

A Correlation Study of Sustainable Development Goal (SDG) Interactions

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Abstract

As universities are the change agent of society, institutions from all nations set their goals to transform the world by exploring various societal challenges that humans are facing. Together, the higher education systems across the world developing strategies based on the United Nations' Sustainable Development Goals (SDGs). This paper assesses the influence of 16 SDGs on each other paving the way for the universities to set a clear goal in attaining Sustainable Development goals by 2030. To analyze the SDGs interactions towards each other, 201844 research publications from India during five years on 16 SDGs are retrieved from the Scopus database. Spearman Rank Correlation is applied to understand the contribution of each SDG towards one another. We could observe converging results out of the interactions among the SDGs. A significant positive and moderately positive correlation between pairs of SDGs are identified. While a significant number of negative correlation is also classified which need deep thinking among researchers to make it positively correlated. The most frequent interactions between SDGs is a positive sign to any university in strategising the goal towards SDGs. The association of all university stakeholders and some constitutional and cultural changes are necessary to put SDGs at the core of the management of the university. Embracing this task by researchers will improve the overall performance of universities.

1. Introduction

United Nations Sustainable Development Goals (SDGs) consist of a set of 17 goals, 169 constituent targets and 230 indicators, an evidence-based indicator, which is to transform the whole world into a sustainable one. The SDGs strategically allowing universities/institutions to monitor and gauge their research activities, strategies, and publish the outcomes globally. This demands global sustainability benchmarking that apply across all universities in a national and global context (Sullivan K et al. 2018). Times Higher Education Impact ranking is giving ample opportunities to universities to showcase their commitment towards society. Being the change leaders in education, research and innovation universities are having a key role in the development of a sustainable society. The new generation universities are more diverse in structure and are more focused on societal needs and benefits as described by (Vilalta, J.M. et al. 2018).

The sustainable development goals start from no poverty, touching all significant aspects of global concern like gender quality, sustainable economic growth, environmental preservation, climate action and good health by addressing all countries (Vilalta, J.M. et al. 2018). SDGs signify the ambitions of the global civic and also for the education institutions, it is a noble effort to address the societal important issues. SDGs represent an elaborate plan for the universities to achieve progressive changes in society (Jain, A.K. et.al. 2019). The inter-connectedness among these SDG goals renders planning, implementation and monitoring challenges as far as university research is concerned. The extraordinary demand is executed by SDGs on the national statistical systems demands to generate and analyze an exceptional quantity of data and it is becoming a huge and complex issue as a whole (Jain, A.K. et.al. 2019).

Times Higher Education launched its SDG ranking in 2019 in the name of THE Impact Ranking (Barrick, J. A. et al. 2019). Universities around the world are engaging to reach the SDGs with the world's ambition to achieve the SDGs, especially on poverty (SDG1), livelihood and food (SDG2), health (SDG3), education (SDG4), employment (SDG5), and economic growth, infrastructure (SDG9,10) (Stephens, J. C. et al. 2008). This article is an attempt to quantify the SDGs contribution of BRICS countries for the years 2015-19. Detailed analysis is done taking Indian contribution on 16 SDGs and attempted to find out the correlation between each SDG to the other. (Kapur, N. et al. 2020; Ioannidis, J.P. et al. 2007) also done a critical study on different aspects of ranking in detail. This research reveals, how a university can manage its research contributions for the benefit of their society by linking the research with clearly defined SDGs. The work is relevant because the Times Higher Education impact ranking is measuring the research contribution of an institution based on 16 SDGs with clearly defined metrics. In this study, we have tried to find the relationship between 16 SDGs and the correlation of each other. This is important for a university as they are the change agent who wanted to dedicate their research output to the development of society (Molinari, J. F. et al. 2008). Any university that is promoting research can follow this research finding as a guide and try to interconnect each SDGs to the related one while planning their thrust area of research and applying for research grants. It will be a good start for any researcher to deeply evaluate research objectives and link the work with all relevant SDGs possible to get a positive impact on their research.

2. Literature Review

The announcement of the 22nd April 2020 Times Higher Education Impact Ranking has clearly shown, where, each country stands in the promotion of SDGs. Universities play an important role in building a knowledgeable society and thereby help in building a sustainable and secure future for the society (SDG summit 2015). In September 2015, the United Nations (UN) adopted the 2030 Agenda for Sustainable Development (Rosen, M. A. et al. 2020). With one goal of having a sustainable society, the whole world is working towards achieving the 17 SDG targets. (Vilalta, J.M. et al. 2018) also mentioned in their study that universities are no longer act as a political instrument of social policy but progressively an integral part of building a sustainable society. Universities are the primary contributors to build a sustainable society, the scholarly output coming from the Universities are of more importance in the present scenario as indicated by (Stephens, J. C., et al. 2008 and Fonseca, L. M., et al. 2020).

There are several pieces of literature (Sullivan K. et al. 2018; Vilalta, J.M. et al. 2018; Barrick, J. A. et al. 2019; Jain, A. K. et al. 2019). which studied the different aspects of SDGs and the challenges and opportunities of different themes of SDGs in achieving several targets. The contribution of universities has to be focused on all 16 SDGs. This requires skills and mindsets to contribute and meet these challenges as explained by (Perovi'c, L.M. et al. 2020; Fuso-Nerini, F. et al. 2017). The importance and the obligation of universities to sustain sustainability will lead to the inclusion of SDGs in the policies and together aims to achieve the set goals are well appreciated. As (Rosen, M.A et al. 2020) explained in the research article about the universities contribution and the starting of Impact ranking to measure it towards 16 SDGs. Approaching the impact ranking requires skills and mindset to contribute and meet the SDGs challenges. Universities, being change agents and creators of opportunities, need to undergo

different perspectives and expectations to maintain sustainability. It will lead to the inclusion of SDGs in future planning to achieve the set goals (Stephens, J. C et al. 2008; Ivanova, D. et al. 2016).

The unexpected challenges facing by society due to Covid-19 infectious disease adversely affected the current trends and patterns of resource use, improvement in health care and research in these areas. Research article mentioning the correlation between SDGs and their necessity while doing a related study is still not accepted or re-researched in its full strength to the research world. (Fonseca, L. M. et al. 2020) an elaborated correlation study was done which explain the importance of correlation of SDGs among each other as well as the areas (SDGs) which need to be carefully dealt with while doing research. This is because the improvement of research in one area should not adversely affect the other areas. (Molinari, J.F. et al. 2008; Fuso-Nerini, F. et al. 2017). Here intensifies the importance of SDG 17 Partnerships for the Goals. Research in these areas is of great relevance at the present stage. The pandemic has challenged the health sector research, lively-hood, poverty, education in rural villages and economic growth. This is a challenging time for all universities in the world to think of international investments and support to lead to innovative technological developments (Jain, A. K. et al. 2019). There are ample opportunities for the research-oriented institutions to evaluate these challenges and recommend solutions for them (Nilsson, M. et al. 2016; Singha, G.G et al. 2018; Pradhan, P 2017).

3. Methodology

The data for the study related to 16 SDGs has been retrieved from the Scopus database. Properly defined keywords used in Scopus has retrieved data related to particular SDGs. We have quantified the research publications of the world on 16 SDGs and also quantified the research contributions of the BRICS countries to benchmark with each other's contribution towards achieving the sustainability of the world. The period selected for data retrieval is from 2015-19. A detailed analysis of the publication contribution of India on each SDGs is done using Spearman's Rank Correlation. Tableau software is used for visualizing the analyzed data.

The nonparametric Spearman's Rank Correlation (ρ) analysis is carried out in this study to know the relationship between each SDGs (Spearman, C. 1987). Here, the data is nonlinearly correlated between the variables so Spearman's analysis is the best choice as it is less sensitive to outliers (Pearson's, C. O. V. O. 2011). We have performed the correlation analysis with the research data from India for the past five years (2015-19) on 16 SDGs. This result will explain the synergies/trade-offs in the SDGs and it will help the institutions to plan their future.

The present work aims at knowing the contribution of BRICS nations in strengthening the SDGs in the country and thereby enhance cooperation and establish networks between universities in the world for research and education. In addition, it aims to improve the interactions between University research, its contribution to societal improvement and strategy in formulating new research policy. The work finally concludes by finding out the correlation between each SDGs and its contributions to one another. The main objective of the present work is to explore all the 16 SDGs research contributions and their

relationship with each goal. This will be the aspirational guidance for the 2020 – 2030 period to strengthen the relationship more.

3.1 TERMINOLOGIES AND EXPLANATIONS

- SDG (Sustainable Development Goals)

United Nations Sustainable Development Goals consist of a set of 17 goals, 169 constituent targets and 230 indicators built to transform the whole world into a sustainable one. SDG 17 Partnerships for the Goals is not considered for the study as the target for this is achieved from all other 16 SDGs

Table 1
SDGs and abbreviations

Sustainable Development Goals (SDGs)	
SDG 01. No poverty	SDG 09. Industry, innovation, and infrastructure
SDG 02. Zero hunger	SDG 10. Reduced inequalities
SDG 03. Good health and well-being	SDG 11. Sustainable cities and communities
SDG 04. Quality education	SDG 12. Responsible consumption and production
SDG 05. Gender equality	SDG 13. Climate action
SDG 06. Clean water and sanitation	SDG 14. Life below water
SDG 07. Affordable and clean energy	SDG 15. Life on land
SDG 08. Decent work and economic Growth	SDG 16. Peace, justice and strong institutions

- Scholarly Output

The research article published by a researcher or researchers

- BRICS

The BRICS countries are Brazil, Russia, India, China and South Africa

3.2. MATERIALS AND METHODS

With the overall objective to identify the correlation between 16 SDGs with each other related to the focus areas of academia in India, the study was designed to get the source of the data from SciVal and Scopus. According to (Fonseca, L. et al. 2020) Mcorrelation analysis is the best method to map the relationship between different variables. The search method used was keyword search, there are a set of keywords for each SDGs, which is developed by subject experts to map the scientific publications in the Scopus

database. We have retrieved data for BRICS countries and have done a benchmarking of their research output. A detailed study on 16 SDGs has been done retrieving the data for the country India and its relation between one SDG to the other studied in detail. The period chosen for the study was a five-year window (2015–2019) because the number of publications during this period was quite satisfactory. Due to the different theoretical ramifications of SDGs, it is important to transfigure the text data into a measurable gauge to study the impact. Spearman's Rank Correlation metrics is built with an overall aim to identify SDG related goals and relationships in particular with each other. Mini-Max scaling is used to normalize the data (Spearman, C. 1987). The principle scores were normalized to the same scale (0–1). Python's Scikit Learn library was used for this process.

3.3 DATA EXTRACTION AND PREPROCESSING

The data for analysis has been retrieved from Scopus where row data sets of bibliographic details like; links to articles, affiliation, Scopus author IDs, author names etc. were available. Natural Language Processing (NLP) technology is used to clean the data and make it in the desired form.

4. Total Publication On 16 Sdgs In The World

Different metrics are considered for the analysis, and the sample data is taken for five years duration. The contribution of the world in all the 16 SDGs parameters are plotted in Fig. 1. The data were plotted using the python graphics library Plotly. The highest number of publications (30,81203) comes from SDG 3 Good Health and Well-being followed by SDG 7, Affordable and Clean Energy having a total publication number of 3,58930. The lowest quantity of world publications contribution goes to SDG 1 No Poverty with only 10,533 publications, followed by SDG 4 Quality Education having a count of 23806. It is quite natural that SDG 1 No poverty and SDG 4 Quality Education are the vital component of SDG 3 Good Health and Well-being, and it is surprising to see that it doesn't keep any relation between them as publications are concerned.

5. The Publication Contribution Of Brics Nations On 16 Sdgs

We have analyzed the contribution of BRICS countries ((Brazil, Russia, India, China and South Africa) to see the number of publications they contribute to the UN SDGs (Table 2). Worlds' largest contributions come from SDG 3 - Good Health and Well-being followed by SDG 7 - Affordable and Clean Energy, as far as BRICS countries are concerned they are also contributing more to these two SDGs. China is the most significant contributor among BRICS countries. The scholarly output of India is more than China in SDG 5, Gender Equality and SDG 16, Peace and Justice Strong Institutions. When evaluating SDG 5, Gender Equality, after India, the countries South Africa and Brazil contributed more than China. To keep a strong stand in the world university impact ranking, Indian Universities have to work more intensively to focus their research in the areas defined by UN SDGs. Most of the 16 SDGs are interconnected with each other, and careful management of research programs on these focused areas can improve Indian Universities ranking status in the world.

Table 2. Total publication number for 16 SDGs contributed by BRICS Countries and the World

	SDG 1	SDG 2	SDG 3	SDG 4	SDG 5	SDG 6	SDG 7	SDG 8	SDG 9	SDG 10	SDG 11	SDG 12	SDG 13	SDG14	SDG 15	SDG 16
Brazil	285	4505	80641	1313	753	1457	7123	1721	906	946	4260	2719	4873	3638	4822	3108
Russia	146	1513	29574	1016	196	412	7048	4175	1116	1060	2952	1400	3641	2657	2075	2881
India	613	6987	121979	427	1125	2763	27142	3621	2310	1182	7031	5125	7134	4213	4372	5820
China	627	14775	372391	978	436	9685	95489	11334	6443	2408	27509	14843	25852	15053	20162	5402
South Africa	518	1863	27225	585	957	831	2573	2447	634	1048	1649	946	2770	1435	1878	3154
World	10533	86526	3081203	23806	33360	42767	358930	82729	36041	44509	131563	79000	169649	99682	104693	159734

5.1 BRICS CONTRIBUTION ON SDG 1, SDG 2, SDG 3, AND SDG 4

The measure of the contribution of universities in any county on SDGs is a challenging one. The problem is how to quantify the publications in terms of SDGs when there is not much external information available.

An option formulated in this quantification is the Impact Ranking by Times Higher Education. There are many limitations on ranking (Molinari, J. F. et al. 2008) still, it is an eye-opener to the universities to act upon and formulate a proper strategy for a sustainable society. In Fig. 1, the core area in which more researches are happening among BRICS countries is SDG 3- Good Health and Well-being. The quantity of publications is very less in the area SDG 1 - No Poverty and it says that research in this area is less compared to other areas of importance. Among BRICS countries, Russia and Brazil contributed more in research publication number for SDG 4 (Quality Education) and India's contribution comes less than those countries. The lack of strategies on gender equality and related commitment in recruiting and promoting women is reflecting when we analyze the data on SDG 5 (Gender Equality).

5.2 BRICS CONTRIBUTION ON SDG5, SDG6, SDG7, AND SDG8

In Fig. 3, apart from SDG 5 Gender Equality, China leads in publication numbers. The rights of a citizen in research are reflecting in SDG 5 and India leads in SDG 5 among BRICS countries. South Africa and Brazil

contribute more than other countries.

This research area can be polished and more focused research can be nurtured in this area by other countries in BRICS. Among the sets in Fig. 3, SDG 5 is the only SDG where China is contributing less among the BRICS but intensive research is concentrated on energy production, consumption and different aspects of it. China's contribution to SDG 7 Affordable and Clean energy is visible in Fig. 3. A good extent of research is going on in this area by China more than other BRICS nations. India and other BRICS countries must make an effort to concentrate their research more on SDG 6, 7 and 8 like China, because of its relevance to the progress of any society.

5.3 BRICS CONTRIBUTION ON SDG9, SDG10, SDG11, AND SDG12

Figure 4 shows the BRICS contribution to SDG9, SDG10, SDG11, and SDG12. China is contributing more to SDG 9, 10, 11 and 12. A close study on the data SDG 10 (Reduce Inequality), the publication contributions is almost equal in number among India, Russia and South Africa. Here also China leads among all but the publication number shows that other countries can also achieve the target in time. In Fig. 4, SDG 11 and 12 are important SDGs that needs more research and innovation to build a sustainable society. The contribution of universities will reflect in the form of publications that will be delivered to society in the form of technology transfer.

5.4 BRICS CONTRIBUTION ON SDG 13, SDG 14, SDG 15, AND SDG 16

Indian research publication contribution to the important themes like SDG13 (Climate Action), SDG14 (Life Below Water) and SDG15 (Life on Land) is very less compared to the publications from China. This contrast of data may be the result of keywords used to express these SDGs in their publications. When we have a search by selecting the exact keywords, only the related documents will reflect in the result. So it is time for India to evaluate the keywords which reflect each SDGs and plan accordingly while publishing the related research work. While in SDG16 (Peace and Justice Strong Institutions), Indian research contributions are more than in China. It is high time for all universities in India to evaluate its publications and find out the reason for not reflecting its publications in 16 SDGs and strategize a new policy for the mapping. University Grant Commission (UGC), Govt. of India can seriously look into all these aspects of SDGs metrics and give directions to universities to redirect research programs in tune with to get higher world rankings.

6. Correlation Matrix Of Sdg

The data for India on 16 SDGs was extracted using Scopus keyword search. The dataset has been normalized to make it into a standard scale without disturbing the range. As mentioned earlier, Mini-Max scaling is used to normalize the data The complete nature of the SDGs indicates that a large number of potential publications across the 16 SDGs have to be considered by policymakers and an outline has to

be proposed to illustrate SDG interactions. In this paper, we have done a systematic data-driven analysis of interactions between all SDG indicators. Statistically, we have tried to classify all 16 SDGs and their existing interactions with each other and classified them as synergies and trade-offs. In the present study, the progress in one SDG can be a goal favours to the progress in other SDGs and we can see a highly positive correlation among many SDGs.

Table 3. Correlation Matrix

	SDG -1	SDG -2	SDG -3	SDG -4	SDG -5	SDG -6	SDG -7	SDG -8	SDG -9	SDG -10	SDG -11	SDG -12	SDG -13	SDG -14	SDG -15	SDG -16
SDG -1	1.00	-0.08	-0.19	0.79	0.86	-0.29	-0.34	0.35	0.01	0.77	-0.57	-0.36	-0.31	-0.46	-0.32	0.53
SDG -2	-0.08	1.00	0.64	-0.16	-0.20	0.83	0.65	-0.13	0.12	-0.12	0.46	0.72	0.87	0.73	0.86	-0.05
SDG -3	-0.19	0.64	1.00	-0.10	0.08	0.64	0.54	-0.20	0.17	0.05	0.43	0.66	0.52	0.53	0.57	0.41
SDG -4	0.79	-0.16	-0.10	1.00	0.80	-0.33	-0.31	0.12	-0.05	0.70	-0.56	-0.28	-0.42	-0.47	-0.43	0.57
SDG -5	0.86	-0.20	0.08	0.80	1.00	-0.33	-0.39	0.22	-0.01	0.79	-0.56	-0.33	-0.49	-0.51	-0.44	0.73
SDG -6	-0.29	0.83	0.64	-0.33	-0.33	1.00	0.72	-0.18	0.29	-0.26	0.64	0.75	0.86	0.73	0.89	-0.08
SDG -7	-0.34	0.65	0.54	-0.31	-0.39	0.72	1.00	0.29	0.67	-0.10	0.81	0.92	0.74	0.67	0.64	0.11
SDG -8	0.35	-0.13	-0.20	0.12	0.22	-0.18	0.29	1.00	0.70	0.48	0.22	0.22	-0.17	-0.31	-0.31	0.39
SDG -9	0.01	0.12	0.17	-0.05	-0.01	0.29	0.67	0.70	1.00	0.32	0.66	0.61	0.21	0.14	0.14	0.41
SDG -10	0.77	-0.12	0.05	0.70	0.79	-0.26	-0.10	0.48	0.32	1.00	-0.31	-0.09	-0.28	-0.33	-0.38	0.85
SDG -11	-0.57	0.46	0.43	-0.56	-0.56	0.64	0.81	0.22	0.66	-0.31	1.00	0.82	0.63	0.48	0.62	-0.06
SDG -12	-0.36	0.72	0.66	-0.28	-0.33	0.75	0.92	0.22	0.61	-0.09	0.82	1.00	0.71	0.66	0.68	0.12
SDG -13	-0.31	0.87	0.52	-0.42	-0.49	0.86	0.74	-0.17	0.21	-0.28	0.63	0.71	1.00	0.86	0.95	-0.16
SDG -14	-0.46	0.73	0.53	-0.47	-0.51	0.73	0.67	-0.31	0.14	-0.33	0.48	0.66	0.86	1.00	0.83	-0.17
SDG -15	-0.32	0.86	0.57	-0.43	-0.44	0.89	0.64	-0.31	0.14	-0.38	0.62	0.68	0.95	0.83	1.00	-0.22
SDG -16	0.53	-0.05	0.41	0.57	0.73	-0.08	0.11	0.39	0.41	0.85	-0.06	0.12	-0.16	-0.17	-0.22	1.00

We have used nonparametric Spearman's Rank Correlation (ρ) in the present study as the data is not normally distributed. To extract all possible combinations of the unique indicator data pairs for each SDG and to get the monotonic relationships, we have used Spearman's Rank Correlation. Spearman's Correlation Coefficient (ρ) provides a measure to evaluate the strength of an association between two variables. Spearman's analysis can capture the nonlinear correlation between the variables and is less sensitive to outliers. Spearman's analysis is widely used to identify general relations beyond the linear correlation between two variables in various disciplines (Spearman, C.1904).

Table 4. Highly correlated variables (with threshold value 0.80 and above)

Highly correlated variables (threshold value 0.80 and above)			
SDG 1- No Poverty			SDG 5 - Gender Equality
SDG 2 - Zero Hunger			SDG 6 - Clean Water and Sanitation
SDG 2 - Zero Hunger			SDG13 - Climate Action
SDG 2 - Zero Hunger			SDG15 - Life on Land
SDG 6 - Clean Water and Sanitation			SDG13 - Climate Action
SDG 6 - Clean Water and Sanitation			SDG15 - Life on Land
SDG 7 - Affordable and Clean Energy			SDG11 - SDG Sustainable Cities and Communities
SDG 7 - Affordable and Clean Energy			SDG12 - Responsible Consumption and Production
SDG10 - Reduced Inequality			SDG16 - Peace and Justice Strong Institutions
SDG11 - Sustainable Cities and Communities			SDG12 - Responsible Consumption and Production
SDG13 - Climate Action			SDG14 - Life Below Water
SDG13 - Climate Action			SDG15 - Life on Land
SDG14 - Life Below Water			SDG15 - Life on Land

Since Python has excellent support for statistical analysis, we built a correlation matrix using the Python programming language. Correlation analysis was carried out with the 16 Sustainable Development Goal datasets. We could find a high correlation among many SDGs. From our dataset of publication from India, the highly correlated variable in the SDG list keeping a threshold value of 0.8 and above is put in Table 4. Particularly, SDG1 (No poverty) with SDG5 (Gender Equality), SDG2 (Zero Hunger) with SDG6 (Clean Water and Sanitation), SDG13 (Climate Action), and SDG15 (Life on Land), SDG6 with SDG13

(Climate Action) and SDG 15 (Life on Land), SDG7 (Affordable and Clean Energy) with SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production), SDG 10 (Reduced Inequality) with SDG 16 (Peace and Justice Strong Institutions), SDG 11 (Sustainable Cities and Communities) with SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action) with SDG 14(Life Below Water) and SDG 15 (Life on Land), and SDG 14(Life Below Water) with SDG 15 (Life on Land) show synergetic relations with ρ values greater than 0.8.

The SDGs which are highly correlated in the dataset are sharing the same document in both the related SDGs. A careful study of these highly correlated variables will help to plan clear strategies for a university. An institution that is enthusiastic to participate in the ranking process and wanted to strategize properly their future activities and get ready for world ranking can follow these studies as an example. Some publications are not mapped in any of the 16 SDGs whereas some are in the real sense related to one or the other SDGs. We should have a new strategy on each topic and can relate the same topic with highly correlated and moderately correlated SDGs. We have taken the data with a threshold value range from 0.5 to 0.79 and extracted the moderately correlated variables as shown in Table 5.

Table 5. Moderately correlated variables (threshold value 0.5 to 0.79)

Moderately correlated variables (threshold value 0.5 to 0.79)		
SDG 1 - No Poverty		SDG 4 - Quality Education
SDG 1 - No Poverty		SDG10 - Reduced Inequality
SDG 1 - No Poverty		SDG16 - Peace and Justice Strong Institutions
SDG 2 - Zero Hunger		SDG 3 - Good Health and Well-being
SDG 2 - Zero Hunger		SDG 7 - Affordable and Clean Energy
SDG 2 - Zero Hunger		SDG12 - Responsible Consumption and Production
SDG 2 - Zero Hunger		SDG14 - Life Below Water
SDG 3 - Good Health and Well-being		SDG 6 - Clean Water and Sanitation
SDG 3 - Good Health and Well-being		SDG 7 - Affordable and Clean Energy
SDG 3 - Good Health and Well-being		SDG12 - Responsible Consumption and Production
SDG 3 - Good Health and Well-being		SDG13 - Climate Action
SDG 3 - Good Health and Well-being		SDG14 - Life Below Water
SDG 3 - Good Health and Well-being		SDG15 - Life on Land
SDG 4 - Quality Education		SDG 5 - Gender Equality
SDG 4 - Quality Education		SDG10 - Reduced Inequality
SDG 4 - Quality Education		SDG16 - Peace and Justice Strong Institutions
SDG 5 - Gender Equality		SDG10 - Reduced Inequality
SDG 5 - Gender Equality		SDG16 - Peace and Justice Strong Institutions
SDG 6 - Clean Water and Sanitation		SDG 7 - Affordable and Clean Energy
SDG 6 - Clean Water and Sanitation		SDG11 - Sustainable Cities and Communities
SDG 6 - Clean Water and Sanitation		SDG12 - Responsible Consumption and Production
SDG 6 - Clean Water and Sanitation		SDG14 - Life Below Water
SDG 7 - Affordable and Clean Energy		SDG 9 - Industry, Innovation and Infrastructure
SDG 7 - Affordable and Clean Energy		SDG13 - Climate Action
SDG 7 - Affordable and Clean Energy		SDG14 - Life Below Water
SDG 7 - Affordable and Clean Energy		SDG15 - Life on Land
SDG 8 - Decent Work and Economic Growth		SDG 9 - Industry, Innovation and Infrastructure
SDG 9 - Industry, Innovation and Infrastructure		SDG11 - Sustainable Cities and Communities
SDG 9 - Industry, Innovation and Infrastructure		SDG12 - Responsible Consumption and Production
SDG11 - Sustainable Cities and Communities		SDG13 - Climate Action
SDG11 - Sustainable Cities and Communities		SDG15 - Life on Land
SDG12 - Responsible Consumption and Production		SDG13 - Climate Action
SDG12 - Responsible Consumption and Production		SDG14 - Life Below Water
SDG12 - Responsible Consumption and Production		SDG15 - Life on Land

Looking at the moderately correlated variables, it will be easy for any researcher and university to plan its publications in the related SDGs, so that with a limited number of publications you will be able to qualify in participating in different subject area rankings. The highly published area SDG 3 (Good Health and Well Being) is moderately correlated with SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG12 (Responsible Consumption and Production), SDG13 (Climate Action), SDG14 (Life Below Water) and SDG15 (Life on Land). It clearly shows that the need of the hour has come to an end for a better strategic evaluation of SDGs. It needs to have a study on the relationship

of SDG publications and work on strengthening the SDG partnership more. If the institution can produce more paper in the same direction, by focusing on SDG3 and strengthen the relationship with all the 7 SDGs by using the correct keywords, we can achieve a better rank in the Times Higher Education Impact Ranking. The relationship between all 16 SDGs is worth studying and implementing.

In the same way, if we could relate all the possible SDGs while working on a research topic, writing for the research funds, we could qualify in different SDGs with the same number of publications. This strategy can be followed by any university in qualifying to participate in all 17 Impact Rankings of Times Higher Education. This study also highlights the existence of negative correlations between many SDGs and this is a matter to be considered seriously. Progress in one indicator must give an improvement in another indicator then we can expect drastic changes in the overall data mapping. In the present study, SDG01 (No Poverty) is negatively correlated with most of the SDGs like SDG 02,03,06,07,11,12,13,14 and 15. If a university having a well-planned strategy in achieving the SDGs, it is very much necessary to study the collaboration of each SDG with one another and couple the publications and promote them within their domain of influence. As we considered Indian publications for identifying the correlation between SDGs, a notable difference is that SDG01(No Poverty) is negatively correlated with many related SDGs such as SDG02 (Zero Hunger), SDG03 (Good Health and Well Being), SDG12 (Responsible Consumption and Production), SDG13 (Climate Action), SDG14 (Life Below Water) and SDG15 (Life on Land). These SDGs are somehow favourably related to each other when we do a proper study on SDG01. A university's research and innovation always have a key role in helping the society where it belongs by addressing these challenges. Our analysis reveals that a well-planned strategic approach to SDG mapping will address almost all challenges in the society which in turn will help universities to address THE Impact Ranking. Our study highlights the existence of typically more interactions within and among the SDGs. This specifies a strong groundwork for the successful implementation of the SDG indicators in future research. The evidence calls for a deeper investigation and demands advanced strategic planning. For this, all related research work needs to act as a system of interacting cogwheels that together move with different SDGs. Therefore, policies promoting cross-sectoral and supportive relations between SDGs has to be instigated and it will play a crucial role in the understanding of the SDG mapping at the researcher level.

7. Conclusion

Benchmarking of the BRICS countries revealed the extent of work that has been done to address the societal challenges globally and addressing it through 16 SDGs is the best way to intricate that universities are the change agent of the society. The responsibilities of the universities in building a sustainable society are reflecting in the research output of each country. Primarily, it highlights the existing SDG research competencies at the national level among the BRICS countries. The findings in the present study will act as the foundation for formulating possibilities for SDG implementation and will serve as an input for integrating sustainable developments into research and education at universities in any country. The Spearman's Rank Correlation results of Indian contribution on 16 SDGs demonstrated that there is already a strong relationship between many SDGs in research programs. While interpreting

these findings, we could see that the current basic research activities are not directly linked to the SDGs. Our study highlights the existence of more correlation between few SDGs and this indicates the need for a strong foundation for the successful implementation of the SDG agenda in universities' future research. The correlation among SDGs is a positive sign for the universities to implement it properly. The India level publication output study indicates that the positive correlations among the SDGs largely outweigh the negative ones and suggest that we need a clear strategy in mapping the existing research to SDGs. The shreds of evidence call for a deeper investigation and demand advanced strategic planning. For this, all SDGs need to act as a system of interacting cogwheels that together move with the academic research. Therefore, policies fostering multi-sectoral and cross-goal cooperative relations between SDGs need to be implemented. It will play a crucial role in the implementation of the SDG mapping at the researcher and university levels.

Declarations

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Conflicts of interest/Competing interests:

This is to certify that there is no conflict of interest associate with this study.

Availability of data and material:

Yes, the data is available on request

Code availability:

The software is an open source available in the web

Authors' contributions:

The idea conceived and the manuscript written is by Sheeba Pakkan, the corresponding author. Shubham Tripathi carried out the analysis of the data. Christopher Sudhakar and Mahabaleshwara Rao review the manuscript.

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Figures

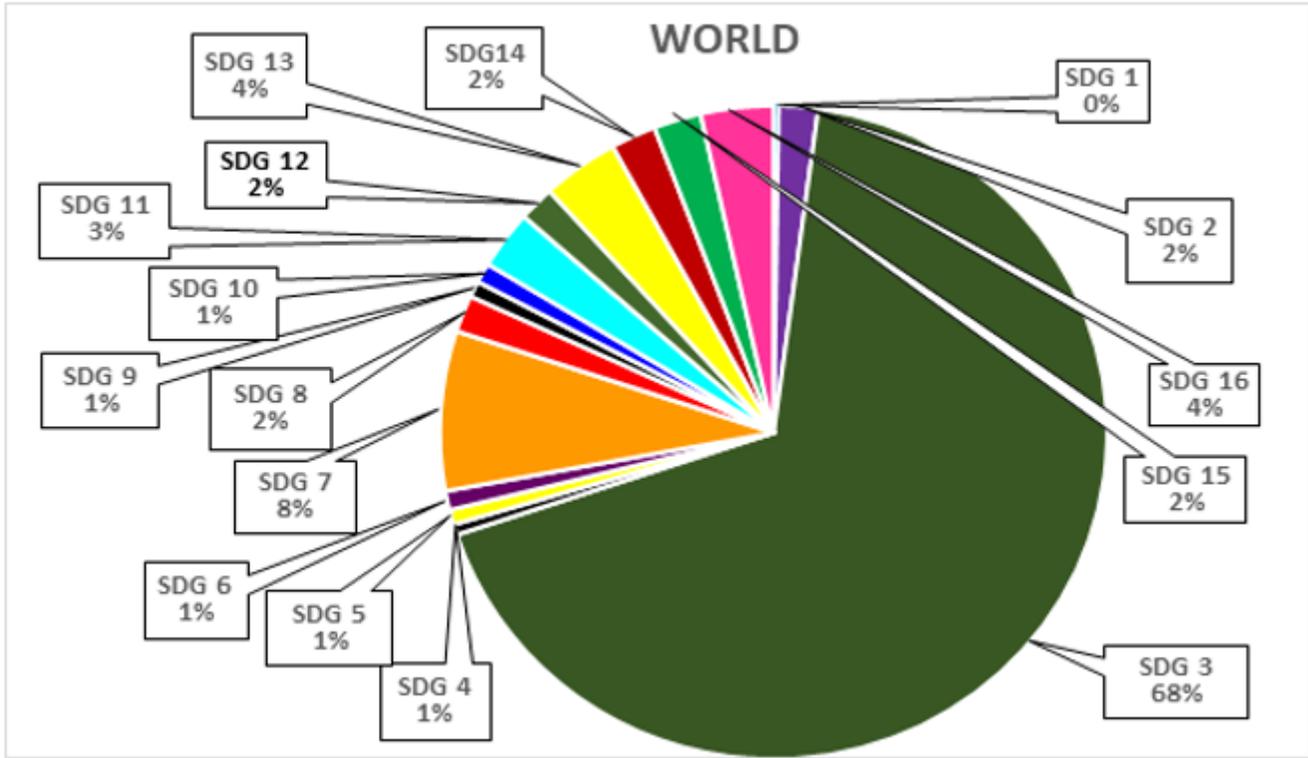


Figure 1

Percentage distribution of all the 16 SDGs in total world publication.

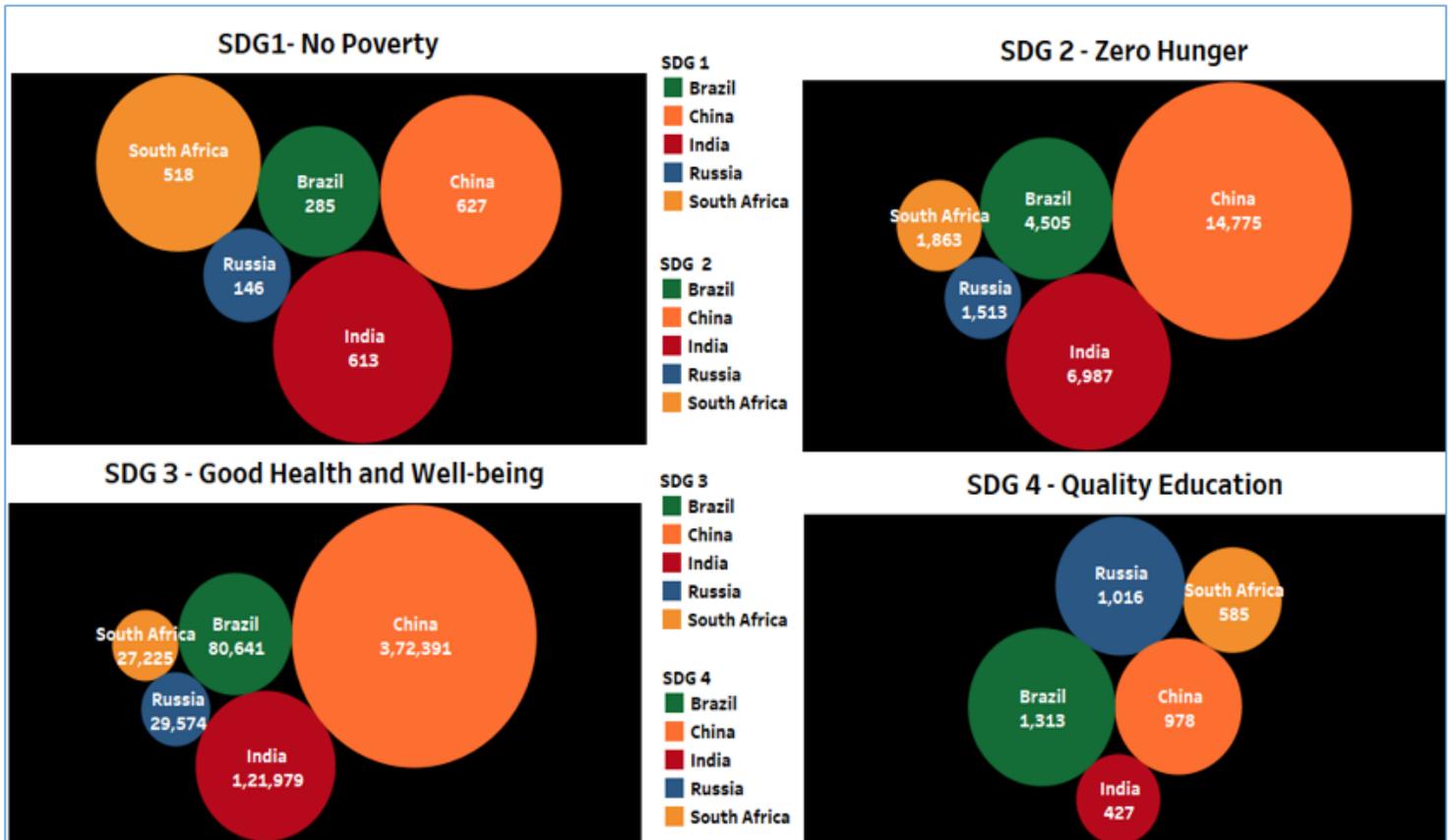


Figure 2

Publication contribution of BRICS countries in SDG 1, SDG 2, SDG 3 and SDG 4

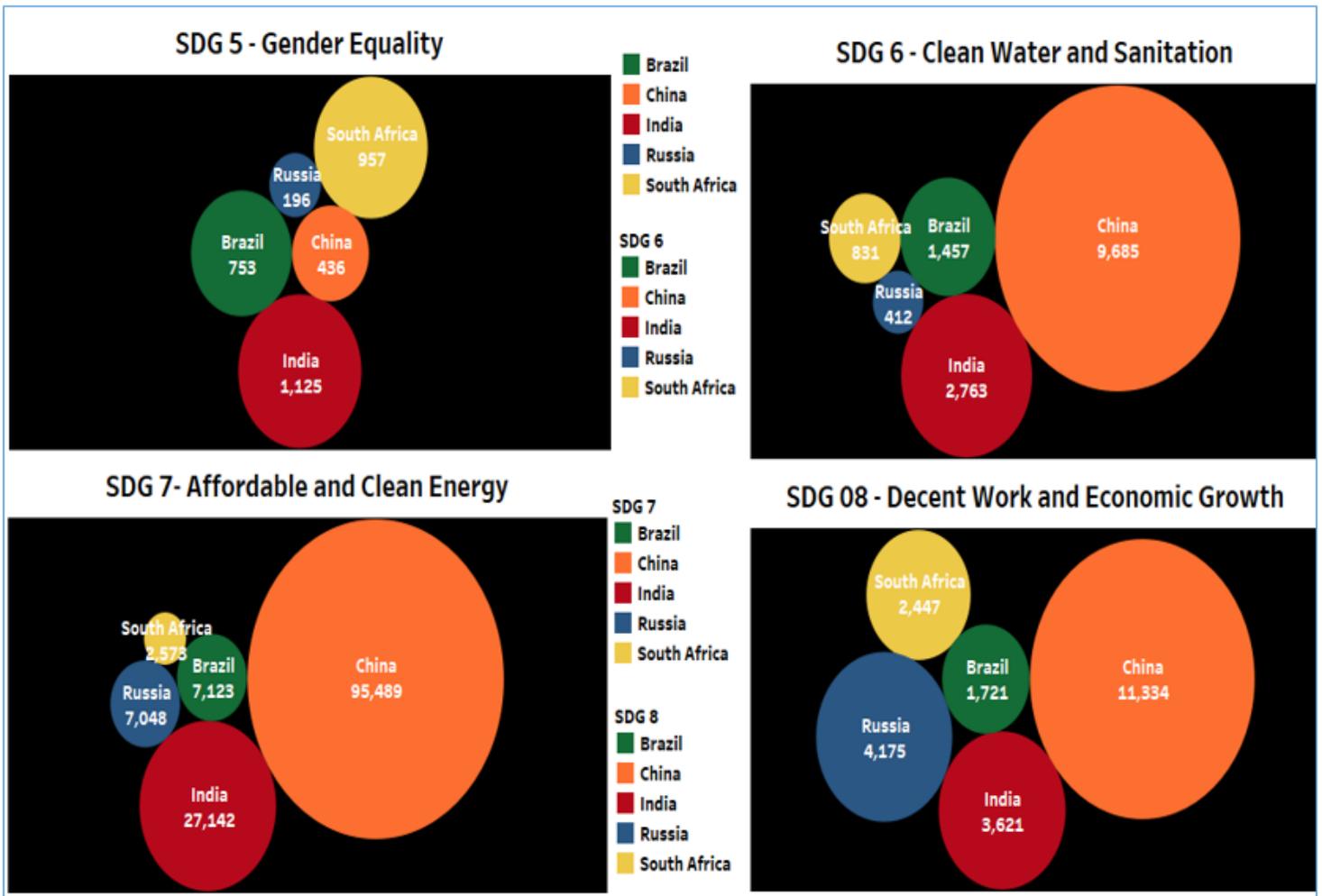


Figure 3

Publication contribution of BRICS countries in SDG5, SDG6, SDG7 and SDG8

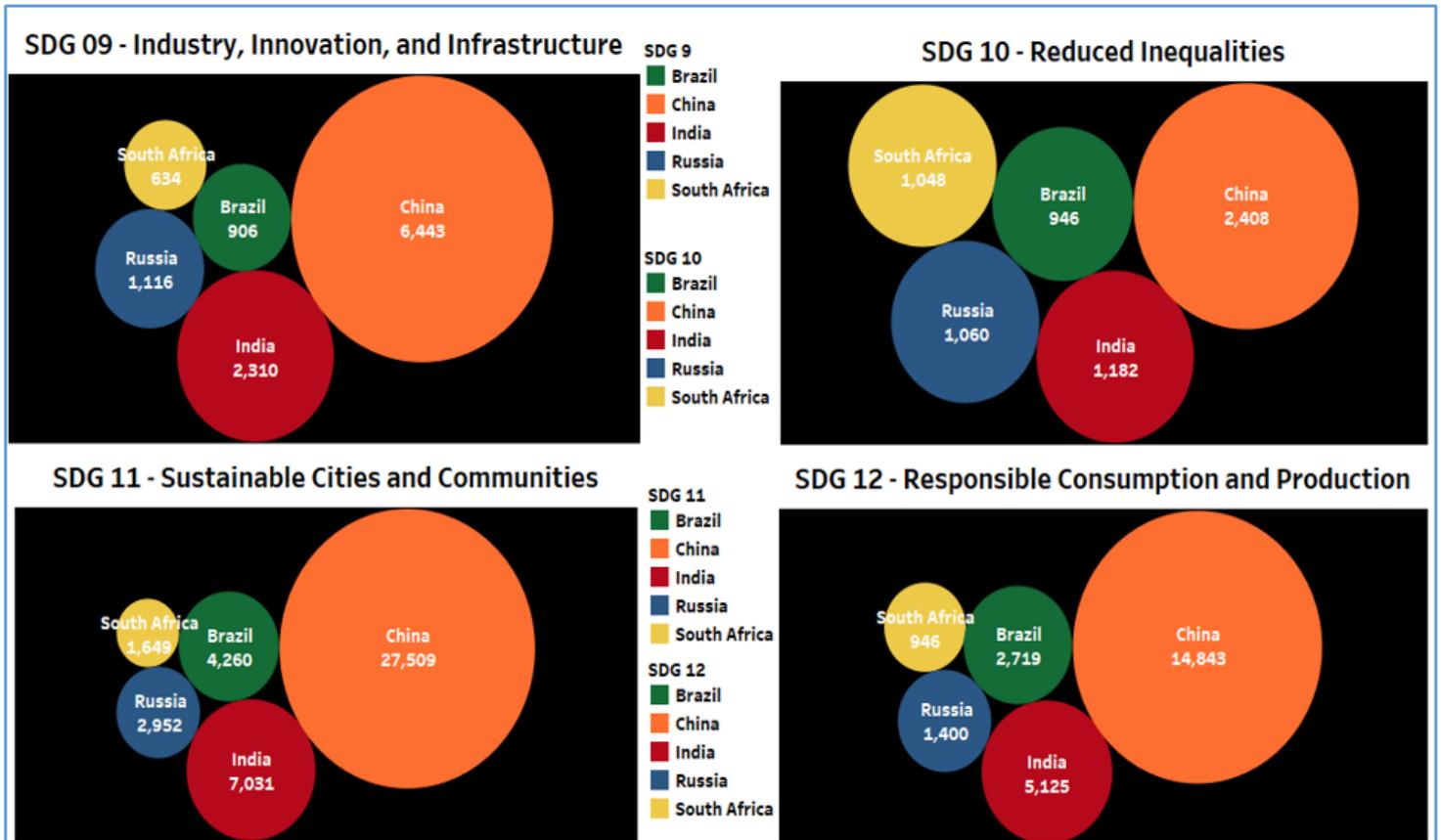


Figure 4

Publication contribution of BRICS countries in SDG9, SDG10, SDG11 and SDG12

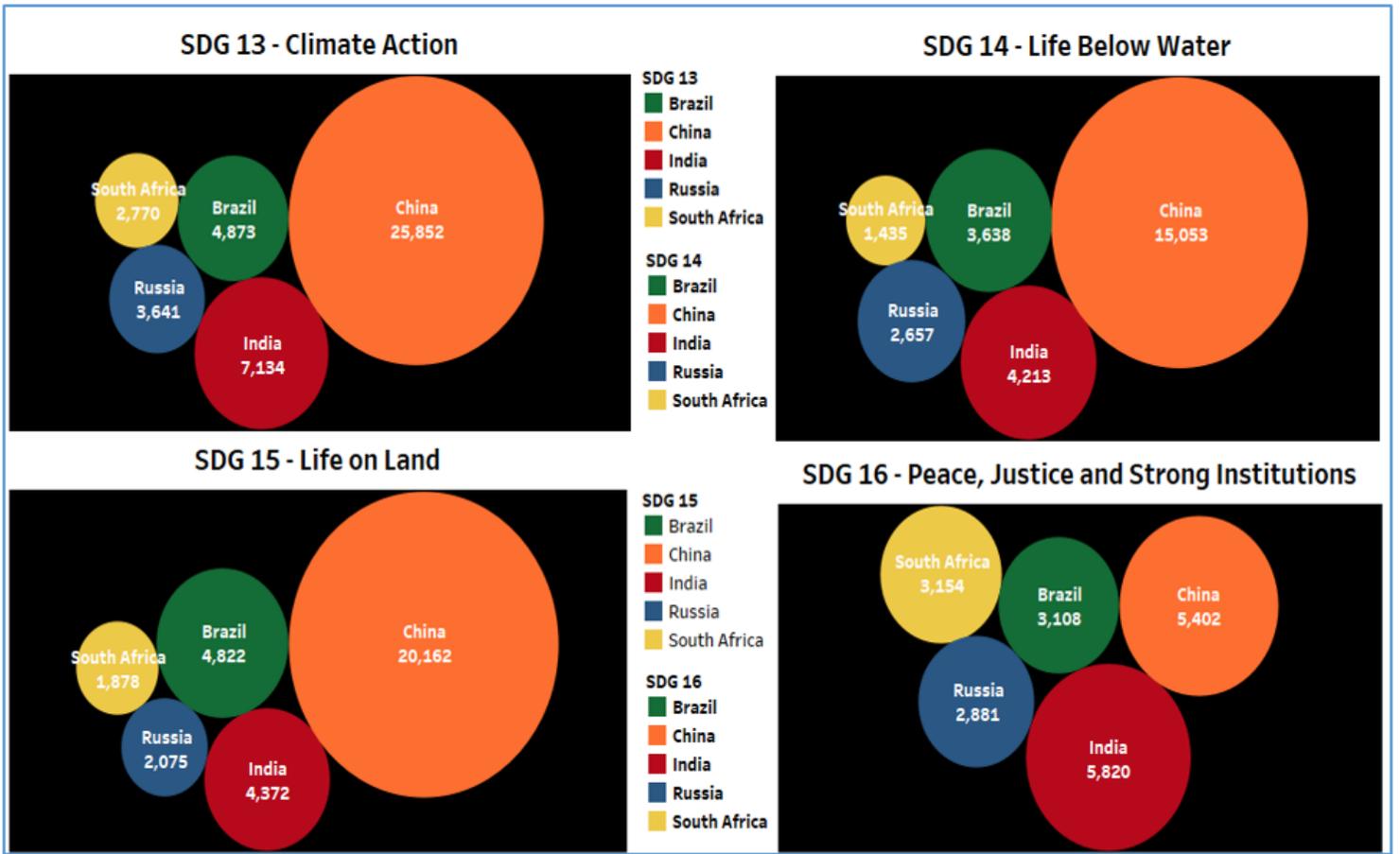


Figure 5

Publication contribution of BRICS countries in SDG13, SDG14, SDG15 and SDG16