

Bibliometric Analysis of Water Resource Development and Utilization Based Research Studies in Sri Lanka

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Abstract— Sri Lanka's science and technology research and development activities are now being directed towards facilitating the country's development process. In this connection main scope of this study is focused on Water Resource Development Studies based publications of Sri Lankan scholars. Studies on evaluation, development and quality of water Water Resource Development Studies based research of Sri Lanka will led to development of new scholarly activities. A total of 1026 records of contributions of 2254 authors with Sri Lankan affiliation were analyzed in this study to identify the research trend of Sri Lankan contributions in water Water Resource Development Studies based research with bibliometric indicators. The analysis of the data reveals that generally there is no progressive increase in Relative growth rate of contributions and Degree of Collaboration was 0.83 during the study span. Among the productive authors Giordano, M. is in the top position and 'Agricultural Water Management' was preferred by scholars for scholarly communication. .

Index Terms— Library Science, Bibliometrics, Water research Sri Lanka, Degree of Collaboration.

1 INTRODUCTION

UNLIKE other natural resources, water is a unique resource, which renews itself. It is due to its constant circulation in the ocean-atmosphere-earth-ocean system. No matter how much water is consumed in daily life, its amount seldom dwindles. With time and under certain conditions water regains its properties and becomes fit for reuse. This is probably the reason why water resources appear to be unlimited for a long time. Irrigation of fields, orchards and estates claim almost 80% of the water consumed the world over. Unfortunately, 97.5% of all water resources on earth are salty. Consequently, fresh water including the one in glaciers accounts for only 2.5% Even here the most accessible one is as little as 0.3% moreover the natural distribution is extremely uneven. Many countries are short of this clean water.

Studies on evaluation of water research of Sri Lanka will led to development of new scholarly activities. Even though the Government has been developing water resources, it has found that the scope for further development is reducing gradually. This urged the need for this kind of study focused on water research development research publications of Sri Lanka. Main objective of this study is to identify the research trend of Sri Lankan contributions in water research with bibliometric indicators. Research publications are often considered as an essential activity of researchers in every discipline. They play an important role in facilitating communication and exchange of ideas between scholarly writers and scholarly read-

ers. Studies on evaluation of academic publications in water research of Sri Lanka have led to development of new scholarly activities and paradigm shifts in water research activities in future.

2 CORE ELEMENTS OF WATER RESEARCH

2.1 Institutions

The main institutions carrying out the research in water are the Universities, Irrigation Department, Water Resource Board, Water Supply and Drainage Board, International Water Management Institute, etc. Technical and engineering solutions, designs and plans to secure water supply, water pollution, water quality, water resource management and planning, modeling, catchment-scale studies and a multidisciplinary approach are considered remarkable scope areas for water research.

2.2 Bibliometrics

Bibliometrics is an important intersection between communication research and information science. Etymologically, bibliometrics is derived from two Greek words, 'biblio' and 'metrikos' meaning book and measurement. The term 'bibliometrics' is preferred by Pritchard (1969) in place of the term 'statistical bibliography'; to mean the application of mathematics and statistical methods to books and other media of communication, which means bibliometrics is a sort of measuring technique by which inter-connected aspects of written communication can be quantified. Philosophically, bibliometrics contributes to a better understanding of the information universe because it is the study of how humans relate to information (Bates 1999). In general Bibliometrics is defined as the use of mathematical and statistical methods to study and identify patterns in the usage of materials and services within a library, or to analyze the historical development of a specific

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body of literature and especially its authorship, publication and use (ODLIS 2002).

3 STATEMENT OF RESEARCH PROBLEM

Basically bibliometric characteristics of research output are used to take correct decisions at institutional and national, regional, and international levels. When the current trend of research output in a particular subject area is identified, it makes sense to propose changes and suggest new developments. SCImago (2007) reported that output of water science and technology research of Sri Lanka is ranked at ten in Asiatic region.

Further it could be observed that the research trend is decreasing after 2007 and among the competitive countries Sri Lanka is in the last. It is visible that if the trend continued Sri Lanka has to go down at fifteenth rank in near future. Therefore there is a demand for comprehensive research on bibliometric characteristics of Sri Lankan contributions to Water research. The research tried to answer for the research questions such as what are the characteristics and contributions of research articles published and how these contributions pave the way for bibliographic growth is identified.

4 OBJECTIVES OF THE RESEARCH

Main objective of this study is to identify the research trend of Sri Lankan contributions in water research with bibliometric indicators.

Specific Objectives are

- To identify growth trend of publications with relevant indicators.
- To study authorship pattern of articles.
- To identify most productive authors

5 REVIEW OF LITERATURE

Bibliometric studies are intended to show the current state and development of a subject in a country. Sometimes they analyze the scientific output of the country as a whole. In some cases the analysis sheds light on a particular nation's authors. The findings indicate distribution and growth of the scientific production of a county. Mostly these kinds of studies conducted a descriptive bibliometric analysis of content, trends, and patterns found in number of contributions of a particular subject field.

Al-Kharafi and Janini (1987) reviewed the scientific output of the State of Kuwait on the 25th anniversary of its independence. Based on the analysis of Kuwait's scientific output in the areas of the physical and life sciences and in engineering throughout the period 1970-1984, the quality of Kuwaiti research was discussed. Gupta (1989) has analyzed a bibliography of biochemical literature of Nigeria for the period, 1970-1984 containing a total of 500 items, analyzed to test the applicability of Lotka's law and 80/20-rule to the author productivity distribution patterns.

Bordons and Barrigon (1992) analyzed of Spanish pharmacology publications referenced in the journals of the Pharmacology

and Pharmacy subfield of the Science Citation Index-CD edition from 1984-1989. They found that the scientific output of Spanish pharmacologies nearly doubled during this period. Nasir, Hamid and Agha (1994) conducted a bibliometric analysis of agricultural literature published in Malaysia from 1981 to 1990. Tapaswi and Maheswarappa (1999) have presented a bibliometric analysis of 2,475 Indian oceanographic research contributions and 38,886 references cited by them. Results show a shift in the number of contributions among the disciplines of oceanography, the forms of documents as the communication channel, and even the items cited over a period of three decades.

Kim (2001) reported the research performance of Korean physicists, comparing Korean-authored papers with internationally co-authored papers indexed in the Science Citation Index 1994-1998. In order to explore the status of library and information science research and its subject trends in Iran, the total scientific production (2,490 titles) was surveyed and analyzed by Horri (2004) employing bibliometrics. Ahmed and Rahman (2008) have studied periodical articles on various aspects of nutrition research of Bangladesh published during 1972-2006. Thanuskodi and Venkatalakshmi (2010) examined the growth and development of ecological research in India.

A master level study was conducted by Anbuselvi (2011) on the publication output of India in marine cyanobacteria research and found a remarkable increase in output over the years. Rana (2012) evaluated national scientific output in Singapore with the help of bibliometric indicators. The way of communication between the scientists in Singapore has been elaborated with the help of document types and the formats where over 61% of research results were published as articles. Siebrits, R; Winter, K; Jacobs, I (2014) performed a scientometric analysis of water research publications extracted from four decades of South African related papers to identify paradigms and paradigm shifts within water research in South Africa

6 METHODOLOGY

The research method of this study was Bibliometric analytical method that adopts detailed analysis of secondary data using a range of bibliometric tools, techniques and formulas along with statistical techniques. The required data was collected from SCOPUS database considering the reliability and availability of access at National Science Foundation Sri Lanka. The process of selection of population of publications was as follows:

Document type - 'ALL'
AND
Any field - "Water" OR Irrigation"
AND
Affiliation - 'Sri Lanka' OR 'Srilanka' OR 'Ceylon',
AND
Publication year - "up to July 2104"

As said by the criteria a total of 1026 records of contributions authored by 2254 authors with Sri Lankan affiliation published during the period of 1972 - July 2014 were analyzed in this study.

Each individual bibliographic details of contributions were

checked, and tabulated in to separate sheets and analyzed using Ms excel and Bibexcel software developed by Olle person. (Persson, O, Danell, R, &Wiborg Schneider, J 2009) Chronological distributions of publications were presented in the tables. Analysis of Research trend and growth of publications was carried out by calculating the, accumulated growth and average. Authorship patterns were identified by distribution of co-authorship. Author productivity was identified based on number of publications.

7 DATA ANALYSIS AND FINDINGS

7.1 Distribution of Types of Publications

The analysis of publications of the total 1026 records reveals that journal articles occupy predominant position sharing 86.26% (885) of total research output; the other ranked major sources are Conference papers (11.89%) and Serial publications (1.66%). (Table 7-1)

Table 7.1 - Distribution of Types of Publications

Document Type	Numbers	Percentage
Journal Article	885	86.26
Conference Paper	122	11.89
Serial publication	17	1.66
Book Chapters	1	0.10
In print	1	0.10
	1026	100.00

7.2 Analysis of growth of publications

While analyzing the growth trend of publications, it is observed that the range of number of articles published per year during the period under study is in between 1- 107. It is also observed that approximately 50% of entire publications output brought from 1972 to2006 and the balance (50%) were published between 2007 and 2014. The analysis of relative growth rate of publication output aims to identify the trends and growth of prospects in the present research. The relative growth rate is a measure to study the increase in the number of publications per unit of publications per unit of time (Mahapatra 1985). Here, one year is taken as the unit of time. It was also assumed base e for natural logarithm=2.7183. The Relative growth rates for publications were calculated according to the following formula.

$$R(1 - 2) = \frac{\ln(w_2) - \ln(w_1)}{t_2 - t_1}$$

Where

R (1-2)= Mean relative growth rate over the specific of interval

ln (W₁) =Natural log of the number of previous publications

ln (W₂) =Natural log of the number of current publications)

t₂- t₁ = Time difference (in years) between current and

previous years

Calculated relative growth rate of total contributions fluctuated over the years with positive and negative values. Generally there is no progressive increase in relative growth rate of contributions over the study span. (Table 7.2)

7.3 Analysis of authorship pattern

It could be noted that three authored contributions take the first position that occupying 22.5% of the total publication. The next place is recorded by two authored papers having 21.9% of the total research contributions. Multi authored contributions take the top position that occupying 87.3% of the total publication. It indicates that the single authored work (12.7) is extremely less than that of the multi authored contributions. Range of number of authors was one to twenty six and the highest number of collaborative authors for a single publication was observed in the years 2003 with twenty six authors. (Table 7.2)

The degree of collaboration is defined as the ratio of the number of collaborative research papers to the total number of research papers in the discipline during a certain period of time. The formula suggested by Subramanyam K (1983)is used in this study. It is expressed as where;

$$C = N_m / (N_m + N_s)$$

C is the degree of collaboration in a discipline. N_m is the number of multi-authored research papers in the discipline published during a year. N_s is the number of single authored research papers in the discipline published during a year. It was observed that Average Degree of Collaboration was 0.83 during the study span. (Table 7.3)

7.4 Most productive authors based on number of publications

In order to identify the productive authors, individual authors were ranked in terms of their productivity based on number of publications over the years. Among the productive authors Giordano, M. is in the top position with 41 publications. Van Der Hoek, W. was in the second rank with 34 publications followed by Molden, D., Dissanayake, C.B., Bastiaanssen, W.G.M. with the contribution of 30, 24 and 20 respectively. (Table 7.4)

Table 7.4 - Ranked list of most productive authors

Rank	Name of the author	Number of contributions
1	Giordano, M.	41
2	Van Der Hoek, W.	34
3	Molden, D.	30
4	Dissanayake, C.B.	24
5	Bastiaanssen, W.G.M.	20
6	Turrall, H.	19
7	Konradsen, F.	19

8	de Fraiture, C.	18
9	Qadir, M.	18
10	Vithanage, M.	17
11	De Costa, W.A.J.M.	17
12	Smakhtin, V.	17

7.5 Analysis on Ranking of publication output

There have been 50 contributions published by a single journal 'Agricultural Water Management'. It is ranked at the first position. The second position is taken by 'Proceedings of the 32nd WEDC International Conference', which is accounted to 37 publications. 'International Journal of Water Resources Development' was in third position with 31 publications. More than 14 Sources or journals have more than 10 publications during the study span. (Table 7.5)

8 CONCLUSIONS AND RECOMMENDATIONS

Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions. Authors are strongly encouraged not to call out multiple figures or tables in the conclusion—these should be referenced in the body of the paper. A total of 1026 records of contributions of 2254 authors with Sri Lankan affiliation were collected from SCOPUS database and analyzed in this study to identify the research trend of Sri Lankan contributions in water research with bibliometric indicators. The analysis of the data reveals that generally there is no progressive increase in Relative growth rate of contributions. Maximum numbers of 107 were published in 2007. Approximately 50% of entire publications output brought in 34 years (from 1972 to 2006) and the balance (50%) were published in seven years (between 2007 and 2014). Multi authored contributions take the top position and Degree of Collaboration was 0.83 during the study span. Among the productive authors Giordano, M. is in the top position and 'Agricultural Water Management' was preferred by scholars for scholarly communication. Journal articles occupy predominant position sharing 86.26% (885) of total research output. Generally there is no progressive increase in relative growth rate of contributions over the study span.

The suggestions of this study focused with a dire need of increase in water research. This could be increased by increasing the enrollment of universities or increasing the funding for research in water or developing pre-existing infrastructure for excellence in research or attracting trained diaspora to return to this nation.

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Table 7.2 - Relative growth rate of contributions

Year	Previous year contributions	Number of current year contributions	W1=Natural log of the number of previous year publications	W2=Natural log of the number of current year publications	Time difference (in years)	Relative Growth Rate
1972	0	1	#NUM!	0.000	1.000	#NUM!
1973	1	1	0.000	0.000	1.000	0.000
1974	1	1	0.000	0.000	1.000	0.000
1976	1	2	0.000	0.693	1.000	0.693
1977	2	1	0.693	0.000	1.000	-0.693
1979	1	2	0.000	0.693	1.000	0.693
1980	2	5	0.693	1.609	1.000	0.916
1981	5	2	1.609	0.693	1.000	-0.916
1982	2	2	0.693	0.693	1.000	0.000
1983	2	4	0.693	1.386	1.000	0.693
1984	4	1	1.386	0.000	1.000	-1.386
1985	1	1	0.000	0.000	1.000	0.000
1986	1	2	0.000	0.693	1.000	0.693
1987	2	3	0.693	1.099	1.000	0.405
1988	3	4	1.099	1.386	1.000	0.288
1989	4	6	1.386	1.792	1.000	0.405
1990	6	4	1.792	1.386	1.000	-0.405
1991	4	3	1.386	1.099	1.000	-0.288
1992	3	5	1.099	1.609	1.000	0.511
1993	5	7	1.609	1.946	1.000	0.336
1994	7	7	1.946	1.946	1.000	0.000
1995	7	9	1.946	2.197	1.000	0.251

1996	9	12	2.197	2.485	1.000	0.288
1997	12	19	2.485	2.944	1.000	0.460
1998	19	13	2.944	2.565	1.000	-0.379
1999	13	33	2.565	3.496	1.000	0.932
2000	33	24	3.496	3.178	1.000	-0.318
2001	24	34	3.178	3.526	1.000	0.348
2002	34	22	3.526	3.091	1.000	-0.435
2003	22	62	3.091	4.127	1.000	1.036
2004	62	52	4.127	3.951	1.000	-0.176
2005	52	56	3.951	4.025	1.000	0.074
2006	56	34	4.025	3.526	1.000	-0.499
2007	34	107	3.526	4.673	1.000	1.146
2008	107	68	4.673	4.219	1.000	-0.453
2009	68	76	4.219	4.331	1.000	0.111
2010	76	83	4.331	4.419	1.000	0.088
2011	83	72	4.419	4.277	1.000	-0.142
2012	72	72	4.277	4.277	1.000	0.000
2013	72	63	4.277	4.143	1.000	-0.134
2014	63	51	4.143	3.932	1.000	-0.211



Table 7.3 - Authorship pattern and Degree of Collaboration

Year	Number of authors					Multi au- thored	DC
	Single	2<10	10<20	20<30	Total		
1972		1			1	1	1
1973		1			1	1	1
1974		1			1	1	1
1976		2			2	2	1
1977		1			1	1	1
1979	2	0			2	0	0
1980	2	3			5	3	0.6
1981		2			2	2	1
1982		2			2	2	1
1983	2	2			4	2	0.5
1984	1	0			1	0	0
1985		1			1	1	1
1986		2			2	2	1
1987		3			3	3	1
1988		4			4	4	1
1989	2	4			6	4	0.67
1990	2	2			4	2	0.5

1991		3		3	3	1
1992	1	4		5	4	0.8
1993	2	5		7	5	0.71
1994		7		7	7	1
1995	2	7		9	7	0.78
1996	2	10		12	10	0.83
1997	6	13		19	13	0.68
1998	4	9		13	9	0.69
1999	3	30		33	30	0.91
2000	4	20		24	20	0.83
2001	5	29		34	29	0.85
2002	2	20		22	20	0.91
2003	6	55	1	62	56	0.9
2004	12	39	1	52	40	0.77
2005	8	48		56	48	0.86
2006	3	28	3	34	31	0.91
2007	21	85	1	107	86	0.8
2008	5	62	1	68	63	0.93
2009	9	66	1	76	67	0.88
2010	11	68	4	83	72	0.87
2011	4	68		72	68	0.94
2012	2	69	1	72	70	0.97
2013	1	61	1	63	62	0.98
2014	6	43	2	51	45	0.88
Total	130	880	15	1026	896	0.87

Table 7.5 - Ranked list of Most Prolific sources based on number of publications

Rank	Name of the Journal	Number of contributions
1	Agricultural Water Management	50
2	Sustainable Development of Water Resources, Water Supply and Environmental Sanitation: Proceedings of the 32nd WEDC International Conference	37
3	International Journal of Water Resources Development	31
4	Irrigation and Drainage Systems	26
5	Water Policy	26
6	Water International	26
7	Journal of the National Science Foundation of Sri Lanka	20
8	Irrigation and Drainage	16
9	Journal of Hydrology	16
10	IAHS-AISH Publication	14

11	Water Resources Research	12
12	Water Resources Management	11
13	Water Science and Technology	11
14	Tropical Medicine and International Health	10

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