Asian Journal of Information Science and Technology
ISSN: 2231-6108 (P) Vol.2 No.1, 2012, pp.35-41
© The Research Publication, www.trp.org.in
DOI: https://doi.org/10.51983/ajist-2012.2.1.34

Mapping of Indian Ecology Research Literature

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(Received on 25 September 2011 and accepted on 28 March 2012)

Abstract - **This study attempts to analyse the research profile of Ecology research in India during 1999-2010, country's performance based on its research output, its publication share and rank in global context, and annual publication growth rate. It also analyses the share of international collaborative papers in India's research output, the characteristics of research output of major Indian institutions, authors, and highly-cited papers. The patterns of research communication by Indian scientists in most productive journals in this discipline have also been evaluated.**

Keywords: **Indian Ecology Research, Scientometric study**

I. Introduction

Ecology is the branch of biology dealing with the relations and interactions between organisms and their environment, including other organisms. Also called human ecology, the branch of sociology concerned with the spacing and interdependence of people and institutions. The word Ecology is derived from Greek is the scientific study of the relations that living organisms have with respect to each other and their natural environment.

The relationships among organisms are limited and controlled by energy flow (Odum, 1988). In spite of the importance surrounding this theme, consistent evaluations have not yet been conducted regarding scientific production on this topic. The advancement in knowledge produced by researchers must be transformed into information accessible to the scientific community. The objective of science is the production of new knowledge. (Solange de Fátima Lolis, *et.al*.2009)

In order to define its ideas and terms, Ravichandra Rao and Suma (1999) considers that bibliometrics comprises the application of statistical analyses to study the characteristics of the use and creation of documents, whereas scientometrics applies bibliometric techniques. Scientometrics may establish comparisons between investigative policies and countries by analyzing their economics and social aspects, and is a segment of the sociology of science, with applications in the development of scientific policies. The same author also affirms that scientometrics involves quantitative studies of scientific activities, including publication-thereby superseding bibliometrics.

Scientometric is the study of the measurement of scientific and technological progress (Garfield 1979), The bibliometric and scientometric technique used to study various quantitatively aspects of scientific endeavours have been studied (Surwase *et.al*., 2008).

II. Related Literature

Leeuwen Van(2005), studied the research activities of Netherlands Institute of Ecology during 1998-2004 to provide insight in important aspects of publication output and international impact of research at the KNAW Netherlands Institute for Ecology (NIOO-KNAW) based on Science Citation Index expanded.

Authors from a variety of disciplines have explored different elements of the history of ecology, many with an eye toward the policy and cultural contexts that have led to changes in research priorities. Kwa (1987, 2005), for example, used interviews to examine how the International Biological Program (IBP) and the International Geosphere-Biosphere Program (IGBP) influenced research priorities in the field of ecology. Kohler (2002) explored how ecologists adjusted their research to maintain and build credibility in the face of pressures from both within and outside of the discipline. Other historians have taken a broader look at ecology and the factors that shape research priorities (Worster 1994; Kingsland 1995, 2005; Cooper 2003). Mark William Neff and Elizabeth A. Corley (2009) analyses and identified policy-relevant trends in the field of ecology, a discipline that helps to identify and frame many contemporary policy problems. The results provide a new foundation for exploring the relations among public policies, technological change, and the evolution of science priorities.

III. Objectives

The main objective of this study is to analyse the research performance of India in ecology in national and global context during 1999-2010. In particular, the study focuses on the following objectives:

1. To study the research output of India's publication productivity and 10 most productive countries of the world;
2. To study the patterns of research collaboration;
3. To study the publication productivity and impact of leading institutions of India;
4. To study the characteristics of prolific authors and highly cited papers;
5. To study the patterns of research communication in most productive Indian and foreign journals.

IV. Methodology

For this study, the data has been retrieved from the ISI Web of Science (http://www.isiwebofknowledge.com) database, currently contains approximately 5900 world leading scholarly science and technical journals covering more than 150 disciplines from 1945 to date. In data in ecology published during 1999-2010, India was compared with the research output of 10 most productive countries of the world.

V. Results And Discussion

The analysis of the country-wise distribution of authors is an essential phenomenon to understand the progress of research in a particular field of study, which reflects overall economic growth and future of a country (Kademani *et al*. 2006).

There were many countries and a number of International organizations engaged in research in the field of agriculture. The top 10 countries actively pursuing research in ecology are analysed in the Table I. The United States is the top productivity country with 22960 (39.17%) publications of the total output, followed by England with 5688 (9.70%) publications, Canada with 4373 (7.46%) publications, Australia with 4186(7.14%), Germany with 3776 (6.55%). More than 50% of the publications are from the top 3 countries, i.e. United States, England and Canada. India's place in this list was 11th with publication output of 729 papers and global publication share of 1.25 % in the cumulative publication output.

Table I Country-wise Distribution Of Publications

S.No.	Countries/ Territories	No. of Publications	%	Cumulative	Cum. %
1	United States	22960	39.17	22960	39.17
2	England	5688	9.70	28648	48.88
3	Canada	4373	7.46	33021	56.34
4	Australia	4186	7.14	37207	63.48
5	Germany	3776	6.44	40983	69.92
6	France	3295	5.62	44278	75.55
7	Spain	2391	4.08	46669	79.62
8	Brazil	1957	3.34	48626	82.96
9	Italy	1754	2.99	50380	85.96
10	China	1672	2.85	52052	88.81
11	India	729	1.24	52781	90.05
12	Others	5830	9.95	58611	100
		58611	100		

During 12 years (1999-2010) a total of 58411 publications were published in the field of ecology. Indian contributions are 729 publications during the study period.

Indian publication output in ecology during the period 1999-2010 consists of 729 publications, with an average publication per year as 61. The highest percentage of 14.13 was recorded in 2010 and the lowest percentage of 3.16 in 1999. The cumulative output of India in this field increased from 23 publications in the year 1999 to 103 papers in the year 2010.

Table II Year-wise Distribution Of Publications By Indian Authors

Year	No. of Publications	Percent	Cumulative	Cumulative Percent
1999	23	3.16	23	3.16
2000	40	5.49	63	8.65
2001	39	5.35	102	14.00
2002	46	6.31	148	20.31
2003	45	6.17	193	26.48
2004	53	7.27	246	33.75
2005	58	7.96	304	41.71
2006	61	8.37	365	50.07
2007	76	10.43	441	60.50
2008	93	12.76	534	73.26
2009	92	12.62	626	85.88
2010	103	14.13	729	100
Total	729	100		

An important quantity that characterizes exponential growth is doubling time. Doubling time does not depend on the size of the population when the population is growing exponentially. Exponential growth of a population is often referred to as unrestricted growth. Exponential growth is equivalent to a constant relative growth rate. There exists a direct equivalence between the relative growth rate and the doubling time. If the number of articles/pages of a subject doubles during a given period then the difference between the logarithms of numbers at the beginning and end of this period must be logarithms of number 2. If natural logarithm is used this difference has a value of 0.693. Then the Doubling time (Dt) = 0.693/R

From the Table III it is observed that the mean RGR for the first six years block period is 0.394 and the Dt is 1.576, for the second block period it is 0.181 and 3.876 respectively. Dt is the period of time required for a quantity to double in size or value. Hence it can be seen that the Dt is doubled during the second decade. When the RGR is constant, the quantity undergoes exponential growth and has a constant Dt or period which can be calculated directly from the growth rate.

Table Iii Relative Growth Rate And Doubling Time

Year	No. of Publications	Cumulative	W1	W2	RGR	Mean RGR	Doubling Time	Mean Dt
1999	23	23	0	3.135		0.394		1.576
2000	40	63	3.135	4.143	1.008		0.688	
2001	39	102	4.143	4.625	0.482		1.438	
2002	46	148	4.625	4.997	0.372		1.862	
2003	45	193	4.997	5.263	0.265		2.610	
2004	53	246	5.263	5.505	0.243		2.856	
2005	58	304	5.505	5.717	0.212	0.181	3.274	3.876
2006	61	365	5.717	5.900	0.183		3.790	
2007	76	441	5.900	6.089	0.189		3.664	
2008	93	534	6.089	6.280	0.191		3.622	
2009	92	626	6.280	6.439	0.159		4.360	
2010	103	729	6.439	6.592	0.152		4.550	
Total	729							

RGR decreased from the rate of 1.008 in 1999 to 0.152 in 2010. The mean relative growth for the first 6 years (i.e. 1999-2004) showed a growth rate of 0.394 whereas the mean RGR for the last 6 years (i.e. 2005-2010) reduced to 0.181. The corresponding Dt for different years gradually increased from 0.688 in 1999 to 4.550 in 2010. The mean Dt for the first 6 years was only 1.576 which was increased to 3.876 during the last 6 years. Thus as the rate of growth of publication was decreased, the corresponding Dt was increased (Table III).

Among the research publications, the type of documents has a specific role to play in dissemination of information. The form of the document reveals the nature, scholarliness and currency of the information. Table IV gives the data on the type of documents, used as a vehicle for communication, by the Indian engineers. All the publications were published in English language only.

TABLE IV INDIAN PAPERS CLASSIFIED ACCORDING TO DOCUMENT TYPE

Document Type	No. of Publications	%
Article	617	84.64
Review	71	9.74
Editorial Material	15	2.06
Book Review	13	1.78
Meeting Abstract	7	0.96
Others	6	0.82
Total	729	100

The degree of collaboration is calculated using the formula given by K.Subramanyan(1983), As per the formula:

Degree of collaboration, $DC = N_m/N_m+N_s$

Where DC = Degree of collaboration

N_m = Number of multi-authored research papers in a discipline published during a period.

N_s = Number of single authored research papers in a discipline publishedDuring the same period.

Authorship pattern and degree of collaboration of Indian contributors in the field of ecology has been listed in Table V.

Only 109 articles have been produced by the single author and 620 articles were produced by two or more than two authors, which show the collaborative research. Degree of collaboration in the field of ecology by the Indian authors shows 0.85 and shows that solo authors are only 14.95 %.

H-index, introduced by Hirst (2005) is widely used as an indicator to quantify an individual scientific research output. The h-index is computed automatically in commercial database-index based on lifetime citations of the research article. The h-index has rapidly become an alternative to more traditional metrics of journal impact factor in the evaluation of the impact of the work of a particular researcher.

Table VI shows the 19 journals which together contributed 31.34 % of India's total publication output in ecology during 1999-2010. Of these 19 journals, Current Science India had scored the highest number of publications with 89 (12.21%) and highest h index with 12. India publishing 9 journals followed by Netherlands (4), England (3), and New York, United States and Africa publishing each one journal.

The most productive Indian authors participating in ecology research were provided with citations and average number of citations alongwith the h index in Table VII.

TABLE V AUTHORSHIP PATTERN

Sl. No.	Number of Authors	No. of Records	%
1	Single Author	109	14.95
2	Two Authors	223	30.59
3	Three Authors	175	24.01
4	Four Authors	102	13.99
5	Five Authors	41	5.62
6	More Than Five Authors	79	10.84
	Degree of Collaboration	0.85	

Taken into account the number of article published by Singh J S with 239 publications from Banaras Hindu University, Uttarpradesh, India holds the first position and having the highest h-index (8). The top 10 authors belongs to 10 different institutions.

The major Indian Institutions contributing to ecology literature are Indian Institute of Science, National Institute of Oceonology, etc. (Table VIII)

TABLE VIII TOP 10 INDIAN INSTITUTIONS

S.No.	Institutions	Record Count	% of null
1	Indian Institute of Science	43	5.90
2	National Institute of Oceonology	37	5.08
3	Banaras Hindu University	31	4.25
4	Wildlife Institute of India	29	3.98
5	University of Delhi	28	3.84
6	Indian Institute of Technology	24	3.29
7	Andhra University	20	2.74
8	Ashoka Trust Research Ecological Environment	12	1.65
9	Indian Statistical Institute	12	1.65
10	Annamalai University	11	1.51
	Others	482	66.12
	Total	729	100

It is observed from the table 8, among the top 10 institutions Indian Institute of Science holds the first position with 43 publications and the Annamalai University holds 10th rank with 11 publications. These 10 institutions contributes 34% of the Indian publications.

Country-wise share total international collaborative papers of India with their percent are given table IX:

TABLE VI PRODUCTIVE JOURNALS WHICH PUBLISHED PAPERS OF INDIA IN ECOLOGY

Name of The Journal	No. of Publications	%	Country	No. of Citations	Average Citations	H Index
Current Science	89	12.21	India	526	5.91	12
Indian Journal of Marine Science	15	2.06	India	21	1.47	3
Journal of Environmental Biology	13	1.78	Lucknow	40	3.08	3
Hydrobiologia	10	1.37	England	103	10.3	6
Journal of Zoology	9	1.23	United States	135	15	6
Biodiversity and Conservation	8	1.10	Netherlands	102	12.75	6
Journal of Biosciences	8	1.10	India	34	4.25	3
Journal of the Geological Society of India	8	1.10	India	13	1.62	2
Tropical Ecology	8	1.10	India	8	1	2
Ecological Modelling	7	0.96	Netherlands	40	5.71	3
Environmental Monitoring and Assessment	7	0.96	Netherlands	18	2.57	2
Indian Journal of Animal Sciences	7	0.96	India	8	1.14	2
Journal of the Indian Society of Remote Sensing	6	0.82	India	1	0.17	1
Journal of Tropical Ecology	6	0.82	New York	31	5.17	3
Man in India	6	0.82	India	14	2.33	2
African Journal of Biotechnology	5	0.69	Africa	5	1	1
Aquatic Ecology	5	0.69	Netherlands	16	3.2	2
Biological Conservation	5	0.69	England	108	21.6	5
Crop Protection	5	0.69	England	35	7	4
Other Journals	502	68.86		4155	8.26	27
Total	729	100				

India's average annual share of international collaborative papers in its total cumulative publications output during 1999-2010 has been 45.13 %, India and United States witnessed number one of the international collaborative papers with 1.11 per cent during 1999-2010. Out of 729 publications 329 publications were published along with the authors from other 63 countries. (Table IX)

TABLE VII MOST PRODUCTIVE AUTHORS

Authors	No. of Publications	%	Institute	No. of Citation	Average Citation	H Index
Singh JS	14	1.92	Banaras Hindu Univ, Dept Bot, Varanasi 221005, Uttar Pradesh, India	239	17.07	8
Borges RM	12	1.65	Indian Inst Sci, Ctr Ecol Sci, Bangalore 560012, Karnataka, India	90	7.5	5
Raju AJS	10	1.37	Andhra Univ, Dept Environm Sci, Visakhapatnam 530003, Andhra Pradesh, India	45	4.5	4
Inderjit	9	1.23	Univ Delhi, CEMDE, Delhi 110007, India	151	16.78	6
Chattopadhya Y J	8	1.10	Indian Stat Inst, Agr & Ecol Res Unit, Calcutta 700108, W Bengal, India	86	10.75	5
Sharma BK	8	1.10	NE Hill Univ, Dept Zool, Shillong 793022, Meghalaya, India	23	2.88	3
Anil AC	7	0.96	Natl Inst Oceanog, Council Sci & Ind Res, Panaji 403004, Goa, India	52	7.43	4
Gupta AK	7	0.96	Indian Inst Technol, Dept Geol & Geophys, Kharagpur 721302, W Bengal, India	40	5.71	3
Kumar A	7	0.96	CSIR, Inst Himalayan Bioresource Technol, Palampur 176061, Himachal Prades, India	61	8.71	4
Kumar S	7	0.96	Natl Dairy Res Inst, Dairy Microbiol Div, Karnal 132001, Haryana, India	19	2.71	3

TABLE IX TICP OF INDIA

S.No.	Countries	TICP	TICP %
1	USA	81	11.11
2	ENGLAND	22	3.02
3	FRANCE	21	2.88
4	GERMANY	17	2.33
5	CANADA	13	1.78
6	NETHERLANDS	13	1.78
7	PEOPLES R CHINA	13	1.78
8	AUSTRALIA	10	1.37
9	JAPAN	8	1.10
10	SCOTLAND	7	0.96
11	SPAIN	7	0.96
12	SWEDEN	7	0.96
13	BELGIUM	6	0.82
14	ITALY	6	0.82
15	PANAMA	5	0.69
16	PORTUGAL	5	0.69
17	SOUTH KOREA	5	0.69
18	TAIWAN	5	0.69
19	SWITZERLAND	4	0.55
20	ARGENTINA	3	0.41
21	AUSTRIA	3	0.41
22	BANGLADESH	3	0.41
23	FINLAND	3	0.41
24	MEXICO	3	0.41
25	NORWAY	3	0.41
26	PHILIPPINES	3	0.41
27	WALES	3	0.41
28	BRAZIL	2	0.27
29	CHILE	2	0.27
30	CROATIA	2	0.27
31	DENMARK	2	0.27
32	ISRAEL	2	0.27
33	KUWAIT	2	0.27
34	MALAYSIA	2	0.27
35	NEPAL	2	0.27
36	NEW ZEALAND	2	0.27
37	PERU	2	0.27
38	SINGAPORE	2	0.27
39	SOUTH AFRICA	2	0.27
40	SRI LANKA	2	0.27
41	THAILAND	2	0.27
42	BENIN	1	0.14
43	BOLIVIA	1	0.14

44	COLOMBIA	1	0.14
45	COSTA RICA	1	0.14
46	ETHIOPIA	1	0.14
47	GUINEA	1	0.14
48	HUNGARY	1	0.14
49	INDONESIA	1	0.14
50	IRAN	1	0.14
51	KENYA	1	0.14
52	MADAGASCAR	1	0.14
53	MALAWI	1	0.14
54	MALI	1	0.14
55	MONGOL PEO REP	1	0.14
56	MOROCCO	1	0.14
57	NORTH IRELAND	1	0.14
58	REUNION	1	0.14
59	RUSSIA	1	0.14
60	SAUDI ARABIA	1	0.14
61	SENEGAL	1	0.14
62	SLOVENIA	1	0.14
63	UKRAINE	1	0.14
	TOTAL	329	45.13

VI. Conclusion

In this study, research trends in Global Ecology literature based on data retrieved from the Web of Science database has been analyzed. The results obtained are significant outcomes about the global ecology research performance throughout this study period i.e. from 1999 to 2010. The global ecology research is presently showing upward trend, which has been confirmed based on the quantity of literature published in the past 12 years. As regards to country-wise distribution of publications in ecology, the United States stands as the top most country in publishing research articles on ecology. The most preferred journal by the Indian scientists was Current Science, which is published from Bangalore, India. In addition to this, 84.64% of the publications are in the form of article and 100% of the articles are published in English by Indian scientists. The top Indian contributor in the field of ecology is from Banaras Hindu University, Uttar Pradesh. Indian Institute of Science is the top most institution produces more publications in the field of ecology as far as concerned with India.

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