VISUALIZING ENERGY AND ENVIRONMENT RESEARCH PRODUCTIVITY IN AUSTRALIA: A SCIENTOMETRIC PROFILE

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Abstract

The present study conducted over the period of 1991-2014, selected to ascertain research trends, yielded a total of 2802 papers published in the wide-ranging field of energy and environment in Australia. Of the 2802 publications, 83.4% were journal articles and 99.7% were the English language. The result shows that a steady increase in Australia's literature output from 21 papers to 308 papers in November 2015 (1466% increase); in Environmental Sciences Ecology (10.547%) is in the 4th rank and Energy Fuels (8.394%) is in the 6th of world literature during the study period. According to Australian research, the output of Environmental Sciences Ecology (13.807%) account for the largest increase, and it has been occupied in the first place and Energy Fuels (6.208%) is in the 6th place during the present study. The three most productive journals with huge citations were 'Ecological Applications' (= 4, 2721 citations), 'Astrophysical Journal' (= 44, 1614 citations), and 'Monthly Notes of the Royal Astronomical Society' (= 38, 1389 citations).

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INTRODUCTION

The study deals with the quantitative analysis of scholarly communications published in journals and indexed the Web of Science (WoS). To meet the energy necessities of supportable economic growth, policy makers, analysts, and corporate leaders have progressively referred to the role that energy and environment would perform. For that reason, this paper has taken into consideration to find out the publications growth trends and development in the field of energy and environment research in Australia as indexed the web of science. The same study has already done in the energy and solar energy by various scientists (Tijssen 1992; Gupta 1980; Lawson, Kostrewsi & Oppenheim 1980; Pouris & Pouris 1987; ASSAf 2006).

Parent et al (2004) have analyzed by their study entitled, 'Scientometric study on collaboration between India and Canada, 1990-2001 Phase 1 of the 2004 Canada - India Science and Technology (S&T) Mapping study' identified that India is being a developing country, the scholarly communications largely evident in the disciplines of Chemistry, Physics, Mathematics, Engineering, Biology, Biomedical, Clinical Medicine, Earth and Space and Technology. Though India witnessed in the specialization of physics, chemistry and engineering, but, have been produced any publications in global level journals that are highly cited. The study carried out by ASSA in 2014 in the field of energy during the period between 2000 and 2011 in South Africa to evaluate the research trends and found steady increase from 82 papers in 2000 to 293 papers in 2011 with 257% increase; the publication count was higher level compare with other countries such as the USA, China, Germany, Japan, the UK and France. Nguyen and Pham (2011) in their report, the results reveal that the share of 2.2% of world literature output out of 244, 404 papers, 13.7% was the compound annual growth rate and showed the annual average growth rate of ASEAN countries.

To enhance strong suit of this paper, researchers have booked into account a small number of authors' earlier works under different domain in addition to individual journal of scientometric analysis in different period of study for the present analysis such as Research analysis on Biotechnology by Velmurugan and Radhakrishnan (2015), Journal of Information Literacy (2015), Quantitative Analysis of Scientific Publications Output on Engineering Journal (2015), Literature output of Supply Chain Management (2015), Authorship trends and collaborative research work on Library Herald (2015), Scientometric Analysis of Research Papers on Pharmacognosy as reflected in the Web of

Science (2015), Scientometric observations on DESIDOC Journal of Library and Information Technology by Velmurugan and Radhakrishnan (2015), Journal of Intellectual Property rights, Annals of Library and Information Studies by Velmurugan (2013, 2014), Indian Journal of Pure and Applied Physics for the Year 2009 – 2012, Technical Review-Journal in 2014 by Velmurugan (2014).

LIMITATIONS OF THE STUDY

The present study is limit the period of 26 years beginning from 1989 to 2015 (till November 2015) but the data have been retrieved as it is available in the database (started 2016). Hence, the data have taken into account and made specific observations based on the study in the Australia scenario with a comparison of India and world output.

OBJECTIVES OF THE STUDY

The present study delineates the research with computing the energy and environment publication trends for the period between January 1989 and November 2015 indexed at Web of Science database. The study involves a total of 2803 scientific literature output from 1200 journals with 64994 citations and 14546 authors in 85 various countries. The purposes of the present study are to determine the:

(1) Growth rate of literature output,
(2) Publication productivity of Australia and India with institutional affiliation,
(3) Kinds of manuscript pattern,
(4) Ranking pattern of highly cited scientific papers and authors,
(5) Ranking of funding agencies of publication,
(6) Ranking of highly cited references,
(7) Geographical production and
(8) Source and research area pattern publication.

MATERIALS AND METHOD

For the purpose of the study, the web of science core collection database has been selected to retrieve the sample data of all records of peer reviewed journals and other forms during the period from 1991 to 2016 as it is available in the database. We collected a total of 73227 world output data on energy and environment and Australia and the data again refined country wise and selected 'AUSTRALIA' in the country domain and collected the data of 2802 till November 2015 for further analysis. The observations provided in this study are: (1) Benchmarking research activity of countries, (2) Chronological distribution of publication, (3) Types of manuscript pattern, (4) Highly productive authors as well as highly cited authors, (5) Ranking of Institution and international collaboration, (6)Ranking of journals and ranking of most papers, (7)Ranking of Research Areas and source titles.

For evaluate and determine the research output the following indicators have been used for this analysis to retrieve the better output during the period of study.

1. Annual growth rate (AGR)
2. Ratio of growth (RoG)
3. Compound annual growth rate (CAGR)
4. Trend line for publications (Liner growth rate and Exponential growth rate) and
5. R^2 Value for publications.

RESULTS AND DISCUSSION

Growth of publication in Energy and Environment in World, India and Australia

The global outputs have evaluated in Energy and Environment compare with India and Australia during the period of study between 1989 and 2015. In this context, a total of World Literature outputs are 73194 and the range of outputs 43 papers from 1989 to 6476 papers in November 2015 with (15060 % increase) steady growth in the field of Energy and Environment category and the maximum number of papers (7088, 9.679%) published in the year 2014 and the least number of papers (43, 0.059%). Based on the Indian literature, the research outputs range is one paper from 1989 to 353 papers in the year 2015 with (353, 00% increase) radical growth in the Energy and Environment filed. The majority of 353 (12.7%) papers published in 2015 whereas the least number of papers are produced in the year 1989. It shows that the growth rate has been gradually increased in the year 1991 onwards. According to Australian outputs, the growth rate ratio is 21 papers in 1991 and 308 papers in 2015 with 1466% increase. The world research outputs growth trends are measured and also the exponential growth rate trend line is $y = 1E\text{-}105e^{0.1245x}$ and R^2 value is 0.7587 (Table I, Figure 2).

Table I: Growth of publication

S. No	PY	World		India		Australia	
		Recs	Percent	TR	TP	TR	TP
1	1989	43	0.059	1	0.0	-	-
2	1990	126	0.172	3	0.1	-	-
3	1991	922	1.259	17	0.6	21	0.7
4	1992	911	1.244	24	0.9	28	1.0
5	1993	998	1.363	26	0.9	33	1.2
6	1994	1126	1.538	25	0.9	33	1.2
7	1995	1149	1.569	24	0.9	37	1.3
8	1996	1321	1.804	30	1.1	50	1.8
9	1997	1335	1.823	30	1.1	49	1.7
10	1998	1562	2.133	40	1.4	56	2.0
11	1999	1583	2.162	38	1.4	45	1.6
12	2000	1701	2.323	42	1.5	55	2.0
13	2001	1752	2.393	51	1.8	59	2.1
14	2002	1933	2.640	59	2.1	66	2.4
15	2003	2202	3.007	50	1.8	91	3.2
16	2004	2351	3.211	79	2.8	82	2.9
17	2005	2604	3.556	90	3.2	80	2.9
18	2006	2983	4.074	113	4.1	126	4.5
19	2007	3322	4.537	139	5.0	119	4.2
20	2008	3592	4.905	116	4.2	108	3.9
21	2009	4163	5.685	148	5.3	162	5.8
22	2010	4532	6.189	180	6.5	170	6.1
23	2011	5087	6.947	196	7.0	227	8.1
24	2012	5898	8.054	253	9.1	238	8.5
25	2013	6434	8.786	316	11.4	279	10.0
26	2014	7088	9.679	335	12.0	280	10.0
27	2015	6476	8.844	353	12.7	308	11.0
Total		73194	100	2781	100	2802	100

Figure 1: Growth of publication in World

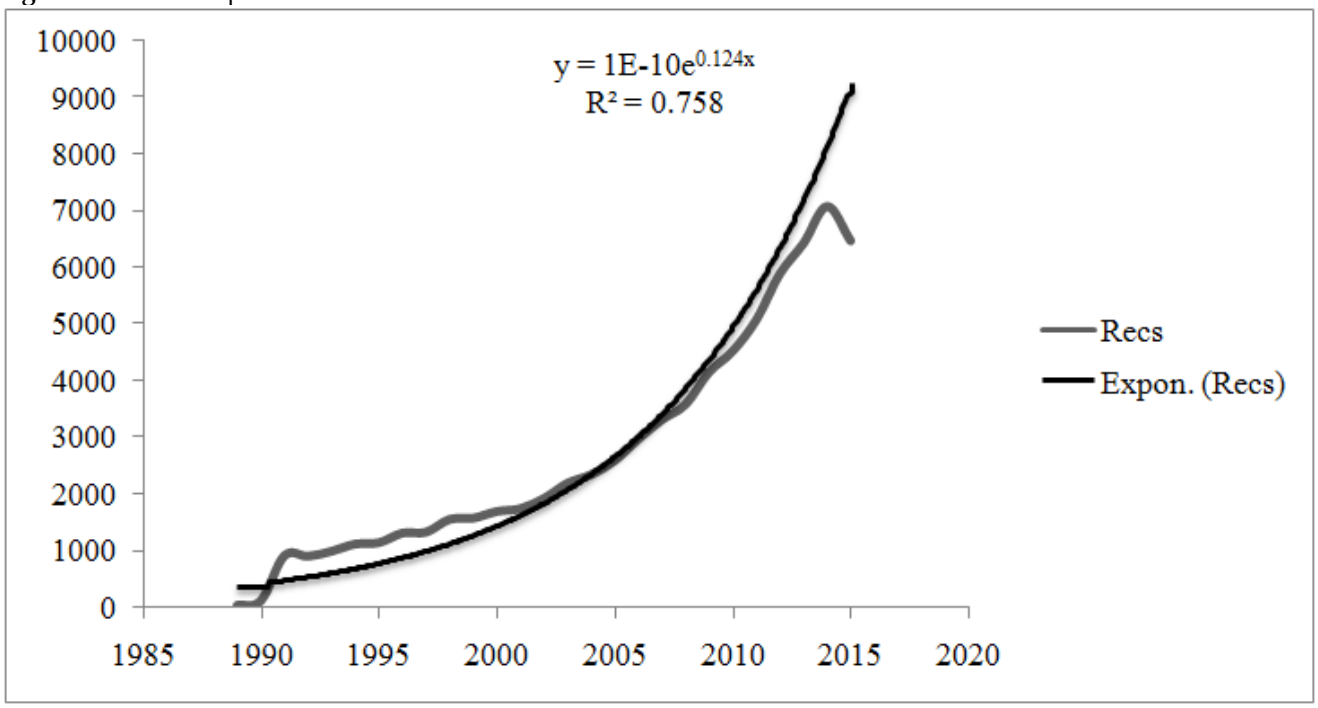
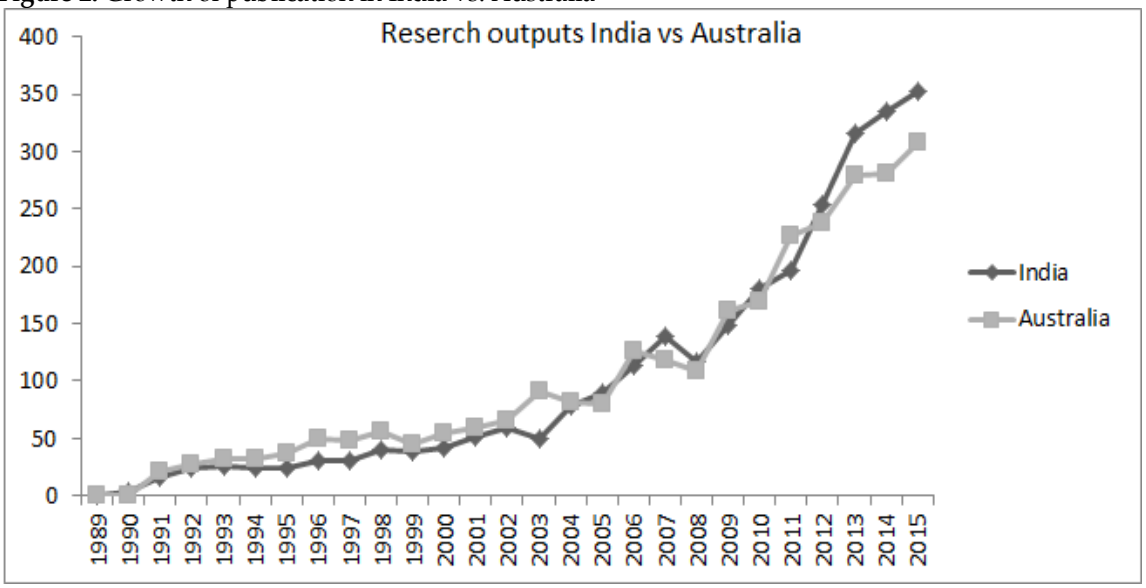


Figure 2: Growth of publication in India vs. Australia



Australia's publication share in world literature outputs

Table II represents that the global publications share of Australia during 1991-2015 was 3.828183 which has gradually increased from 2.277657 in 1991 to 4.756022 in 2015. This growth pattern could also be counted based on the journals increase via the web of science database over the years. The maximum growth share is 4.75% in the year 2015 and followed 4.462355 % in 2011, 4.336338 % in 2013, 4.223936 % in 2006, 4.132607 % in 2003, and 4.035266 % in 2012, whereas the least growth share in 1994 is 2.930728 % and in the year 1991 is 2.27 percent. The results illustrate that the growth share of Australia and compare with world outputs during the period and indicates that the growth level is fluctuation trend.

Table II: Australia's publication share in world literature outputs

S. No	PY	Australia	World	Australia's Share%
1	1989	-	43	-
2	1990	-	126	-
3	1991	21	922	2.277657
4	1992	28	911	3.073546
5	1993	33	998	3.306613
6	1994	33	1126	2.930728
7	1995	37	1149	3.220191
8	1996	50	1321	3.785011
9	1997	49	1335	3.670412
10	1998	56	1562	3.585147
11	1999	45	1583	2.842704
12	2000	55	1701	3.233392
13	2001	59	1752	3.367581
14	2002	66	1933	3.414382
15	2003	91	2202	4.132607
16	2004	82	2351	3.487877
17	2005	80	2604	3.072197
18	2006	126	2983	4.223936
19	2007	119	3322	3.582179
20	2008	108	3592	3.006682
21	2009	162	4163	3.891424
22	2010	170	4532	3.751103
23	2011	227	5087	4.462355
24	2012	238	5898	4.035266
25	2013	279	6434	4.336338
26	2014	280	7088	3.950339
27	2015	308	6476	4.756022
1989-2015		**2802**	**73194**	**3.828183**

Global wise benchmarking research activity of countries

Of the 172 countries, we select only top ranked countries for the present analysis. In which, the worldwide literature output share of the top 10 most published countries in energy and environment research varied from 3.828% to 32.422% for the year 1991-2015. The United States is in the top most rank with share of 32.422 percent. China and Germany second and third position with the share of 10.231% and 8.009 and followed by England and France at fourth and fifth rank with publication share of 7.632 % and 6.560% respectively. Japan (=5.088%), Canada (=5.083%), Italy (=4.859%) have ranked in the sixth, seventh and eighth position in sharing of research output and Spain (=3.873%) and, Australia (=3.828%) has ranked at ninth and tenth position respectively and followed by India is in the eleventh.

Table III: Ranking of research collaboration in global wise

S. No	Countries/Territories	Record Count	% of 73227
1	USA	23742	32.422
2	Peoples R China	7492	10.231
3	Germany	5865	8.009
4	England	5589	7.632
5	France	4804	6.560
6	Japan	3726	5.088
7	Canada	3722	5.083
8	Italy	3558	4.859
9	Spain	2836	3.873
10	Australia	2803	3.828

Ranking of International Collaboration

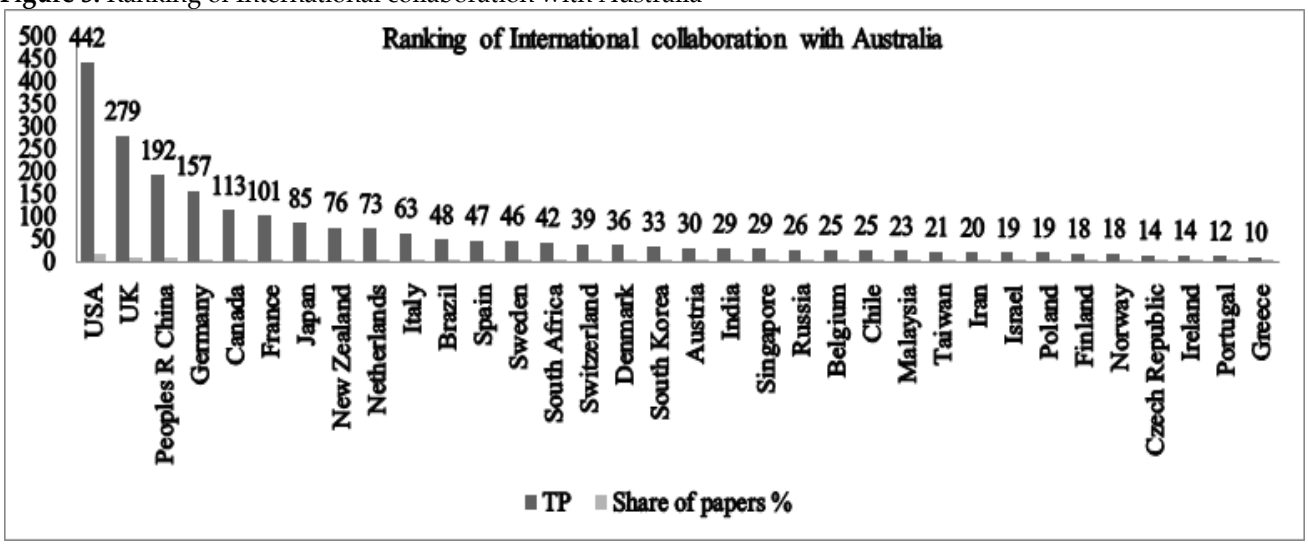
Table 4 and Figure 3 depicts that out of 84 countries collaborated with Australia regarding publication activity. Regarding research productivity from Australia has got that the maximum number of 2754 article (=98.3%) with 63275 citations and the average citation per paper is 22.98. And we have scrutinized only more than ten articles in this study and the most research papers from USA with 442 (=15.8%) research papers with 17430 citations and the average citation per paper is 39.44 which is the top ranked among the collaborative countries. The UK is in the second rank with 279 research papers (=10.0%) along with 12025 citations and the average citation per paper is 43.10 and the China is in the third rank with 192 papers (=6.8%) with 2697 citations and ACPP is 14.05. The findings expressed from the study that the USA is the top-ranked and have the good relationship and collaborated regarding producing the publication, and the UK is in the next one.

Table IV: International collaboration with Australia in Energy and Environment Research

Rank	Country	TP	Share of papers %	TC	ACPP
1	USA	442	15.8	17430	39.44
2	UK	279	10.0	12025	43.10
3	Peoples R China	192	6.8	2697	14.05
4	Germany	157	5.6	4728	30.11
5	Canada	113	4.0	4034	35.69
6	France	101	3.6	2978	29.48
7	Japan	85	3.0	1893	22.27
8	New Zealand	76	2.7	4457	58.45
9	Netherlands	73	2.6	2640	36.16
10	Italy	63	2.2	1917	30.43
11	Brazil	48	1.7	1186	24.71
12	Spain	47	1.7	933	19.85
13	Sweden	46	1.6	1528	33.22
14	South Africa	42	1.5	914	21.76
15	Switzerland	39	1.4	1716	44.0
16	Denmark	36	1.3	1113	30.92
17	South Korea	33	1.2	429	13.0
18	Austria	30	1.1	371	12.37
19	India	29	1.0	565	19.48
20	Singapore	29	1.0	635	21.90
21	Russia	26	0.9	1303	50.12

Rank	Country	TP	Share of papers %	TC	ACPP
22	Belgium	25	0.9	543	21.72
23	Chile	25	0.9	1029	41.16
24	Malaysia	23	0.8	191	8.30
25	Taiwan	21	0.7	294	14.0
26	Iran	20	0.7	189	9.45
27	Israel	19	0.7	1186	62.42
28	Poland	19	0.7	649	34.16
29	Finland	18	0.6	666	37.0
30	Norway	18	0.6	377	20.94
31	Czech Republic	14	0.5	592	42.28
32	Ireland	14	0.5	327	23.36
33	Portugal	12	0.4	91	7.58
34	Greece	10	0.4	145	14.5

Figure 3: Ranking of International collaboration with Australia



Chronological distribution of publication in Australia

Table V and figure 4 indicate the year wise literature trends on Energy and Environment Research in Australia during the period from 1991 to 2015. Publication growth is significant in every academic research throughout the world. In such a way, here, we have evaluated the publication growth trend in the field of Energy and Environment Research, and the below table picture the ratio of growth (RoG), annual growth rate (AGR), annual citation per paper (ACPP) have measured during the study. Based on the outputs, the growth ratio range is from 0.80 to 1.58 and followed by the annual growth rate range is from 0.36 to 57.5. The citation range is from 263 in 2015 to 5674 in 2000 (figure 5). The highest number of 308 (=11.0%) articles have published in 2015, and the small number of papers (=21 papers) are produced in the begging year. The greatest number of average annual citation per paper is 53.05 in the year 2005. The liner growth rate and trend line are calculated, and the growth rate of publication is $y = 11.066x - 31.78$ and the R^2 value is 0.8415 and the growth of citation is $y = 1548e^{0.0238x}$ and R^2 value is 0.0554.

Table V: Year wise output in Energy and Environment Research

S. No	PY	Recs	Percent	RoG	AGR	TC	ACPP
1	1991	21	0.7	-	-	974	46.38
2	1992	28	1.0	1.33	33.33	936	33.43
3	1993	33	1.2	1.18	17.85	1383	41.91
4	1994	33	1.2	1	0	601	18.21
5	1995	37	1.3	1.12	12.12	1145	30.95
6	1996	50	1.8	1.35	35.13	1959	39.18
7	1997	49	1.7	0.98	-2	2460	50.20
8	1998	56	2.0	1.14	14.28	1710	30.54
9	1999	45	1.6	0.80	-19.64	1708	37.96
10	2000	55	2.0	1.22	22.22	5674	10.32

S. No	PY	Recs	Percent	RoG	AGR	TC	ACPP
11	2001	59	2.1	1.07	7.27	1807	30.63
12	2002	66	2.4	1.19	11.86	2919	44.23
13	2003	91	3.2	1.38	37.88	3608	39.65
14	2004	82	2.9	0.91	-9.89	3100	37.81
15	2005	80	2.9	0.97	-2.44	4244	53.05
16	2006	126	4.5	1.58	57.5	3866	30.68
17	2007	119	4.2	0.94	-5.55	3830	32.18
18	2008	108	3.9	0.91	-9.24	3925	36.34
19	2009	162	5.8	1.5	50.0	3870	23.89
20	2010	170	6.1	1.05	4.94	3929	23.11
21	2011	227	8.1	1.34	33.52	4581	20.19
22	2012	238	8.5	1.05	4.85	3442	14.46
23	2013	279	10.0	1.17	17.22	2134	7.65
24	2014	280	10.0	1.00	0.36	926	3.31
25	2015	308	11.0	1.1	10.0	263	0.85
Total		**2802**	**100**			**64994**	**23.20**

RoG- Ratio of growth, AGR – Annual growth rate, TC – Total citations, ACPP- Average citation per paper

Figure 4: Chronological wise publications

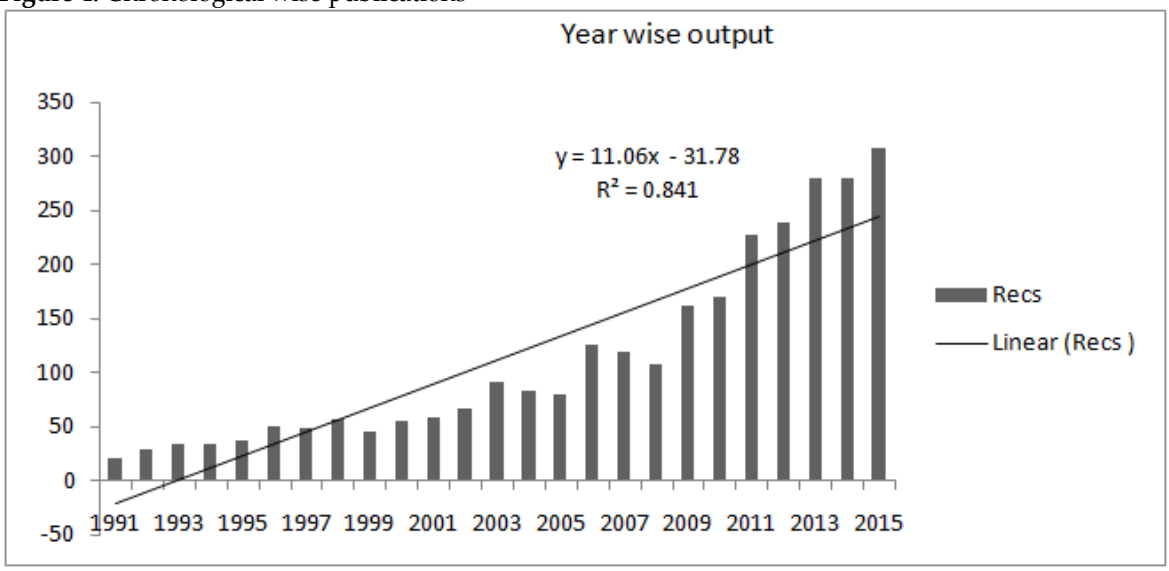
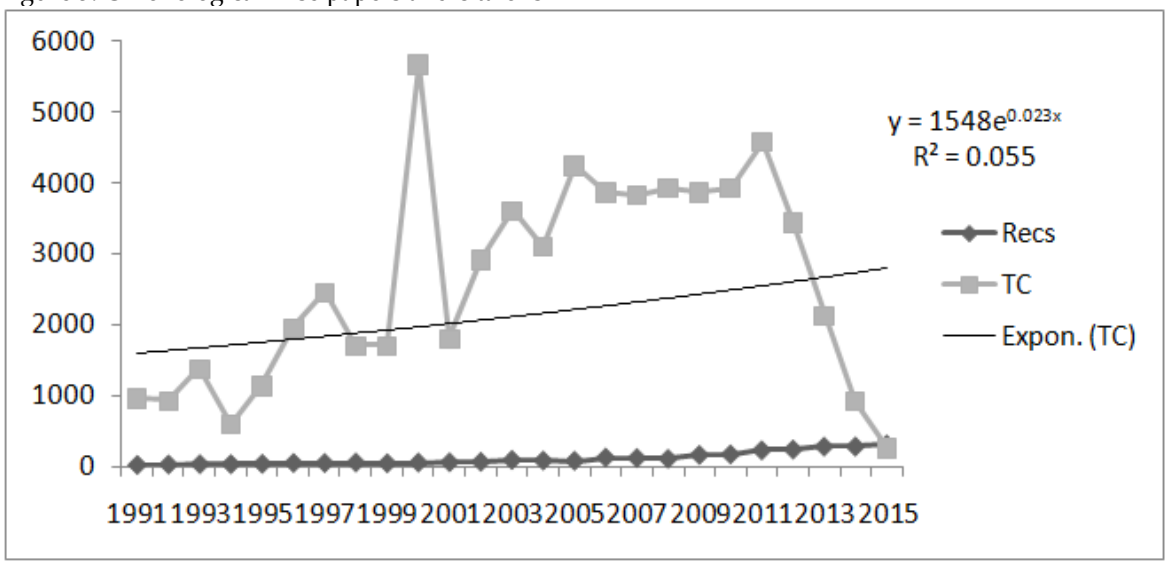


Figure 5: Chronological wise papers and citaions



Compound annual growth rate (CAGR)

As per the equation, we calculate the CAGR for the present study.

$$CAGR = \left(\frac{\text{Ending Value}}{\text{Beginning Value}}\right)^{\left(\frac{1}{\#\text{ of years}}\right)} - 1$$

To calculate the CAGR of the collection of research papers from the period from 1991 to 2015, we divide the final value of our portfolio by the portfolio's initial value (308/21 = 14.6667). Next we raise the result to the power of 1 divided by the number of years (1-24). Finally, we subtract one from the resulting value. As per the equation, we can measure;

= [(308/21) ^ (1/24)]
= 1.11839 -1
= 0.1183 or 11.83%

Thus, the compound annual growth rate of 25 years of literature output is equal to 11.83%.

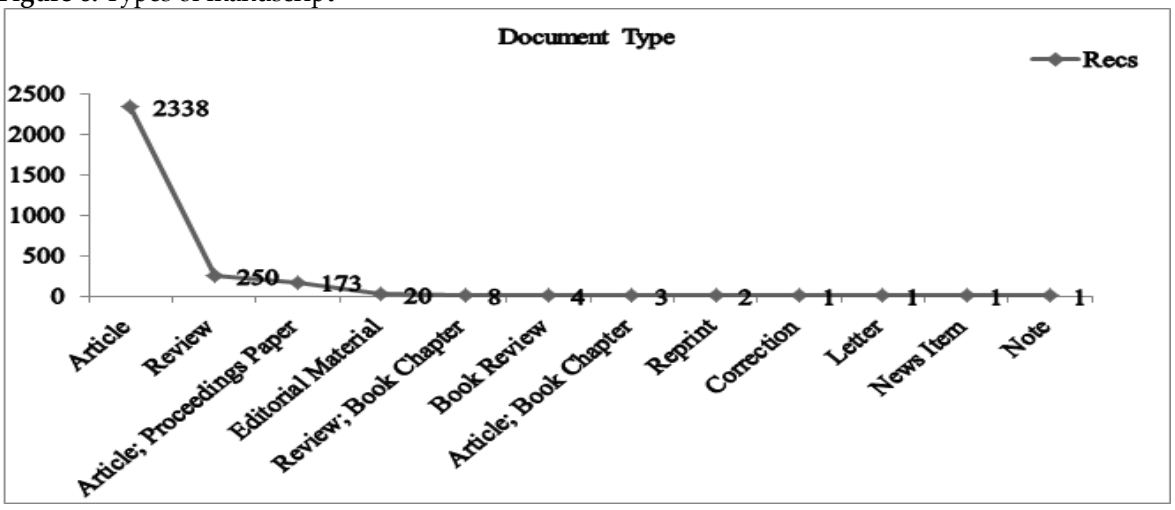
Types of manuscript pattern of publication

The manuscript publications of energy and environment includes Article, Review, Article; Proceedings Paper, Editorial Material, Review; Book Chapter, Book Review, Article; Book Chapter, Reprint, Correction, Letter, News Item and Note. Counting the sample of scientific research papers, it is disseminated that more than 80% of the documents are 'articles' (=2338, 83.4%) with 66.09% (= 42957) global citations and has occupied in the top position and followed by 'review' (=250, 8.9%) with 25.48% (= 16561) citations in the next, and the six percent of proceeding papers with 3808 citations has placed in the third position and other types such as Editorial Material, Review; Book Chapter, Book Review, Article; Book Chapter, Reprint, Correction, Letter, News Item and Note are in the least numbers during the study.

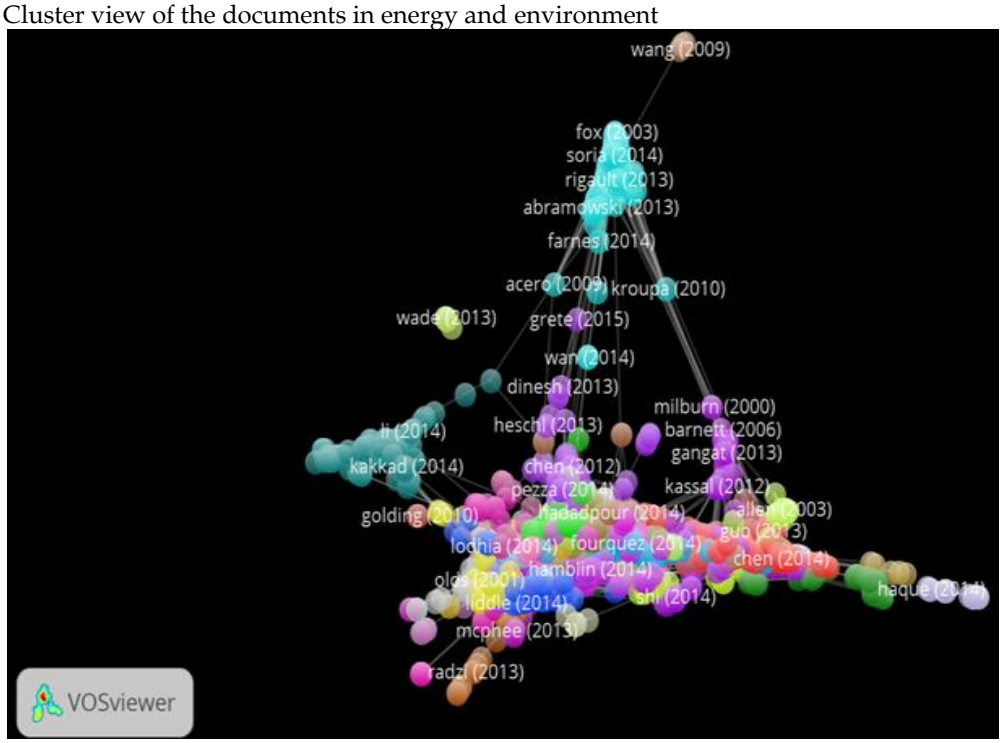
Table VI: Types of manuscript in Energy and Environment Research

S. No	Document Type	Recs	Percent	TLCS	TGCS
1	Article	2338	83.4	765	42957
2	Review	250	8.9	74	16561
3	Article; Proceedings Paper	173	6.2	60	3808
4	Editorial Material	20	0.8	6	349
5	Review; Book Chapter	8	0.3	4	1192
6	Book Review	4	0.2	0	0
7	Article; Book Chapter	3	0.1	1	68
8	Reprint	2	0.1	0	29
9	Correction	1	0.0	0	12
10	Letter	1	0.0	0	12
11	News Item	1	0.0	0	2
12	Note	1	0.0	0	4
Total		2802	100	910	64994

Figure 6: Types of manuscript



Cluster view of the documents in energy and environment



Researchers have analyzed the language wise production in energy and environment based on that the publications are produced by various languages such as English, Chinese, French, German, and Italian in which the maximum number of 2795 research papers with (=99.7%) 64959 citations are English, and it is occupied the top rank, and followed by other languages such as Chinese (=2 records), French (=2 records), German, (=2 records) respectively.

Table VII: Language based production in Energy and Environment Research

S. No	Language	Total Records	Percent	Total Citations
1	English	2795	99.7	64959
2	Chinese	2	0.1	1
3	French	2	0.1	16
4	German	2	0.1	18
5	Italian	1	0.0	0
Total		2802	100	64994

Author Productivity on Energy and Environment Research

Table 8 represents that the data evaluates regarding author productivity and characterizes that the average total number of authors per paper is 6.69. The maximum number of average number of authors per author is 10.21 in the year 2008 whereas the minimum number of an average number of authors per author is 2.58 in the years 1994 and 1996 respectively. The total average productivity per author is 0.15. The highest number of average productivity per author is 0.44 in the years 1999 however the least number of average productivity per author is 0.10 in the year 2008.

Table VIII: Author Productivity

#	Year	TP	TA	h-index	AAPP	APPA
1	1991	21	56	16	2.67	0.38
2	1992	28	78	13	2.79	0.36
3	1993	33	102	21	3.09	0.33
4	1994	33	85	15	2.58	0.39
5	1995	37	102	18	2.76	0.36
6	1996	50	129	20	2.58	0.39
7	1997	49	145	22	2.96	0.34
8	1998	56	193	25	3.45	0.29
9	1999	45	102	18	2.27	0.44
10	2000	55	152	26	2.76	0.36
11	2001	59	192	26	3.25	0.31

12	2002	66	289	27	4.38	0.23
13	2003	91	364	31	4.0	0.25
14	2004	82	289	31	3.52	0.28
15	2005	80	342	28	4.28	0.24
16	2006	126	544	30	4.32	0.23
17	2007	119	577	33	4.85	0.21
18	2008	108	1102	31	10.21	0.10
19	2009	162	852	33	5.26	0.19
20	2010	170	810	32	4.76	0.21
21	2011	227	1293	30	5.69	0.18
22	2012	238	1379	26	5.79	0.17
23	2013	279	1919	20	6.88	0.15
24	2014	280	1356	12	4.84	0.21
25	2015	308	2054	6	6.69	0.15

TP-Total Papers, TA- Total Authors; Average Authors per Paper (AAPP) = Number of authors/ Number of papers, Average Productivity per author= Number of papers/ Number of authors.

Ranking of highly cited authors

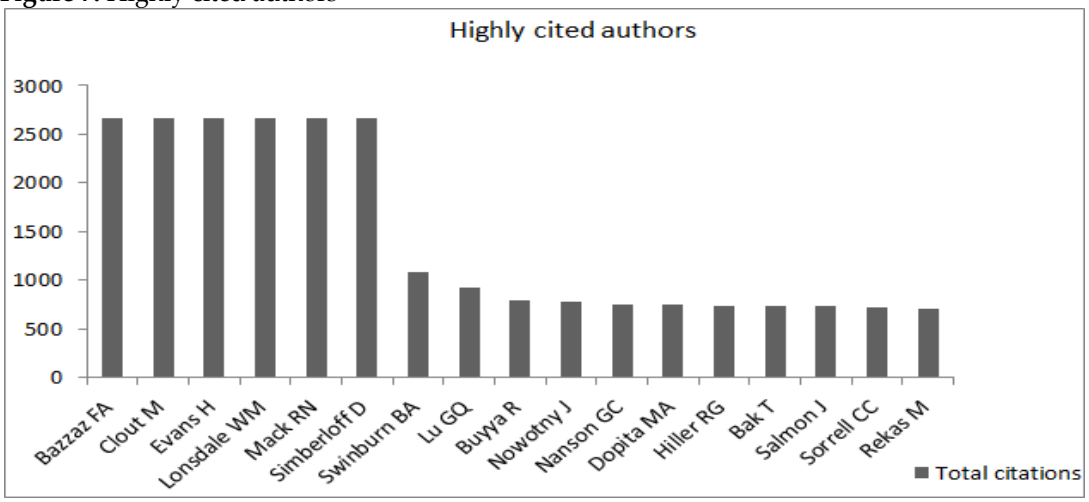
It can be observed form the table 9 and figure 6 depicts that the highly cited authors in the field of Energy and Environment Research in Australia during the period of study. The results reveal that a total of 64994 citations had contributed entire research outputs in the period of study. Out of that, more than 700 times cited papers of authors have collected for the present study. The maximum number of citations contributed by 'BAZZAZ FA' from Harvard University, USA, 'CLOUT M' from University of Auckland, New Zealand, 'EVANS H' from England, 'LONSDALE WM' from CRC Weed Management System, Australia, 'MACK RN' from University of Tennessee, USA, 'SIMBERLOFF D' from CSIRO Entomology, Australia with 2667 citations with one paper who have occupied in the first rank respectively, and the lowest citations (=1, 708 citations) is received by 'REKAS M' from University of New South Wales, Australia.

Table IX: Highly cited authors in Energy and Environment Research

Rank	Author	Affiliation	TR	TC
1	Bazzaz FA	Harvard University, Biological Labs, Cambridge, USA	1	2667
1	Clout M	University of Auckland, Scheme of Biological Science, New Zealand	1	2667
1	Evans H	CABI Bioscience, England.	1	2667
1	Lonsdale WM	CRC Weed Management System, Canberra, Australia	1	2667
1	Mack RN	University of Tennessee, Dept Ecology & Evolution Biology, USA	1	2667
1	Simberloff D	CSIRO Entomology, Canberra, ACT 2601, Australia	1	2667
2	Swinburn BA	Deakin University, Scheme of Health Science, Melbourne, Australia	6	1074
3	Lu GQ	University of Queensland, Scheme of Chemical Engineering, Brisbane, Australia	4	914
4	Buyya R	University of Melbourne, Dept Computer Science & Software Engineering, Australia	8	795
5	Nowotny J	Univ New S Wales, Scheme of Material Science & Engineering, Sydney, Australia	7	770
6	Nanson GC	University of Wollongong, Dept Geology, Wollongong, Australia	5	753
7	Dopita MA	Australian National University, Institute of Advanced Studies, Australia	7	744
8	Hiller RG	Macquarie Univ, Dept Biological Science, Australia	11	731
9	Bak T	University of New South Wales, Scheme of Material Science & Engineering, Australia	4	729
10	Salmon J	Deakin University, Centre for Physics Act & Nutrition Research, Australia	8	726
11	Sorrell CC	University of New South Wales, Scheme of Material Science & Engineering, Australia	2	721
12	Rekas M	University of New South Wales, Scheme of Material Science & Engineering, Australia	1	708

Note: TR- Total records, TC- Total citations

Figure 7: Highly cited authors



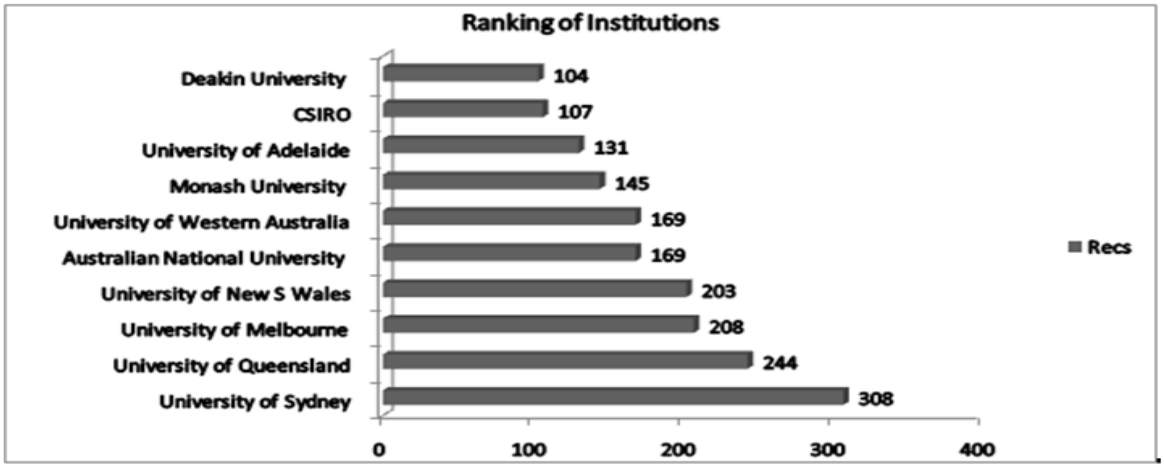
Identification of highly productive Institutions (top 10, totally 2292)

Table 10 and figure 8 indicates only top ten most research institutions regarding significant outputs of more than 100 records. Findings illustrate that out of the top ten institutions, the University of Sydney has the highest productive publications in the field of Energy and Environment Research in Australia with 308 (11.0%) articles along with 7728 citations and the average citation per paper is 25.09 and the h-index is 44 and followed by University of Queensland has contributed 244 articles with 5985 citations, and the average citation per paper is 24.53 and the h-index is 36, University of Melbourne who has produced 208 papers with 4665 citations and the h-index is 34, University of New S Wales has published 203 articles with 5678 citations, and h-index is 36 and Australian National University has contributed 169 papers with 4112 citations, and the results indicate that the highest citation has produced by University of Queensland (=5985 citations) and the greatest average citation per paper is published by CSIRO (=28.82%) and the least number of papers (=108 papers) published by Deakin University with least h-index is 25.

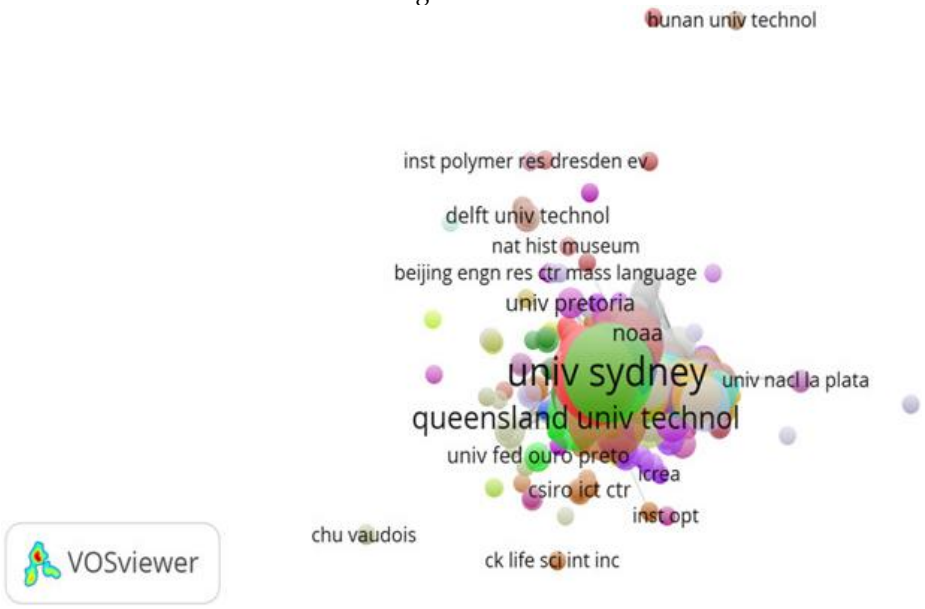
Table X: Ranking of Institution on Energy and Environment Research in Australia

S. No	Institution	TP	TP%	TC	CPP	h-index
1	University of Sydney	308	11.0	7728	25.09	44
2	University of Queensland	244	8.7	5985	24.53	36
3	University of Melbourne	208	7.4	4665	22.43	34
4	University of New S Wales	203	7.2	5678	27.97	36
5	Australian National University	169	6.0	4112	24.33	33
6	University of Western Australia	169	6.0	4378	25.91	28
7	Monash University	145	5.2	3697	25.50	29
8	University of Adelaide	131	4.7	2586	19.74	28
9	CSIRO	107	3.8	3084	28.82	31
10	Deakin University	104	3.7	3391	32.61	25

Figure 8: Ranking of Institution



Label view of Network-based Ranking of Institution



Ranking of core Journals (top 25, totally 1200)

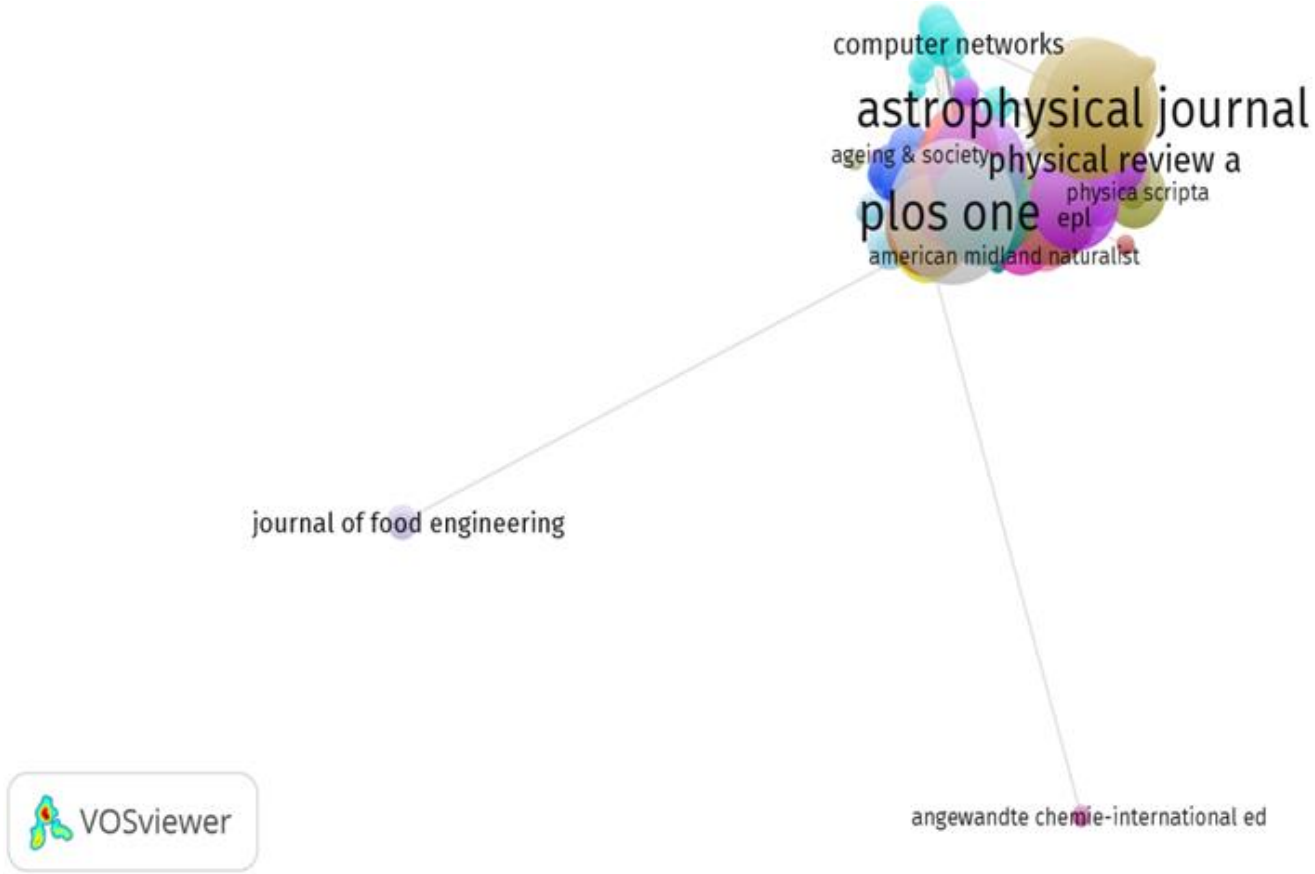
Periodicals such as journal articles and serials are the most important instrument for policy-making and they are the benchmarking for researchers and academicians and scientists. Counting ranking wise core journals (Table 11) in the field of energy and environment totally covered 1200 journals for publications. Out of 1200, we have chosen for analysis only top 25 most productive journals with more than 13 research outputs. In this study, journals are evaluated based on the literature outputs in which PLOS One is in the top ranked with 11 h-index and 46 records and the citations are 384, and followed by Astrophysical Journal is the next position with 44 articles with 1614 citations and h-index is 21, Monthly Notices of the Royal Astronomical Society occupies in the third rank with 38 articles (=1389 citations, 11 h-index), Journal of Coastal Research(=28, 350 citations, 11 h-index), Renewable Energy (=28, 180 citations, 8 h-index), Astronomy & Astrophysics (=25, 730 citations, 13 h-index), Journal of Experimental Biology (=23, 563 citations, 13 h-index), Physical Review B (=23, 616 citations, 13 h-index), Energy Policy (=19, 242 citations, 7 h-index) and Energy and Buildings (=17, 184 citations, 6 h-index). It indicates from the analysis that more citations among the journals occupied by Monthly Notices of the Royal Astronomical Society (=1389 citations) and followed by Astrophysical Journal (=1614 citations).

Table XI: Ranking of Journals on Energy and Environment Research in Australia

Rank	Journal	TP	TC	h-index
1	PLOS One	46	384	11
2	Astrophysical Journal	44	1614	21
3	Monthly Notices of the Royal Astronomical Society	38	1389	17
4	Journal of Coastal Research	28	350	11
4	Renewable Energy	28	180	8
5	Astronomy & Astrophysics	25	730	13
6	Journal of Experimental Biology	23	563	13
6	Physical Review B	23	616	13
7	Energy Policy	19	242	7
8	Energy and Buildings	17	184	6
8	Journal of Physical Chemistry B	17	761	10
8	Marine Geology	17	441	12
8	Minerals Engineering	17	238	9
8	Renewable & Sustainable Energy Reviews	17	237	9
9	Australian Journal of Experimental Agriculture	15	231	8
9	Building and Environment	15	178	8
9	International Journal of Hydrogen Energy	15	841	7
10	Australian Journal of Agricultural Research	14	209	9
10	Australian Journal of Earth Sciences	14	164	8
10	Journal of Zoology	14	185	7

Rank	Journal	TP	TC	h-index
10	Proceedings of the National Academy of Sciences	14	902	12
10	Sedimentary Geology	14	267	8
11	Geomorphology	13	754	11
11	Marine Ecology Progress Series	13	335	9
11	Physiological and Biochemical Zoology	13	219	9

Note: TP- Total publications, TC- Total citations



Label view of Network-based source title of publications

Ranking of Research Areas (top 10, totally 116)

Out of 116 research areas, we have chosen for analysis only top-ranked research areas as reflected in the web of science during the period of study. Table 12 and figure 9 represents that the most productive papers have produced in the domain of by Environmental Sciences Ecology with scholarly communications of 387 (=13.807%) and top-ranked research area during the study period. The results show that the majority of research papers have identified in the field of Environmental Sciences Ecology as the scientists are interesting to do their research.

Table XII: Ranking of Research Areas in Energy and Environment Research

Rank	Research Areas	Record Count	% of 2802
1	Environmental Sciences Ecology	387	13.807
2	Engineering	356	12.701
3	Chemistry	256	9.133
4	Physics	234	8.348
5	Geology	206	7.349
6	Energy Fuels	174	6.208
7	Agriculture	163	5.815
8	Materials Science	161	5.744
9	Astronomy Astrophysics	143	5.102
10	Science Technology Other Topics	124	4.424

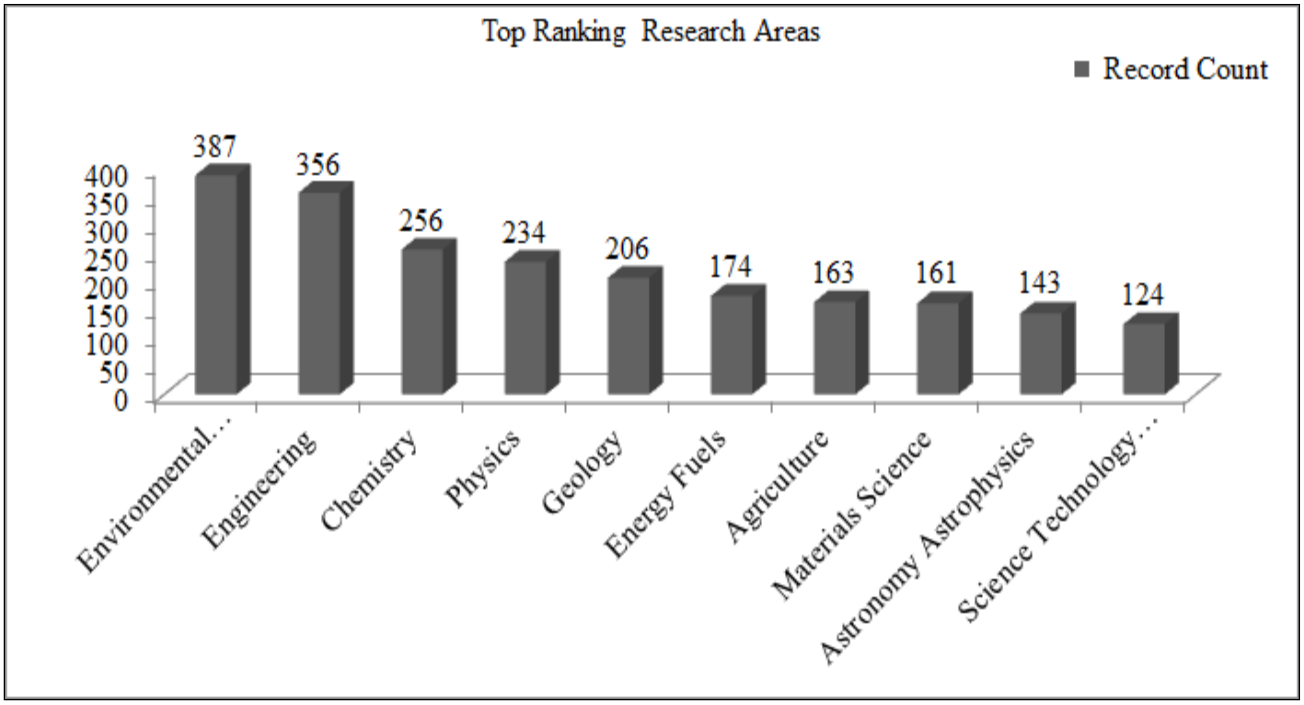


Figure 9: Ranking of Research Areas

Ranking of Source Titles of publications (top 10, totally 1201)

Of the 1201 source titles, the top ranked source titles have taken into consideration for current analysis. Table 13 and figure 10 indicates that out of top 10 source titles of publications, the most productive source is PLOS One (=46, 1.641%) is the top-ranked position and followed by Astrophysical Journal (=44, 1.570%) is the second-ranked, and in the third rank is the Monthly Notices of the Royal Astronomical Society Source title (=38, 1.356%), fourth and fifth ranked at Journal of Coastal Research and Renewable Energy with 28 research papers (= 0.999%) respectively, and the sixth has got by Astronomy Astrophysics with share of 25 papers (=0.892%), the seventh and eighth position has occupied by Journal of Experimental Biology and Physical Review B with share of 23 research articles in each (=0.821%) respectively. The ninth rank has received by Energy Policy with 19 papers (=0.678%), and the Renewable Sustainable Energy Reviews has placed in the tenth position with the share of 17 papers (0.606%).

Table XIII: Ranking of Source Titles of publications

Rank	Source Titles	Record Count	% of 2802
1	PLOS One	46	1.641
2	Astrophysical Journal	44	1.570
3	Monthly Notices of the Royal Astronomical Society	38	1.356
4	Journal of Coastal Research	28	0.999
5	Renewable Energy	28	0.999
6	Astronomy Astrophysics	25	0.892
7	Journal of Experimental Biology	23	0.821
8	Physical Review B	23	0.821
9	Energy Policy	19	0.678
10	Renewable Sustainable Energy Reviews	17	0.606

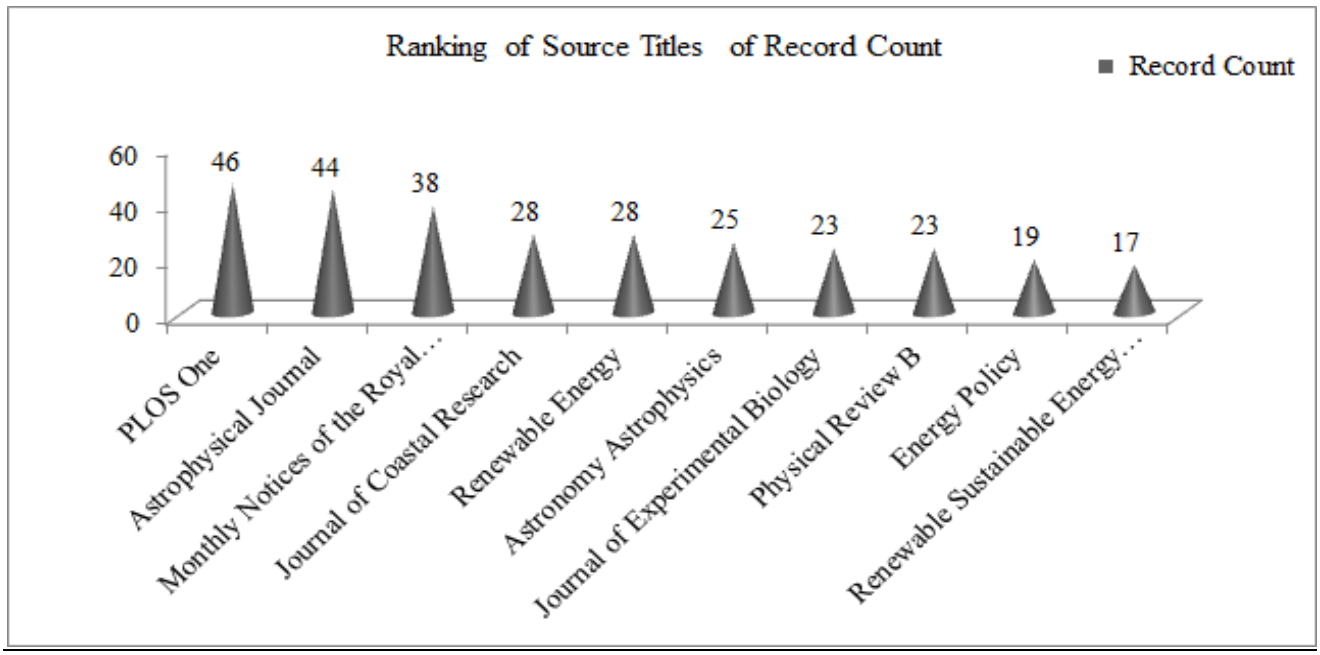


Figure 10: Ranking of Source Titles

CONCLUSION

We can conclude from the study in the field of energy and environment in Australia, and the findings show that the global publications share of Australia during 1991-2015 was 3.828183 which have gradually increased from 2.277657 in 1991 to 4.756022 in 2015. This growth pattern could also be counted based on the journals increase via the web of science database over the years. The most papers have produced in the domain of by Environmental Sciences Ecology with scholarly communications of 387 (=13.807%) and top-ranked research area, and Energy Fuels is in the 6th place during the present study. Out of top 10 source titles, the most prolific source of publication is PLOS One (=46, 1.641%) is the top ranked position.

Some scientometric studies have already done in different fields by researches and scientist, this scientometric analysis on energy and environment research of Australia, we hope this may trigger more scientometric studies for the resolution of evaluating energy and environment research in the country. Such studies would be valuable and beneficial in formulating appropriate policies to improve the energy and environment research of Australia

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