

Research Productivity in the Universities of Haryana: A Scientometric Analysis

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ABSTRACT

Purpose: To evaluate the research productivity in terms of year-wise growth, authorship patterns, preferred channels of scholarly communication and identify highly cited publications of the six state universities in Haryana using scientometric indicators. **Methodology:** For the current study, bibliographic data is extracted from Scopus through affiliation search tag. Data collection was restricted to the period of 2011-2020, as a decade is considered a good sample to study research growth. The complete records were downloaded in Microsoft Excel csv format and categorised into articles, conference papers, etc., with bibliographical details and author affiliations. **Findings:** The research output of the six state universities considered for study is continuously growing, with collaboration taking place within the state itself with other HEIs in the country and overseas too. The most significant number of papers were published by 3 authors, followed by 2 authors. The most preferred channels of communication, viz. journals and conference proceedings, were also analysed. The 'AIP Conference Proceedings' and 'International Journal of Biological Macromolecules' were the most preferred sources for research, and 'Agriculture and Biological Sciences' was the most prominent research area among selected state universities. **Originality/Value:** The research output of the six state universities in Haryana is studied in this paper, based on a scientometric analysis of their publications from 2011 to 2020, covering 12074 publications from Scopus. The results reflect the publication patterns, productivity of researchers, level of collaboration and productivity of the universities during the study period.

Keywords: Research productivity, Haryana, State universities, Scientometric study, Scopus.

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INTRODUCTION

The National Education Policy (NEP 2020) launched in 2020 heralds a revolutionary education system in India. The stress on the five pillars, namely Affordability, Accessibility, Quality, Equality and Accountability, leads the new generation of students to be critical thinkers. The reforms at the school level and higher education level aim to increase Gross Enrolment Ratio. The proposal to set up the National Research Foundation will indeed boost research initiatives in the country. NEP 2020 has motivated the government and industries to invest in Research and Development. This has encouraged innovation and commitment from academia and industries. Currently, there are more than a thousand universities in the country. Many of them are state universities. Some state Universities are doing exceedingly well in research, while the research scenario in some state universities is grim. Hence there is a pressing need to study the status of research in universities in various states.

There is more than 1027 state, central, deemed, and private universities in the higher education sector in India. In Haryana, there are currently many state-funded, deemed and private functional universities. Out of them, twenty-one are state universities. The universities funded by the Haryana Government play a significant role in research and academia. These institutions are crucial in accomplishing the state's research needs and providing new opportunities for future research. These universities' research output and academic literature are significant and therefore need a systematic analysis using appropriate methods. Most researchers use quantitative methods to explain publication patterns within a given discipline. Scientometric techniques are specifically used to find research trends, growth, prominent author, preferred source, etc., in any given domain. The present study provides an assessment of the research performance of six state universities in Haryana state.

LITERATURE REVIEW

Over the years, various research assessment studies have been undertaken to assess an institute's research output, subject, region, researcher, sources, etc.



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Dhawan *et al.* (2017) did a comparative analysis of six state universities of Haryana through scholarly data drawn from Scopus. They observed that Kurukshetra University was comparatively more productive than other universities during the study period. Dwivedi (2017) did a bibliometric evaluation of Banaras Hindu University. She collected data of 16556 records from Web of Science for the period 1989-2016. Since 2005, there has been an exponential increase in the number of publications, according to this analysis. The most preferred source was *Current Science*, and Chemistry was the key research area at the university. Kumar *et al.* (2017) analysed Kurukshetra University by accumulating data from Scopus to analyse contributions. They observed an exponential growth in research, and the largest share of publications was contributed to physics field. Batcha (2018) explored the research articles published by the six leading universities of Tamil Nadu state for the last eighteen years indexed in Web of Science and found that 9.7 is the compound growth rate for these Universities, and Chemistry was the primary research area. Siwach and Parmar (2018) did a bibliometric analysis of Haryana Agricultural University to determine the research trends and perceived that the *Annals of Biology* was the most preferred source for research publication. Shettar and Hadagali (2020) conducted a quantitative study of scientific literature produced by the newly established National Institute of Technology by collecting data from the Web of Science. This study showed that NIT Rourkela ranked first among all the NITs based on the number of research contributions.

Using the web of science, Kappi *et al.* (2021) assessed the research progress of institutions in Karnataka state and discovered that Mysore University had the most papers published. Mahala and Singh (2021) evaluated the research output in the science discipline of leading universities as seen in the web of knowledge database, viz. Delhi University, Banaras Hindu University, and Panjab University, and observed that Delhi University has the highest number of publications. Mondal and Chakrabarti (2021) presented the research contribution of selected IISERs as covered in the Clarivate database, and IISER Pune was ranked first in terms of highest publications. Pal and Bhattacharjee (2022) examined the research output of nine north-eastern Indian central universities. They obtained bibliographic information from the Web of Science database. Tezpur University has the most research publications. The most common sources were *Current Science* and *RSC Advances*, and Chemistry was the primary research area among selected central universities. From 2002 to 2021, Rahman and Batcha (2022) studied the research output of selected West Bengal state universities. The most popular kind of document is journal articles published by scholars. They observed that Jadavpur University published the highest number of papers in open-access journals.

The review of research evaluations points to the fact that such findings are essential to showcase the research performance of academic institutions and help in research assessment.

OBJECTIVES

- The current study is an assessment of the science and technology literature of the six leading universities in Haryana, covering these objectives.
- To determine the annual research growth and citation distribution of six state universities.
- To calculate the research evolution and doubling time of the publications.
- To identify the authorship pattern and collaborative measures.
- To demonstrate the key research areas and preferred sources of scholarly communication.
- To identify the most prolific researchers and top-cited papers.

MATERIALS AND METHODS

This study analyses the bibliographical data of six state universities funded by the Government of Haryana. Currently, there are many bibliographic databases, viz. Web of Science, Scopus, Dimensions, Lens, PubMed etc. For this study, Scopus was considered for the time span of ten years, from 2011 to 2020, as this is one of the largest databases globally, including millions of published literature from years ago until today. It was chosen for its comprehensive subject coverage, quality standards, and data collection and visualisation tools. There are six leading universities: Maharshi Dayanand University (MDU), Kurukshetra University (KUK), Chaudhary Devi Lal University (CDLU), Deenbandhu Chhotu Ram University (DCRUST), CCS Haryana Agricultural University (HAU), Guru Jambheshwar University (GJU) were identified for the study. The search was conducted in July 2022, and the bibliographic data of research articles were extracted. The advanced search query was AF-ID ("Kurukshetra University" 60032618) OR AF-ID ("Maharshi Dayanand University" 60004880) OR AF-ID ("Chaudhary Devi Lal University" 60097532) OR AF-ID ("Guru Jambheshwar University of Science and Technology" 60001406) OR AF-ID ("CCS Haryana Agricultural University" 60023050) OR AF-ID ("Deenbandhu Chhotu Ram University of Science and Technology" 60076923) AND (LIMIT-TO 2011-2020).

The search extracted 12074 bibliographic records from 2011 to 2020 that included information regarding types of documents, authors' names and affiliations, source names, citations received, article titles and keywords etc. The downloaded data were tabulated and analysed using Microsoft excel. Further, the

Bibliometrix package has been used for various scientometric indicators.

DATA ANALYSIS AND DISCUSSION

Description of Study

Many authors have conducted studies to measure the research growth of universities on the pan-India level. However, very few research assessment studies have been done on the universities of Haryana. This study intends a scientometric analysis of six state universities. Table 1 has an outline of the complete research survey.

University-wise Total Publications

As shown in Table 2, the selected state universities had substantial growth in research output over the last ten years. These six universities published a total number of 12074 publications. The

Table 1: Study outline.

Data Essentials	
Timespan	2011-2020
Sources (Journals, Books, etc.)	2772
Documents	12074
Average years from publication	6.04
Average Citation per paper	10.05
Average Citation per document	1.466
Authors Collaboration	
Single-authored documents	421
Documents per author	2.47
Authors per document	0.405
Co-Authors per documents	7.64
Author Keywords	25290

Table 2: University-wise total Research Publications.

University	Establishment Year	NP	Cumulative	%	h-index
MDU	1976	3113	3113	25.78	69
KUK	1956	3055	6168	25.3	55
HAU	1970	2120	8288	17.56	42
GJU	1995	2075	10363	17.19	70
DCRUST	1987	1244	11607	10.3	45
CDLU	2003	467	12074	3.87	30
Total		12074		100	

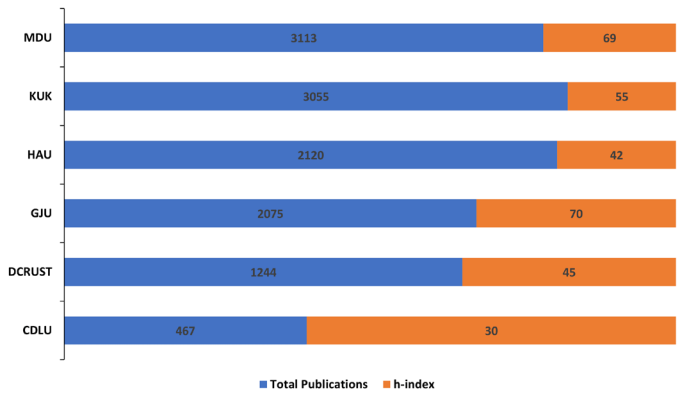


Figure 1: University-wise total Publications and h-index.

comprehensive view research contributions of these universities and their h-index can be seen in Figure 1.

University-wise Annual publications and Citation received

Table 3 and Figure 2 show the university-wise annual distribution of publications and citations from 2011 to 2020. There was a continual growth from 924 to 1641 in documents during the study period. From the citation outline of these universities' research, it was observed that during the research period, there were 89881 citations received. The number of citations per article ranges from 3.83 to 11, with a mean of 7.44 per article.

Annual Growth of Publications and Citations

The citation patterns among 12074 documents are analysed and depicted in Table 4. A changing trend in citation per paper can be seen, as it varies from 0.90 to 15.55. Thus, 89881 citations were received, with a 7.44 average per paper. The highest number of publications was observed in 2020, i.e., 1641 (13.59%), and in 2011, 924 (7.65%) had minimal publications. In 2014, there was a negative change of -3.76% and an increase of 24.98% per cent in 2019; there was a drop in 2012. The values of Average Annual Growth Rate (AAGR) and Compound Annual Growth Rate (CAGR) are 6.92% and 6.59%, respectively.

Relative Growth Rate and Doubling Time

The relative rate of growth and doubling time for the research articles produced by the state universities in Haryana during the last ten years, from 2011 to 2020, can be seen in Table 5. The relative growth rate examines how the quantity of documents has increased over time. If the natural number's log is applied to analyses, the difference value is 0.693. For example,

In the present study, RGR values lie between 0.77 and 0.15. The highest value (0.77) of relative growth was observed in 2012 and doubling time (4.74) in 2020. It reveals that there are up and downs in the values of growth patterns. The average relative

Table 3: University-wise Annual publications and Citation received.

University 2011		Year										Total
		2012	2013	2014	2015	2016	2017	2018	2019	2020		
MDU	NP	171	237	264	249	238	315	307	357	471	504	3113
	TC	3636	3503	3635	2442	2140	2989	2514	2228	1617	559	25263
	CPP	21.26	14.78	13.77	9.81	8.99	9.49	8.19	6.24	3.43	1.11	8.12
KUK	NP	333	338	302	264	288	290	274	269	387	310	3055
	TC	4546	3523	3614	2523	2292	2019	1422	900	674	194	21707
	CPP	13.65	10.42	11.97	9.56	7.96	6.96	5.19	3.35	1.74	0.63	7.11
HAU	NP	172	193	244	264	175	182	260	190	189	251	2120
	TC	1828	1071	2140	742	702	348	395	458	275	156	8115
	CPP	10.63	5.55	8.77	2.81	4.01	1.91	1.52	2.41	1.46	0.62	3.83
GJU	NP	169	181	186	164	175	203	208	235	282	272	2075
	TC	3340	3560	2476	2615	2367	2041	2550	2531	1044	301	22825
	CPP	19.76	19.67	13.31	15.95	13.53	10.05	12.26	10.77	3.7	1.11	11
DCRUST	NP	34	86	75	101	130	119	106	153	194	246	1244
	TC	386	961	879	764	1717	1016	1243	987	576	224	8753
	CPP	11.35	11.17	11.72	7.56	13.21	8.54	11.73	6.45	2.97	0.91	7.04
CDLU	NP	45	41	46	33	39	33	62	57	53	58	467
	TC	634	347	359	298	305	170	545	330	179	51	3218
	CPP	14.09	8.46	7.8	9.03	7.82	5.15	8.79	5.79	3.38	0.88	6.89

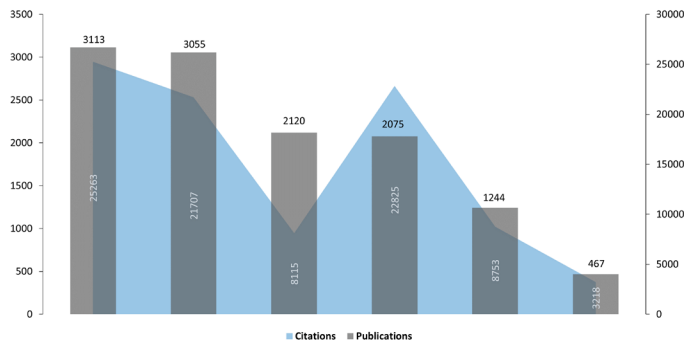


Figure 2: University-wise Annual publications and Citation received.

growth rate and doubling time were noted at 0.26 and 2.89, respectively.

Authorship Outline and Collaborative Measures

The annual structure of the authorship is shown in Table 6. It was revealed that the tri-author pattern contributed to the maximum number of publications.

Degree of Collaboration (DC)

This indicator measures co-authored documents published in a particular year and the total documents published in a field. The formula is mentioned below:

$$DC = \frac{N_m}{N_m + N_s}$$

N_m = multi-authored papers, N_s = solo-author papers

Using data in Table 6, in the year 2020;

Table 4: Annual Growth Rates.

Year	NP	(%)	Annual Growth Rate (%)	Citation	CPP	AAGR	CAGR
2011	924	7.65	---	14370	15.55	6.92%	6.59%
2012	1076	8.91	16.45%	12965	12.05		
2013	1117	9.25	3.81%	13103	11.73		
2014	1075	8.9	-3.76%	9384	8.73		
2015	1045	8.65	-2.79%	9523	9.11		
2016	1142	9.46	9.28%	8583	7.52		
2017	1217	10.08	6.57%	8669	7.12		
2018	1261	10.44	3.62%	7434	5.9		
2019	1576	13.05	24.98%	4365	2.77		
2020	1641	13.59	4.12%	1485	0.9		
Total	12074	100		89881			

$$DC = \frac{1594}{1594 + 47} = \frac{1594}{1641} = 0.971$$

In the present study, the highest degree (0.971) value was observed in 2020 and 2017 during the study period, and the average value was 0.965.

Collaboration Index (CI)

An average of authors per document determines the collaborative index. The formula is as follows:

$$CI = \frac{\sum_{j=1}^k j(f_j)}{N}$$

Table 5: Relative Growth Rate and Doubling time.

Year	Publications	log _e W ₁	log _e W ₂	RGR	\bar{x}	T _d	\bar{x}
2011	924	0	6.83	0	0.26	0	2.89
2012	1076	6.83	7.6	0.77		0.9	
2013	1117	7.6	8.04	0.44		1.56	
2014	1075	8.04	8.34	0.3		2.34	
2015	1045	8.34	8.56	0.22		3.11	
2016	1142	8.56	8.76	0.2		3.51	
2017	1217	8.76	8.94	0.17		3.97	
2018	1261	8.94	9.09	0.15		4.51	
2019	1576	9.09	9.25	0.16		4.23	
2020	1641	9.25	9.4	0.15		4.74	

The highest value of the collaboration index was observed in 2020 (3.979), and the lowest (3.510) in 2011. 3.7 is noted as the average collaboration index value.

Collaborative Coefficient (CC)

The collaborative co-efficient eliminates the shortcomings related to the collaborative index and degree of collaboration. The formula is as below:

$$CC = 1 - \frac{\sum_{j=1}^k \left(\frac{1}{j}\right) f_j}{N}$$

The highest collaborative coefficient value of 0.683 was observed for 2020, followed by 0.669 in 2017 and 0.668 in 2019. 0.666 was noted as the mean value during the study.

Preferred Sources for Publication

Table 7 reveals the fifteen top preferred sources by the authors during the study period. The topmost source for research communication was *AIP Conference Proceedings* (NP=201; n=8), followed by the *International Journal of Biological Macromolecules* (NP=129; n=32), *Journal of Molecular Liquids* (NP=100; n=22), *Medicinal Chemistry Research* (NP=87; n=24) and *Annals of Biology* (NP=75; n=4). 7626 citations were received from five journals during the study period (Table 7). *International Journal of Biological Macromolecules* tops the list in terms of total citations (TC=3360), followed by *Medicinal Chemistry Research* (TC=1971), *Journal of Molecular Liquids* (TC=1636), *Journal of Alloys and Compounds* (TC=1613) and *Journal of Food Science and Technology* (TC=1581). In addition, a Sankey plot has been drawn in Figure 3 to show the relationship between leading sources, countries, and authors.

Table 6: Pattern of Authorship and Collaborative Indicators.

Year	Authors							Total	CC	CI	DC
	1	2	3	4	5	6	7 or more				
2020	47	375	339	297	208	137	238	1641	0.683	3.979	0.971
2019	52	376	403	278	174	132	161	1576	0.668	3.753	0.967
2018	44	309	314	218	154	93	129	1261	0.665	3.733	0.965
2017	35	296	304	223	156	104	99	1217	0.669	3.721	0.971
2016	38	263	332	206	140	86	77	1142	0.663	3.624	0.967
2015	52	216	281	220	122	87	67	1045	0.658	3.644	0.95
2014	32	254	296	227	145	65	56	1075	0.663	3.575	0.97
2013	38	228	334	245	138	57	77	1117	0.666	3.623	0.966
2012	50	222	297	231	133	63	80	1076	0.660	3.636	0.954
2011	33	216	277	184	118	51	45	924	0.656	3.510	0.964
2011-20	421	2755	3177	2329	1488	875	1029	12074	0.666	3.7	0.965

Table 7: Preferred Sources.

Source Name	Location	Publication	Citation	h-index	g-index	m-index
AIP Conference Proceedings	USA	201	535	8	11	0.67
Int J of Biological Macro	Netherlands	129	3360	32	49	2.67
Journal of Molecular Liquids	Netherlands	100	1636	22	32	1.83
Medicinal Chemistry Research	USA	87	1971	24	39	2.00
Annals of Biology	India	75	124	4	5	0.33
Annals of Agri Bio Research	India	72	127	4	6	0.33
J of Alloys & Compounds	Netherlands	67	1613	25	36	2.08
Journal of Food Sci & Tech	India	67	1581	19	38	1.58
Journal of Materials Science: Materials in Electronics	USA	66	753	15	20	1.25
Int J of Pharm & Pharma Sc	India	65	675	12	22	1.00
Indian Journal of Agri Sc	India	63	210	7	9	0.58
Ceramics International	UK	58	1167	24	29	2.67
Advances in Intelligent Systems and Computing	Germany	48	136	5	7	0.50
3 Biotech	Switzerland	44	504	12	19	1.33
Der Pharma Chemica	India	38	98	5	6	0.42

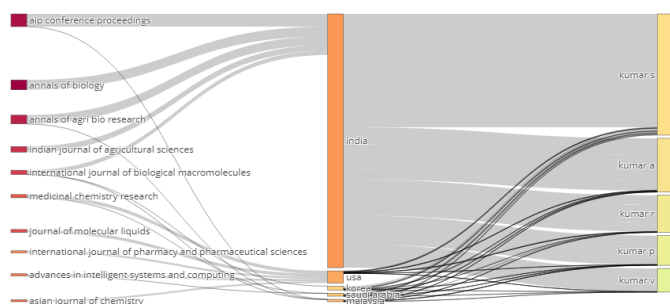


Figure 3: Three-Field plot (Sources-Countries-Authors).

Most Prolific Authors

Aiming at individual research productivity, Prof. Rajneesh Kumar from Kurukshetra University was the most productive author with 195 papers, followed by Chandrashekhar Pundir ($n=169$), Sandeep Kumar ($n=166$), Pratyooash Shukla ($n=147$) and Ashish Agarwal ($n=140$) respectively. Sarvajeet Singh Gill and Sujata Sanghi produced 97 papers each. Chandrashekhar Pundir ranked first in citations received, and Rajneesh Kumar in maximum contributions during the study period. In the top-ranked list, each four authors are associated with GJU and MDU. Table 8 displays the top 10 most productive authors.

Focus Research Areas of Universities

Figure 4 discloses the data related to research emphasis areas as reflected in the Scopus research areas. The researchers of selected universities produced a majority of 2810 research articles (23.27%) in the field of 'Agricultural and biological sciences', followed by 'Engineering' discipline having 2272 articles (18.82%)

and 'Biochemistry and molecular biology' having 1766 articles (14.63%). Inside out, very few research articles appeared in the areas of 'Social Sciences', 'Business and management', 'Earth and planetary sciences', 'Economics' and 'Multidisciplinary' areas.

Most Cited Papers and Citation Impact

Table 9 depicts the highly cited papers of universities that opted for the study. These papers have gained 250 or more citations after being published in various sources. All of the ten top articles were co-authored. The paper entitled "Solar energy: Potential and future prospects" authored by Kabir *et al.* and published in *Renewable and Sustainable Energy Reviews*, was cited 730 times with a 146 mean annual citation rate, followed by; "Genome-wide comparative diversity [...]" authored by Cavanagh *et al.* ($TC=657$, $TCpY=65.7$) and "Microsatellite markers: An overview of the recent progress in plants" by Kalia *et al.* ($TC=592$, $TCpY=49.33$) were the most cited papers during the study.

The citation profile of 12074 publications is displayed in Table 10. It was found that others cite 75.13% of the total publications, and 24.87% remain uncited. Furthermore, 103 papers (0.85%) received more than one hundred citations, 290 (2.40%) ranging between 51-100, 175 (1.45%) received between 41-50, and 4293 documents (35.56%) received citations between 1-5.

Analysis of Author keywords

The analysis of terms used by authors gives intuition to the fundamental subjects that emerge throughout the literature (Figure 5). The co-occurrence distribution of the most often

Table 8: Prolific authors.

Name	NP	TC	h-index	CPP	AC ₅₀	Affiliation
Rajneesh Kumar	195	1059	18	5	6	KUK
Chandrashekhar Pundir	169	4229	47	25	40	MDU
Sandeep Kumar	166	3687	42	22	31	GJU
Pratyoosh Shukla	147	2302	40	16	26	MDU
Ashish Agarwal	140	1886	30	13	11	GJU
Narasimhan B.	127	1699	26	13	12	MDU
Neeraj Dilbaghi	112	2793	39	25	27	GJU
Sarvajeet Singh Gill	97	2518	31	26	21	MDU
Sujata Sanghi	97	1450	28	15	10	GJU
Amalendu Pal	93	1140	23	12	5	KUK

Table 9: Most Cited Papers.

Author	DOIs	University	TC	TCpY
Kabir E, 2018	10.1016/j.rser.2017.09.094	GJU	730	146
Cavanagh CR, 2013	10.1073/pnas.1217133110	HAU	657	65.7
Raza W, 2018	10.1016/j.nanoen.2018.08.013	HAU	596	119.2
Kalia RK, 2011	10.1007/s10681-010-0286-9	GJU	592	49.33
Ambawat S, 2013	10.1007/s12298-013-0179-1	HAU	443	44.3
Singh K, 2013	10.1039/c3nr33962a	MDU	427	42.7
Kumar S, 2011	10.4103/0973-7847.79096	KUK	390	32.5
Mudgil D, 2014	10.1007/s13197-011-0522-x	GJU	355	39.44
Duhan JS, 2017	10.1016/j.btre.2017.03.002	CDLU	327	54.5
Kharb R, 2011	10.3109/14756360903524304	KUK	320	26.67
Singh J, 2015	10.1016/j.carbpol.2014.10.012	KUK	279	34.88
Sharma P, 2011	10.1007/s10661-011-1914-0	KUK	270	22.5
Jamdagni P, 2018	10.1016/j.jksus.2016.10.002	DCRUST	264	52.8
Gill SS, 2013	10.1016/j.plaphy.2013.05.032	MDU	256	25.6
Gupta M, 2017	10.1016/j.rser.2017.02.073	GJU	256	42.67
Total Citations of Highly Cited Papers			6162	

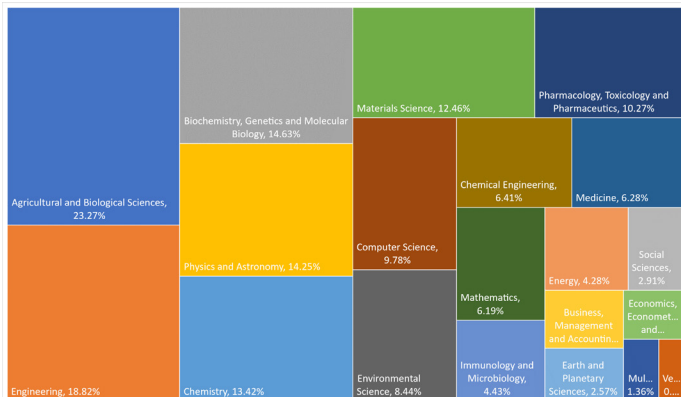


Figure 4: Key research areas of universities.

Table 10: Citation Impact.

Citation Range	NP	NP (%)	TC	TC (%)
Uncited	3003	24.87	---	---
1-5	4293	35.56	10698	8.82
6-10	1661	13.76	12946	10.67
11-20	1535	12.71	22461	18.52
21-30	656	5.43	16391	13.51
31-40	358	2.97	12562	10.36
41-50	175	1.45	7878	6.50
51-100	290	2.40	19548	16.12
>100	103	0.85	18806	15.50
Total	12074			

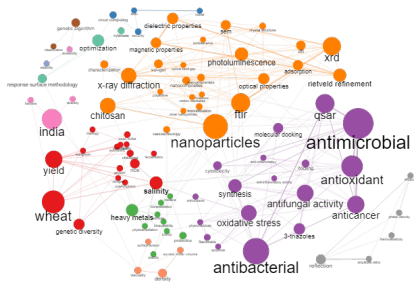


Figure 5: Keywords co-occurrence.

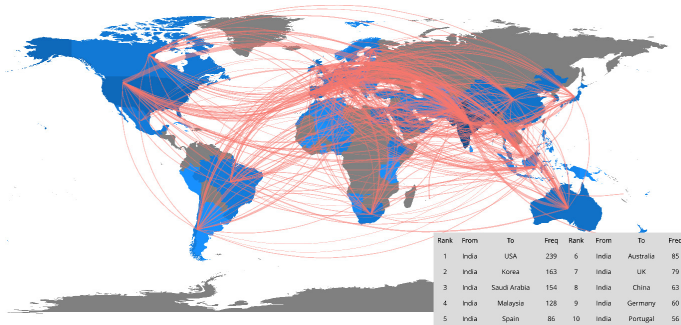


Figure 6: Country-wise research collaboration.

used keywords enables the identification of the popularity of the research themes and gaps and potential research paths.

Author keywords and database keywords are provided by abstracting and indexing databases such as Scopus and Web of Science etc. According to the centrality measures of keywords co-occurrences, ‘nanoparticles’ formed five clusters, with betweenness ($C_b=804.43$) and closeness ($C_c=0.0044$), followed by ‘ftr’ five clusters ($C_b=790.24$), closeness ($C_c=0.0045$); ‘antimicrobial’ with four sets ($C_b=389.09$) ($C_c=0.0041$).

Research Collaboration

A graph of country-wise research collaboration is also displayed in Figure 6. The authors from the state universities of Haryana have shared publications with many countries across the globe. The United States ranks first on this list with 239 publications. Next are Korea ($NP=163$), Saudi Arabia ($NP=154$), Malaysia ($NP=128$) and Spain ($NP=86$).

CONCLUSION

The current study presents a comparative assessment of overall research performances in terms of publications and their influence on citations from 2011 to 2020 of six state universities in Haryana state. The study found that research growth is inconsistent, despite the fact that the scientific literature of six universities grew from 924 in 2011 to 1641 in 2020. The study focuses on various factors of research production like publications

growth, preferred sources, most cited papers, and keyword map. Most of the published papers were in the form of articles, and a growing trend in research documents was observed during the present study. A large number of manuscripts by authors from all the selected universities appeared in national and global journals. The top-most cited papers are related to the science domain. Maharshi Dayanand University, Rohtak, performed pretty well in most of the factors among the selected universities and the others, too, as per some quantitative values. Haryana’s state universities shall prioritise the publication of high-quality research publications with high-impact factors or that are indexed in the major international database, viz. Scopus or Web of Science etc. Access to electronic periodicals, research databases, research support tools, and intensive training and motivation of faculty members and researchers may influence the university’s research output. While considering the citation pattern, it may be stated that these universities’ research impact is highly tied to Science and Technology.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

NP: Total publications; **TC:** Total citations; **CPP:** Average citations per article; **RGR:** Relative growth rate; **T_d:** Doubling time; **CC:** Collaborative Coefficient; **CI:** Collaboration Index; **DC:** Degree of Collaboration; **AC₅₀:** Papers having at least fifty citations or more; **TCpY:** Total citations received per year; **C_c:** Closeness centrality; **C_b:** Betweenness centrality.

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