collaboration and co-authorship pattern and determine the degree of collaboration in Green Computing research. (v) To identify the continental with country-wise distribution of publications. (vi) To assess the Institution wise research concentration of Green Computing. (vii) To identify the authors and Institutions wise h-
index, g-index and gh-index. (viii) To identify the highly cited papers with Citation Map in the field of Green Computing. (ix) To find out the historiography of Local Citation Scores and Global Citation Scores links for selective journals and authors on Green Computing research.

Keeping the objectives stated above in view, the following hypotheses are formulated and tested with appropriate statistical tools: (i) The relative growth rate of total scientific publications show a progressive increase and the doubling time for publications reflects an increasing trend. (ii) The journal source of publication of Green Computing research output absorbs the predominant place in comparison with other source of publications. (iii) The distribution of Green Computing research output in journals and articles conform the implications of Bradford’s law. (iv) The implication of Lotka’s law related with author productivity in Green Computing research output is scrutinized. (v) The scientific productivity of authors in the discipline of Green Computing research conforms to Lotka’s (n – value) inverse square law of scientific productivity. (vi) There has been an increasing trend in collaborative research during the study period.

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. Further based on citation per paper with Citation map, number of high quality papers, and relative quality index are also applied to find out the quality of the research output. This research study explores the growth rate and relative growth level during the study period. 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. The researcher has applied for the following statistical tools: (i) Relative Growth Rate, (ii) Exponential growth rate, (iii) Doubling Time for the Publications (iv) Authorship Pattern (v) Degree of Collaboration (vi) Histrographic analysis

Based on the analysis undertaken the present study reveals the following findings: The research productivity in Green Computing as evidenced from the study has the highest publication of 263 papers in 2010 with 455 Global Citation Scores followed by 259 papers in 2009 with 973 Global Citation Score and 238 papers in 2007 with 2223 Global Citation Scores. Finding from triennial growth rate, the period 1991-2011 has the highest publication in the subject of green computing. 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 2145 institutions the contributions are from 91 different countries. Among these institutions, MIT and University Heidelberg contributed the highest number of research publications 42 each and CNRS ranked first in terms of Global Citation Scores and followed by Institute of nazl Fis Nuclear, University Illinois, University Calif Sandiego University Coimbra. Among the institutions Harvard University contains the highest number of citation per article (C/A 49.25). Out of 1091 journals, “PHYSICAL REVIEW B” has published the highest number of articles 166 (5.0 %) and it dominates in the first place of research output, followed by “JOURNAL OF CHEMICAL PHYSICS” and it occupies the second position and “PHYSICAL REVIEW D” has 69 (2.1 %) holding the third position of the publication output in Green Computing. “BULLETIN OF THE SEISMOLOGICAL SOCIETY OF AMERICA” has the highest TLCR values.

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. 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 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. Out of 16 African countries that have contributed only 50 articles in the subject of green computing. 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 contribution 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 note 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.