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Research Productivity of Wadia Institute of Himalayan Geology

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Abstract

Bibliometric analysis was used to assess the research productivity of the Wadia Institute of Himalayan Geological (WIHG) during 1991-2020. Data was collected from the Scopus database, and VOSviewer software used for visualization. The study focused on various bibliometrics parameters like year-wise research growth, Authors productivity, Growth rates measures (AGR, RGR, Dt), Collaboration measures (DC and CC), subject-wise distributions, most prolific authors, highly collaborative institutions, most cited documents, top funding agency, types of documents, etc. The results showed that the maximum number of documents, 93 (7.21%), were published in 2017. India and the United States of America contributed the highest numbers of documents, 1289 & 97. The highest number, 995(60.78%) of scholarly publications, has come from the subject of Earth and Planetary Sciences. P Srivastava is the most prolific and highly cited author. WIHG collaborates with many IITs like IIT Roorkee, IIT Kharagpur, and central universities such as HNB Garhwal University, BHU, etc."The Randolph glacier inventory: A globally complete inventory of glaciers" is the most highly cited publication in the Journal of Glaciology by Pfeffer et al. in 2014 with 515 citations. "The Current Science," has the first rank of productive and cited source with 156 documents and 2380 citations.

Keywords: Bibliometrics, Geology, Himalaya, Seismic hazard, geochemistry, earthquake, India

Introduction

The Wadia Institute of Himalayan Geology (WIHG) is an autonomous research institute under the Ministry of Science and Technology, Govt. of India, which appeared in 1968. The Institute is an advanced center for the study of Geology of the Himalaya of Biostratigraphy, Geomorphology and Environmental Geology, Geophysics, Petrography and Geochemistry, Structure Tectonics and Sedimentology. The Institute has its origins in the Department of Geology at the University of Delhi and later shifted to Dehradun as the Institute of Himalayan Geology in 1976. The Institute was renamed as Wadia Institute of Himalayan Geology in memory of its founder, late Prof. Darashaw Nosherwan Wadia (F.R.S.), in honor of his contributions to the geology of the Himalayas. Darashaw Nosherwan Wadia enjoyed being the first geologist to be made a National Professor by the Government of India (Stubblefield, 1970).

There are many methods for measuring the scientific production of the Institute. Among others, bibliometric analysis is receiving increasing attention from the scientific community (Laengle et al., 2017; Laengle et al., 2020). Bibliometrics originated from the field of library and information science (Broadus 1987; Pritchard 1969; Tella & Aisha Olabooye, 2014). Bibliometric analysis refers to combining different frameworks, tools, and methods with studying and analyzing scholarly publications' citations (Akhavan et al., 2016). Bibliometrics study used to evaluate academic departments' research performance in universities and research centers (Lee, 2003). The result of these studies helps in enhancing the trends of research productivity and research collaboration. A few of such research studies reviewed as under:

Pradhan et al. (2020a) performed a study on the National Institute of Technology, Rourkela. Pradhan et al. (2020b) studied the Sambalpur University research publications, Odisha, India, from 1990 to 2019 and identified a significant enhancement in the number of publications after

2010. Parida et al. (2020) analysed the productivity of research at the Indian Institute of Medical Sciences (AIIMS), Bhubaneswar using scientometric parameters. This study revealed that most research publications appeared with an average growth rate of 46.43%, and R.R. Das was the most prolific author. Kuri et al. (2020) performed a scientometric analysis of the Indian School of Business, Hyderabad, from 2002 to 2020. This study concluded that 2015 and 2018 are the most productive years with 52 publications, and the majority of the papers have appeared under three authorship patterns. Kumar et al. (2015) conducted a bibliometric analysis of the research publications of Gujarat University during the ten years between 2004 and 2013. The study indicated that journals are the most preferred form of publication by Gujarat University researchers. Wani et al. (2013) measured the research contribution of India's leading health care institute AIIMS. The study identified that Biochemistry, Genetics & Molecular Biology are the most cited subject area with 16769 citations, and AIIMS has made 973 International and 2450 National collaborations.

The following objectives of the study included: To analyse the year-wise research productivity of WIHG from 1991 to 2020; To find out the author productivity of WIHG from 1991 to 2020; To find out the authorship pattern, degree of collaboration (DC), and Collaborative coefficient (CC); To find out the annual growth rate (AGR), relative growth rate (RGR), and Doubling time (Dt); To identify the most prolific authors, collaborative institutes, collaborative countries; To find out the most preferred sources for publication of research output; To find out the top funding agency; To analyse the subject-wise distribution; To find out types of documents.

Methodology

A bibliometric analysis was conducted to evaluate Wadia Institute of Himalayan Geology's research productivity between 1991-2020. The Scopus database (https://www.scopus.com) was chosen

because of its comprehensive coverage. The Affiliation Search "Wadia Institute of Himalayan Geology" was conducted. The search string was used for the study "AF-ID ("Wadia Institute of Himalayan Geology" 60031092) AND (LIMIT-TO (PUBYEAR, 2020) LIMIT-TO (PUBYEAR, 1991)) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (LANGUAGE, "English"))." A total of 1289 data was collected from the Scopus database on January 4, 2021. The various bibliometrics parameters used to evaluate growth measures (AGR, RGR, and Dt), author productivity, collaboration measures (DC, and CC), co-authorship network analysis of countries, subject-wise distribution, co-authorship analysis of Authors with prolific authors, highly collaborative institutions, topmost funding agencies, top-cited documents, highly productive Vs. Highly-cited sources, distribution of publications, co-occurrence analysis of keywords, etc. In this study, the researchers applied VOSviewer software version 1.6.16 for better visualization of results.

Results

Year-wise growth rate of documents with citations

Figure 1 describes the year-wise distribution of the papers with citations during 1991-2020. Among the total of 1289 documents, the average document per year is 43(42.97), while the average citation per year is 750.5. The highest number of 93 documents was published in 2017, while the lowest number was 12 documents in 1993 and 1995. During the entire study, the researchers observed that out of 1289 documents, 378(29.33%) documents were published between the last five years, i.e., 2016-2020, and 695(53.92%) documents published between the previous 10 years, i.e., 2011-2020. While 82(6.36%) documents were published between the first 5 years, i.e., 1991-1995, and 208(16.14%) documents were published between the first 10 years, i.e., 1991-2000. It is clear from the study that there is an uncertain growth pattern of documents. Further, to all 1289 papers, a total of 22515 citations were received, with an average of 20.58

citations per document (ACPD). The highest, i.e., 1596 citations, appeared in 2010. It is concluded that during the study period, there were continuously fluctuating trends found in research productivity and citation.

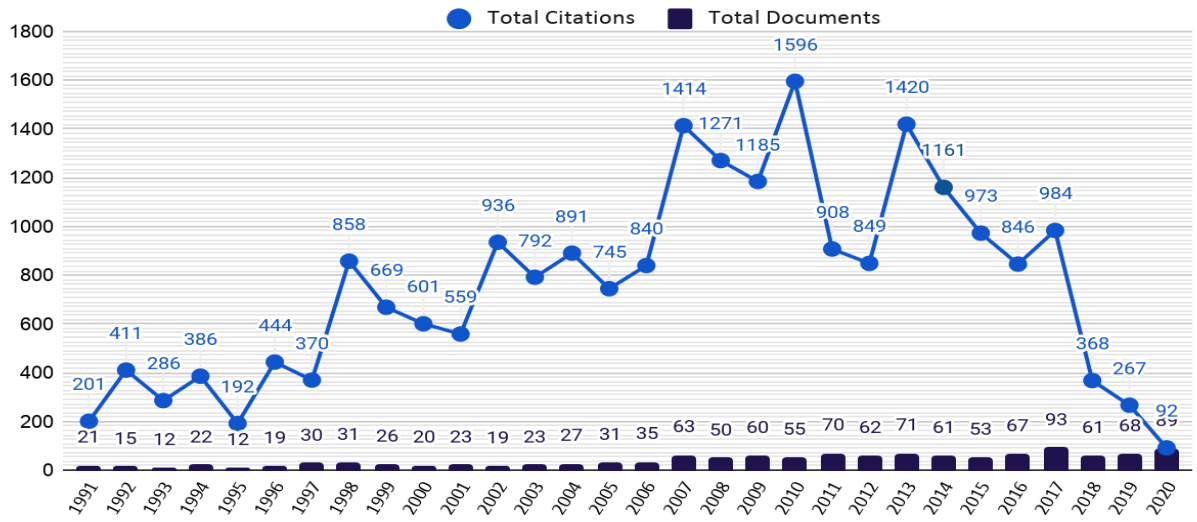


Figure 1. The year-wise growth rate of documents with Citations

Author Productivity of Wadia Institute of Himalayan Geology

Table 1 shows the author productivity of Wadia Institute of Himalayan Geology. After analysing the data, it was found that the year-wise authorship patterns increased with fluctuating trends, and the average author per document is 3.45, while productivity per author is 0.32. It shows that the last nine-years i.e., 2012-2020 have more value than the average value of authors per document.

Table 1. Author Productivity of Wadia Institute of Himalayan Geology

Year	TD	TA	AAPD	PPA	Year	TD	TA	AAPD	PPA
1991	21	45	2.14	0.47	2007	63	211	3.35	0.30
1992	15	35	2.33	0.43	2008	50	172	3.44	0.29
1993	12	20	1.67	0.60	2009	60	192	3.20	0.31
1994	22	51	2.32	0.43	2010	55	207	3.76	0.27

1995	12	37	3.08	0.32	2011	70	202	2.89	0.35
1996	19	45	2.37	0.42	2012	62	219	3.53	0.28
1997	30	77	2.57	0.39	2013	71	315	4.44	0.23
1998	31	82	2.65	0.38	2014	61	287	4.70	0.21
1999	26	77	2.96	0.34	2015	53	254	4.79	0.21
2000	20	57	2.85	0.35	2016	67	358	5.34	0.19
2001	23	59	2.57	0.39	2017	93	484	5.20	0.19
2002	19	66	3.47	0.29	2018	61	266	4.36	0.23
2003	23	84	3.65	0.27	2019	68	302	4.44	0.23
2004	27	86	3.19	0.31	2020	89	492	5.53	0.18
2005	31	102	3.29	0.30	Total	1289	5003	3.88	0.26
2006	35	119	3.40	0.29	AVG AAPD=3.45			AVG PPA=0.32	

Note* TA= Total no. of authors, AAPD= Average author per documents, PPA= Productivity per Authors

Year wise growth rate measures

Annual growth rate (AGR)

Table 2 explains the annual growth rate of publication of 'Wadia Institute of Himalayan Geology' during the study period. The maximum AGR was noted with 83.33 in 1994, followed by 80 AGR in 2007, and the minimum -45.45 AGR recorded in 1995. The formula for calculating of annual growth rate (AGR) is as given below:

$$AGR = (End\ value - First\ value) / (First\ value) \times 100$$

Relative growth rate (RGR)

The RGR determines the growth in terms of a rate of increase in size per unit of measure (Hunt, 1990). For calculating the mean relative growth rate (RGR) over the specific period of the interval, the formula:

$$RGR = (1-2^{r}) = (Ln(W2) - Ln(W1))/(T2 - T1) \times 100$$

Table 2 indicates the highest Relative growth rate with a value of 0.54 in 1992, whereas the lowest was 0.06 in 2015, 2018, and 2019. The average relative growth rate during the study was 0.14.

Doubling Time (Dt)

Whereas Doubling Time (Dt) indicates the period required for a quantity to double in size or value. The researchers applied this formula to know the doubling time:

$$Dt=0.693/RGR$$

During the study period, it showed that the average doubling time was 6.65. However, the value of doubling time increased with fluctuation from 1.29 to 12.51 from 1992 to 2020.

Table 2. Year-wise, AGR, RGR, and Dt of documents

Year	**TD**	**CN**	**W1**	**W2**	**AGR**	**RGR**	**Dt**	**Year**	**TD**	**CN**	**W1**	**W2**	**AGR**	**RGR**	**Dt**
1991	21	21	-	3.04	-	-	-	2007	63	429	5.9	6.06	80	0.16	4.36
1992	15	36	3.04	3.58	-28.57	0.54	1.29	2008	50	479	6.06	6.17	-20.63	0.11	6.29
1993	12	48	3.58	3.87	-20.00	0.29	2.41	2009	60	539	6.17	6.29	20	0.12	5.87
1994	22	70	3.87	4.25	83.33	0.38	1.84	2010	55	594	6.29	6.39	-8.33	0.10	7.13
1995	12	82	4.25	4.41	-45.45	0.16	4.38	2011	70	664	6.39	6.5	27.27	0.11	6.22
1996	19	101	4.41	4.62	58.33	0.21	3.33	2012	62	726	6.5	6.59	-11.43	0.09	7.76
1997	30	131	4.62	4.88	57.89	0.26	2.66	2013	71	797	6.59	6.68	14.52	0.09	7.43
1998	31	162	4.88	5.09	3.33	0.21	3.26	2014	61	858	6.68	6.75	-14.08	0.07	9.4
1999	26	188	5.09	5.24	-16.13	0.15	4.66	2015	53	911	6.75	6.81	-13.11	0.06	11.56
2000	20	208	5.24	5.34	-23.08	0.10	6.85	2016	67	978	6.81	6.89	26.42	0.07	9.77
2001	23	231	5.34	5.44	15.00	0.10	6.61	2017	93	1071	6.89	6.98	38.81	0.09	7.63
2002	19	250	5.44	5.52	-17.39	0.08	8.77	2018	61	1132	6.98	7.03	-34.41	0.06	12.51
2003	23	273	5.52	5.61	21.05	0.09	7.87	2019	68	1200	7.03	7.09	11.48	0.06	11.88

2004	27	300	5.61	5.70	17.39	0.09	7.35	2020	89	1289	7.09	7.16	30.88	0.07	9.69
2005	31	331	5.70	5.80	14.81	0.10	7.05	Total	1289	2578	7.16	7.85	1348.31	**0.14**	**6.65**
2006	35	366	5.80	5.90	12.90	0.10	6.89								

Note* CN= Cumulative numbers, AGR= Annual growth rate, RGR= Relative growth rate, Dt= Doubling time

Collaboration Measures:

Degree of Collaboration

The degree of collaboration (DC) is counted by the formula which Subramanyam, 1983 suggests. The degree of collaboration is expressed as:

$$DC=Nm/(Nm+Ns)$$

DC = degree of collaboration; Nm = Number of multi-authored papers; Ns = number of single-authored papers.

The number of collaborative research papers to the total number of research papers in the discipline during a specific period is measured and varied from 0.52 to 1.00 in different years with an average (mean) degree of collaboration with a value of 0.85.

Collaboration Coefficient

The collaboration coefficient (CC) is counted by the formula suggested by Ajiferuke et al., 1988. The formula is as given below:

$$CC = 1 - \frac{\sum_{j=1}^{A} \frac{1}{j}(fj)}{N}$$

Where j = The number of authors in an article, i.e., 1, 2, 3 ……; fj = The number of j authored articles; N = The total number of articles published in a year, and A = The total number of authors per paper.

The researchers have measured from the study of Wadia Institute of Himalayan Geology and found that the minimum collaboration coefficient of 0.31 was 1993, while the maximum was 0.70 in 2020. The average Collaborative Coefficient is 0.55. The study clearly shows that the coefficient of cooperation is less than 0.6. It indicates that Wadia Institute of Himalayan Geology research collaboration is average.

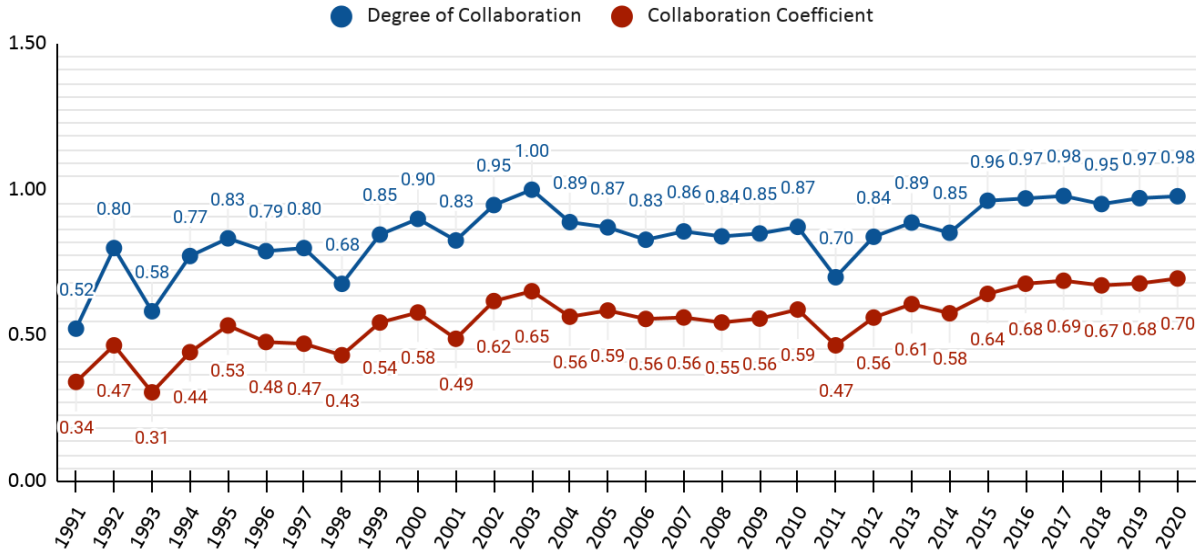
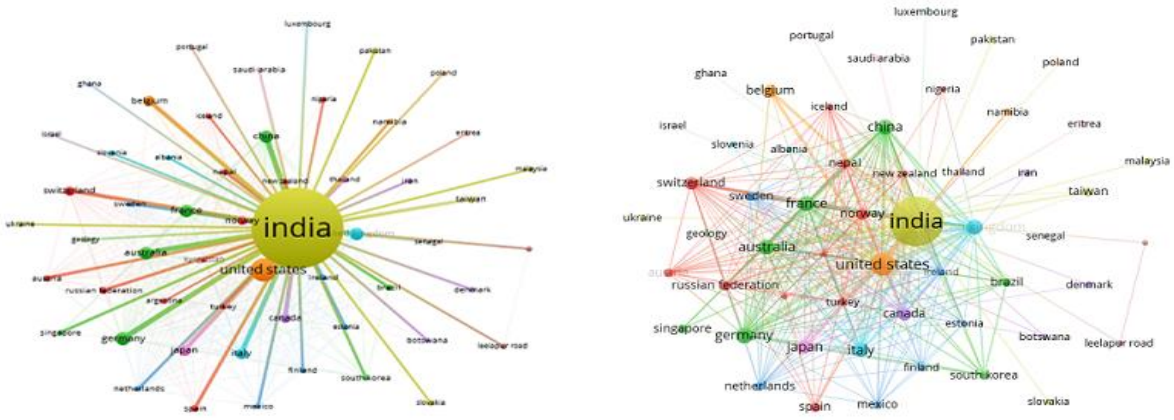


Figure 2. Degree of collaboration and Collaboration coefficient

Network visualizations of co-authorship analysis of countries

Figure 3a it Shows India has the highest number of 412 link strength than other highly prolific countries, and further, it shows India's connectivity with other countries. Out of 55 countries, 2 minimum documents of a country, 32 meet the threshold. Figure 3b depicts the network connectivity of all countries. The different colors represent the various clusters of countries. Every cluster describes a group of similar countries. The red colors cluster 1 represent 12 countries, including Switzerland, Austria, Norway, Spain, etc., while the green colors define cluster 2 consists of 7 countries, including China, France, Germany, and Australia, etc. The blue colors denoted cluster 3 consists of 6 countries, including Sweden, Netherlands, Finland, and

Ireland. The yellow colors represent cluster 4 consists of 5 countries, including India, Pakistan, Malaysia, Ukraine, etc. colors represent other corresponding countries.



Figures 3a. India's links with other countries & Figure 3b. Most collaborative Countries

Subject-wise distributions

Figure 4 shows the discipline-wise distribution of research output produced from 1991 to 2020. It indicates 18 subject categories are broad research disciplines in which researchers are pursuing their research in the Wadia Institute of Himalayan Geology. The study's findings revealed that approximately 61 percent of research works were carried out in Earth and Planetary Sciences. The remaining 39 percent of research works in all other disciplines were carried during the study period.

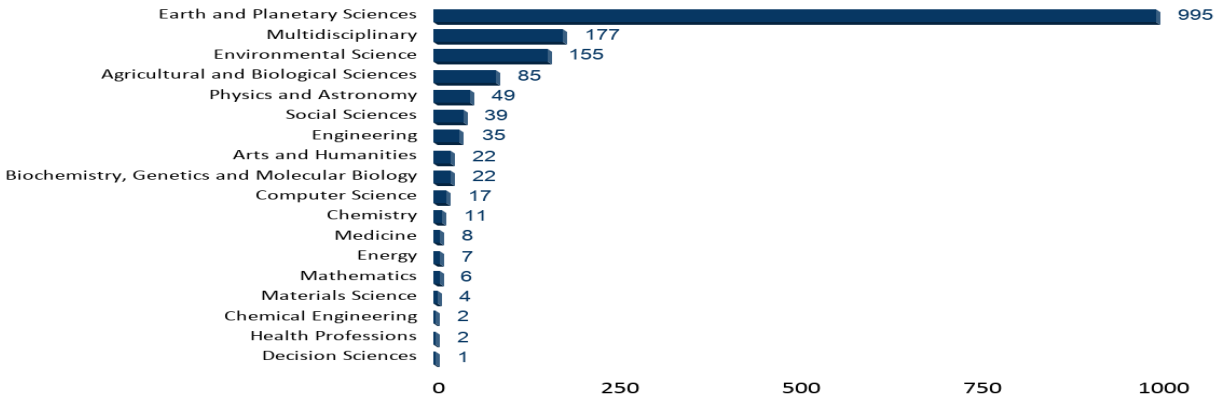
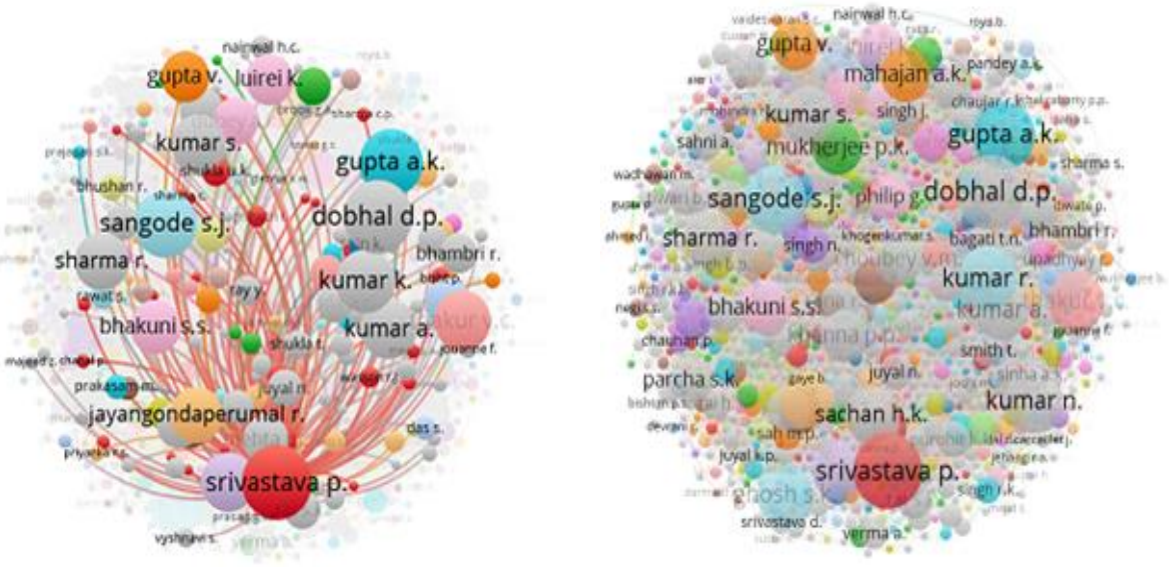


Figure 4. Subject wise distribution

Network visualizations of co-authorship analysis of author's

Figure 5a illustrates that Srivastava P. has the highest 302 link strength than other highly prolific authors and showed Srivastava P.'s connectivity with other authors. Out of 1364 authors, 3 minimum documents, and 5 minimum number of authors' citations, 365 meet the threshold. Figure 5b demonstrates the network connectivity of all authors. The different colors represent different clusters of authors' networks. Each cluster represents a group of similar authors. The red colors represent cluster 1 consisting of 47 authors, including Srivastava P., Ghosh R., Chahal P., Bisht P., etc. In comparison, green colors define cluster 2 consists of 46 authors, including Mukherjee P.K., Singhal S., Jain A.K., and Seth P., etc. The blue colors denoted the cluster 3 consists of 43 authors, including Sharma G., Singh A., Mondal S.K., and Arora S., etc.; the yellow colors represents cluster 4 consists of 42 authors, including Tiwari S., Ojha N., Deep A., and Khan Z., etc. and other colors represent corresponding other authors.



Figures 5a. Srivastava P's links with other authors & Figure 5b. Network Visualization of co-authorship analysis of authors

Highly collaborative Institutions

It analyzed the research performance of the top institutions which collaborated with the Wadia Institute of Himalayan Geology. The computational results show that approximately half of the publications were contributed by the Wadia Institute of Himalayan Geology itself, while the remaining half of publications collaborated with other 51 institutions. Figure 6 lists the top ten collaborative institutions. It is observed from figure 6 that authors of the Wadia Institute of Himalayan Geology were collaborating with many institutions to publish their publications, for example, 77 publications with the Indian Institute of Technology Roorkee, 74 publications with H.N.B. Garhwal University, 62 publications with the Indian Institute of Technology Kharagpur and 55 publications with Banaras Hindu University. The remaining contributions are less than 50 publications with other institutions.

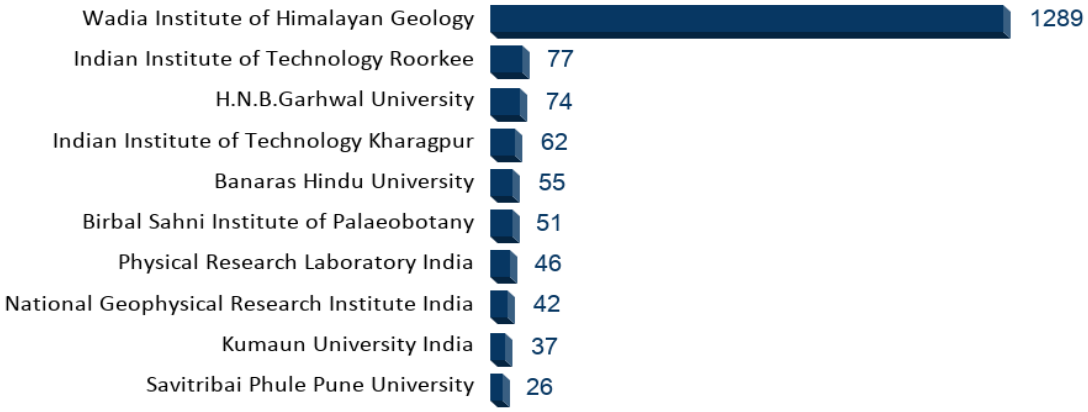


Figure 6. Highly collaborative Institutes

Top most funding Agency

Figure 7 shows the top ten most funding agencies in the Wadia Institute of Himalayan Geology during the study period. Further, it is clear from the finding that the top highly funded agency is the Department of Science and Technology, Government of Kerala, with contributions for 94(20.17%) of all documents and followed by the Department of Science and Technology,

Ministry of Science and Technology, India 66(14.16 %) of all documents. Science and Engineering Research Board is the third highly funding agency with 22(4.72%) of all documents. These three funding agencies have contributed 40.31% of total papers. The remaining other top funding agencies have contributed 60.69% of all documents.

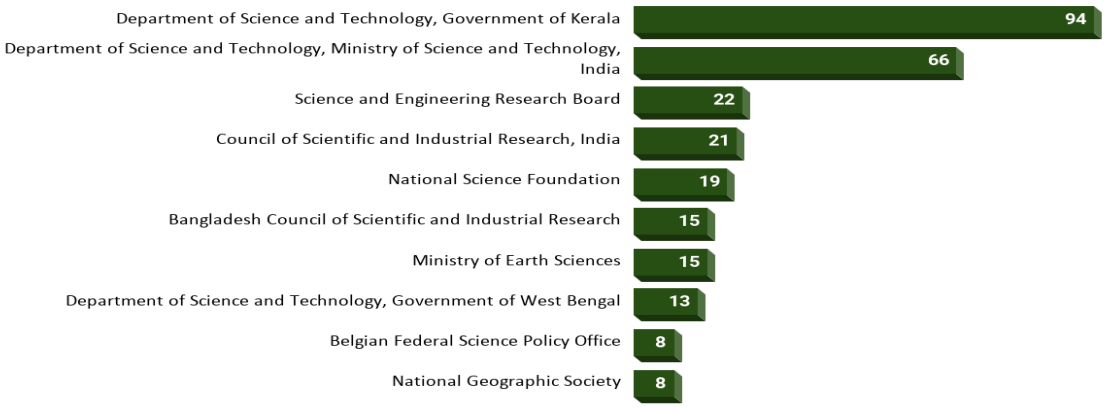


Figure 7. Top most funding Agency

Top cited documents in Wadia Institute of Himalayan Geology

Table 3 lists the ten most cited publications with affiliated authors, sources, publication year, and citations. These top ten publications attracted 2544(11.30%) of all citations. Citations perceived by a publication vary according to the time variables for which citations are given. These top-cited publications are published from only eight various sources. Here showed that "The Randolph Glacier Inventory: A globally complete inventory of glaciers" is the most highly cited publication by Pfeffer et al. from the Journal of Glaciology in 2014 with 515 citations. Followed by "Convergence across the northwest Himalaya from GPS measurements" by Banerjee, P., Burgmann, R. from Geophysical Research Letters in 2002 with 262 citations and "Uplift and convergence along the Himalayan Frontal Thrust of India" by Wesnousky et al. from Tectonics in 1999 with 244 citations. In this description, researchers found six highly journals whose citation is more significant than 200.

Table 3. Top cited documents in Wadia Institute of Himalayan Geology

Title	Authors	Year	Source title	Cit.
The Randolph glacier inventory: A globally complete inventory of glaciers	Pfeffer et al.	2014	Journal of Glaciology	515
Convergence across the northwest Himalaya from GPS measurements	Banerjee P., Burgmann R.	2002	Geophysical Research Letters	262
Uplift and convergence along the Himalayan Frontal Thrust of India	Wesnousky et al.	1999	Tectonics	244
Strontium isotopes and rubidium in the Ganga-Brahmaputra river system: Weathering in the Himalaya, fluxes to the Bay of Bengal and contributions to the evolution of oceanic 87Sr/86Sr	Krishnaswami et al.	1992	Earth and Planetary Science Letters	210
Extraordinary transport and mixing of sediment across Himalayan central Gondwana during the Cambrian-Ordovician	Myrow et al.	2010	Bulletin of the Geological Society of America	200
Whales originated from aquatic artiodactyls in the Eocene epoch of India	Thewissen et al.	2007	Nature	200
Integrated tectonostratigraphic analysis of the Himalaya and implications for its tectonic reconstruction	Myrow et al.	2003	Earth and Planetary Science Letters	197
Ion microprobe 207Pb/206Pb ages of zircons from the Bundelkhand massif, northern India: Implications for crustal evolution of the Bundelkhand-Aravalli protocontinent	Mondal et al.	2002	Precambrian Research	187
Glacier changes in the Garhwal Himalaya, India, from 1968 to 2006 based on remote sensing	Bhambri et al.	2011	Journal of Glaciology	179
Climate-related changes in peatland carbon accumulation during the last millennium	Charman et al.	2013	Biogeosciences	176

Note* Cit.= citations

Network visualizations of sources based on citation analysis

Figure 8a illustrates the connectivity of *current science* with other sources and figure 8b indicates the connectivity of all sources with different colors, which represent different clusters of sources. Out of 39 clusters with 1 minimum number of cluster size, cluster 1 represented by red colors consists of 48 sources including Geomorphology (31 documents, 161 links, 9846 total links strength), Scientific Reports (9 documents, 81 links, 1330 total links strength), Global and Planetary Change (5 documents, 98 links, 1351 total links strength), etc. and cluster 2 represented by green colored consists of 38 sources including Geological magazine(5 documents, 92 links, 1110 total links strength), journal of the palaeontological Society of India(5 documents, 58 links, 765 total links strength) and Journal of vertebrate paleontology (5 documents, 26 links, 449 total links strength), etc. Cluster 3 represented by blue-colored consists of 36 sources, including Journal of Asian earth science (67 documents, 178 links, 1886 total links strength), Geological journal(17 documents, 142 links, 5035 total links strength), and Precambrian research(9 documents, 102 links, 1496 total links strength), etc. and cluster 4 represented by yellow-colored consists of 31 sources including current science (156 documents, 212 links, 16939 total links strength), natural hazards(16 documents, 121 links, 3007 total links strength) and pure & applied geophysics(9 documents, 109 links, 2890 total links strength), etc.

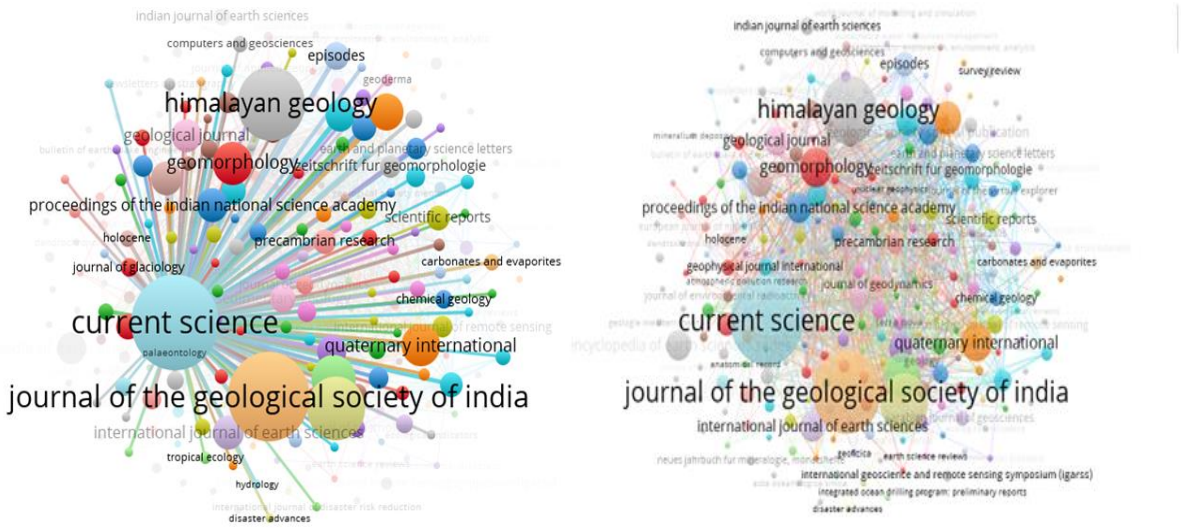


Figure 8a. Current science links with other sources & 8b. Network visualizations of citation analysis of source

Forms distribution of Publications

Interpretation of datasheet, the researchers depicts the types of publications as well as a datasheet. i.e., articles (1149, 89.14%) are important documents and followed by conference paper (56, 4.34%), review (24, 1.86%), and remains others note, letter, book chapter, editorial, erratum, and book. According to the researchers, this Institute has essential documents in articles (89.14%).

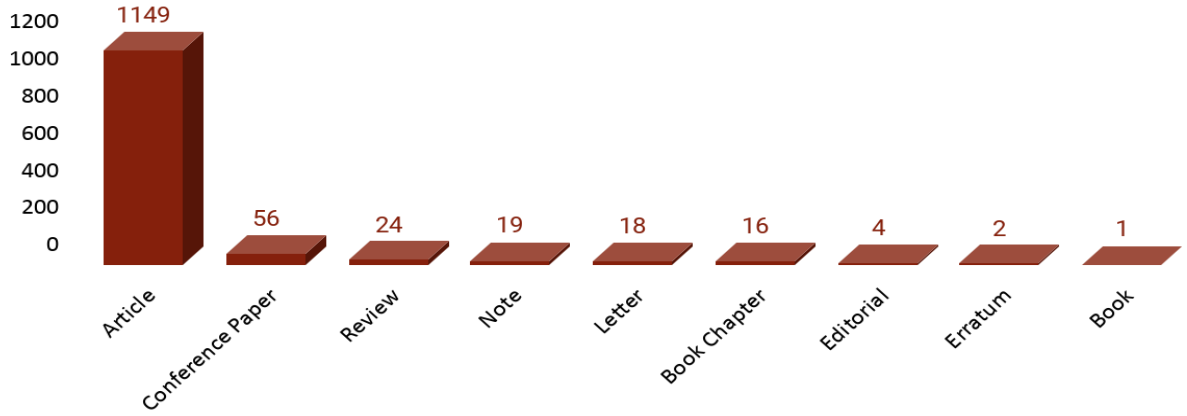


Figure 9. Forms distribution of Publications

Occurrence analysis of keywords

Keywords are more credible parts of any publication, and sometimes it is more reasonable for citations. All publications have some prominent keywords to show their technical view of publications. As per the figure, the researcher interprets that "Himalaya," with 126 occurrences, is the more preferred and more linked keyword. Its connectivity with other keywords shown in figure 10a. The connectivity of all keywords shown in figure 10b with different colors represents different clusters. Out of 2685 keywords, with 5 minimum numbers of keywords, 113 meet the thresholds within 7 clusters with 12 minimum items. Cluster 1 is represented by a red color that primarily deals with concepts like 'Himalaya' (67 links, 142 total link strength, & 126 occurrences), 'seismic hazard' (11 links, 16 total link strength, & 9 occurrences), 'seismicity' (6 links, eight total links strength & 6 occurrences) and others, Cluster 2 is represented by green colors that deals with the concepts like 'geochemistry' (30 links, 57 total link strength, & 39 occurrences), 'eastern Himalaya' (12 links, 23 total link strength, & 23 occurrences), 'petrogenesis' (11 links, 21 total link strength, & 12 occurrence) and others. Cluster 3 is represented by blue color dealing with concepts like 'active tectonics' (17 links, 24 total link strength, & 13 occurrences), 'Kumaun Himalaya' (12 links, 14 total link strength, & 12 occurrences), 'earthquake' (7 links, 9 total link strength, & 12 occurrence) and others. And other clusters are represented by different colors with different concepts of keywords.

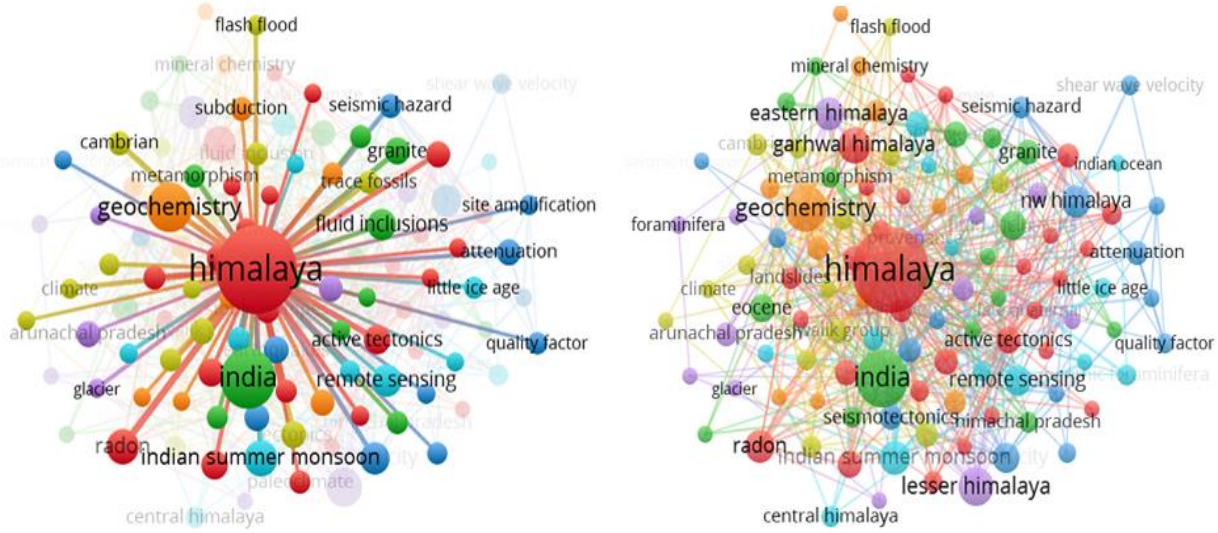


Figure 10a. cluster where 'Himalaya' is the most relevant term

Figure 10b. Network Visualizations of occurrence analysis of keywords.

Conclusion and Discussion

This study aims to conduct a bibliometric analysis of the Wadia Himalayan Institute of Geology's research productivity in 1991-2020. It indicates an increasing trend in research productivity as well as a citation with fluctuating trends. It is also observed that single authors mainly researched in the starting years, but later on, joint authorship has taken over in terms of the number of publications. Srivastava P is the most prolific author, whose citation is also very high compared to other collaborative authors. The WIHG has a majority of collaboration with many IITs like IIT Roorkee, IIT Kharagpur, and central universities such as HNBGU, BHU, etc., and with many foreign countries like the USA, Germany, and Australia, etc. According to this study, this Institute has some major research strengths, for example, Earth and Planetary Sciences and Multidisciplinary, etc. The primary research publications of Wadia Institute were published in the Current Science journal, whose h-index is 110 with 0.24 SJR established position in the second Quartile. It is an autonomous institute under the Department of Science and Technology, MOC, GOI. Therefore, funding issues are solved by the Government of India

and the Department of Science and Technology, Government of Kerala. It was noticed that most of the researchers of this Institute preferred to publish their research work in journals, which are the premier medium of information dissemination.

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