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Open Science in Addressing Responsible Research and Innovation: Evidence from India and other Countries

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ABSTRACT
This paper highlights the brief background of the concept of Responsible Research and Innovation (RRI). The RRI concept has some key issues, one of which is open access that brings forth the concept of Open Science. The global trend of Open Science research is presented here on the basis of data obtained from Scopus, Web of Science and PubMed. The global Open Access movements got strengthened after the release of the Budapest Open Access Initiative (BOAI) public statement on February 14, 2002, supporting the principles relating to open access to the research literature. The state of India in production and dissemination of open access resources, in comparison with other BRICS nations is pointed out here. The Directory of Open Access Journals (DOAJ) and the Directory of Open Access Repositories (OpenDOAR) have recorded a significant number of open access journals and open access repositories from India, one of the best from the developing nations. However, in other Open Science areas such as ensuring open research data and publishing research publications with an explicit Open Licensing term, India needs to take the lead in the developing world. The recent advancements in open science frameworks in the world vis-à-vis the open science strategies and practices in India as compared to other emerging economies are highlighted.
Keywords: Responsible Research and Innovation, Science Policy, RRI-Indian context, Open Science, Open Access-India, BRICS Nations.

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INTRODUCTION

Responsible Research and Innovation (RRI) indicates an integrated research and innovation process that encounters effects and potential impacts on the environment and society. By June 2014, there were at least a dozen international research projects, most of them funded or co-funded by the European Commission, that were involved in developing a Responsible Research and Innovation governance framework.[1] The Leaflet of European Commission[2] declared in 2012, "The Directorate-General for Research and Innovation of the European Commission is determined to bridge the gap between the scientific community and society at large. In 2001, the «Science and Society» Action Plan was launched to set out a common strategy to make a better connection between science and European citizens. In 2007, under the Seventh Framework Programme for Research and Technological Development (FP7), «Science and Society» became «Science in Society (SiS)» with the primary objective to foster public engagement and a sustained two-way dialogue between science and civil society. Since 2010 the focus of SiS has been to develop a concept responding to the aspirations and ambitions of European citizens: a framework for Responsible Research and Innovation (RRI).

The European Commission (EC) described RRI as a framework that consisted of six Key Action Points:[2]

1. **Engagement:** It implies that societal challenges should be framed by widely representative social, economic and ethical concerns and common principles on the strength of joint participation of all societal actors - researchers, industry, policymakers and civil society.
2. **Gender Equality:** Addresses the underrepresentation of women, indicating that human resources management must be modernized and that the gender dimension should be integrated into the research and innovation content.
3. **Science Education:** Faces the challenge to better equip future researchers and other societal actors with the necessary

knowledge and tools to fully participate and take responsibility in the research and innovation process.

4. **Open Access:** States that RRI must be both transparent and accessible. Free online access should be given to the results of publicly funded research (publications and data).
5. **Ethics:** Requires that research and innovation respect fundamental rights and the highest ethical standards to ensure increased societal relevance and acceptability of research and innovation outcomes.
6. **Governance:** Addresses the responsibility of policymakers to prevent harmful or unethical developments in research and innovation. The latter is a fundamental basis for the development of the rest of the dimensions.[2]

Figure 1 indicates Open Access as an integral part of the RRI Framework, as suggested in the Horizon 2020 strategy documents. More recently in September 2018, eleven research funders in Europe unveiled 'Plan S' to make all research publications open access as soon as they are published.[3] The Delhi Declaration on Open Access 2018 recommended similar provision for the public-funded research outputs.[4] Open science efforts are now accelerated to engage the citizens in the research processes as well as to ensure public engagement of the informed citizens. This paper addresses fourth point i.e. open access in science information dissemination, or open science. The state-of-the-art of the global open science research along with its relevant facets are analysed here, for instance, growth of open science research, the core countries involved, the core journals and subject areas of open science etc. The Horizon 2020 is the EU Research and Innovation programme with nearly €80 billion of funding available over seven years, viz., 2014 to 2020. The open access is being supported by major institutions such as the European Commission, Wellcome Trust, Department of Biotechnology (India), Council of Scientific and Industrial Research (India) and many academic bodies of various countries.

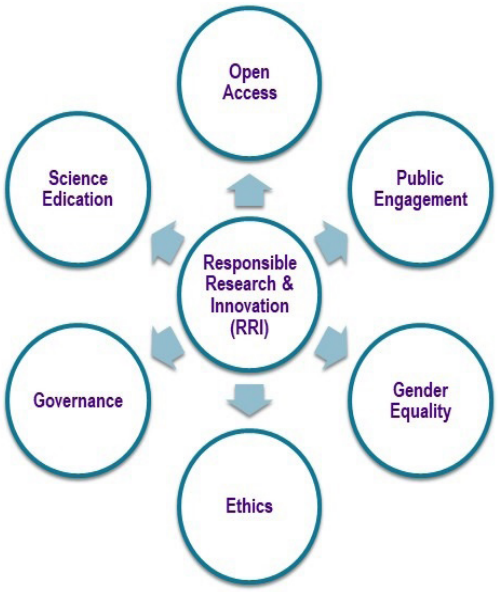

Figure 1: Open Access as an Element in RRI Framework.

Brief Background of Responsible Research and Innovation

According to Stilgoe[5] *et al*. "Responsible innovation is an idea that is both old and new. Responsibility has always been an important theme of research and innovation practice, although how it has been framed has varied with time and place. Francis Bacon's imperative to support science 'for the relief of man's estate', the institutionalisation and professionalisation of science from the 17th century onwards, Vannevar Bush's (1945) 'Endless Frontier', JD Bernal's (1939) arguments for science in the service of society and Michael Polanyi's (1962) 'Republic of Science' counter-argument have all contained particular notions of responsibility".

The Responsibility, in a true sense, indicates some sort of reliability or dependability. As Wikipedia[6] said, the "term RRI was coined in Europe and the United States in the first decade of the 21st century. Among the first authors who developed this concept from 2003 onwards, were Hellstrom, Guston, Owen, Robinson and others".[6] But Research is an old and classical concept of the society. The earliest recorded use of the term dates back to the year 1577. Now, an interesting question may instinctively arise, i.e., was the Research before the year 2003 held no Responsibility at all? At this juncture, let us recall that the main glue functioning behind the amalgamation of Responsibility and Research is its interactions with the Society.[7] The Atomium European Institute[8] declared, "Citizens have a right — and are expected — to be involved in the crucial decisions of what their futures will look like and how science and technology can contribute to its betterment. The framework for Responsible Research and Innovation (RRI) stresses the fact that grand societal challenges will have a better chance of being successfully tackled if all societal actors are fully engaged in the co-construction of innovative solutions, products and service. Thus, RRI is being developed to foster the creation of a research and innovation policy driven by the needs of society and engaging all societal actors via inclusive, participatory approaches." As outlined by Nobel Laureate and former Director General of CERN, Professor Carlo Rubbia, the most severe scientific problems are those responding to long-term issues, like cancer, climate change or changing demographics. We need to critically assess how society and the different stakeholders can be engaged in the whole governance process to avoid the risk of investing only in short-term solutions; as Michael Faraday tells us "electricity was not invented by improving candles".

Responsible Research and Innovation as a Movement

Keeping in mind the reciprocities between research and society, the former gradually was shaped into a movement to emphasize the impacts of science on society and the influences of society on science. As Angelaki[9] mentioned in 2016, Responsible Research and Innovation (RRI) is a key action of the "Science with and for Society" programme of Horizon 2020 (H2020). The European Commission defines RRI as "an approach that anticipates and assesses potential implications and societal expectations concerning research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation". This paper aims to contribute to a better understanding of this increasingly topical concept while focusing on one of its core features: Open Access. This program highlighted the major role of Open Access within the RRI framework. The responsibility issues are contemplated with research functions at the crossroad when the society marches towards democratization. As the democratization radically demands sustainability issues, therefore RRI is the key factor in today's research scenario.

Open Science Movement

Why does science need to be open? Perhaps one of the most burning issues of today's society. In this context, let us recall Swartz's[10] famous quotation, "Information is Power". But like all power, there are those who want to keep it for themselves. The world's entire scientific and cultural heritage, published over centuries in books and journals, is increasingly being digitized and locked up by a handful of private corporations.

Irina Bokova, Director-General of UNESCO, elaborates the importance of Open Science:[11] "To overcome the knowledge divides, we need more cooperation across disciplines and across borders to help governments develop more effective and inclusive policies, North and South. International networks, open data sources, co-creation of knowledge, open access to publishing and software – these are all vital to achieving this."

Since the birth of science journal in the year 1665, scientists have been publishing papers without remuneration. Usually, the scientists get royalties for their textbooks and monographs. But generally, the papers are published in journals to bring the scientists even more valuable rewards, i.e., the citation, the time-stamp or other forms of impact. For more than 350 years, the papers contributed by authors are being distributed in print journals, whose costs were covered by subscription fees. The rise of internet ensured free distribution of scholarly content to readers, a new environment in the academic world, known as Open Access. It is interesting to note that the price of journals began to escalate steeply as the internet was born. The average price hike of a science journal was about four times in the internet era compared to only one/two decades back. This resulted in an access crisis while hardly any institution could access scholarly content particularly in developing nations like India and South Asian countries. At this cross-point the open access movement started, which eventually persuaded 80% of non-OA journals to let their authors deposit the peer-reviewed versions of their work in OA repositories. Today, open science movement is gathering high momentum. There are several thousands of OA journals and repositories. Besides the well-known subscribed bibliographic cum citation databases like Scopus and Web of Science, there is also OA database like PubMed or CiteSeerX. The notable feature is that there are so many facets of open science publication and dissemination. Canessa and Zennaro[12] pointed out six key features that researchers need to know about open science. Hippel and Krogh[13] described two prevalent models of innovation in open science organization, i.e., the private investment model and the collective action model and assessed the role of open source software in implementing the same. Gonzalez[14] highlighted licensing issues involved in open science movement. Atkins[15] *et al*. discussed the role of open-educational resources in open science movement. Ruth[16] developed the concept of the Open Science Grid (OSG) that provides a distributed facility where the Consortium members provide guaranteed and opportunistic access to shared computing and storage resources. Nosek[17] described transparency, openness and reproducibility as vital features of open science research. Boulton[18] described the open science movement as an open enterprise.

As of 6th December, 2018, PubMed contains more than 29.1 million records. About 500,000 new records are added every year. As of the same date, 13.1 million of PubMed's records are listed with their abstracts and 14.2 million articles have links to full-text (of which 3.8 million articles are available, full-text for free for any user). The WoS is a huge database, which seriously lacks in OA indexing. By using the list, they have provided there are only 726 open access journals in WoS. The DOAJ is currently indexing 12,142 OA Journals. That means WoS is indexing only about 7% of the OA content available. Today, Scopus indexes 4153 OA journals. The total number of journals covered by Scopus is more than 30,000. Thus, the percentage of OA journals covered is around 14%. Thus, compared to WoS, Scopus covers OA better.

Research in Open Science: Global Scenario

The open science movement gained momentum particularly in recent years, i.e., since the beginning of the second decade of the 21st Century, as also evident from Scopus, Web of Science and PubMed. The gaining momentum of Open Science concept endorses itself as a self-sufficient subject domain that is also clear from these three bibliographic databases. We have searched these databases by the search term "Open Science" OR "Open Science Movement". The results of the retrieved

data are presented below. The growth pattern of global research on Open Science is presented in Figure 2.

Growth of Literature

It is interesting to note that Scopus records a maximum number of Open Science research output followed by Web of Science and PubMed. The PubMed records a minimum number of output though it is an open-access database, while the other two are a subscription-based database. An exponential growth of outputs is observed after 2010 for all the three databases.

The growth patterns of open science research at per three databases, viz. WoS, Scopus and PubMed are hereby analysed by non-linear regression method (Figure 3).

The open science growth of literature since 1989 to 2017, as observed in Web of Science, Scopus and PubMed are hereby fitted by regression method.[19] In all three databases, the best fit curve found is exponential of the form Y = a*Exp(b*X), where, a and b are constants, Y represents a number of publications over the years (dependent variable) and X represents years (independent variable. The values of a and b for three databases are presented in Table 1.

It is observed from Figure 3 that Open Science growth was started more of less since 2009 that touched the crest after 2015. The sudden hike took place actually during the last three/ four years. This growth pattern agrees with Price' growth model. [20] The open science research is on the full swing right now, which is signalled by the exponential growth pattern (Table 1). In the context of long-term growth, Price suggested Logistic curve, that is S-shaped to follow a saturation or decaying phase (third phase) after the exponential growth phase. It is thus clear that in the case of open science the third phase is yet to come in future.

Core Parameters associated with Global Open Science research.

Subject Areas Covered

The main subject domain attached with Open Science research is computer sciences followed by information sciences, social sciences, etc. No similarity is observed between the ranking of the results from Scopus and Web of Science other than the first one. However, the dominating subjects in Global Open Science Research are computer sciences, library and information sciences, social sciences, physics, astronomy, mathematics, etc. (Table 2)

Core Journals

The ranking of journals is also varying widely between two databases. The core journals are, however, include, eLife, Journal of Physics: Conference Series, Research Policy, PLOS One, ACM International, etc. (Table 3)

Core Countries

The list of top 20 countries is given in Table 4. The ranking here particularly for the top ten countries is nearly the same. In Scopus' list, India is absent, while secured 20th position in WoS' list. The topper country is the USA, followed by UK, Germany, Canada, *et al.*

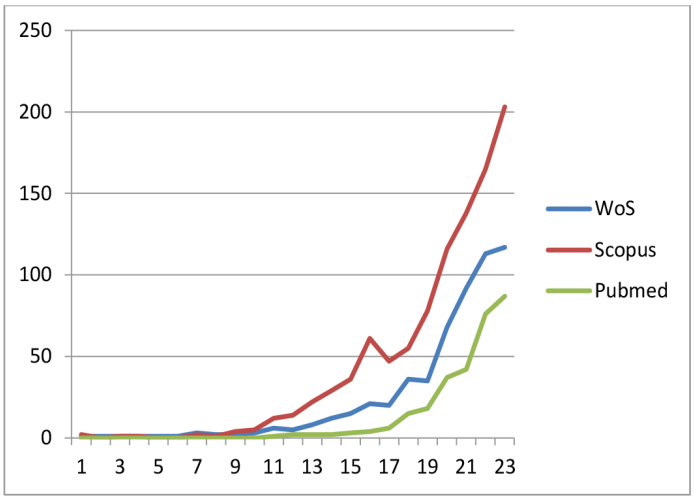

Figure 2: Growth of Literature in Open Science research (Observed).

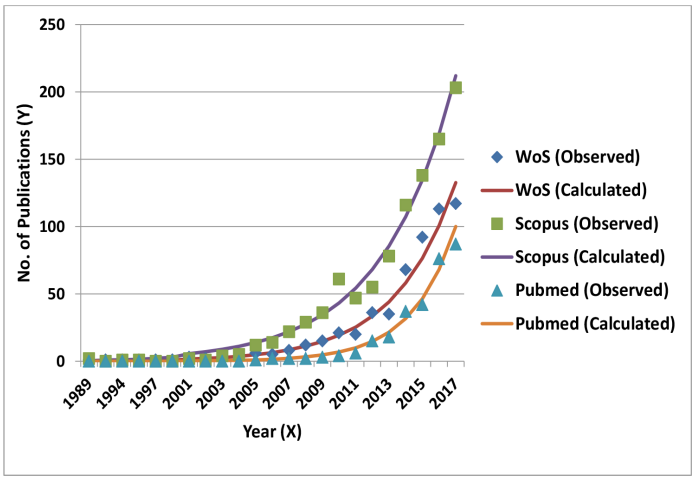

Figure 3: Exponential curve fitting.

Table 1: Exponential Curve as Best–Fit Function.

S.No.	Database	Equation	a	b	Residual sum of squares (RSS)	Coefficient of determination (*R2*)
1	Web of Science	Y = 0.06*Exp(0.28*X)	0.06	0.28	866.2	0.95
2	Scopus	Y = 0.37*Exp(0.23*X)	0.37	0.23	744.5	0.98
3	PubMed	Y = 0.002*Exp(0.38*X)	0.002	0.38	319.8	0.96

Table 2: Major subject areas covered in Global Open Science research.

Research areas as per Web of Science	Records (% age share)	Research areas as per Scopus	Records(%age share)
Computer science	117 (15%)	Computer science	352 (26%)
Information science library science	101 (13%)	Social sciences	230 (17%)
Psychology	98 (12%)	Medicine	177 (13%)
Science technology other topics	87 (11%)	Biochemistry, genetics and molecular biology	121 (9%)
Mathematical computational biology	87 (11%)	Physics and astronomy	104 (8%)
Life sciences biomedicine other topics	76 (9%)	Engineering	98 (7%)
Business economics	65 (8%)	Neuroscience	78 (6%)
Behavioral sciences	64 (8%)	Agricultural and biological sciences	68 (5%)
Genetics heredity	56 (7%)	Immunology and microbiology	58 (4%)
Environmental sciences ecology	55 (7%)	Mathematics	52 (4%)

Accessing Open Science Online

Open Science promotes proliferation of open access (OA) scholarly resources and open research data to be available in the public domain and accessible through the Internet. The research outcomes are often captured in research publications and those publications are made available either through Gold OA channel (e.g., open access journals) or the Green OA channel (e.g., institutional or subject repositories and data repositories, allowing self-archiving). Various research institutions and funding agencies across the world have agreed to support OA publications as outcomes from their funded research projects and scholarships.

Table 5 shows the distribution of OA resources in BRICS nations as recorded on different online directories. These open science directories are maintained by various global organizations, which verify credentials of OA resources before enlisting. For example, ROAD is jointly managed by UNESCO and ISSN (International Standard Serial Number International Centre). ROAD data shows that 4489 OA periodicals are published from BRICS nations, covering 14.71% of global OA periodicals (including scholarly journals, as of 18th September 2018). The Directory of Open Access Journals (DOAJ) maintains a searchable online database of Gold OA journals. DOAJ data shows that 2004 OA journals are published from BRICS nations, covering 16.5% of global OA journals (as of 18th September 2018). These journals provide an appropriate venue to publish in their respective national language, in addition to English as a dominant language of scientific discourses. The majority of these journals follow Creative Commons open licensing. Open licensing is the key enabler in the OA environment where the readers can view the literature without any payment and copyright restrictions. Some open licensing modes also allow readers to share and re-use the scholarly information in their future works. OpenDOAR data shows that 352 OA repositories are in operation from BRICS nations, covering 9.32% of global OA repositories.

A research data repository facilitates archiving processed research data, while an OA repository facilitates self-archiving of publications in pre-print, post-print, or published format. Table 5 also shows an open science indicator from Re3Data.org, which is a global Registry of Research Data Repositories. The registry covers research data repositories from different academic disciplines. It presents repositories for the permanent storage and access to data sets to researchers, funding bodies, publishers and scholarly institutions. It aims to promote a culture of sharing, increased access and better visibility of research data. The website Re3Data.orgshows that 124 research data repositories are in operation from BRICS nations, covering 5.66% of global data repositories. The Table indicates that Brazil and India are most supportive of Open Science causes, while other countries are catching up.

Declining of OA Journals on DOAJ Database

In June 2016, DOAJ announced the engagement of DOAJ Ambassadors for streamlining inclusion of new OA journals from the Global South, while they recruited 15 ambassadors from 10 countries. Due to certain changes in the journals inclusion policy as well as the inclusion process on DOAJ, OA journals from India and few other countries started delisting. Unfortunately, many scholarly journals published by the science academies in India and other public funded institutions, although publishing freely accessible online journals for many years, had shown little interest in the inclusion of their journals in this directory. Surprisingly, many of these Indian journals are indexed on Scopus, Web of Science and other abstracting and indexing databases, but they consciously are not taking part of the DOAJ database. DOAJ Ambassadors in India are still trying to figure out how OA journals published by the public-funded institutions (including science academies in India and CSIR-NISCAIR) could be included in the DOAJ

Table 3: Core Journals in Open Science Literature.

Core Journals as per WoS	Frequency	Core Journals as per Scopus	Frequency
eLife	30	Journal of Physics Conference Series	68
Research Policy	16	eLife	30
PLOS One	9	ACM International Conference Proceeding Series	17
Gigascience	9	Research Policy	16
PeerJ	7	Communications In Computer And Information Science	15
Information Wissenschaft Und Praxis	7	F1000research	15
PLOS Biology	6	Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics	15
Journal of Technology Transfer	6	Procedia Computer Science	13
Abstracts of Papers of The American Chemical Society	6	Journal of Science Communication	10
Abstracts of Papers American Chemical Society	6	CEUR Workshop Proceedings	9
Science	5	Liber Quarterly	9
Circulation Cardiovascular Quality and Outcomes	5	PLOS One	9
Trials	4	Gigascience	8
Scientometrics	4	PeerJ	7
Scientific Data	4	Behavior Research Methods	6

database. Table 6 presents how Indian OA journals are declined over the period of 14 months, while other BRICS countries are improving their presence on DOAJ.

Celebration of Promotional Weeks for Open Science

The organizations engaged in promoting open science movements globally in association with the research funding are engaged with the stakeholders throughout the year. But they also celebrate dedicated weeks locally across the world to involve scientific workers and academic researchers in the folds of open science practices. Three such promotional OS weeks are namely, International Open Access Week, International Open Education Week and International Data Week. The respective week maintains a searchable database of events and activities planned during the declared period.

- **International Open Access Week** |21-27 October 2019| Everywhere [Openaccessweek.org]: Open Access Week is an annual scholarly communication event focusing on open access and related topics. It takes place globally during the last full week of October in a multitude of locations both on- and offline. Typical activities include talks, seminars, symposia, or the announcement of open access mandates or other milestones in open access.
- **International Open Education Week** | 4-8 March 2019 | Everywhere [Openeducationweek.org]: Open Education Week is a celebration of the global Open Education Movement. Its goal is to raise awareness about the movement and its impact on teaching and learning worldwide.
- **International Data Week** | 5-8 November 2018 | [Internationaldataweek.org]: The theme of IDW 2017 was "From Big Data to Open Data: Mobilising the Data Revolution", while IDW 2018 theme is "Digital Frontiers of Global Science". IDW brings together data scientists, researchers, industry leaders, entrepreneurs, policy makers and data stewards to explore how best to exploit the data revolution to improve our knowledge and benefit society through data-driven research and innovation.

Global Collaborative Projects in Open Science

This section records some of the significant OS projects implemented in the Global South, while many international organizations are collaborating with the national and local scientific institutions for rolling out open science platforms for the benefits of the scientists and researchers in the respective region or the country.

- **Journals Online (JOLs) Project Managed by INASP:** INASP (International Network for the Availability of Scientific Publications), established by the International Council for Science (ICSU) in 1992, is managing JOL projects as indicated in Figure 4.
- Following JOL projects are rolling out country-specific online platforms for the scientific journals in South Asia:
- ***BanglaJOL***[Banglajol.info]: is managed by the Editing and Publication Association of Bangladesh (EPAB) and the Bangladesh Academy of Science (BAS). Presently it

Table 4: Core Countries in Open Science Literature.

Countries as per Web of Science	Records (% age share)	Countries as per Scopus	Records (% age share)
USA	267 (33%)	United States	463 (36%)
England	102 (13%)	United Kingdom	167 (13%)
Germany	62 (8%)	Germany	108 (8%)
Canada	54 (7%)	Canada	59 (5%)
Australia	36 (4%)	Italy	56 (4%)
Italy	34 (4%)	Netherlands	52 (4%)
Netherlands	33 (4%)	France	50 (4%)
France	32 (4%)	Switzerland	45 (4%)
UK other than England	31 (4%)	Australia	44 (3%)
Switzerland	28 (3%)	Spain	40 (3%)
Belgium	21 (3%)	Japan	31 (2%)
Spain	18 (2%)	Belgium	28 (2%)
Japan	17 (2%)	Finland	23 (2%)
Sweden	14 (2%)	Austria	22 (2%)
Scotland	14 (2%)	Denmark	17 (1%)
Norway	12 (1%)	Norway	17 (1%)
Denmark	12 (1%)	Sweden	16 (1%)
Peoples R China	10 (1%)	Poland	14 (1%)
Austria	9 (1%)	Greece	13 (1%)
India	7 (1%)	China	12 (1%)

covers 140 Journals, while about 18,882 Full Text (PDF) articles are made available.

- **SLJOL** [Sljol.info]: is managed by University of Colombo and the National Science Foundation of Sri Lanka. Presently it covers 73 Journals, while about 8196 Full Text (PDF) articles are made available.
- **NepJOL**[Nepjol.info]:is managed by Tribhuvan University Central Library (TUCL).Presently it covers 118 Journals, while about 11,704 Full Text (PDF) articles are made available.
- **SciELO (Scientific Electronic Library Online):** SciELO started in Brazil in 1997 as a partnership among FAPESP (the State of São Paulo Science Foundation) and BIREME (the Latin America and Caribbean Center on Health Sciences Information), a center of the Pan American Health Organization (PAHO/WHO). Presently it covers 1,447 journals, while about 49,910 journal issues and 713,987 articles are made available (as on 10th October 2017). SciELO country collections include contributions from 14 Latin America and the Caribbean countries, viz. Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Spain, Mexico, Peru, Portugal, South Africa, Uruguay and Venezuela.

Table 5: Open Science Proliferation in BRICS Nations.

Open Science Channel/ Country	No. of items on Directory of Open Access Scholarly Resources (ROAD)	No. of items on Directory of Open Access Journals (DOAJ)	No. of items on Directory of Open Access Repositories (OpenDOAR)	No. of items on Registry of Research Data Repositories (RE3Data.org)
Brazil	1259	1280	99	8
Russia	685	269	31	22
India	2361	253	81	48
China	39	116	102	38
South Africa	145	86	39	8
Total from BRICS Nations	4489 (14.71%)	2004 (16.5%)	352 (9.32%)	124 (5.66%)
Global Total	30514	12142	3775	2191

[Data as on 18th September 2018]

Global Open Research Data Initiatives

GODAN.info (Global Open Data for Agriculture and Nutrition): It aims at challenging global poverty and promoting food security through opening up data in agriculture and nutrition for everyone. GODAN is a rapidly growing network of over 940 partners from government, international and private sector organizations all committed to making data relevant to agriculture and nutrition available, accessible and usable worldwide. It published two booklets on success stories on open data for agriculture and nutrition covering about 30 success stories from the Global South (Godan.info/resources/success-stories).

Advocacy for Open Science: Recent Success Stories from India

In India, a scientific community was emerged in recent time to support the open science movement in the country. This community is formally known as 'Open Access India (OAI),' which maintains its website and social media profiles for promoting principles and practices of OA to scientific workers and academic researchers in India and South Asia. Its social media accounts have been outreaching to more than 11,000 determined followers. OAI maintains Twitter handle @OAIndia. OAI is advocating proliferation of national/ institutional OA platforms and OA policies. Some of the OA platforms and policies unfolded in recent time in India include the following:

In 2011, *Shodhganga: A Reservoir of Indian Theses* was launched by INFLIBNET Centre, to serve the mandates of the UGC Notification (Minimum Standards and Procedure for Award of MPhil/Ph.D Degree, Regulation, 2009) dated 1 June 2009,

Table 6: Open Access Journals in BRICS Nations on DOAJ.

	No. of OA Journals as on 25-08-2016	No. of OA Journals as on 10-10-2017	Status	Difference
Brazil	876	1081	Increase	+23.4%
Russia	155	186	Increase	+20%
India	345	198	Decrease	(-)57.39%
China	48	102	Increase	+112.5%
South Africa	60	63	Increase	+5%
BRICS Total	1484	1630	Increase	+9.84%
Global Total	9188	10213	Increase	+11.15%

[Data as on 10th October 2017]

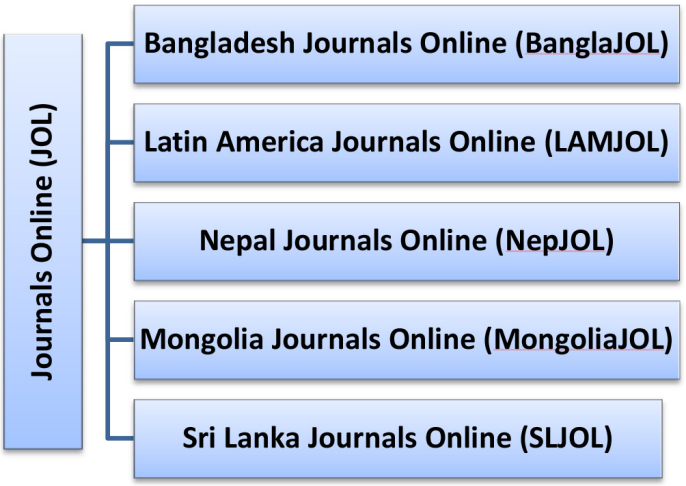

Figure 4: INASP-supported Journals Online (JOL) Projects.

to facilitate open access to Indian theses and dissertations for global dissemination to the academic community worldwide. In December 2014, the Department of Biotechnology (DBT) and the Department of Science and Technology (DST), Government of India had jointly adopted the DST/DBT Open Access Policy. In March 2015, UNESCO and CEMCA jointly launched an *Open Access Curriculum for Researchers* and an *Open Access Curriculum for Library Schools*.[21]

Shodhganga (Shodhganga.inflibnet.ac.in): As a reservoir of Indian theses, Shodhganga fulfills the mandates of the UGC Notification (Minimum Standards and Procedure for Award of M.Phil. / Ph.D Degree, Regulation, 2016) dated 5th May 2016. It presently covers 203,400+ theses and dissertations from 355+ universities.

ICSSR Data Service (ICSSRDataService.in): It is the culmination of the signing of Memorandum of Understanding (MoU) between the Indian Council of Social Science Research (ICSSR) and Ministry of Statistics and Programme Implementation (MoSPI). The MoU provides for setting-up of "ICSSR Data Service: Social Science Data Repository" and host NSS and ASI datasets generated by MoSPI. This service aims at providing seamless and integrated access to a wide range of datasets generated by the MoSPI, Social Science Institutions under direct purview of ICSSR and other Government organizations, to researchers who are looking for high quality social and economic research datasets; serving as a national data service for promoting powerful research environment through sharing and reuse of data among social science community in India; acquiring, processing, organizing, preserving and hosting research data and its metadata along with ETL (extract, transform and load) facilities of raw data in social sciences and related domains collected from diverse sources for easy sharing and access; facilitating online submission, access, search, browse, discovery, conversion, analysis and visualization of data through intuitive interfaces; imparting training and spread awareness about benefits of data sharing and reuse amongst social science research community in India; and interacting, cooperating and collaborating with other national and international data services and repositories for data and resource sharing and improved management of data services.

Self-Archiving of Scientific Data in Data Repositories

The scientific communities are aided with different global online platforms for self-archiving open research data after fully or partially completion of their respective research studies. Some of the popular platforms are briefly mentioned here.

- **Figshare (Figshare.com):** It securely stores and manages your research outputs in the cloud, or makes them openly available and citable (with a DOI) for free. It helps in fulfilling the research data management (RDM) policy of many research institutions and scientific journals.
- **Dryad (DataDryad.org):** It is a curated repository that makes the data underlying scientific publications discoverable, freely reusable and citable. This portal also helps in fulfilling the research data management (RDM) policy of many research institutions and scientific journals.
- **Dataverse.org** (Dataverse Project): This site provides a web application for sharing, citing, analyzing and preserving research data, created by Institute for Quantitative Social Science (IQSS) at Harvard University, in the United States. This portal also helps in fulfilling the research data management (RDM) policy of many research institutions and scientific societies.
- **DataCite.org:** It is a leading global non-profit organisation that provides persistent identifiers (DOIs) for research data. Its goal is to help the research community to locate, identify and cite research data with confidence.

It is a member-based organization that helps make data and other research outputs more accessible by developing/ supporting methods to locate and cite them.

CONCLUSION

This paper highlights the brief background of the concept of Responsible Research and Innovation (RRI). The RRI framework has six key elements, one of which is Open Access. This key element brings forth the concept of Open Science. Today, the idea Open Science itself bloomed as an individual subject domain in the universe of knowledge. The Global trend of Open Science research is presented here by data obtained from Scopus, Web of Science and PubMed. It shows an overall growth of Open Science initiatives in the BRICS nations. In some areas, BRICS countries have been stagnated and could not reach the mark of global 10% share. The advocacy from the scientific and professional societies needs to be strengthened to overcome the stagnation. Some of the takeaway points and recommendations from this paper are shown in the bullet points for the easy grasp of the situations by the targeted stakeholders of local open science movement. A sustained Advocacy is required to pledge to use OA resources as users and authors; to encourage researchers to share their research data and publish OA publications and to introduce Research Data Literacy programmes for the researchers and research scientists.

It is expected that research outcomes of the public funded research be made available through the Open Access publications with open licensing. Archiving of research data from public funded research in open data repositories and research journals maintained by the public-funded institutions need to be encouraged. Journals published by the public-funded institutions usually don't have any APC for publishing.

There is a need to have a cross-country collaboration between the research academies and research funders in developing countries (i.e., the Global South) to curb the menace of predatory OA publishers and journals. The menace of plagiarism also needs to address. There is a need to make use of OA knowledge repositories/open data repositories, both at the institutional and funders' level and also subject-specific OA repositories (e.g., AgriXiv for agricultural research literature, or IndiaRxiv – Preprints Server for India). There is a need to establish cross-country formal linkages in the Global South for mutual learning from the best practices/ success stories in open science initiatives. A cross-country collaboration between the national science academies in the Global South for the proliferation of open research data/ open science initiatives, OA journals/ publications, with no or very nominal article process charges (APC). A sustained open access movement in the Global South would ensure research funders show their commitments to cover APC for funded research. Not many international collaborative studies in the areas of RRI have been initiated or taking place amongst the countries in the Global South. A cross-country collaboration between the research academies and research funders in the Global South will also ensure reuse of published open research data. An integrated approach to open science is, thus, required to support the activities towards achieving the whole of RRI Framework and also the Sustainable Development Goals (SDGs).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

ABBREVIATIONS

APC: Article Process Charge; **BOAI:** Budapest Open Access Initiative; **BRICS:** Brazil, Russia, India, China, South Africa; **DOAJ:** Directory of Open Access Journals; **GODAN:** Global Open Data for Agriculture and Nutrition; **OA:** Open Access; **OpenDOAR:** Directory of Open Access Repositories; **RRI:** Responsible Research and Innovation; **SDGs:** Sustainable Development Goals.

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