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A Scientometric Assessment of Indian Himalayan R&D Publications during 2004-13

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Abstract

The paper analyses 9909 global and 4862 Indian Himalayan R&D publications, as covered in Scopus database during 2004-13. It compares the contribution, citation impact and international collaborative publications share of top 10 most productive countries, and the place of India among them. It mainly examines Indian output, with a focus its annual average growth rate (13.21%), citation impact per paper (1.86%), distribution of citations (with 62.40% publications received one or more citations), share of international collaborative papers (16.29%) and contribution of leading collaborative countries, distribution of output by broad subject areas, publication productivity and citation impact of thirty leading institutions and authors; media of communications and characteristics of highly cited papers. The paper stresses the need for developing a national policy for Himalayan R&D, which will help in increasing the output, raising the research quality and in increasing international collaborative output.

Keywords: Himalaya, R&D, India, Publications, Scientometrics, Bibliometrics

1. Introduction

The Himalaya region consists of series of parallel and converging mountain ranges forming the highest mountain region (with more than 30 peaks above 25000 ft) in the world. and extends over 3500 km^2 length and cover an area of 43 lakh km^2 across the countries of Afghanistan, Pakistan, China, India, Nepal, Bhutan, Bangladesh and Myanmar. This region is highly rich in natural resources, but is still considered as underdeveloped with poor infrastructure [1].

The Indian Himalayan region (IHR) has a wide width (with 250-300 km at its widest part with an average width of 80 Km.) stretches over 2,500 km and covers partially/fully twelve states of India, viz., Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya and hills of Assam & West Bengal. It is inhabited by 3,96,28,311 people from multiple ethnic compositions and representing different cultural and biological diversity, representing about 16.2%

of total area and 3.86% of total population of India, respectively. Natural geological wealth, forestry, wild life, flora, fauna and biodiversity, snow, ice and water bodies, traditional knowledge and mountain agriculture which characterize the region are special [1-2].

The Himalayan mountain range, developed in a series of stages 30 to 50 million years ago, was the result of collision of India with Asia along the convergent boundary. There were powerful earth movement between the Indo-Australian plate and the Eurasian plate that resulted in the creation of Himalayan range. The earth movements raised the deposits laid down in the ancient, shallow Tethys Sea (on the present site of the mountains) to form the Himalayan ranges. The collision of India and Asia was due to mechanics below the earth surface. There are various plates that collide, recede and slide from each other at about 2cm/per year. This action beneath the earth's surface leads to the rising of Himalayas by about 5 mm per year. The height and width of the mountain will change according to the action beneath the earth's surface. The region is also characterized by its geological phenomena and hazards of natural disasters like drought, floods, cyclones , landslides and frequent earthquakes [3].

The Himalaya has vast area under permanent snow cover and glaciers (estimated to be 33,000 km2 and about 17% of IHR), and about 30-40% under seasonal snow cover, form a unique water reservoir. The glaciers provide estimated 8.6x106 m3 of water annually, feeding many rivers, that provide water for drinking, irrigation, and hydropower.[1-2].

The Himalayas are a globally recognized biodiversity hotspot, a repository of the most amazing biodiversity and a wealth of other resources, a source of valuable medicinal & food plants, rare and beautiful animal species. The region serves as a rich repository of plant and animal wealth in diverse ecological systems [6]. More than 41.5% of IHR is under forests representing one-third of the total forest cover in India. The IHR is a storehouse of several species (including rare & valuable species) of medicinal & aromatic plants. A bio-geographically unique region, with vast of its range of altitudes, it provides diverse agro-climatic conditions that support about 8000 species of flowering plants, i.e., nearly 50% (of which 30% are endemic) of the total flowering plants of India. There are over 816 tree species, 675 edibles and nearly 1748 species of medicinal value in the IHR. In addition, different parts such as roots, tubers, fruits, flowers, seeds and leaves/fronds of over 200 species of medicinal plants are consumed either raw, roasted, boiled, fried, cooked or in the from of oil, spice and seasoning materials, jams, pickles, etc. Most species form supplementary/substitute food at the time of scarcity. Many medicinal plants in the IHR have multipurpose use and about 81 medicinal plant species are also the source of important fatty and essential oils used for edible as well as industrial purposes [1-2, 4] .

In view of critical importance pf Indian Himalaya, the Indian Government Cabinet on 28 February 2014 approved the plan outlay of $55 million for India's National Mission for Sustaining the Himalayan Ecosystem (NMSHE), to be monitored under India's National Action Plan on Climate Change (NAPCC),

launched in 2008.. The primary objective of NMSHE is to develop a sustainable national capacity to assess the health status of the Himalayan ecosystem and enable policy bodies in their policy-formulation functions as also to assist States in the Indian Himalayan Region with implementation of actions selected for sustainable development. It will attempt to address the following issues: (i) Himalayan glaciers and associated hydrological consequences; (ii) Prediction and management of natural hazards; (iii) Biodiversity conservation and protection; (iv) Wild life conservation and protection; (v) Traditional knowledge societies and their livelihood; (vi) Capacity in regulation of science and critical peer evaluation to help governance issues related to sustenance of the Himalayan Ecosystem and (vii) Assist in restoration and rehabilitation process of Uttarakhand [5-6]

1.1 Literature Review

There are only few publications in Himalayan R&D. Among them, Sivasekaran and Srinivasaragava[7] examined 3841 global publications in Himalayan R&D during 2001-11, with a focus on its literature growth, authorship pattern, the extent of collaboration and identification of top 10 most productive institutions, authors and journals. Wang and Ma[8] coupled the bibliometrics and Geographical Information System (GIS) technologies and by using the spatial information mining and visualization techniques studied Qinghai-Tibet Plateau's region literature of China Himalayan region. However, there are many scientometric studies which are focused on various areas closely related to Himalayan R&D, such as plate tectonics[9], geographical information system [10-12], remote sensing [13-14], climate change [15-16], earthquakes [17], sediment related research in earth science[18], landslide [19], water resources [20], biodiversity [21-22] and medicinal plants [23-24]

2. Objectives

The main objectives of this study are to analyze the Indian research performance in Himalayan R&D during 2004-13, based on publications output, as indexed in Scopus database. In particular, the study focuses on the following objectives:

1. To study the global and Indian research output, its growth and citation impact
2. To study the contribution & citation impact of top 10 most productive countries;
3. To study the distribution of citations registered by Indian papers;
4. To study the international collaboration share in publication output of top 10 most productive countries and the extent of inter-country collaborative linkages between them;
5. To study the share of international collaborative papers in Indian research output and share of leading foreign collaborators in Indian research output;
6. To study the distribution of Indian research output by broad subject areas;
7. To study the publication productivity and citation impact of thirty leading institutions and authors;
8. To study the media of communications;
9. To study the characteristics of highly cited papers

3. Methodology

The study retrieved and downloaded the publication data of the world and of 10 most productive countries in Himalayan R&D from the Scopus database (http://www.scopus.com) for 10 years during 2004-13. The keyword "himalay*" was used in "title, abstract and keyword" tag and restricting it to the period 2004-13 in "date range tag" for searching the global publication data in the study and this was the main search string. Date on India and 9 other most productive countries were obtained, by restricting the main search string to "India" and other 9 most productive countries in "country tag", as shown below. When the main search string is further restricted to "subject area tag", "country tag", "source title tag", "journal title name" and "affiliation tag", we got information on distribution of publications by subject, collaborating countries, organization-wise and journal-wise, etc. For citation data, the three years, two years, one year citation window was used for publications during 2004-11, 2012 and 2013. In addition, citations of publications was also collected from date of publications till the end of June 2014 for sections on media of communication and high cited publications.

(TITLE-ABS-KEY(himalay*) AND PUBYEAR > 2003 AND PUBYEAR < 2014)

(TITLE-ABS-KEY(himalay*) AND PUBYEAR > 2003 AND PUBYEAR<2014 AND (LIMIT-TO (AFFILCOUNTRY, "India")))

4. Analysis

A total of 9909 and 4862 publications appeared globally and from India on Himalayan R&D during 2004-13, increasing from 580 and 254 in 2004 to 1474 and 757 in 2013, witnessing an annual average growth rate of 11.11% and 13.21%. Their cumulative output have increased from 3796 and 1695 during 2004-08 to 6113 and 3167 during 2009-13, registering a growth rate of 61.04% and 86.84%. The average citation per paper registered by global and Indian publications in Himalayan R&D was 3.01 and 1.86 during 2004-13, which decreased from 3.10 to 2.96 and increased in India from 1.81 to 1.88 from 2004-08 to 2009-13 (Table 1).

Table 1. Growth, Citation Impact and International Collaborative Share of World and India in Himalayan R&D during 2004-13

Publication Year/s	World			India				
	TP	TC	ACPP	TP	TC*	ACPP	ICP	%ICP
2004	580	1904	3.28	254	429	1.69	47	18.50
2005	655	1986	3.03	301	653	2.17	52	17.28
2006	771	2114	2.74	320	519	1.62	58	18.13
2007	886	2496	2.82	389	705	1.81	66	16.97
2008	904	3249	3.59	431	769	1.78	62	14.39
2009	946	3240	3.42	467	940	2.01	69	14.78
2010	1155	4598	3.98	595	1605	2.70	100	16.81
2011	1245	4930	3.96	683	1551	2.27	118	17.28
2012	1293	3664	2.83	665	1270	1.91	101	15.19
2013	1474	1677	1.14	757	592	0.78	119	15.72

2004-08	3796	11749	3.10	1695	3075	1.81	285	16.81
2009-13	6113	18109	2.96	3167	5958	1.88	507	16.01
2004-13	9909	29858	3.01	4862	9033	1.86	792	16.29
* Citations are collected on a three-years citation window								
TP=Total Papers; TC=Total Citations; ACPP=Average Citation Per Paper; ICP=International Collaborative Papers								

Of the total Indian publications on Himalayan R&D during 2004-13, 37.60% and did not receive any citation and 62.40% received one or more citations (since their publication till July 2014). Of the cited publications, 0.4% publications (receiving above 100 citations) contributed 4.48% citations, 1.07% publications (receiving citations from 51 to 100) contributed 13.39% citations, 1.71% publications (receiving citations from 31 to 50) contributed 12.56% citations, 11.48% publications (receiving citations from 11 to 30) contributed 35.42% citations and 48.00% publications (receiving citations from 1 to 10) contributed 34.15% citations. (Table 2) .

Table 2. Citations Received by Indian Publications in Himalayan R&D, 2004-13

No. of Citations	No. of Publications	Total Citations*	% Publications	% Citations
0	1828	0	37.60	0.00
1-10	2334	8768	48.00	34.15
11-30	558	9093	11.48	35.42
31-50	83	3225	1.71	12.56
51-100	52	3439	1.07	13.39
>100	7	1149	0.14	4.48
Total	4862	25674	100.00	100.00
* Citations are from date of publications till 20 July 2014				

4.1 Global Contribution & Citation Impact of Top 10 Most Productive Countries

The research output in Himalayan R&D originated in 113 countries during 2004-13, of which 69 countries published 1 to 10 papers, 12 countries 11 to 30 papers, 6 countries 31 to 50 papers, 10 countries 51 to 100 papers, 11 countries 101 to 500 papers, 2 countries 501 to 700 papers, 2 countries 1401 to 1800 papers and 1 country 4801 to 4900 papers. The global publication share of top 10 most productive countries in Himalayan R&D (Tables 3-4) varied from 2.83% to 49.07% during 2004-13, with highest share (49.07%) coming from India, followed by China (17.43%), USA (14.74%), U.K. (6.28%), Germany (5.08%), Nepal (3.81%), Japan (3.80%), France (3.70%), Canada (2.99%) and Pakistan (2.83%). The global publication share has increased by 7.16% in India and 0.69% in Pakistan, as against decrease by 1.82% in China, 1.73% in USA, 1.31% in Japan, 1.08% in France, 0.87% in Nepal, 0.69% in Canada, 0.46% in U.K and 0.40% in Germany from 2004-08 to 2009-13.

The global citation share of top 10 most productive countries in Himalayan R&D (Tables 3-4) varied from 2.28% to 30.25% during 2004-13, with highest share (33.87%) coming from USA, followed by India (30.25%), China (24.14%), U.K.(12.46%), France (8.46%), Germany (8.35%), Canada (6.35%), Japan (5.26%), Nepal (4.58%) and Pakistan (2.28%). The global citation share has increased by 6.73% in India, followed by 3.71% in China, 1.60% in Germany, 1.18% in Canada, 0.53% in Pakistan and 0.10% in France, as against decrease by 7.77% in Japan, 5.62% in USA and 1.55% in U.K. from 2004-08 to 2009-13.

Among top 10 most productive countries in Himalayan R&D during 2004-13, the highest (6.92) average citation per paper (ACPP) is achieved by USA, followed by France (6.89), Canada (6.40), U.K.(5.98), Germany (4.96), China (4.17), Japan (4.16), Nepal (3.62), Pakistan (2.43) and India (1.86) during 2004-13. The largest increase (1.71) in ACPP was reported by France, followed by Germany (1.11), Canada (0.96), China (0.88), Nepal (0.64) and India (0.07), as against decrease in Japan (3.96), followed by USA (0.64), U.K.(0.57) and Pakistan (0.14) from 2004-08 to 2009-13. Eight out of 10 most productive countries have achieved higher relative citation index (RCI)(1 and above) during 2004-13: USA (2.30), France (2.29), Canada (2.12), U.K. (1.98), Germany (1.64), China (1.39), Japan (1.38), Nepal (1.20), Pakistan (0.81) and India (0.62). The RCI index has increased by 0.66 in France, followed by Germany (0.43), Canada (0.40), China (0.35), Nepal (0.27) and India (0.05), as against decrease by 1.21 by Japan, USA (0.12), U.K.(0.10) and Pakistan (0.01) from 2004-08 to 2009-13 (Tables 3-4).

Table 3. Number of Publications and Citations and Average Citation per Paper of Top 10 Most Productive Countries in Himalayan R&D during 2004-13

S.No	Country	Number of Papers			Number of Citations			Average Citation per Paper		
		2004-08	2009-13	2004-13	2004-08	2009-13	2004-13	2004-08	2009-13	2004-13
1	India	1695	3167	4862	3075	5958	9033	1.81	1.88	1.86
2	China	704	1023	1727	2572	4636	7208	3.65	4.53	4.17
3	USA	600	861	1461	4340	5672	10112	7.23	6.59	6.92
4	U.K.	249	373	622	1574	2146	3720	6.32	5.75	5.98
5	Germany	202	301	503	867	1626	2493	4.29	5.40	4.96
6	Nepal	165	213	378	538	830	1368	3.26	3.90	3.62
7	Japan	175	202	377	1565	1005	1570	8.94	4.98	4.16
8	France	166	201	367	987	1540	2527	5.95	7.66	6.89
9	Canada	114	182	296	662	1233	1895	5.81	6.77	6.40
10	Pakistan	91	189	280	230	451	681	2.53	2.39	2.43
	World	3796	6113	9909	11749	18109	29858	3.10	2.96	3.01

Table 4. Share of Publications and Citations and Relative Citation Index of Top 10 Most Productive Countries in Himalayan R&D during 2004-13

S.No	Country	Share of Papers			Share of Citations			Relative Citation Index		
		2004-08	2009-13	2004-13	2004-08	2009-13	2004-13	2004-08	2009-13	2004-13
1	India	44.65	51.81	49.07	26.17	32.90	30.25	0.59	0.64	0.62
2	China	18.55	16.73	17.43	21.89	25.60	24.14	1.18	1.53	1.39
3	USA	15.81	14.08	14.74	36.94	31.32	33.87	2.34	2.22	2.30
4	U.K.	6.56	6.10	6.28	13.40	11.85	12.46	2.04	1.94	1.98
5	Germany	5.32	4.92	5.08	7.38	8.98	8.35	1.39	1.82	1.64
6	Nepal	4.35	3.48	3.81	4.58	4.58	4.58	1.05	1.32	1.20

7	Japan	4.61	3.30	3.80	13.32	5.55	5.26	2.89	1.68	1.38
8	France	4.37	3.29	3.70	8.40	8.50	8.46	1.92	2.58	2.29
9	Canada	3.00	2.98	2.99	5.63	6.81	6.35	1.88	2.28	2.12
10	Pakistan	2.40	3.09	2.83	1.96	2.49	2.28	0.82	0.81	0.81

4.2 International Collaboration

The international collaborative publications share of top 10 most productive countries in Himalayan R&D varied from 16.29% to 77.78% during 2004-13, with highest share (77.78%) coming from Nepal, followed by Pakistan (44.64%), U.K. (39.87%), France (38.96%), China (36.60%), Canada (33.11%), USA (32.51%), Japan (21.75%), Germany (21.47%) and India (16.29%). Among the inter-country collaborative links studied among these 10 countries during 2004-13, highest number of collaborative links (1040) were registered by USA, followed by China (679), India (644), UK (508) Germany (402), Nepal (311), France (309), Japan (285), Canada (284) and Pakistan (130) during 2004-13. Among inter-country collaborative linkages, the largest number (278) are between China-USA, followed by India-USA (232), USA-UK (128), India-Germany (103), China-UK (100), USA-France (85), India-UK (84), China-Germany (80), USA-Germany (78), USA-Canada (73), USA-Nepal (70), India-Japan (61), Japan-Nepal (60), etc. Among the India's major foreign collaborative partners, the largest contribution (31.82% share) comes from United States, followed by Germany (13.01%), U.K. (10.61%), Japan (7.70%), Canada (5.68%), Netherlands and Nepal (5.56% each), Australia and France (4.67% each), Italy (4.17%), China (3.91%), Norway (3.54%), Switzerland (2.78%), and Sweden and Taiwan (2.02% each) (Table 5)

Table 5. Inter-Country Collaborative Links among Top 10 Most Productive Countries in Himalayan R&D during 2004-13

	IND	CHI	USA	UK	GER	NEP	JAP	FRA	CAN	PAK	Total
IND		31	232	84	103	44	61	37	45	7	644
CHI	31		278	100	80	27	54	50	54	5	679
USA	232	278		128	78	70	52	85	73	44	1040
UK	84	100	128		47	36	17	31	38	27	508
GER	103	80	78	47		21	12	29	19	13	402
NEP	44	27	70	36	21		60	33	18	2	311
JAP	61	54	52	17	12	60		7	8	14	285
FRA	37	50	85	31	29	33	7		24	13	309
CAN	45	54	73	38	19	18	8	24		5	284
PAK	7	5	44	27	13	2	14	13	5		130
Total	644	679	1040	508	402	311	285	309	284	130	

IND=India, CHI=China; USA=United States; U.K.=United Kingdom; GER=Germany; NEP=Nepal; JAP=Japan; FRA=France; CAN=Canada and PAK=Pakistan

4.3 Subject-Wise Distribution

The India's publication output in Himalayan R&D during 2004-13 has been published in the context of eight sub-fields (as reflected in database classification based on journal title subject), with highest

publication output coming from agricultural & biological sciences (1786 papers, 36.73% share), followed by earth & planetary sciences (1584 papers, 32.58% share), environmental science (927 papers, 19.07% share), biochemistry, genetics & molecular biology (455 papers, 9.36% share), medicine (356 papers, 7.32% share), engineering (248 papers, 5.10% share), pharmacology, toxicology & pharmaceutics (245 papers, 5.04% share) and immunology & microbiology (182 papers, 3.74% share) during 2004-13. It was observed that research activity has decreased in terms of activity index in three sub-fields: agricultural & biological sciences, earth & planetary sciences and immunology & microbiology, as against increase in: environmental science, biochemistry, genetics & molecular biology, medicine, engineering and pharmacology, toxicology & pharmaceutics from 2004-08 to 2009-13. Immunology & microbiology had scored the highest citation impact per paper of 2.91, followed earth & planetary sciences (2.50), medicine (1.93), biochemistry, genetics & molecular biology (1.84), pharmacology, toxicology & pharmaceutics (1.82), environmental science (1.66), agricultural & biological sciences (1.52) and engineering (0.84) during 2004-13 (Table 6).

Table 6. Subject-Wise Distribution of Indian Publications Output in Himalayan R&D during 2004-13

S.No.	Subject Area	Total Papers (TP)			Activity Index		TC	ACPP	h-index	%TP
		2004-08	2009-13	2004-13	2004-08	2009-13	2004-13	2004-13	2004-13	2004-13
1	Agricultural & Biological Sciences	697	1089	1786	111.94	93.61	2714	1.52	2714	36.73
2	Earth & Planetary Sciences	566	1018	1584	102.50	98.66	3955	2.50	46	32.58
3	Environment Science	318	609	927	98.40	100.86	1541	1.66	25	19.07
4	Biochemistry, Genetics & Molecular Biology	126	329	455	79.43	111.01	837	1.84	18	9.36
5	Medicine	90	266	356	72.52	114.71	687	1.93	15	7.32
6	Engineering	82	166	248	94.84	102.76	208	0.84	12	5.10
7	Pharmacology, Toxicology & Pharmaceutics	31	214	245	36.29	134.10	447	1.82	14	5.04
8	Immunology & Microbiology	68	114	182	107.17	96.16	529	2.91	20	3.74
	Total of the country	1695	3167	4862						
TP=Total Papers; TC=Total Citations; ACPP = Average Citations Per Paper										

4.4 Keyword Analysis

Important keywords were identified (as listed in Table 7), which through light on the type of research carried out under different subject fields in Himalayan R&D. Among various keywords, the largest publications (238) were reported on earthquake, followed by medicinal plants (228), remote sensing (202), climate change (173), biodiversity (157), plant extract (139), satellite data or imaginary (137), landslide (135), bacteria (132), glacier (132), tectonics (125), animals (121), essential oils (116), conservation (115), seismicity (104), diversity (104), phylogeny (99), monsoon (97), soils (94), deformation-land (92), phyto-chemistry (89), plant leaf (89), geographical information system (GIS)(88), landforms (86), chemical composition-plant (84), triticum aestivum (83), tectonic setting (81), watersheds (80), plant root (79),

biomass (77), sedimentology (75), rivers (73), new species-biology (72), rain (72), snow (70), hazard assessment (67), geomorphology (64), paleo-climatology (64),seismology (63), herbs (62), tectonic evolution (59), erosion (59), seismic hazard (58), Indian plate (57), forestry (56), genetics (56), quaternary (52), etc

Table 7. Important Keywords in Himalayan R&D during 2004-13

Broad Subject Field	Name of Keywords along with their Publication Output
Agriculture	Agricultural ecosystem (15), Agroforstry (12), Crop production (36), Crop practice (14), Crop Specific–Maize (53), Rice (30) and Wheat (39), Farming system (12), Harvesting (29), Rainfed agriculture (14), Traditional agriculture (10) Vegetation (41), vegetables (12)
Animals	Animals (121),Animal disease (8), Animal husbandry (13), Animal genetics (9), Animal species conservation (7), Animal species diversity (13), Animals – Specific- Aves (41), Birds (17), Mammals (28), Reptiles (5) and Sheep (14), Fodder (16), Habitat conservation (18), Livestock (31), Livestock farming (8) and Wildlife management (12)
Biology	Biodiversity (156), Conservation (115), Genetics (56), Genetics, Molecular (24), Genetics, Population (21) , Genetic diversity (46), Genetic markers (21), Genetic resource (51), Genetic variability (51), Species, Endangered (41), Species, New (66), Species diversity (104)
Climate	Climate (48), climatology (16), Climate change (173), Climate effect (35), Climate modeling (13), Climate variation (31), Monsoon (55), Paleoclimate (53), Precipitation (Climatology)(27)
Earth	Earthquake (238), Geochemistry (55), Geochrology (45), Geomorphology (64), Geophysics (20), Hydrogeology (23), Hydrochemistry (11), Hydrological hazard (10), Hydrological modeling (29), Hydrology (29), Lithology (45), Meta-sedimentary rocks (8), Neotectonics (42), Plate tectonics (15), Quaternary (45), Sediment chemistry (20), Sediment transport (31), Sedimentary rocks (9) Sedimentary structure (9), Sedimentation (38), Sedimentology (75), Sediments (46), Seismic attenuation (33), Seismic hazard (58), Seismic source (20), Seismicity (104), Seismology (63), Seismotectonics (45), Structural geology (51), Tectonic evaluation (59), Tectonic setting (81), Tectonic structure (14) Tectonics (125)
Ecology & Environment	Ecology (34), Ecosytem (42), Environmental impact (30), Environment monitoring (37), Environment protection (44), Forest ecosystem (280. Sustainable development (44)
Energy	Energy (12), Fuelwood (20), Energy policy (7), Energy resources (8), Hydroelectric power (24), Renewable energy resources (8)
Forestry	Forestry (56), Agroforestry (29), Biomass (45), Deforestation (19), Forest cover (21), Forest ecosystem (28), Forest management (28), Fuelwood (12), Specific Forestry Trees – Abies pindrow (12), Cedrus deodara (29), Coniferous forest (29), Conferophyta (18), Deciduous forest (20), Phylogenetic tree (13), Pinus oroxburghii (38), Pinus wallichiana (19), Quercus floribunda (10), Quercus leucotri chophora (34), Rhododentron arboseum (14), Species diversity (42)

Glacier	Glacier (132), Avalanches (51), Glacier dynamics (18), Glacier geology (15), Glacier hydrology (7), Glacier retreat (22), Specific glacier – Gangotri (28) and Siachen (9)
Hazards	Hazard assessment (67), Flood hazard (25), Lake hazard (10),
Land	Land cover (33),Land deformation (83), Land degradation (12), Land use (52), Landforms (88), Landscape (52), Landslide (135),
Minerals	Minerals (16), Calcium (19), Cadmium (10), Chromium (9), Clay minerals (7), Heavy metals (22), Lucustrine deposits (29), Lead (15), Magnesium (18), Rare earth elements (19), Silicate minerals (20), Uranium (6), Zink (26), Zircon (36)
Plants	Bacteria (132), Botany (55), Ethno-botany (36), Chemical compound structure (45), Consevation (70), Chemical Composition (84), Drug Isolation (44), Essential oils (1160, Fatty acids (22), Fruits (33), Fungi (77), Genetic diversity (46), Genetic variability (31), Herbs (62), Medicinal plants (228), Microbiology (20), Phytochemistry (83), Phylogeny (99), Physiology (30), Plant diversity (46), Plant extract (139), Plant leaf (89), Plant root (79), Plant species diversity (45), Plant species, Endangered (41), Plant seed (30), Shrubs (24), Specific Plants-Tea (21) and Texus wallichiana (22), Triticum aestivum (83), Toxonomy (80), and Volitile oils (22)
River	River (73), River basin (29), River pollution (13), River water (24), Specific Rivers – Alkanda (10),), Beas (34), Bhagirathi (11), Brahmaputra (230, Chenab (19),. Ganges (33), Indus (28),), Jhelum (13), Ravi (8) Sutlej (17) and Yamuna (18)
Soils	Soils (94), Soil conservation (24), Soil erosion (58), Soil fertility (18), soil mechanics (15), soil microbiology (48), Soil organic matter (25)
Snow	Snow (70), Snow cover (43), Snowmelt (27), Snow slides (Avalanche)(15)
Water	Water catchments (39), Water chemistry (24), Water conservation (11), Water quality (59), Water management (31), Water pollution (22), Water resources (46), Water supply (13), Water, Ground (43) and Watersheds (33), Water sources (41) – Catchments (39), Lakes (33), Rain (33), Rainfall (33), Reservoirs (13), River water (254), Springs (10)
Others	Geographical information system (89), Satellites data or imaginary (137), Remote sensing (202)

4.6 Institutional Contribution

Among major Indian organizations contributing to Himalayan R&D, the largest publication output and share (2473 papers, 50.86%) comes from 68 research institutions during 2004-13, followed by 46 universities & colleges (1711 papers, 35.19%), 10 Institutes of national importance (462 papers, 9.50%), 3 medical colleges (67 papers, 1.38%), 3 engineering colleges (56 papers, 1.15%) and 3 non-governmental organizations (49 papers, 1.0%).

4.7 Profile of Top 30 Most Productive Organizations in Himalayan R&D

The Indian Himalayan R&D research output was published from several organizations, of which the top 30 have published 50 to 345 each and together contributed 67.81% share (3297 papers) in its total output during 2004-13. The scientometric profile of these 30 Indian organizations is presented in Table 6. Nine organizations have registered higher output than the group average productivity per organization (109.9): WIHG- Dehradun with 345 papers, followed by GBPIHED-Kosi-Katarmal, (289 papers), HNBGU-Sringar, (252 papers), IIT- Roorkee (225 papers), KUMU-Nainital (220 papers), UNIVD-Delhi (181 papers), NGRI- Hyderabad (126 papers), UNIVK-Srinagar (120 papers) and IHBT-Palampur (115 papers) during 2004-13. Thirteen organizations have registered higher citation impact than the group average of 2.07: IISc-Bangalore with citation impact per paper of 5.25, followed by PRL-Ahmedabad (4.64), ISRO-Bangalore (3.65), UNIVD-Delhi (3.15), NGRI-Hyderabad (3.13), VIHA-Almora (2.58), WIHG-Dehradun (2.41), IIT-Kharagpur (2.41), WII-Dehradun (2.33), IHBT-Palampur (2.27), JNU-New Delhi (2.25), UNIVL-Lucknow (2.23) and IIT), Mumbai (2.10) during 2004-13.

Twelve organizations have achieved higher h-index value than the group's average of 12.67: WIHG-Dehradun with h-index value of 25, followed by IIT-Roorkee (21), UNIVD- Delhi (20), BPIHED-Kosi-Katarmal (19), PRL- Ahmedabad, ISRO-Bangalore and NGRI-Hyderabad (17 each), IHBT-Palampur (15), VIHA- Almora, JNU-New Delhi and HNBGU- Sringar (14 each and KUMU- Nainital (13) during 2004-13. Sixteen organizations have achieved higher international collaborative papers (ICP) share than the group's average of 15.29%: UNIVD-Delhi with ICP share of 34.25%, followed by IISc-Bangalore (30.19%), IIT- Mumbai (28.40%), PRL- Ahmedabad (25.37%), IIT - Roorkee (23.56%), GSI - Kolkata (22.54%), WII - Dehradun (22.41%), NGRI – Hyderabad and JNU - New Delhi (22.22% each), PANJU–Chandigarh (20.0%),WIHG–Dehradun (18.55%), IIT – Kharagpur (17.39%), BHU-Vararanasi (17.14%), UNIVL- Lucknow (16.98%), GNPUAT- Pantnagar (16.67%) and BSIP- Lucknow (15.85%) during 2004-13. Five organizations have registered relative citation index more than 1 and 12 organizations more than the average (0.70) of all organizations: IISc - Bangaloreof 1.74, followed by PRL-Ahmedabad (1.54), ISRO- Bangalore (1.21), UNIVD- Delhi (1.05), NGRI- Hyderabad (1.04), VIHA- Almora (0.86), WIHG-Dehradun and IIT- Kharagpur (0.80 each), WII- Dehradun (0.77), JNU- New Delhi and IHBT-Palampur, (0.75 each) and UNIVL- Lucknow (0.74) during 2004-13.

The largest number of national collaborative linkages (140) is registered by WIHG-Dehradun (with 60 organizations), followed by HNBGU- Sringar (130 linkages with 55 organizations), GBPIHED-Kosi Katarmal (110 linkages with 58 organizations), ISRO-Bangalore (91 linkages with 25 organizations), IIT-Roorkee (89 linkages with 35 organizations), UNIVD-Delhi (84 linkages with 27 organizations), KUMU-Nainital (71 linkages with 30 organizations), PRL-Ahmedabad (45 linkages with 38 organizations), NGRI-Hyderabad (42 linkages with 24 organizations), IARI-New Delhi (40 linkages with 27 organizations), JNU-New Delhi (38 linkages with 20 organizations), IIT-Kharagpur (38 linkages with 30 organizations), Institute of Himalayan Bioresource Technology, Palampur, H.P.(35 linkages with 30 organizations), etc.

Among inter-institutional collaborative linkages, the largest (27) are between GBPIHED-Kosi Katarmal - UNIVD-Delhi (27), followed by IIT-Roorkee – National Institute of Hydrology, Roorkee (24), WIHG-Dehradun-HNBGU- Sringar (21), UNIVD-Delhi – JNU-New Delhi (20), GBPIHED-Kosi Katarmal - HNBGU- Sringar (19), GBPIHED-Kosi Katarmal–JNU-New Delhi (16), WIHG-Dehradun - IIT-Roorkee (16), GBPIHED-Kosi Katarmal - KUMU-Nainital (13), WIHG-Dehradun - University of Pune (13), ISRO-Dehradun - Aryabhatta Research Institute of Observational Sciences, Nainital (13), HNBGU- Sringar- UNIVD-Delhi (12), GBPIHED-Kosi Katarmal – State Biotechnology Programme, Uttrachal (12), UNIVD-Delhi – IIT-Kanpur (12), ISRO-Bangalore – IISc-Bangalore (11), PRL-Ahmedabad – WIHG-Dehradun (10), VIHA-Almora – IARI – New Delhi (11) , ISRO-Bangalore – IISc-Bangalore (11), WIHG-Dehradun - BSIP-Lucknow (10), GBPIHED-Kosi Katarmal – Himachal Pradesh University (9), WIHG-Dehradun – NGRI-Hyderabad (9), HNBGU- Sringar – ISRO-Bangalore (8), IIT-Roorkee – BHU-Varanasi (8), IIT-Roorkee – CBRI-Roorkee (8), NBRI-Lucknow-University of Lucknow (8), IARI-New Delhi – VIHA-Almora (8), IISC-Bangalore- Aryabhatta Research Institute of Observational Sciences, Nainital (8), VIHA-Almora –Indian Institute of Soil Science (8), HNBGU-Srinagar – Mizoram University (7), IIT-Kharagpur – NGRI-Hyderabad (7), etc.

Table 8. Scientometric Profile of Top 30 Most Productive Indian Organizations in Himalayan R&D during 2004-13

S.No.	Name of Organization	Abreviation of the Organization	TP	TC	ACPP	ICP	%ICP	HI	RCI	COLL (NO)
1	Wadia Institute of Himalayan Geology, Dehradun	WIHG-Dehradun	345	833	2.41	64	18.55	25	0.80	140(60)
2	G B Pant Institute of Himalayan Environment & Development, Kosi-Katarmal, Almora,	GBPIHED-Kosi Katarmal	289	464	1.61	25	8.65	19	0.53	110(58)
3	H N Bahuguna Garhwal University, Sringar, Uttaranchal	HNBGU- Sringar	252	349	1.38	25	9.92	14	0.46	130 (55)
4	Indian Institute of Technology, Roorkee	IIT-Roorkee	225	449	2.00	53	23.56	21	0.66	89(35)
5	Kumaun University, Nainital, Uttaranchal	KUMU-Nainital	220	292	1.33	23	10.45	13	0.44	71(30)
6	University of Delhi	UNIVD-Delhi	181	570	3.15	62	34.25	20	1.05	84(27)
7	National Geophysical Research Institute, Hyderabad	NGRI-Hyderabad	126	395	3.13	28	22.22	17	1.04	42(24)
8	University of Kashmir , Srinagar	UNIVK-Srinagar	120	186	1.55	16	13.33	9	0.51	32(23)
9	Institute of Himalayan Bioresource Technology, Palampur, H.P.	IHBT-Palampur	115	261	2.27	6	5.22	15	0.75	35(30)
10	Indian Space Research Organization , Bangalore	ISRO-Bangalore	92	336	3.65	4	4.35	17	1.21	91(25)
11	Punjabi University, Patiala	PUNJU-Patiala	89	155	1.74	1	1.12	9	0.58	11(8)
12	Birbal Sahni Institute of Paleobotany, Lucknow	BSIP-Lucknow	82	165	2.01	13	15.85	12	0.67	37(24)
13	Indian Institute of Technology, Mumbai	IIT-Mumbai	81	170	2.10	23	28.40	11	0.70	27(21)
14	National Botanical Research Institute, Lucknow	NBRI-Lucknow	77	136	1.77	4	5.19	11	0.59	34(24)
15	Dr Yashwant Singh Parmar University of Horticulture & Forestry, Solan, H.P.	DYSPUHF-Solan	72	29	0.40	4	5.56	7	0.13	26(22)
16	G B Pant University of Agriculture & Technology, Pantnagar, Uttaranchal	GNPUAT-Pantnagar	72	105	1.46	12	16.67	8	0.48	30(22)
17	Jawaharlal Nehru University, New Delhi	JNU-New Delhi	72	162	2.25	16	22.22	14	0.75	38(20)
18	Geological Survey of India, Kolkata	GSI-Kolkata	71	110	1.55	16	22.54	10	0.51	18(16)
19	Banaras Hindu University, Vararanasi,	BHU-Varanasi	70	110	1.57	12	17.14	9	0.52	33(26)

	Uttar Pradesh									
20	Indian Institute of Technology, Kharagpur, West Bengal	IIT-Kharagpur	69	166	2.41	12	17.39	12	0.80	38(30)
21	Vivakand Institute of Hill Agriculture, Almora, Uttranchal	VIHA-Almora	69	178	2.58	5	7.25	14	0.86	27(14)
22	Physical Research Laboratory, Ahmedabad, Gujarat	PRL-Ahmedabad	67	311	4.64	17	25.37	17	1.54	45(28)
23	CSK Himachal Pradesh Krishi Viswavidalaya, Palampur, H.P	CSKHPKV-Palampur	67	68	1.01	5	7.46	9	0.34	28(28)
24	Indian Agricultural Research Institute, New Delhi	IARI-New Delhi	59	111	1.88	3	5.08	9	0.62	40(27)
25	Wildlife Institute of India, Dehradun	WII-Dehradun	58	135	2.33	13	22.41	12	0.77	23(16)
26	University of Lucknow, Lucknow	UNIVL-Lucknow	53	118	2.23	9	16.98	11	0.74	30(21)
27	Indian Institute of Science, Bangalore	IISc-Bangalore	53	278	5.25	16	30.19	11	1.74	30(21)
28	Snow and Avalanche Study Establishment, Chandigarh	SASE-Chandigarh	51	71	1.39	4	7.84	9	0.46	18(13)
29	National Bureau of Plant Genetic Resources, New Delhi	NBPGR-New Delhi	50	38	0.76	3	6.00	6	0.25	25(25)
30	Panjab University, Chandigarh	PANJU-Chandigarh	50	83	1.66	10	20.00	9	0.55	24(22)
	Total papers		3297	6834	2.07	504	15.29	12.67	0.70	
	Total of the country		4862							
	Share of top 30 organizations in the country total		67.81							
TP=Total Papers; TC=Total Citations; ACPP = Average Citations Per Paper; RCI=Relative Citation Index; HI=h-indexCOLL (NO)=Collaborative linkages among top 30 organizations with (Number of Organizations)										

4.8 Profile of Top 30 Indian Authors in Himalayan R&D

The Indian Himalayan R&D research output was published from several authors, of which the top 30 have published 22 to 53 each and together contributed 17.07% share (830 papers) to its total output during 2004-13. The scientometric profile of these 30 Indian authors is presented in Table 9. Ten authors have registered higher output than the group average productivity per author (27.67): R.K..Maikhuri with 53 papers, followed by H.S.Gupta (49 papers), K. S. Rao (34 papers), A.K. Srivasatava (32 papers), R.S.Verma (31 papers), G. Venkataraman (30 papers) and G. S. Rawat, A. Pandey, S. J. Sangode and S. Kundu (28 papers each) during 2004-13. Fourteen authors have registered higher citation impact than the group average of 2.13: T. Ahmad with citation impact per paper of 4.68, followed by S. Kundu (4.07), V. Prakash (3.77), M.K. Arora (3.57), H.S.Gupta (2.96), R.C. Padalia (2.91), A. Pandey (2.89), A. Chauhan (2.74), R.S.Verma (2.71), L.M.S.Palni (2.67), C.M. Sharma (2.46), B. Singh (2.44), P.S. Ahuja (2.19) and J. C. Kuniyal (2.15) during 2004-13. Eleven authors have achieved higher h-index value than the group's average of 8.16: B.P.Bhatt with h-index value of 19, followed by M.K. Arora and H.S.Gupta (13 each), S. Kundu (12), V. Prakash, A. Pandey and S. J. Sangode (10 each), T. Ahmad, R.S.Verma and K. S. Rao (9 each), and R.K..Maikhuri (9) during 2004-13. Thirteen organizations have achieved higher international collaborative papers (ICP) share than the group's average of 13.01%: T. Ahmad with ICP share of 90.91%, followed by K. S. Rao (29.41%), G. Venkataraman (26.67%), M.K. Arora (26.09%), R.K..Maikhuri (18.87%), V. Prakash (18.18%), S. Kundu and S. J. Sangod (17.86% each), U.Dhar (17.39%), A.K. Srivasatava (15.63%), D. K. Uprati (14.81%), A. Pandey (14.29%) and G. S. Rawat (14.29%) during 2004-13. Only 14 authors received more than the average value of relative index (0.37) of all authors: T. Ahmad

with relative citation index of 0.91, followed K. S. Rao (0.71), G. Venkataraman (0.64), M.K. Arora (0.53), R.K..Maikhuri (0.53), V. Prakash (0.52), S. Kundu (0.51), S. J. Sangode (0.51), U.Dhar (0.46), A.K. Srivasatava (0.42), D. K. Uprati, A. Pandey and G. S. Rawat (0.40 each). and R.S. Rawal (0.38) during 2004-13.

Table 9. Scientometric Profile of Top 30 Most Productive Indian Authors in Himalayan R&D during 2004-13

S.No.	Name	Affiliation	TP	TC	ACPP	ICP	%ICP	HI	RCI
1	R.K..Maikhuri	G B Pant Institute of Himalayan Environment & Development (GBPIHED), Kosi-Katarmal, Almora	53	84	1.58	10	18.87	9	0.53
2	H.S.Gupta	Vivakand Institute of Hill Agriculture (VIHA), Almora, Uttranchal	49	145	2.96	5	10.20	13	0.91
3	K. S. Rao	University of Delhi, Centre for Indisciplinary Studies, Delhi	34	67	1.97	10	29.41	9	0.42
4	A.K. Srivasatava	Vivakand Institute of Hill Agriculture (VIHA), Almora, Uttranchal	32	48	1.50	5	15.63	8	0.30
5	R.S.Verma	Central Institute of Medicinal & Aromatic Plants (CIMAP), Lucknow	31	84	2.71	0	0.00	9	0.53
6	G. Venkataraman	Indian Institute of Technology, Center for Studies in Resource Engineering, Mumbai	30	14	0.47	8	26.67	3	0.09
7	G. S. Rawat	H N Bahuguna Garhwal University, Sringar, Uttaranchal	28	49	1.75	4	14.29	8	0.31
8	A. Pandey	G B Pant Institute of Himalayan Environment & Development (GBPIHED), Kosi-Katarmal, Almora	28	81	2.89	4	14.29	10	0.51
9	S. J. Sangode	Wadia Institute of Himalayan Geology (WIHG), Dehradun	28	45	1.61	5	17.86	10	0.28
10	S. Kundu	Vivakand Institute of Hill Agriculture (VIHA), Almora, Uttranchal	28	114	4.07	5	17.86	12	0.71
11	J. C. Kuniyal	G B Pant Institute of Himalayan Environment & Development (GBPIHED), Kosi-Katarmal, Almora	27	58	2.15	0	0.00	8	0.36
12	A. Chauhan	Central Institute of Medicinal & Aromatic Plants (CIMAP), Lucknow	27	74	2.74	0	0.00	8	0.46
13	D. K. Uprati	National Botanical Research Institute (NBRI), Lucknow	27	37	1.37	4	14.81	7	0.23
14	R.S. Rawal	G B Pant Institute of Himalayan Environment & Development (GBPIHED), Kosi-Katarmal, Almora	26	52	2.00	3	11.54	5	0.33
15	C.M. Sharma	H N Bahuguna Garhwal University, Sringar, Uttaranchal	26	64	2.46	0	0.00	7	0.40
16	S. S. Samant	Environment & Development (GBPIHED), Kosi-Katarmal, Almora	26	33	1.27	0	0.00	6	0.21
17	P.S. Ahuja	Institute of Himalayan Bioresource Technology (IHBT), Palampur, H.P	26	57	2.19	2	7.69	7	0.36
18	A. Ganju	Snow and Avalanche Study Establishment (SASE), Chandigarh	26	27	1.04	0	0.00	5	0.17
19	N.P.Todaria	H N Bahuguna Garhwal University, Deptt. of Forestry, Sringar, Uttaranchal	25	19	0.76	0	0.00	5	0.12
20	B. Singh	Institute of Himalayan Bioresource Technology (IHBT), Palampur, H.P	25	61	2.44	1	4.00	6	0.38
21	L.M.S.Palni	G B Pant Institute of Himalayan Environment & Development	24	64	2.67	2	8.33	8	0.40

		(GBPIHED), Kosi-Katarmal, Almora							
22	A.P.Dimri	Jawaharlal Nehru University, DEptt. of Environmental Science, New Delhi	24	34	1.42	2	8.33	8	0.21
23	M.K. Arora	Indian Institute of Technology, Deptt. of Civil Engineering, Roorkee	23	82	3.57	6	26.09	13	0.51
24	B.P.Bhatt	ICAR Research Complex for NEH Region, Umiam, Meghalaya	23	20	0.87	0	0.00	19	0.13
25	G.H.Dar	University of Kashmir, Center for Plant Taxonomy, Srinagar	23	24	1.04	2	8.70	3	0.15
26	T. Ahmad	University of Delhi, Deptt. Of Geology, Delhi	22	103	4.68	20	90.91	9	0.64
27	U.Dhar	Environment & Development (GBPIHED), Kosi-Katarmal, Almora	23	31	1.35	4	17.39	5	0.19
28	R.C. Ramola	H N Bahuguna Garhwal University, Sringar, Uttaranchal	22	46	2.09	2	9.09	7	0.29
29	R.C. Padalia	Central Institute of Medicinal & Aromatic Plants (CIMAP), Lucknow	22	64	2.91	0	0.00	8	0.40
30	V. Prakash	Vivakand Institute of Hill Agriculture (VIHA), Almora, Uttranchal	22	83	3.77	4	18.18	10	0.52
	Total of 30 authors		830	1764	2.13	108	13.01	8.16	0.37
	Total of the country		4862						
	Share of top 30 authors in country output		17.07						
TP=Total Papers; TC=Total Citations; ACPP = Average Citations Per Paper; RCI=Relative Citation Index; HI=h-indexCOLL (NO)=Collaborative linkages among top 30 organizations with (Number of Organizations)									

4.9 Media of Communication

The 20 most productive journals contributed from 25 to 338 publications and together contributed 26.78% share (1302 publications) to the total journal publication output in Indian Himalayan R&D during 2004-13. Their combined publication share decreased from 32.68% to 23.62% from 2004-08 to 2009-13. Of these 20 journals, the highest citation impact per paper of 18.54 by *Geomorphology,* followed by *Journal of Geophysical Research. D (14.81), Tectonophysics (10.00), International Journal of Remote Sensing (7.87), . Journal of Asian Earth Science (6.32), Current Science (6.05), Natural Hazards (4.32), Journal of Earth System Science (4.22), International Journal of Earth Sciences* (3.55), etc.

Table 10. Most Productive Journal Media of Publications of Indian Publications in Himalayan R&D during 2004-13

S.No.	Name of the Journal	Total Papers (TP)			TC*	ACPP
		2004-08	2009-13	2004-13	2004-13	2004-13
1	Current Science	183	155	338	2046	6.05
2	Journal of Geological Society of India	98	83	181	536	2.96
3	Journal of Asian Earth Science	29	48	77	487	6.32
4	Himalayan Geology	28	48	76	125	1.64
5	Journal of Earth System Science	12	47	59	249	4.22
6	Indian Journal of Agricultural Sciences	30	29	59	67	1.14

7	Indian Journal of Traditional Knowledge	4	48	52	148	2.85
8	Natural Hazards	11	36	47	203	4.32
9	International Journal of Remote Sensing	21	25	46	362	7.87
10	Journal of Indian Society of Remote Sensing	18	26	44	124	2.82
11	National Academy of Science Letters	12	30	42	42	1.00
12	Acta Horticulturae	29	12	41	43	1.05
13	Tropical Ecology	14	22	36	93	2.58
14	Tectonophysics	11	23	34	340	10.00
15	Journal of Mountain Science	15	17	32	114	3.56
16	International Journal of Ecology & Environment	23	7	30	25	0.83
17	International Journal of Earth Sciences	1	28	29	103	3.55
18	Geomorphology	10	18	28	519	18.54
19	Journal of Geophysical Research. D	5	21	26	385	14.81
20	Journal of Forestry Research	0	25	25	52	2.08
	Total of 20 journals	554	748	1302		
	Total of the Country	1695	3167	4862		
	Share of top 20 journals in countries total output	32.68	23.62	26.78		
TP=Total Papers; TC=Total Citations; ACPP = Average Citations Per Paper						
* Citation are collected in this table from date of publication till June 2014						

4.10 Higher Cited Papers

The 20 top higher cited papers (listed in Table 11) from India in Himalayan R&D have received citations from 83 to 332 (since their publication till June 2014).Of these 20 papers, 17 appeared as articles, 2 as reviews and one as conference paper These 20 papers together have received 2369 citations, registered an average citation per paper of 118.45. Of the 20 highly cited papers, 12 papers have received citations from 83 to 100, 6 papers from 101 to 200, 1 paper 236 citations and 1 paper 332 citations. Of the 20 high cited papers, 12 involve international collaboration, 7 national collaboration and 3 zero collaboration. Twenty two Indian organizations are involved in these high cited papers. They include 4 papers from IIT-Roorkee, 3 papers from University of Delhi, 2 papers each from G B Pant Institute of Himalayan Environment & Development, Kosi-Katarmal, Almora, CBRI-Roorkee and IISc-Bangalore, and 1 paper each from ISRO Space Application Centre, Ahmedabad, Physical Research Laboratory, Ahmedabad, Indian Institute of Astronomy, Bangalore, Indian Institute of Geomagnetism, Mumbai, Aryabhatta Institute of Observational Sciences, Nainital; Vikram Sarabhai Space Center, Thiruvanathapuram; Wadia Institute of Himalayan Geology, Dehradun, etc. These 20 high cited papers are published in 17 journals, including 2 paper each in *Earth & Planetary Science Letters, Journal of Geophysical Research B. Solid Earth and Journal of Ethniobiology and Ethnomedicine* and 1 paper each in *Nature, Science, Current Science, Applied Geochemistry, Engineering Geology, Remote Sensing of the Environment, Geophysical Journal International, Landslides, Journal of Sedimentary Research, Journal of Applied Ecology, Geochimica et Cosmochimica Acta, Journal of Geophysical Research. D, Geology and Conservation Biology.*

Table 11. List of Top Twenty Higher Cited Papers in Himalayan R&D, 2004-13

1	McArthur, J.M., Banerjee, D.M., Hudson-Edwards, K.A., et al.	UCL, Deptt of Earth Sciences. London, UK; University of Delhi, Delhi, Deptt. of Geology, University of London, Sch. of Earth Science, London, UK	Natural organic matter in sedimentary basins and its relation to arsenic in anoxic ground water: The example of West Bengal and its worldwide implications (Article)	*Applied Geochemistry*, 2004, 19 (8), pp. 1255-1293	332
2	Leech, M.L., Singh, S., Jain, A.K., Klemperer, S.L., Manickavasagam, R.M.	Stanford University, Deptt.of Geological & Environmental Sciences, USA; IIT, Deptt. of Earth Sciences & Instrumentation Center, Roorkee, India	The onset of India-Asia continental collision: Early, steep subduction required by the timing of UHP metamorphism in the western Himalaya (Article)	*Earth and Planetary Science Letters*, 2005, 234 (1-2), pp. 83-97.	236
3	Unsworth, M.J., Jones, A.G., Wei, W., et al	University of Alberta, Deptt. f Physics, Edmonton, Canada; Dublin Institute for Advanced Studies, Sch.of Cosmic Physics, Dublin , Ireland; Indian Institute of Geomagnetism, Colaba, Mumbai, India	Crustal rheology of the Himalaya and Southern Tibet inferred from magnetotelluric data (Article)	*Nature,*2005,438 (7064), pp. 78-81	154
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5. Summary and Conclusion

India has published 4862 publications in Himalayan R&D during 2004-13, which has increased from 254 in 2004 to 757 in 2013, leading to an annual average growth of 13.21%. Its cumulative publications on Himalayan R&D has increased from 1695 during 2004-08 to 3167 during 2009-13, witnessing a growth rate of 86.84%. India's publications in Himalayan R&D during 2004-13 have received 9033 citations on a three years citation window, leading to average citation per paper of 1.86, which has increased from 1.81 to 1.88 from 2004-08 to 2009-13. Of the total Indian publications in Himalayan R&D, 62.40% publications received 1 or more citations (since their publication till July 2014) and out of them only 0.4% publications contributed 4.48% citations, 1.07% publications 13.39% citations, 1.71% publications 12.56% citations, 11.48% publications 35.42% citations and 48.00% publications 34.15% citations during 2004-12.

India's global publication and citation share was 49.07% and 30.25% during 2004-13, which increased from 44.65% to 51.81% and 26.17% to 32.90% from 2004-08 to 2009-13. Similarly India has registered the lowest score in average citation per paper (1.86) and relative citation index (0.62) in Himalayan R&D among the top 10 most productive countries. India's average citation per paper and relative citation index have, however, increased in both from 1.81 to 1.88 and 0.59 to 0.64 from 2004-08 to 2009-12.

India's has registered the lowest international collaborative publication share of 16.29% during 2004-13 among the top 10 most productive countries in Himalayan R&D, which has decreased from 16.81% to 16.01% from 2004-08 to 2009-13.

India's also stands at third place (after USA and China) in terms of inter-country collaborative links among top 10 most productive countries during 2004-13 in Himalayan R&D. The USA registered the highest

publications share (31.82%) among India's international collaborative publications during 2004-13, followed by Germany (13.01%), U.K. (10.61%), Japan (7.70%), Canada (5.68%), etc.

Agricultural & biological sciences registered the highest publication share (36.73%) in Indian Himalayan R&D during 2004-13, followed by earth & planetary sciences (32.58%), environmental science (19.07%), biochemistry, genetics & molecular biology (9.36%), medicine (7.32%), engineering (5.10%), pharmacology, toxicology pharmaceutics (5.04%) and immunology & microbiology (3.74% share), etc during 2004-13. The research activity has decreased in three sub-fields: agricultural & biological sciences, earth & planetary sciences and immunology & microbiology, as against increase in: environmental science, biochemistry, genetics & molecular biology, medicine, engineering and pharmacology, toxicology & pharmaceutics from 2004-08 to 2009-13.

On observing research trends as reflected in key words, the largest number of publications (238) were reported on earthquake, followed by medicinal plants (228), remote sensing (202), climate change (173), biodiversity (157), plant extract (139), satellite data or imaginary (137), landslide (135), bacteria-plant (132), glacier (132), tectonics (125), animals (121), essential oils-plants (116), conservation-biology (115), seismicity (104), diversity (biological) (104), etc.

In terms of Indian institutional contribution, the largest contribution (50.86%) came from 68 research institutions, followed by 46 universities& colleges (35.19%), 10 institutes of national importance (9.50%), 3 medical colleges (1.38%), 3 engineering colleges (1.15%), 3 non-governmental organization (1.0%) during 2004-13.

The top 30 Indian organization and authors together contributed 67.81% and 17.87% share in the total Indian publication output in Himalayan R&D during 2004-13. and have registered an average productivity per organization (109.9 and 27.67) , average citation impact per paper (2.07 and 2.13), h-index value (12.67 and 8.16), share of international collaborative publication (15.29% and 13.01%) and relative citation index (0.70 and 0.91) during 2004-13. The top 20 most productive journals together contributed 26.78% share to the total journal publication output in Indian Himalayan R&D during 2004-13, which decreased from 32.68% to 23.62% from 2004-08 to 2009-13.

Of the total Indian publications in Himalayan R&D, the top 20 highly cited papers have received citations from 83 to 332 (since their publication till June 2014) and together received 2369 citations, registered an average citation per paper of 118.45. Of the 20 highly cited papers, 12 papers have received citations from 83 to 100, 6 papers from 101 to 200, 1 paper 236 citations and 1 paper 332 citations. Of the 20 high cited papers, 12 involve international collaboration, 7 national collaboration and 3 zero collaboration. Twenty two Indian organizations and 17 journals are involved in these high cited papers. Among Indian

organizations, the largest number (4) have come from IIT-Roorkee, followed by 3 papers from University of Delhi, 2 papers each from G B Pant Institute of Himalayan Environment & Development, Kosi-Katarmal, Almora, CBRI-Roorkee and IISc-Bangalore, etc. Among 17 journals, 2 publication each has been published in *Earth & Planetary Science Letters, Journal of Geophysical Research B. Solid Earth and Journal of Ethniobiology and Ethnomedicine* and 1 paper each in 13 journals

Conclusions

India, although rank first in publication output among top 10 most productive countries in Himalayan R&D, but stands at 10th rank in terms of citation impact per paper and share of international collaborative papers. Because of the remoteness, terrain difficulties, lack of resources and poor infrastructure in Himalayan region, scholars face lot of problems in conducting effective and quality research. There is a need to take stock of the present state of research and associated gaps on different aspects of Himalayan R&D. Although various Indian government funding agencies such as Department of Space, Ministry of Earth Resources, Ministry of Environment & Forests, DST, CSIR, ICAR, DRDO, etc are involved in R&D through the participation of their research institutes as well as through extramural research, but their research funding is still very small compared to the expected investments and there is not national coordinating mechanism to assess the strength and weakness of research. Therefore, there is a need to create a separate national funding agency, which besides funding various projects, should take the job of coordination, monitoring and evaluation of research projects from different scientific and educational institutions and experts/researchers under one roof There is a need to take stock of the present state of research and associated gaps and attract young researchers and develop strategies to promote field research culture, besides identifying thrust area of research in different sub-areas of Himalayan R&D for the next decade. It is also necessary to coordinate and conduct long term studies through collaboration and networking with all stock holders in the country and develop data sharing mechanism and research network with other Himalayan countries and other developed countries involved in research in this area. Networking and extensive collaboration can play a key role in raising good research questions and hypothesis and subsequently improve the citation impact of research. The quality of research is also affected by inadequate expertise, lack of uniform methodologies and instrumentation and data collection and synthesis protocols. There is also a need for introduction of better field research facilities and system of rewards and establishment of a long-term ecological monitoring sites collect and monitor regular data

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