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Research Article

The Research Growth Rate (2019-2020) of Forty Countries in the Field of the Earth and Planetary Science Research

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Abstract: The project is designed to explore the research output of the world's top forty countries in the field of Earth and Planetary Sciences from 2010 to 2020. The data in the field of earth and planetary sciences for each country was retrieved from Scopus. Based on the number of publications (in 2020), the top three most productive countries are China (n = 39236), United States (n = 27889), and United Kingdom (n = 10784). However, based on the growth rate (for 2019-2020), the top three countries are Pakistan (n = 38.86), Indonesia (n = 31.36), and Finland (n = 22.00). In 2013-14 and 2010-11, Pakistan was on the 3rd position. While for the years (2015-2018) Pakistan have occupied the 2nd position. This motivated us to decode the research productivity of Pakistan since independence (1947). The total number of publications were found to be 4972, where 8814 authors and 10445 institutes significantly contributed. The University of Peshawar was the most productive university with 584 publications. Pakistan produced 90.50 % (n = 4500) publications in the 21st century (after 2000). The astonishing growth could be attributed to several reasons for example, the establishment of Higher Education Commission (HEC), Islamabad, Pakistan, increase in total expenditure on higher education, increase in international collaboration, etc. At the same time (in 2020), Pakistan has a meagre global share of only 0.178 % (total global production is 2,790,854). This confirms that significant measures are needed to increase the overall productivity (both the number and quality of research publication.

Keywords: Earth and Planetary Sciences, Research Progress, Growth Rate, Forty Countries, Pakistan.

1. INTRODUCTION

Bibliometric analysis involves statistical and mathematical examination of published literature such as research documents, books, or book chapters to identify emerging trends in various fields. This method sheds light on the most productive researchers, research institutes, and countries [1-3]. Typically, data for bibliometric analysis is gathered from one or more databases and then quantitatively analyzed based on specific bibliometric indicators [4]. The significance of bibliometric studies is increasingly recognized worldwide and is utilized by various agencies and universities for diverse purposes [5].

Numerous studies have examined research progress, both in terms of quantity and growth rate, across different countries. For instance, recent research has delved into Australia's science and technology output, analyzing collaboration patterns and research domains [6]. Another study focused on contributions from China, Japan, South Korea, and Taiwan in transplantation research, exploring correlations between GDP and research output [7]. Singapore's national scientific output has also been scrutinized using bibliometrics, analyzing 83,439 papers published between 2000 and 2009 [8]. Similarly, extensive bibliometric analysis has been conducted on Brazilian scientific production in building and construction technologies, as well as on collaboration patterns between Brazil and Spain in medical research [9, 10]. Furthermore, a comprehensive study was conducted [11] on the engineering development of BRICS countries (Brazil, Russia, India, China, and South Africa).

Similarly, there have been several studies focusing on Pakistan's progress across various fields. For example, Bajwa and Yaldram [12]

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examined the development of biotechnology research in Pakistan from 1980 to 2011, while Siddique *et al.* [13] analyzed research in library and information science in Pakistan from 1957 to 2018. Additionally, our group reported on Pakistan's chemistry [14] and material sciences [15] research output.

To the best of our knowledge this is the 1st study, to explore the research productivity of Pakistan in Earth and Planetary Sciences from 1947 to 2020. According to Scopus, the following subjects are classified under the title of "Earth and Planetary Sciences".

1. Earth and Planetary Sciences (all)
2. Earth and Planetary Sciences (miscellaneous)
3. Atmospheric Science
4. Computers in Earth Sciences
5. Earth -Surface Processes
6. Economic Geology
7. Geochemistry and Petrology
8. Geology
9. Geophysics
10. Geotechnical Engineering and Engineering
11. Oceanography
12. Palaeontology
13. Space and Planetary Sciences
14. Stratigraphy

The aim of this study is to comprehensively analyze the research output of the top forty countries in the field of Earth and Planetary Sciences over the decade spanning from 2010 to 2020. Specifically, the study aims to:

1. Identify the most productive countries in terms of research publications in 2020.
2. Determine the growth rates of research publications for each country from 2010 to 2020.
3. Investigate the research productivity of Pakistan since its independence in 1947.
4. Highlight factors contributing to Pakistan's research productivity, particularly its significant growth in the 21st century.
5. Assess Pakistan's global share of research production in the field of Earth and Planetary Sciences and propose measures to enhance its overall productivity.

The scope of this study encompasses a detailed examination of various aspects related to research output in Earth and Planetary Sciences, with a particular focus on Pakistan. The scope includes, but is not limited to:

1. Retrieval and analysis of data from Scopus, a leading database in the field, to obtain comprehensive information on research publications.
2. Identification of the most productive countries based on the number of publications in 2020, as well as the top countries with the highest growth rates from 2019 to 2020.
3. Exploration of Pakistan's research productivity since its independence in 1947, including trends in publication output and its position in global rankings over the years.
4. Examination of factors contributing to Pakistan's research productivity, such as the establishment of the Higher Education Commission (HEC), increased investment in higher education, international collaborations, and the growth of educational institutions.
5. Analysis of publication and citation clubs to present the contributions of authors and institutes in Pakistan, with a focus on highlighting the University of Peshawar as the most productive university.
6. Presentation of detailed data on publications and citations for all authors and institutes (from Pakistan) involved in the study, provided in supplementary files.
7. Emphasis on the significant growth in Pakistan's research productivity in the 21st century, with a comparison of publications before and after the year 2000.
8. Evaluation of Pakistan's global share of research production in Earth and Planetary Sciences, indicating areas for improvement and proposing measures to enhance both the quantity and quality of research publications.

Overall, the study aims to provide valuable insights into the research landscape of Earth and Planetary Sciences on a global scale, with a specific focus on Pakistan. In our study, two major indicators, i.e., number of published articles and the growth rate were determined for the top forty (n = 40) countries. For simplicity, the manuscript is divided in following parts.

Part-1: In this part, based on the number of publications (for the year 2020), the ranking of

forty countries is established.
Part-2: In 2nd part, based on the growth rate (for the year 2019-2020), the rankings details of forty countries are provided.
Part-3A: Since, Pakistan has the highest growth rate (in 2019-2020), therefore we retrieved the publication output of Pakistan since independence (1947-2020).
Part-3B: Based on the number of publications, University of Peshawar (UOP), Peshawar, KP-Pakistan is the top ranked University in Pakistan. We will explore the per year publications of UOP.

2. MATERIALS AND METHODS

2.1. Data Sources

The data was retrieved in March-April 2021 from Scopus. The database is one of the largest in world and hosted by Elsevier. It provides data of peer-reviewed articles published in the life, social, physical, and health sciences. In advance search option, we selected the physical sciences as the major domain and later we selected "Earth and Planetary Sciences" [SUBJAREA (EART)]. Based on the number of publications (in 2020) we selected the top forty (n = 40) countries. Next, we retrieved their per year publications data from 2010 to 2020. Furthermore, we calculated their per year growth rates. It's important to note that we only focused on research articles and reviews. The publications of 2021 were ignored in analysis.

2.2. VOSVeiwer Analysis

We used VOSviewer version 1.6.9 for viewing and analyzing the authors, institutes and countries [16].

3. RESULTS AND DISCUSSION

Part-1: Ranking based on number of publications (for the year 2020)

Based on the number of publications, it can be confirmed that the USA and China are arguably the top two global superpowers in the current research publications. According to National Science Foundation report published in 2018, USA has occupied the top rank as the leading producer of science and engineering (S&E) research. United States produced 393,979 S&E publications in 2008, which increased to 422,808 in 2018. While China produced 249,049 publications in 2008 and published extensively in 2018 (i.e., 528,263) [17]. The average annual growth rate 2008–18 (%) for USA was lower (n = 0.71) than China (n = 7.81). Similarly, the nature ranking also confirmed that China is the global leader in high quality chemistry research. This is exactly we observed in the present study. From 2010 to 2014, USA was the top producer with highest number of publications, i.e., 23833, 23527, 21861, 21709 and 20746, respectively. However, from 2015, China has overtaken USA. The per year publications (of China) for the last six years are 2015 (n = 39236), 2016 (n = 35210), 2017 (n = 31773), 2018 (n = 28293), 2019 (n = 27588) and 2020 (n = 26894). In fact, China has astonishingly produced 30.96%, 30.14%, 28.61%, 27.07%, 26.75% and 27.03% research publications for the stated years, respectively.

China's ascent in scientific contributions can be attributed to its substantial investment in research and development (R&D). In 2018 alone, the country allocated approximately $554 billion towards R&D spending in education, reflecting a robust commitment to advancing scientific endeavors. Although, the United States retains its position as the leading R&D nation, its 2018 spending saw a more modest increase, rising by only 5% to approximately $581 billion. Gross domestic spending on R&D encompasses the total expenditure, including both current and capital, on research and development conducted by resident companies, research institutes, universities, government laboratories, and other entities within a country.

Moreover, China's investment in its universities has experienced remarkable growth from 2000 to 2018, multiplying by 10.2 times during this period. In contrast, expenditures in the United States grew at a much slower rate, increasing by only 1.8 times over the same timeframe. The National Science Foundation (NSF) has compiled data from various reputable sources, including the United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute for Statistics database and the Organization for Economic Co-operation and Development (OECD) to corroborate these findings. Additionally, data from the National Bureau of Statistics of China, as presented in the China Statistical Yearbook, further affirm this trend.

1. From 2004 onwards China awarded more

Bachelor's degree in S&E fields.

2. From 2006 onwards China awarded more Doctoral degrees in S&E fields.
3. From 2005 onwards, China has more estimated number of researchers as compared with USA.

The publications data of all forty countries from 2010 to 2020 is provided in supplementary Table S1. While, the data for the year 2020 is presented in Table 1. We can also represent the country-wise data in different regions or continents.

From Europe nineteen countries contributed to research publications. The top five countries from this region are United Kingdom (n = 10784), Germany (n = 10429), France (n = 7783), Russian Federation (n = 6942) and Italy (n = 6620). From Asia eight countries were involved in publications. The highest contribution was offered by China (n = 39236), India (n = 6523), Japan (n = 5135), South Korea (n = 2428) and Taiwan (n = 1295). From North America, three countries have significantly contributed, i.e., United States (n = 27889), Canada (n = 6021), Mexico (n = 1454). Australia (n = 6558), New Zealand (n = 1171) contributed from Oceana, Brazil (n = 3932), Chile (n = 1992), and Argentina (n =1380), from South America; Iran (n = 3344), Saudi Arabia (n = 930) and Israel (n = 894) from Middle East, while South Africa (n = 1843) and Egypt (n = 1049) were the top contributors from Africa.

While, irrespective of the region (in 2020), the top ten countries are China (n = 39236), United States (n = 27889), United Kingdom (n = 10784), Germany (n = 10429), France (n = 7783), Russian Federation (n = 6942), Italy (n = 6620), Australia (n = 6558), India (n = 6523) and Canada (n = 6021). In fact, from 2010-the top two countries are China and USA. Some of the common features of these ten countries are the high-ranking research institutions, rising interest in new fields of science, increase in international collaborations and last but not the least, the increase in government funding. From world bank we also retrieved the per year research and development (R&D) data (from the year 2010 to 2018) for the top ten countries as shown in Table 2 [18]. We will also highlight that based on the number of publications (for the year 2020), Pakistan was ahead of some of the prominent countries. For

Table 1. Number of publications (NOP) of the top forty countries for the year 2020.

S. No.	Country	Total Documents	S. No.	Country	Total Documents
1	China	39236	21	Chile	1992
2	United States	27889	22	South Africa	1843
3	United Kingdom	10784	23	Turkey	1689
4	Germany	10429	24	Belgium	1646
5	France	7783	25	Austria	1507
6	Russian Federation	6942	26	Mexico	1454
7	Italy	6620	27	Denmark	1435
8	Australia	6558	28	Argentina	1380
9	India	6523	29	Portugal	1370
10	Canada	6021	30	Taiwan	1295
11	Japan	5135	31	Czech Republic	1285
12	Spain	5054	32	Finland	1281
13	Brazil	3932	33	New Zealand	1171
14	Iran	3344	34	Egypt	1049
15	Netherlands	3318	35	Greece	1001
16	Switzerland	2918	36	Saudi Arabia	930
17	Poland	2482	37	Hong Kong	897
18	South Korea	2428	38	Israel	894
19	Sweden	2119	39	Indonesia	867
20	Norway	2077	40	Pakistan	854

Table 2. R&D (% of GDP) data of the top ten countries from 2010 to 2020 [18].

Country Name	2010	2011	2012	2013	2014	2015	2016	2017	2018
Germany	2.71	2.80	2.87	2.82	2.87	2.91	2.92	3.04	3.09
United States	2.74	2.77	2.68	2.71	2.72	2.72	2.76	2.82	2.84
France	2.18	2.19	2.23	2.24	2.28	2.27	2.22	2.21	2.20
China	1.71	1.78	1.91	2.00	2.03	2.07	2.12	2.15	2.19
United Kingdom	1.66	1.66	1.59	1.64	1.66	1.67	1.68	1.70	1.72
Canada	1.83	1.79	1.78	1.71	1.72	1.70	1.73	1.67	1.57
Italy	1.22	1.21	1.27	1.31	1.34	1.34	1.37	1.38	1.40
Russian Federation	1.13	1.01	1.03	1.03	1.07	1.10	1.10	1.11	0.99
India	0.79	0.76	0.74	0.71	0.70	0.69	0.67	0.67	0.65
Australia	2.38	2.24	NA	2.18	NA	1.92	NA	1.87	NA

example, Malaysia (n = 802), Ireland (n = 686), Hungary (n = 643), Ukraine (n = 625), Vietnam (n = 558), Thailand (n = 540), Singapore (n = 486), Romania (n = 398), Morocco (n = 384), Slovakia (n = 370), Croatia (n = 338), Bangladesh (n = 312), Slovenia (n = 286), Serbia (n = 274), Iceland (n = 234), Philippines (n = 189), Bulgaria (n = 148), Lithuania (n = 138), Sri Lanka (n = 101), Georgia (n = 99), Lebanon (n = 99), Oman (n = 98), Qatar (n = 76), Luxembourg (n = 66) and Belarus (n = 62).

Part-2: Ranking based on growth rate (for the year 2019-2020)

Based on the growth rate (GR) (for the year 2019-2020), Pakistan is the top ranked country (GR = 38.86), followed by Indonesia (n = 31.36), New Zealand (n = 22.00), Mexico (n = 16.97), Argentina (n = 15.71), Turkey (n = 15.67), Finland (n = 15.66), Taiwan (n = 15.38), India (n = 14.32) and Switzerland (n = 14.12). We further calculated the growth rate for Pakistan and other thirty-nine countries for the last ten years. The data is presented in supplementary Table S2. It is interesting to note that for the years, 2018-19, 2017-18, 2016-17 and 2014-15, Pakistan occupied the 2nd position, for 2013-14 and 2010-11, Pakistan was on 3rd position. The details for the 2019-2020 is presented in Table 3.

Part-3A: Pakistan

This motivated to explore its overall research productivity since independence (from 1947). In total Pakistan published 4972 research documents in earth sciences. The highest documents are published in 2020 (n = 854), followed by 2019 (n = 615), 2018 (n = 492), 2017 (n = 383), 2015 (n = 347), 2016 (n = 333), 2014 (n = 271), 2013 (n = 214), 2012 (n = 178) and 2011 (n = 174). The per year publications details is provided in Table 4.

3.1A. Subject Area or Domains

Scopus categorized the publications in different subject areas, e.g., earth and planetary sciences (n = 4972), environmental science (n = 1493), physics and astronomy (n = 928), engineering (n = 838), agricultural and biological sciences (n = 836), mathematics (n = 454), materials science (n = 369), computer science (n = 256), chemical engineering (n = 204), chemistry (n = 189) and energy (n = 174), to name a few.

3.2A. Authors

Its worthy to note that in all publications (n = 4972), 8814 authors have significantly contributed. Based on the number of publications, the top ten authors are Sharif M. (n = 156), Khan M.A. (n = 124), Ali A. (n = 108), Ali S. (n = 103), Khan S. (n = 101), Ahmad I. (n = 93), Ahmad S. (n = 81), Ali M. (n = 69), Khan A. (n = 69) and Hussain S. (n = 63).
However, the highest citations were recorded for Sharif M. (n = 2036), Khan M.A. (n = 1939), Jan M.Q. (n = 1393), Syed F.S. (n = 1202), Dawood H. (n = 1112), Ashraf M. (n = 1088), Burg J.-P. (n = 1041), Farooq M. (n = 1038), Zubair M. (n = 1004), and Giorgi F. (n = 955).

3.3A. Institutes

10445 institutions are directly involved in all

Table 3. Percent (%) growth rate (GR) of the top forty countries for 2019-2020.

S. No.	Year	2019-20	S. No.	Year	2019-20
1	Pakistan	38.86	21	Spain	9.39
2	Indonesia	31.36	22	Greece	9.28
3	Finland	22	23	Netherlands	9.04
4	Turkey	16.97	24	Mexico	8.18
5	Portugal	15.71	25	Iran	8.08
6	Belgium	15.67	26	Australia	7.74
7	Czech Republic	15.66	27	South Korea	7.29
8	Argentina	15.38	28	Italy	7.14
9	India	14.32	29	Japan	7.14
10	Switzerland	14.12	30	Austria	6.43
11	Brazil	13.87	31	Saudi Arabia	6.29
12	New Zealand	13.58	32	France	6.08
13	Chile	13.05	33	Canada	5.85
14	Israel	12.45	34	United Kingdom	5.37
15	Norway	11.55	35	Germany	5.32
16	China	11.43	36	South Africa	5.13
17	Egypt	10.42	37	Sweden	5.06
18	Hong Kong	10.2	38	Poland	4.81
19	Denmark	10.13	39	United States	4.02
20	Taiwan	10.12	40	Russian Federation	-3.02

publications (n = 4972). The highest number of documents are contributed by Department of Mathematics, University of The Punjab, Quaid-e-Azam Campus, Lahore, 54590, Pakistan (n = 111), followed by National Centre of Excellence in Geology, University of Peshawar, Pakistan (n = 83), University of Chinese Academy of Sciences, Beijing, 100049, China (n = 68), Department of Earth Sciences, Quaid-i-Azam University, Islamabad, Pakistan (n = 67), National Centre of Excellence in Geology, University of Peshawar, Peshawar, Pakistan (n = 55). Institute of Geology, University of The Punjab, Lahore, 54590, Pakistan (n = 44), Department of Earth Sciences, Quaid-i-Azam University, Islamabad, 45320, Pakistan (n = 40), Department of Geology, University of Baluchistan, Quetta, Pakistan (n = 40). Department of Geology, University of Peshawar, Pakistan (n = 40) and Centre of Excellence in Mineralogy, University of Baluchistan, Quetta, Pakistan (n = 36).

However, the highest citations were recorded for Department of Mathematics, University of The Punjab, Quaid-e-Azam Campus, Lahore, 54590, Pakistan (n = 1196), followed by Global Change Impact Studies Centre, Pakistan Meteorological Department, Islamabad, Pakistan (n = 880), National Centre of Excellence in Geology, University of Peshawar, Peshawar, Pakistan (n = 833), Department of Mathematics, University of The Punjab, Quaid-e-Azam Campus, Lahore 54590, Pakistan (n = 761), Center For Atmospheric Physics, Institute of Meteorology, Havana, Cuba (n = 746), Department of Air Pollution and Climate Change, Egyptian Meteorological Authority, Cairo, Egypt (n = 746), Department of Civil Engineering and Environmental Science, Loyola Marymount University, Los Angeles, California, United States (n = 746), Department of Earth Sciences, University of California, Santa Cruz, California, United States (n = 746), Department of Environmental Science, University of California, Berkeley, United States (n = 746), Department of Hydrology and Meteorology, Katmandu, Nepal (n = 746) and Earth Systems Physics Group, The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy (n = 746).

3.4A. Universities

Based on the number of publications the top

Table 4. The per year publications of Pakistan.

Year	Publications	Year	Publications	Year	Publications
1912	3	1976	2	1999	23
1913	1	1977	3	2000	28
1916	3	1978	8	2001	26
1919	2	1979	1	2002	33
1951	1	1980	8	2003	29
1952	1	1981	16	2004	36
1953	1	1982	13	2005	40
1954	1	1983	17	2006	52
1955	3	1984	35	2007	86
1959	2	1985	26	2008	88
1961	3	1986	28	2009	100
1962	1	1987	11	2010	121
1963	3	1988	21	2011	174
1964	1	1989	29	2012	178
1965	1	1990	21	2013	214
1966	2	1991	22	2014	271
1967	3	1992	10	2015	347
1968	2	1993	19	2016	333
1970	3	1994	14	2017	383
1971	2	1995	25	2018	492
1972	2	1996	25	2019	615
1973	4	1997	20	2020	854
1975	3	1998	27		

universities are University of Peshawar (n = 584), University of the Punjab, Lahore (n = 515), COMSATS University Islamabad (n = 488), Quaid-i-Azam University, Islamabad (n = 359), National University of Sciences and Technology, Pakistan (n = 265), University of Engineering and Technology Lahore (n = 231), University of Karachi (n = 223), University of Agriculture, Faisalabad (n = 210), University of Chinese Academy of Sciences (n = 136), Geological Survey of Pakistan (n = 126), Pakistan Institute of Nuclear Science and Technology (n = 116) and University of Baluchistan (n = 109). The list of most productive universities is provided in supplementary Table S3.

3.5A. Citation Details for All Documents

The total citations for all publications (n = 4972) were 62555. However, only two documents received more than six hundred citations, four documents received more than three hundred citations, six documents received more than two hundred citations, fifty seven documents received more than one hundred citations, one hundred and ninety seven documents received between fifty and ninety nine (n = 50-99) citations, one thousand three hundred documents received between ten and forty nine citations (n = 10 to 49), two thousand five hundred and thirteen documents received between one and nine citations (n = 1 to 9), while eight hundred and seventy four documents received zero citations.

3.6A. Sources

All documents were published in 648 sources. Based on the number of publications, the top major sources of Pakistan's publications are Astrophysics And Space Science (n = 292), Arabian Journal of Geosciences (n = 264), European Journal of Scientific Research (n = 209), Journal of Himalayan Earth Sciences (n = 179), International

Journal of Modern Physics D (n = 117), SN Applied Sciences (n = 113), Iranian Journal of Science and Technology Transaction A: Science (n = 112), Environmental Earth Sciences (n = 89), Agricultural Water Management (n = 70) and Journal of Asian Earth Sciences (n = 57).

However, the highest citations were received by Astrophysics and Space Science (n = 3578), Agricultural Water Management (n = 2099), Soil and Tillage Research (n =1996), Atmospheric Environment (n = 1462), Environmental Earth Sciences (n = 1087), Arabian Journal of Geosciences (n = 987), Nature Geoscience (n = 981), Geology (n = 980), Journal of Asian Earth Sciences (n = 967) and Journal of Geochemical Exploration (n = 963).

Part 3B: University of Peshawar (UOP), Peshawar, KP-Pakistan

Since UOP produced the highest number of publications (n = 584) for Pakistan, therefore we also retrieved the research output details. UOP published its 1st document in 1971. The highest number of documents are published in 2019 (n = 74), followed by 2020 (n = 71), 2018 (n = 60), 2016 (n = 56) and 2017 (n = 49). The per year number of publications (University of Peshawar) along with collaboration countries is provided in Table 5.

3.1B. Citation Details for All Documents

The total citations were found to be 7613 for all publications (n = 584). Only one document received more than two hundred citations (n = 200), thirteen documents received between 100-199 citations, twenty documents received between 51 to 99 citations, one hundred and forty-six documents received between 10 to 49 citations, two hundred and ninety nice received between 1 to 9 citations and one hundred and five documents received zero (n = 0) citations.

Table 5. The per year publications and main collaborating countries for University of Peshawar.

Year	Publications	Year	Publications	Collaborating Countries	Publications	Collaborating Countries	Publications
1970	1	1999	5	Pakistan	584	Egypt	3
1973	1	2000	3	China	78	Finland	3
1977	1	2001	3	United States	71	Georgia	3
1978	1	2003	5	United Kingdom	66	Israel	3
1979	1	2004	4	Netherlands	17	Malaysia	3
1981	5	2005	3	Australia	13	Afghanistan	2
1982	4	2006	3	Austria	13	Ireland	2
1983	3	2007	7	Germany	13	Jordan	2
1984	13	2008	6	Canada	11	Kyrgyzstan	2
1985	11	2009	9	Turkey	11	New Zealand	2
1988	3	2010	12	Italy	9	Oman	2
1989	7	2011	13	Iran	8	Taiwan	2
1990	2	2012	17	Japan	8	Tajikistan	2
1991	1	2013	29	Brazil	7	Algeria	1
1992	1	2014	37	France	7	Armenia	1
1993	4	2015	47	Spain	6	Azerbaijan	1
1994	1	2016	56	Thailand	5	Brunei Darussalam	1
1995	2	2017	49	India	4	Estonia	1
1996	7	2018	60	Saudi Arabia	4	Hong Kong	1
1997	1	2019	74	Switzerland	4	Iraq	1
1998	1	2020	71	Denmark	3	Lebanon	1

3.2B. Sources

Total number of sources were 160. The highest documents are published in Journal of Himalayan Earth Sciences (n = 115), followed by Arabian Journal of Geosciences (n = 51), Geological Bulletin, University of Peshawar (n = 21), Journal of Asian Earth Sciences (n = 19), Natural Hazards (n = 12), Journal of Atmospheric and Solar-Terrestrial Physics (n = 11), Journal of Earth System Science (n = 11), Journal of Mountain Science (n = 11), Acta Geologica Sinica (n = 10) and Atmospheric Environment (n = 9).

While the highest citations were received by Palaeogeography, Palaeoclimatology, Palaeoecology (n = 400), Tectonics (n = 362), Special Paper of the Geological Society of America (n = 340), Geology (n = 328), Geomorphology (n = 312), Journal of Asian Earth Sciences (n = 307), Journal of Petrology (n = 284), Journal of the Geological Society (n = 243), Journal of Soils and Sediments (n = 218) and Journal of Himalayan Earth Sciences (n = 195).

3.3B. Authors

Total 1090 authors have contributed in 584 publications. Based on the number of publications, the top ten authors are Khan S. (n = 85), Khan M.A. (n = 52), Jan M.Q. (n = 44), Ahmad S. (n = 42), Hanif M. (n = 36), Ali A. (n = 34), Jan I.U. (n = 34), Shafique M. (n = 31), Shah M.T. (n = 31) and Ahmad I. (n = 27). However, the highest citations were noted for Jan M.Q. (n = 1316), Khan M.A. (n = 1199), Tahirkheli R.A.K. (n = 678), Khan S. (n = 598), Shah M.T. (n = 564), Alam K. (n = 428), Hamidullah S. (n = 390), Shafique M. (n = 294), Ullah S. (n = 235), Ahmad I. (n = 234) and Ali A. (n = 231).

After keeping the minimum number of publications to be five, we also calculated the citation per documents (CPD) for all authors. The highest CPD was noted for Tahirkheli R.A.K. (n = 85), followed by Khattak M.U.K. (n = 41), Jan M.Q. (n = 30), Bibi H. (n = 26), Khan S.F. (n = 25), Bibi S. (n = 25), Khan M.A. (n = 23), Afzal J. (n = 23), Muhammad S. (n = 21) and Sayab M. (n = 19).

The UOP also collaborated with 46 countries. The highest documents are collaborated with China (n = 78), followed by United States (n = 71), United Kingdom (n = 66), Netherlands (n = 17), Australia (n = 13), Austria (n = 13), Germany (n = 13), Canada (n = 11), Turkey (n = 11) and Italy (n = 9).

4. CONCLUSIONS

The substantial growth in Pakistan's scientific output can be attributed to several pivotal factors. A key catalyst was the establishment of the Higher Education Commission (HEC) in Islamabad, Pakistan, on September 11, 2002, which emerged as a major driving force behind this expansion. Notably, Pakistan produced a staggering 90.50% (n = 4500) of its publications in the 21st century (after 2000); whereas, only 9.50% (n = 472) were published from 1947 to 1999. Similarly, the University of Peshawar witnessed a notable shift, with 508 documents published after 2000 compared to only 76 published earlier, with the first document dating back to 1970. The growth of the education sector is evident from the increase in the number of universities, which rose from 74 in 2001-02 to 211 in 2019-20, accommodating a significant increase in both students and faculty members. Public expenditure on education also saw a remarkable surge, escalating from 72.3 billion in 2001 to 315 billion in 2018, reflecting a robust commitment to educational advancement. Notably, the total expenditure on higher education witnessed substantial growth over the years, reaching 44.00 billion in 2009-10. International collaboration in research also experienced a significant upsurge, with collaborations noted with twenty-three countries from 1947 to 1999. Notably, collaborations were primarily with countries such as the USA, UK, and Germany. However, post-2000, a substantial increase in collaboration was observed, with collaborations spanning to 117 countries, with China emerging as Pakistan's most important partner. Despite these significant strides, Pakistan's global share in scientific production remains modest, accounting for only 0.178% of the total global production in 2020. This underscores the need for concerted efforts to further enhance overall productivity in the field of scientific research.

5. CONFLICT OF INTEREST

The authors declare no conflict of interest.

6. REFERENCES

1. J. Hui, L. Wang, R. Liu, C. Yang, H. Zhang, and

A.H.S. Wei. A bibliometric analysis of international publication trends in premature ejaculation research (2008–2018). *International Journal of Impotence Research* 33: 1-10 (2020).
2. P.K. Muhuri, A.K. Shukla, and A. Abraham. Industry 4: A bibliometric analysis and detailed overview. *Engineering Applications of Artificial Intelligence* 78: 218-235 (2019).
3. V. Nunen, K. Li, G. Reniers, and K. Ponnet. Bibliometric analysis of safety culture research. *Safety Science* 108: 248–258 (2018).
4. J.A. Wallin. Bibliometric Methods: Pitfalls and Possibilities. *Basic & Clinical Pharmacology and Toxicology* 97(5): 261–75 (2005).
5. A. Pritchard. Statistical bibliography or bibliometrics. *Journal of Documentation* 25(4): 348-349 (1969).
6. M. Matthews, B. Biglia, K. Henadeera, J.F.D. Hicks, R. Faletic, and O. Wenholz. A Bibliometric Analysis of Australia's International Research Collaboration in Science and Technology: Analytical Methods and Initial Findings. *FEAST Discussion Paper 1/09* (2009).
7. Q.H. Pu, Q.J. Lyu, and H.Y. Su. Bibliometric analysis of scientific publications in transplantation journals from Mainland China, Japan, South Korea and Taiwan between 2006 and 2015. *British Medical Journal Open* 6: e011623 (2016).
8. S. Rana. Bibliometric analysis of output and visibility of science and technology in Singapore during 2000-2009. *Webology* 9(1): 1-12 (2012).
9. P.B. Soares, T.C.J. Carneiro, J.L. Calmon, and O. Castro. Bibliometric analysis of the Brazilian scientific production on Building and Construction Technologies in the Web of Science database. *Ambient Construction* 16: 175-185 (2016).
10. A.A. Arroyo, E.F.T. de Oliveira, M.C.C. Grácio, A. Pandiella, and R.A. Benavent. A bibliometric analysis of collaboration between Brazil and Spain in the field of medical research from 2002 to 2011. *Investigación Bibliotecológica.* 30(69): 198-221 (2016).
11. B. Elango. A bibliometric analysis of literature on engineering research among BRIC countries. *Collection and Curation* 38: 9-14 (2019).
12. R.S. Bajwa and K. Yaldram. Bibliometric analysis of biotechnology research in Pakistan. *Scientometrics* 95(2): 529–540 (2013).
13. N. Siddique, S.Ur. Rehman, M.A. Khan, and A. Altaf. Library and information science research in Pakistan: A bibliometric analysis, 1957–2018. *Journal of Librarianship and Information Science* 53: 89-102 (2021).
14. W. Hassan, M. Khalid, and M.R. Shah. Research Publications Growth Rate of Chemistry and Related Subject Areas in Pakistan and Fifty Countries from 2001 to 2020. *Journal* of the *Chemical Society* of *Pakistan* 2: 144-164 (2021).
15. W. Hassan, S. Rahman, and A. Ara. The Research Publications Growth Rate of Pakistan in the Field of Material Sciences: Comparison with 50 countries: Material Sciences Research in Pakistan: Bibliometric Analysis. *Proceedings of the Pakistan Academy of Sciences: A. Physical and Computational Sciences* 58(3): 1–14 (2021).
16. V.E. Waltman. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* 84(2): 523-538 (2010).
17. J. Veysey. National Science Board, National Science Foundation. U.S. Trends and International Comparisons. Science and Engineering Indicators 2020. *NSB-2020-6* (2019). https://www.nsf.gov/pubs/2020/nsb20201/nsb20201.pdf.
18. The World Bank, Research and development expenditure (% of GDP). Code GB.XPD.RSDV.GD.ZS (2024). https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS.