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Open Access Scholarly Communications on Climate Change Research in SAARC Countries: A Scientometric Analysis

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Abstract

The research aims to examine the development and characteristics of open access (OA) scholarly communication on climate change in the SAARC countries (South Asian Association for Regional Cooperation). The objectives include determining trends in OA publications, measuring research collaboration, identifying leading countries in OA journal distribution, examining doubling periods and relative growth rates, and exploring overlay visualizations of authors and organizations using scientometric indicators. A comprehensive search was conducted in the Web of Science Core Collection from 2008 to 2022 to gather pertinent OA publications. A total of 5,814 publications were retrieved. There is a significant increase in OA from 0.30% in 2008 to 25.76% in 2022. Collaboration among SAARC countries is prevalent, with India leading in joint publications. This study also highlights the top collaborating institutions within each country and the escalated publication growth rate over the years. The doubling time varied from approximately 0.707 to 2.32 years, suggesting a changing growth pace. Overall, all four types of OA publications experienced considerable growth over the 15 years, with Gold OA leading the way with the most growth, followed by Green OA. The results of this research help clarify the landscape of OA scholarly communication on climate change in the SAARC countries; and can guide strategies to enhance research collaboration, promote OA publishing, and effectively address climate change challenges.

Keywords: Climate Change, Open Access Publications, SAARC Countries, Scientometrics, Scholarly Communication.

1. Introduction

Despite the resurgence of interest among academics and policy makers in South Asia to understand the "emergence" of the BICs (Brazil, India, and China) and the "Next 11," very little literature has been written about South Asia on an international relation in general and there is hardly any noteworthy work that examines its institutions (Holmes et al., 2008). The changing climate is now one of the most pressing issues confronting humanity on a global scale. To effectively manage the variations in world climate and its adverse effect, it is

imperative to foster international collaboration to solve this trans-boundary, multi-dimensional problem. The members of SAARC have been among the most severely affected nations in the world. This region is particularly vulnerable due to its geography and unique socio-economic circumstances. The SAARC is trying to reach a regional climate change mitigation and adaptation agreement. The need for effective communication of climate change-related information to stakeholders in the region is thus paramount (Islam & Kieu, 2021). Effective scholarly communication plays an important role here, ensuring knowledge transfer among the experts across the globe. However, one of the primary concerns of researchers is the inadequate availability of journals and the insufficient contemplation of esteemed scholarly publications, resulting in significant research gaps and preventing holistic approach.

The objective of the Open Access (OA) initiative is to resolve this issue by imparting knowledge without any commercial interests or incentives. According to Peter Suber, the concept of OA literature pertains to digital content that is accessible online, devoid of any charges, and largely unencumbered by copyright and licensing limitations (Anderson, 2013). The concept allows researchers to replicate, employ, disseminate, broadcast, and publicly showcase the work, as well as generate and distribute modified versions of it in any digital format for any legitimate purpose, provided that the authorship is appropriately acknowledged. The adoption of OA in scholarly communication has been found to be advantageous over the years and has been implemented by numerous higher education institutions worldwide (Hassan Abdelrahman, 2021). There are several different OA models that aim to provide free and unrestricted access to research and scholarly publications (Nazim, 2018). These models vary in terms of funding, licensing, and distribution methods.

Here are some of the main OA models:

a) Gold Open Access (Gold OA): Research publications are instantly accessible to readers. APCs support publishing expenses for authors. Gold OA journals publish all papers openly (Bjork, 2017).
b) Green Open Access (Green OA): Authors self-archive in institutional or subject repositories. After an embargo period, these repositories provide unfettered access to the papers. Green OA lets researchers publish in subscription-based journals while meeting open access requirements (Bjork, 2017).
c) Hybrid Open Access (Hybrid OA): Combines subscription-based and open access publication. Publishers provide hybrid journals with open access articles for an APC and subscriber-only material. Hybrid OA has been criticized for double-dipping and excessive APCs (Laakso & Bjork, 2016).
d) Diamond Open Access (Diamond OA): Free for readers and writers. They generally use institutional or government financing, donations, or volunteer effort. APC-free. Diamond OA journals encourage research accessibility and openness (Normand, 2018).
e) Bronze Open Access (Bronze OA): Publishers publish papers for free without APCs. Sponsors, institutions, and groups frequently fund (Piryani *et al*., 2019).
f) Freemium/Open Access Plus: Certain publications provide a freemium or open access plus model, making certain articles free while charging for premium material or improved features like data or services (Kitchin *et al.*, 2015).
g) Delayed Open Access: Publishers make papers freely available after an embargo period, which is limited to subscribers. Publishers may embargo for months or years (Laakso & Bjork, 2013).

2. Literature Review and Identification of Research Gap

Numerous scholarly publications have addressed bibliometric facets of research output and productivity within the scientific community across various nations. Banshal *et al*. (2017) analysed the growth rate of research output of the different Indian Institute of Technology (IITs) where it has been compared with top-ranking institutions such as MIT-USA and NTU-Singapore. Bibliometric analysis of publications on climate change has been publishedby Haunschild et al. (2016). Li *et al.* (2020) used bibliometric analysis, scientific knowledge mapping, and a traditional literature review to analyse and visualise historical trend evolution, current research hotspots, and promising future research. Zhang *et al*. (2021) used 3050 Scopus articles published since 1999 to do a bibliometric analysis, network analysis from a national viewpoint, and subject identification to determine current research objectives for bioenergy under climate change. Omoregbe *et al.* (2022) research analyses direct carbon dioxide emission reduction by carbon capture bibliometrically.

The objective of climate change research is to gain insight into the worldwide alterations in the environment and their potential consequences for both the natural world and human society. According to the Intergovernmental Panel on Climate Change (IPCC, 2014), the extensive range of impacts resulting from climate change necessitates a collaborative approach that brings together various fields of study and can promptly address the changing climate concerns in order to achieve effective adaptation and mitigation outcomes. However, to achieve this aim, climate change research practices need updating as key research findings remain behind journal paywalls, and scientific progress is being impeded by low levels of reproducibility and transparency (Morueta-Holme *et al*., 2018). Tai and Robinson (2018) published a scholarly work on the level of attention and involvement from the public and policymakers regarding issues related to climate change that is dependent on the timely distribution of scholarly research to governmental entities. There have been numerous articles published on the communication related to climate change in the SAARC countries. A few studies like Sembiring (2018) investigates regional processes for climate change across several locations, building on prior research that focuses on climate change collaboration in the Lower Mekong River Basin. Maula *et al.* (2018) study compared Indonesian dengue publishing patterns and knowledge structure to South-East Asia (SEA) from 2007 to 2016. Omoregbe *et al.* (2022) included a summary of Sri Lanka's agriculture sector's climate change and adaptation situation in their essay. Shettar and Hadagali (2023) summarised drinking water status in the context of climate change by examining accessible secondary data from published and grey literature. Zacharia *et al.* (2016) synthesised farmers' climate change perceptions using a rigorous literature review. Islam and Kieu (2021) investigated the effectiveness of measures implemented by SAARC in mitigating and adapting to challenges related to food security and climate change.

Anderson (2013) presented journal editor's rationale, methods, challenges, and personal experiences developing, using, and reusing peer-reviewed scientific publications as OER. The researcher's discoveries demonstrate the contrast between digital resources and those that are freely accessible, as well as the academic trend of embracing open access over the course of the past ten years. In the past few years, several recent studies have also analysed the status of OA journals in different countries. In his study, Nazim (2018) analysed the present condition of Gold OA in India, with a specific emphasis on research output published in OA journals. In a similar study, Muniyasamy (2022) explored open education research's worldwide growth with scientometric analysis of 1992-2021 publication trends to locate and evaluate open education research. Zia (2021) explored the study to compare the OA research

output of Brazil, Russia, India, China, and South Africa (BRICS) countries from 2010 to 2019. It was found that, out of 2,219,943 papers published, 402,199 were in OA journals. Singh *et al.* (2020) evaluated SAARC nations' type of repository, fields of study, languages covered, and tools used to create them and found that India leads SAARC in institutional repositories (72.66%). Haunschild et al. (2016) analysed 222,060 articles and reviews between 1980–2014 and found that the publication doubled every 5-6 years. Nazim (2018) examines Gold OA in India using Web of Science-indexed publications and contrasts the general research output of Indian academics published in OA journals with Gold OA, with the advice to consider local journals to measure research output. Kipnis & Brush (2023) found that the Public University in the USA's Science and Engineering department published Gold OA journals from 2013 to 2022.

Despite the abundance of research on OA, no scholarly investigation has been conducted to date regarding the current state of climate change-related publications from SAARC countries that have been published in OA journals. The objective of the present study is to examine the contemporary state of Open Access scholarly communications on climate change in SAARC countries spanning the period from 2008 to 2022.

3. Objectives of the Study

This study aims to conduct a comprehensive review of Open Access Scholarly Communication pertaining to climate change in SAARC countries from 2008 to 2022 with the following specific objectives:

a) To determine the growth trends of OA scholarly communications on climate change published by SAARC countries.
b) To measure research collaboration within SAARC countries and compare it with global trends.
c) To identify the SAARC nation that distributes OA journal articles most widely.
d) To investigate the relative growth rate and time to doubling in OA publications.
e) To determine the co-authorship index (CAI) and degree of collaboration (DC).
f) To create overlay visualizations of co-authorship with organizations and co-authorship with authors.

4. Data Source and Methodology

4.1 Search Strategy

To evaluate research conducted in SAARC nations by extracting data from the Web of Science, the advanced search was conducted using search string (TS="climate change" OR TI="climate change" OR AB="climate change" OR AK="climate change" OR KP="climate change") and INDIA or PAKISTAN or NEPAL or BHUTAN or AFGHANISTAN or MALDIVES or SRILANKA or BANGLADESH (Countries/Regions) and Open Access and 2022 or 2021 or 2020 or 2019 or 2018 or 2017 or 2016 or 2015 or 2014 or 2013 or 2012 or 2011 or 2010 or 2009 or 2008 (Publication Years) and English (Languages).

4.2 Data Collection

The search strategy yielded 5814 documents. The documents were then refined using the "Open Access" filter on the left side of the screen, which enabled the identification of research output from SAARC nations published in OA journals. In this paper, we identify scholarly databases, repositories, and other sources that provide open access to scholarly

communications on climate change. Access these sources to retrieve metadata and full-text articles authored by SAARC researchers. For the analysis, data was gathered for a specific time frame i.e., 2008-2022.

5. Findings of the Study

5.1 Growth Trends in Open Access Scholarly Communications on Climate Change

Open Access (OA) scholarly communication has witnessed remarkable growth in the field of climate change research, providing researchers with unrestricted access to scientific literature and promoting collaboration in addressing the global environmental crisis (Kumara & Govanakoppa, 2019). The growth trends in OA scholarly communication on climate change highlight the increasing availability and impact of open access research in this critical area.One of the significant growth trends in OA scholarly communication on climate change is the rising number of OA publications. As awareness and concern for climate change have grown, so has the production of open access research in this field. Researchers and institutions are recognizing the importance of making climate change research freely accessible to maximize its reach and impact. The increasing number of OA publications serves as evidence of the expanding knowledge base and the commitment of the scientific community to open access principles (Waqas et al., 2020).

We saw that the number of OA publications remained very low in the early years, increasing gradually for a while, and then, in more recent years, showed an active expansion. The last fifteen years may be divided into three phases based on the noticeable variations in the quantity of publications: (i) Around 18 to 98 publications were recorded between 2008 and 2012, (ii) 122 to 348 publications were recorded between 2013 and 2017, and (iii) 437 to 1498 publications were recorded between 2018 and 2022. In the third phase, there was significant increase observed in OA publications as compared to previous two phases. There was more than 83 times higher growth observed in the year 2022 in OA publication as compared to year 2008. Similar trends emerged in the cited references too. The growth in the cited references per paper was also observed. The minimum cited reference per paper was found 48.33 while maximum was 82.54 cited references per paper. The growth rate of the OA publications have been calculated and observed significant growth in OA publications every year. The highest growth rate is observed in 2009 while least growth observed in the year 2015. The number of OA publications increased steadily between 2008 and 2022, rising from 18 to 1498 publications. The percentage of all publications that were OA also increased with time, from 0.3% in 2008 to 25.76% in 2022.

Table - 1: Growth Trends in OA Scholarly Communications on Climate Change

Year	Number of OA Publications	OA publications (% of total OA)	Growth Rate (%)	Cited References	Cited Ref. per Paper
2008	18	0.3096	0.00	870	48.33
2009	30	0.5160	66.67	1635	54.50
2010	43	0.7396	43.33	2312	53.77
2011	69	1.1868	60.47	3909	56.65
2012	98	1.6856	42.03	4972	50.73
2013	122	2.0984	24.49	7849	64.34
2014	167	2.8724	36.89	9510	56.95

2015	191	3.2852	14.37	14914	78.08
2016	262	4.5064	37.17	16187	61.78
2017	348	5.9856	32.82	22142	63.63
2018	437	7.5163	25.57	30593	70.01
2019	602	10.3543	37.76	41064	68.21
2020	785	13.5019	30.40	60062	76.51
2021	1144	19.6766	45.73	94431	82.54
2022	1498	25.7654	30.94	122800	81.98

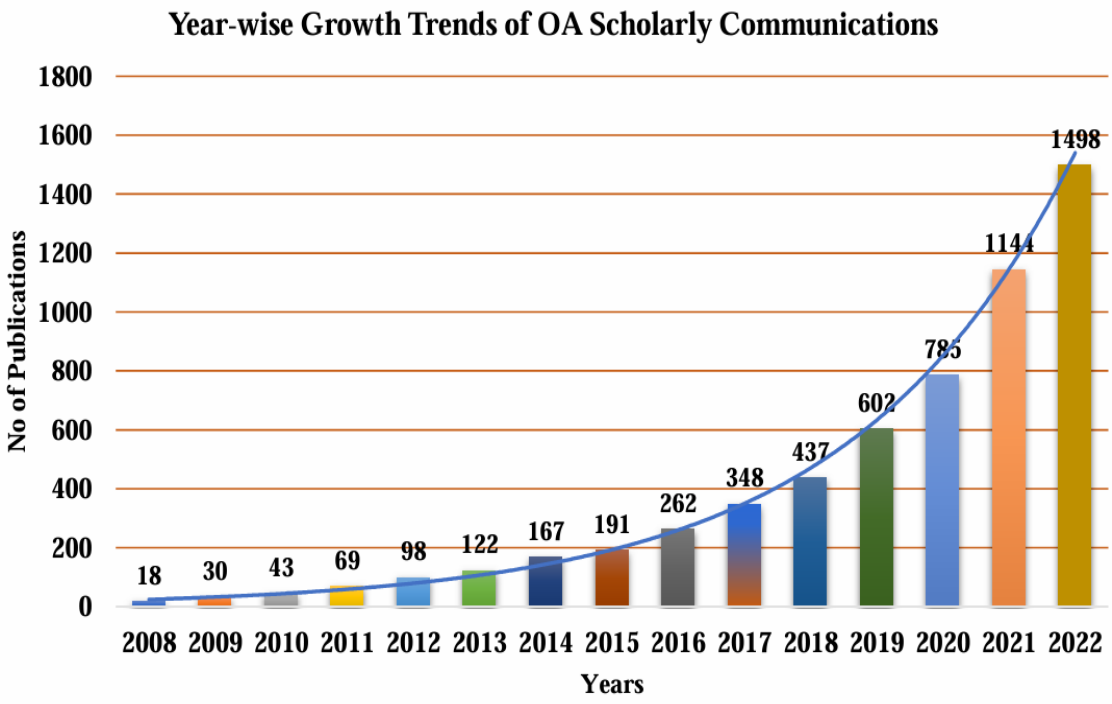

Fig. 1: Growth Trends in OA Scholarly Communications on Climate Change

5.2 Research Collaboration Metrics

Research collaboration plays a crucial role in addressing global challenges like climate change. This section presents an analysis of research collaboration between the SAARC countries and their global counterparts in the context of climate change studies (Adakawa & Harinarayana, 2022). By measuring collaboration patterns and networks, we can gain insights into the level of cooperation and knowledge sharing among researchers within the SAARC region and their engagement with the global scientific community. To measure research collaboration, several metrics can be used, including co-authorship analysis, institutional affiliations, and international collaboration indices. Co-authorship analysis examines the patterns of joint authorship in scientific publications, providing insights into collaborative relationships between researchers (Hossain & Ahmed, 2020). Institutional affiliations indicate the organizations involved in collaborative research efforts. International collaboration indices, such as the collaboration coefficient, measure the extent of collaboration between countries or regions.

5.3 Measuring Collaboration within the SAARC Countries

By analysing research publications, co-authorship networks can be constructed to visualize and quantify collaboration within the SAARC countries. The size and colour of the nodes represent the number of publications and the strength of collaboration, respectively (Sweileh, 2020). Table 2 provides a summary of key collaboration metrics, including the number of joint publications, collaboration coefficients, and top collaborating institutions within the SAARC countries.

The SAARC countries have collaborated on a total of 6252 joint publications. Out of these 438, publications are showing overlapping between SAARC countries. India has the highest number of joint publications (3376) followed by Pakistan (1164) and Bangladesh (746). Other SAARC countries like Nepal (543), Sri Lanka (229), Bhutan (39), Afghanistan (26) and Maldives (19) have joint publications. The highest collaboration coefficient was found for Maldives (1.0) and Afghanistan (1.0) followed by Pakistan (0.997), Bangladesh & Nepal (0.987 each), India (0.977), Bhutan (0.975) and Sri Lanka (0.970). In other way, India has the highest single authored publications (79) followed by Bangladesh (10), Nepal and Sri Lanka (7) each.

Table - 2: Collaboration Metrics within the SAARC Countries

SAARC Country	Number of Joint Publications	Number of Single Publications	Total	Collaboration Coefficient	Top Collaborating Institutions
India	3376	79	3455	0.977	Indian Institute of Science, Delhi University
Pakistan	1164	6	1170	0.995	Lahore University of Management Sciences, Quaid-i-Azam University
Bangladesh	746	10	756	0.987	Bangladesh Agricultural University, Dhaka University
Nepal	543	7	550	0.987	Tribhuvan University, Nepal Agricultural Research Council
Sri Lanka	229	7	236	0.970	University of Colombo, University of Peradeniya
Bhutan	39	1	40	0.975	Royal University of Bhutan, Institute for Conservation and Environment
Afghanistan	26	0	26	1.0	Kabul University, Herat University
Maldives	19	0	19	1.0	Maldives National University, Maldives College of Higher Education

5.4 Measuring Collaboration with the Global Community

Research collaboration is not limited to within the SAARC countries but extends globally (Mulla, 2012). This network helps visualize the extent of collaboration and the reach of research conducted by the SAARC countries. Table 3 displays collaboration metrics, including the number of international collaborations, collaboration coefficients, and top collaborating countries or institutions.

Table - 3: Collaboration Metrics with the Global Community

SAARC Country	International Collaboration		Collaboration Coefficient	Collaborating Countries
	Multiple Author	Single Author		
India	50	240	0.17	United States and United Kingdom
Pakistan	41	113	0.27	China, USA
Bangladesh	38	100	0.28	Canada and Australia
Nepal	42	118	0.26	Netherlands and Sweden
Sri Lanka	12	35	0.26	Germany and Japan
Bhutan	4	6	0.40	Switzerland and Singapore
Afghanistan	3	9	0.25	United States, Germany
Maldives	2	3	0.40	United States, United Kingdom

India had 50 international collaborations (multiple) and single international collaborations of 240 with a collaboration coefficient of 0.17 with top collaborating countries being the United States and United Kingdom. Pakistan had 41 collaborations and also had single collaborations of 113 with 0.27 collaboration coefficient with top collaborating countries China & United States. Bangladesh had 38 collaborations and 100 single international collaborations with 0.28 collaboration coefficient with top collaborating countries Canada and Australia. Nepal had 118 single collaborations and 42 collaborations (multiple) with 0.26 collaboration coefficient and has top collaborating countries Netherlands and Sweden. Sri Lanka had 35 single collaborations and 12 international collaborations (multiple) with 0.26 collaboration coefficient. The top collaborating countries were Germany and Japan for Sri Lanka. Bhutan had top collaborations with Switzerland and Singapore, 0.40 collaboration coefficient having 6 single collaborations and 4 multiple collaborations. Afghanistan had 9 single collaborations and 3 multiple collaborations with 0.25 collaboration coefficient; and collaborated highly with United States & Germany. Similarly Maldives had 3 single collaborations and 2 multiple collaborations with 0.40 collaboration coefficient; and United States & United Kingdom as top collaborating countries.

5.5 Relative Growth Rate & Doubling Time in Open Access

Over the last fifteen years, OA publications have grown remarkably. The number of OA publications published internationally has significantly increased, according to many researches. For instance, statistics from the Web of Science database were studied by (Björk, 2017) who discovered that the worldwide percentage of open access papers across all disciplines increased from around 14% in 2012 to 28% in 2018. In addition, OA publications have grown more quickly than non-OA publications. In a research, examined data from the Scopus database and discovered that between 2005 and 2012, the relative growth rate of open

access papers was almost 2.5 times greater than that of non-OA articles (Archambault *et al.*, 2014).

Doubling time is a concept used to estimate the time it takes for a population or investment to double in size or value. However, within the context of Open Access, the doubling time is not typically employed as a metric to measure its growth. Instead, researchers and stakeholders in the Open Access community often focus on analysing trends, adoption rates, and the absolute number of OA publications (Science, 2016). They examine factors such as the growth of OA journals, the number of articles published under Open Access licenses, and the policies promoting Open Access across institutions and funding agencies. These analyses provide insights into the progression of Open Access over time, illustrating the expansion of freely accessible research outputs and the increasing acceptance of Open Access as a valuable publishing paradigm.

Table - 4: Relative Growth Rate & Doubling Time of Scholarly Communications

Year	Pubs.	Cumulative Publications	Log_eW1	Log_eW2	RGR	Mean RGR	T_d	Mean DT
2008	18	18	0.00	2.890	0.000	0.385	-	1.796
2009	30	48	2.890	3.871	0.981		0.707	
2010	43	91	3.871	4.511	0.640		1.084	
2011	69	160	4.511	5.075	0.564		1.228	
2012	98	258	5.075	5.553	0.478		1.451	
2013	122	380	5.553	5.940	0.387		1.790	
2014	167	547	5.940	6.304	0.364		1.903	
2015	191	738	6.304	6.604	0.299		2.314	
2016	262	1000	6.604	6.908	0.304		2.281	
2017	348	1348	6.908	7.206	0.299		2.321	
2018	437	1785	7.206	7.487	0.281		2.468	
2019	602	2387	7.487	7.778	0.291		2.385	
2020	785	3172	7.778	8.062	0.284		2.438	
2021	1144	4316	8.062	8.370	0.308		2.251	
2022	1498	5814	8.370	8.668	0.298		2.326	

Table 4 represents the publication data from 2008 to 2022, along with the relative growth rate and doubling time for each year. In 2008, there were 18 publications, and the relative growth rate was nothing, indicating no change in the number of publications. The doubling time was calculated by the value 0.6931 divided by RGR (Beaie & Acol, 2009). From 2009 to 2022, the relative growth rate ranged from 0.981 to 0.298, indicating a decrease in the growth rate compared to the previous years. The doubling time during this period ranged from approximately 0.707 to 2.326 years, suggesting a gradual increase in the time it would take for the number of publications to double. In 2016, there was a slight increase in the relative growth rate to 0.304, indicating a higher growth rate compared to the previous year. The doubling time decreased to approximately 2.281 years, suggesting low pace of growth rate. In 2021, there was a slight increase in the relative growth rate to 0.308, indicating a higher pace of growth. Table 4 implies that RGR is inversely proportional to Dt, as RGR increases the doubling time decreases and vice-versa.

5.6 Growth of OA Scholarly Communications in Different OA Models

Table 5 offers information on OA publications in SAARC countries. Along with the overall number of publications, it displays the number of publications in the four separate categories of Gold OA, Green OA, Hybrid OA, and Bronze OA. The data analysis reveals that India regularly has the most overall publications throughout the study period. With 4918 articles published, India had the most publications overall. This suggests a considerable contribution to the body of knowledge on a global scale, reflecting India's vibrant research and publication environment.

Table - 5: Country-wise Scholarly Communications in Different OA Models

Countries	Gold OA Pubs	Green OA Pubs	Hybrid OA Pubs	Bronze OA Pubs	Total OA Pubs
India	2067	463	1751	637	4918
Pakistan	649	116	833	132	1730
Bangladesh	482	120	416	87	1105
Nepal	335	128	308	46	817
Sri Lanka	156	50	121	26	353
Bhutan	18	2	32	6	58
Afghanistan	15	6	16	0	37
Maldives	15	5	9	3	32
Total	**3737**	**890**	**3486**	**937**	**9050**

In contrast to India, other nations had far lower overall publication counts. However, Pakistan's publishing rates continuously raised over time, reaching to second highest position with 1730 publications, Bangladesh in third position with 1105 publications. It's important to note that although India routinely ranks first in terms of total publications, OA publishing is expanding in the other nations as seen in the Table 5. For instance, Bangladesh has steadily increased its overall number of publications over time. Similar to this, Nepal has seen improvement, with 817 publications overall. Overall, the information demonstrates the disparate degrees of OA publishing activity in the aforementioned nations. While Pakistan, Sri Lanka, Bangladesh, and Nepal have made progress in implementing open access methods, albeit at varying rates, India has a solid research output. These Figureures provide light on the dynamic nature of the research environment and the initiatives taken by these nations to improve the availability and exposure of their academic output.

5.7 Co-Authorship Index and Degree of Collaboration

To determine the co-authorship index (CAI) and degree of collaboration (DC), we analyse the patterns of collaboration among authors within a specific research field or academic community (Esh & Ghosh, 2021). These metrics provide insights into the level of collaboration and cooperation among researchers in publishing scholarly works. The CAI and DC quantitatively quantify research cooperation in a field or academic community (Elahi, 2022). These indicators help detect research cooperation trends, collaborative networks, and the influence of collaboration on academic output.

Table - 6: Co-Authorship Index (CAI) and Degree of Collaboration (DC)

Pub. Year	1 Author	CAI	2 Authors	CAI	3 Authors	CAI	4 Authors	CAI	5 and more Authors	CAI	Total	DC
2008	2	571.68	2	118.10	4	163.13	3	116.33	7	64.07	18	0.89
2009	4	686.02	6	212.58	5	122.35	5	116.33	10	54.92	30	0.87
2010	3	358.96	8	197.75	5	85.36	7	113.62	20	76.63	43	0.93
2011	6	447.40	10	154.04	15	159.58	9	91.04	29	69.24	69	0.91
2012	6	315.01	16	173.53	21	157.31	14	99.71	41	68.93	98	0.94
2013	4	168.69	19	165.53	25	150.43	22	125.86	52	70.22	122	0.97
2014	3	92.43	21	133.66	29	127.48	32	133.74	82	80.89	167	0.98
2015	3	80.81	19	105.73	29	111.46	30	109.63	110	94.88	191	0.98
2016	9	176.74	30	121.70	37	103.67	44	117.21	142	89.29	262	0.97
2017	6	88.71	26	79.41	52	109.69	58	116.33	206	97.52	348	0.98
2018	8	94.19	36	87.56	73	122.63	72	115.00	248	93.50	437	0.98
2019	9	76.92	64	113.00	84	102.43	85	98.55	360	98.52	602	0.99
2020	14	91.76	78	105.61	114	106.61	111	98.69	468	98.22	785	0.98
2021	17	76.46	98	91.05	148	94.97	144	87.86	737	106.14	1144	0.99
2022	19	65.26	114	80.89	151	74.00	197	91.79	1017	111.85	1498	0.99
Total	**113**		**547**		**792**		**833**		**3529**		**5814**	**0.96**

Based on the data presented in Table 6, it can be observed that the Co-Author Index (CAI) value for individual authors has exhibited a notable growth, rising from 571.68 to 65.26. The Collaborative Authorship Index (CAI) has exhibited a significant increase, rising from 118.10 to 80.89 in the case of double authorship, and from 163.13 to 74.00 for three authorships. The Co-Author Index (CAI) has exhibited a substantial growth, rising from an initial value of 116.33 to a far higher level of 91.79, as observed throughout the works of four distinct authors. Over the course of the past five years and beyond, there has been a general upward trend in the quantity of authorships, with the majority of years exhibiting rise between 2008 and 2022. The authors' collaboration was found to be highly significant, as indicated by a CAI score of 76.74. Moreover, in instances where there were five authors, the collaborative effort yielded a CAI score of 111.85. The objective of this study was to assess the extent of collaboration among publications released within the SAARC countries throughout the period of 15 years. Regarding collaboration, the dataset comprises 113 publications authored by a sole individual, whereas 5701 articles involve many authors. The degree of collaboration, denoted as DC, is determined to be 64.07 and 111.85. Based on the findings of the study, the mean level of collaboration was determined to be 0.96. This finding suggests that there is a higher prevalence of publications with many authors as opposed to publications with a single author during the study period. The rise in the significance of collaborative efforts is evidenced by the increasing frequency of articles authored jointly.

5.8 Co-authorship with Organizations

Co-authorship analysis examines the collaborations between authors and organizations. Overlay visualization of co-authorship networks with organizations reveals the affiliations and institutional connections of authors within a research field. This visualization can help identify research institutions, universities, or companies that actively collaborate and

contribute to the knowledge production within a specific domain. Researchers can gain insights into collaborative patterns, research partnerships, and the influence of organizations on scholarly output.

The interconnection of co-authorship on organization is determined based on the number of documents they occur together. Co-author on Organization selected from “types of analysis” and chosen from a “unit of analysis”; Counting method: full counting/ fractional counting, and minimum (5) number of documents of an organization for analysis. Out of the total (3097) Organizations, 1035 organisations meet the threshold. For each of organization, the total strength of the co-authorship links with the other organization was calculated, and the sources with the greatest total link strength were selected. A total of 1035 organizations were selected, full item found (1035) with 14 clusters. Figureure2 reveals that Cluster 1 have 259 items followed by Cluster 2 (141 items), Cluster 3 (132 items), Cluster 4 (82 items), Cluster 5 (75 items), Cluster 6 (69 items), Cluster 7 (62 items), Cluster 8 (61 items), Cluster 9 (35 items), Cluster 10 (32 items), Cluster 11 (31 items), Cluster 12 (28 items), Cluster 13 (26 items), and Cluster 14 (2 items). The total links were 27751 with total link strength of 47022.

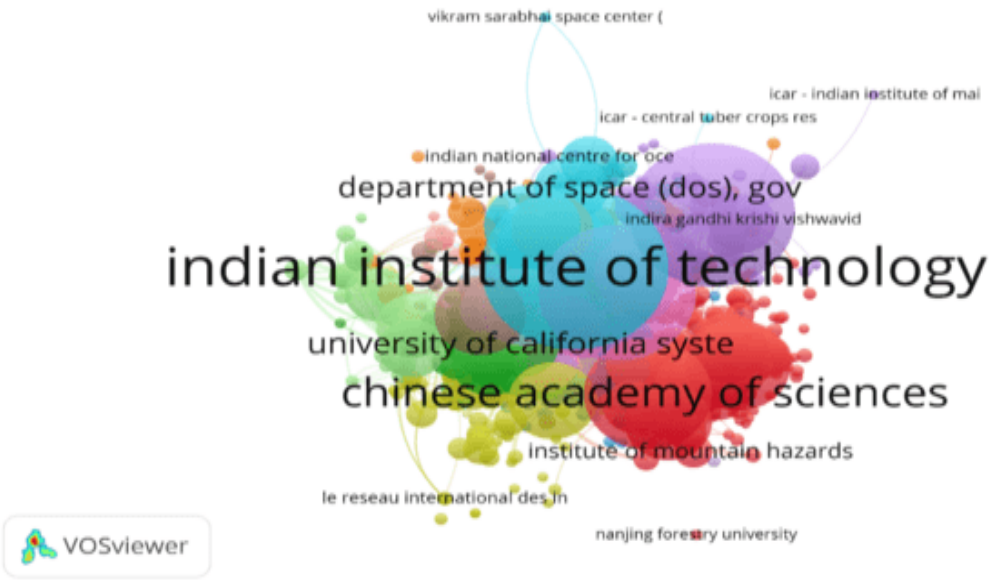

Fig. 2: Co-authorship with Organizations

5.9 Co-authorship with Authors

Overlay visualization of co-authorship networks provides a visual representation of collaborations among researchers. By mapping the connections between authors based on their joint publications, researchers can identify clusters of authors who frequently collaborate on research projects. This visualization helps identify key research communities, influential authors, and interdisciplinary collaborations within a specific field. It enables researchers to identify potential collaborators, experts in specific sub-fields, and emerging trends based on patterns of co-authorship.

The interconnection of co-authorship on authors is determined based on the number of documents they occur together. Co-author on author selected from “types of analysis” and

chosen from a “unit of analysis”; Counting method: full counting/ fractional counting, and minimum (3) number of documents of an author for analysis. Out of the 5777 authors, 10 meet the threshold. For each of (10) author, the total strength of the co-authorship links with the other author was calculated, and the sources with the greatest total link strength was selected. A total of ten items were discovered, with six of them forming a cluster. According to the findings presented in Fig. 3, it can be observed that every cluster contains one item each, from Cluster 1 to 10. The total links were 10 with total link strength (TLS) of 10.

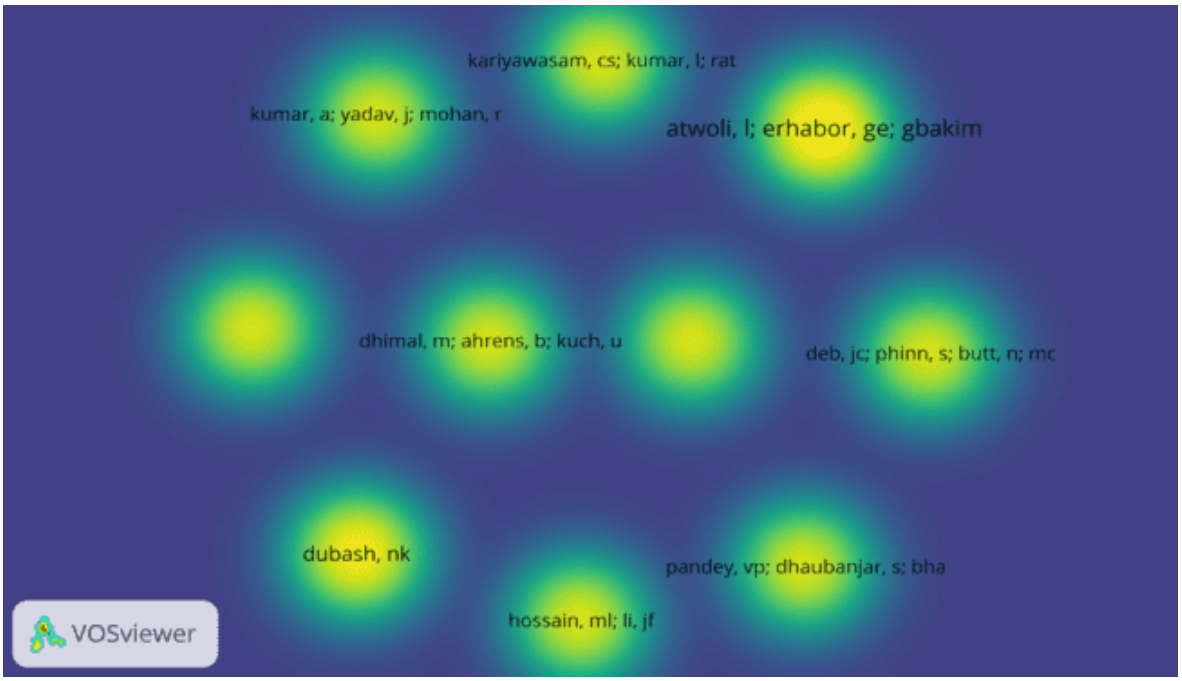

Fig. 3: Overlay Visualization of Co-authorship with Authors

Overlay visualization of these three dimensions such as co-authorship with organizations, and co-authorship with authors offers a holistic view of the scholarly landscape. It allows researchers to explore the relationships and connections between documents, organizations, and individuals, facilitating the identification of research trends, influential entities, and collaborative networks. These visualizations aid in knowledge discovery, interdisciplinary research exploration, and the identification of potential research partnerships. Ultimately, overlay visualization provides a powerful tool for researchers to gain insights and make informed decisions in their respective fields of study.

6. Discussion and Conclusion

In conclusion, the discussion has provided valuable insights into the landscape of Open Access (OA) scholarly communication on climate change research within the SAARC countries. By analysing various aspects, we have gained a deeper understanding of the growth trends, research collaboration patterns, leading countries in OA journal publications, relative growth rate, doubling time in OA, key authors, citation impact, and collaboration indices.

The analysis of growth trends revealed the evolving landscape of OA scholarly communication on climate change, highlighting the increasing importance and contribution of researchers from SAARC countries. This analysis provides valuable information for

researchers, policymakers, and funding agencies to track the progress of OA initiatives. Furthermore, our discussion explored the co-authorship index (CAI) and degree of collaboration (DC) which helps in understanding the level of collaboration among researchers and organizations.

The publication growth rate fluctuated over the years, with relative growth rates ranging from 0.98 to 0.29 and mean of RGR is 0.385. The doubling time varied from approximately 0.707 to 2.326 years, suggesting a changing pace of growth, taking place over a period of fifteen years. This suggests that the total number of publications has been steadily climbing throughout the course of time at an increasing pace. In terms of international collaborations, India had 240 collaborations with the highest collaboration coefficient of 0.17 with the highest collaborating countries being the United States and the United Kingdom, followed by Pakistan with 113 collaborations and 0.27 collaboration coefficients. The total number of joint publications with the SAARC countries was 3376 publications, with India having the highest number with 79 publications and Maldives with 19 joint publications. The percentage of Open Access (OA) publications share increased from 0.30% in 2008 to 25.76% in 2022, while the growth rate was significantly higher than previous years. Remaining SAARC countries have very less OA publications comparatively to India. All the four types of OA publications experienced considerable growth over the 15-years period. The Gold OA publications are leading in terms of number of publications in 2022 for all SAARC countries. The authors have noticed the number of total publications is more than the actual because some of the publications are showing in two or three OA models as per the Scopus database. This indicates that the quality of publications has improved over the years. Overall, the rising number of publications and improving quality indicates increasing research and publication activities taking place in the South Asian region. Overlay visualization of co-authorship with organizations, and co-authorship with authors gives a complete picture of research area partnerships. Researchers may uncover major trends, patterns, and clusters in the intellectual environment by merging numerous data sources and showing their linkages.

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