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# Long Title: Open Science Policy in India & UNESCO initiative

## Short Title: analysis and recommendations

**[1]Name of I[st] Author**: Alpana Saha [a, b]

**[1]Designation of I[st] Author:** Research Scholar

**[1]Name of organization of 1[st] Author: Affiliation_a -** CSIR-National Institute of Science Communication and Policy Research, Dr KS Krishnan Marg, New Delhi-110012, India

**[1]Name of organization of 1[st] Author: Affiliation_b** - Academy of Scientific and Innovation Research (AcSIR), Ghaziabad-201002, India

**Corresponding addresses**:

Home address: Alpana Saha, W/O Satyawan Singh, B12C, Upper Ground Floor, Paryavaran Complex, New Delhi, Delhi 110030/

Institution address: Alpana Saha, Research Scholar, AcSIR, Ghaziabad, Uttar Pradesh. Lab: CSIR-NIScPR, Dr KS Krishnan Marg, Pusa, New Delhi, Delhi 110012, Mobile number: 9873184971.

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**Executive Summary**:

Open Science brings new approaches to science. It is the result of bringing together many open things like open access, open data, open methodology, open source, open peer review and open science resources. In this study, we will study all the open science policies registered in India. The commitment done in the policies and present scenarios is analysed. This clearly shows that India has tried to follow the essence presented to them by the United Nations Educational, Scientific and Cultural Organization (UNESCO). There are many hindrances in path to achieve complete open science environment in India but India is positively moving ahead in democratising science in India.

# I. INTRODUCTION

In general term open science means science for all. More specifically we can say that open science aims at democratization of science. This means science for the people, by the people and of the people. The main pillar of any democracy is the need to have educated citizens. Science is the basic part of education as it leads to development and sustainability. So, we can say that open science will lead to a better and sustainable society.

*i. Definition of Open Science:*

Open Science (OS) represents a **new approach to the scientific process** based on cooperative work and new ways of diffusing knowledge by using digital technologies and new collaborative tools [1]. The OECD defines

Open Science as: "*to make the primary outputs of publicly funded research results – publications and the research data – publicly accessible in digital format with no or minimal restriction"*[2], but it is more than that.

Open science encompasses unhindered access to scientific articles, access to data from public research, and collaborative research enabled by ICT tools and incentives. Broadening access to scientific publications and data is at the heart of open science, so that research outputs are in the hands of as many as possible, and potential benefits are spread as widely as possible:

- Open science promotes a more accurate verification of scientific results. By combining the tools of science and information technologies, scientific enquiry and discovery can be sped up for the benefit of society.
- Open science reduces duplication in collecting, creating, transferring and re-using scientific material.
- Open science increases productivity in an era of tight budgets.
- Open science promotes citizens' trust in science. Greater citizen engagement leads to active participation in scientific experiments and data collection.
- Open science results in great innovation potential and increased consumer choice from public research[3].

Open Science has the potential of making the scientific process more transparent, inclusive and democratic [4].

Open Science is the movement to make scientific research, data and their dissemination available to any member of an inquiring society, from professionals to citizens. It impinges on principles of scientific growth and public access including practices such as publishing open research and campaigning for open access, with the ultimate aim of making it easier to publish and communicate scientific knowledge. From development to dissemination of knowledge, several concepts belong under the umbrella term of 'Open [5].

Open Science is a disruptive phenomenon that is emerging around the world and especially in Europe. Open Science brings about socio-cultural and technological change, based on openness and connectivity, on how research is designed, performed, captured, and assessed [6].

Open science aims to bolster scientific research in part by testing the reproducibility and replicability of findings [7].

Open science is the growing movement to make science open. Science was itself used as a primary example for the efficacy of the open-source movement, citing practices such as open dissemination of information, methods, and peer review of the scientific literature (onesource.com).

*ii. Principles of Open Science*

The six principles of open science are: [8]
Open methodology
Open source
Open data
Open access
Open peer review
Open educational resources
The 8 pillars of Open Science are FAIR Data, Research Integrity, Next Generation Metrics, Future of Scholarly Communication, Citizen Science, Education and Skills, Rewards and Initiatives, and EOSC[9].

The FAIR principles steward researchers in making outputs of research:

- Findable – making research outputs discoverable by the wider academic community and the public,
- Accessible – using unique identifiers, metadata and a clear use of language and access protocols,
- Interoperable – applying standards to encode and exchange data and metadata and...
- Reusable – enabling the repurposing of research outputs to maximise their research potential.

When combined, these four elements are designed to help lower barriers to research outputs and facilitate potential secondary researchers finding, understanding reusing and repurposing them to realise additional research opportunities and maximise existing resources.

Research integrity is the practice of researchers acting honestly, reliably, respectfully and is accountable for their actions.

The next-generation metrics pillar of Open Science seeks to catalyse a shift in cultural thinking around the way in which bibliometrics are utilised in research, particularly when evaluating quality, and go beyond simply citation counts and journal impact. Appropriate metrics, drawn from different sources and describing different things, can help us gain a broader understanding of the significance and impact of research.

Citizen Science is a movement towards members of the public having a greater role within research and recognising the invaluable role they play in providing insights a researcher may not typically have.

Harnessing the advantages of the internet, openly available software packages and local knowledge, citizen science brings about a change in the way research is conducted – no longer limited to academic researchers; it encourages collaboration from groups across society.

*iii. Indian Open Science Policy*

The Department of Science and Technology (DST), Ministry of Science and Technology, Government of India says that an all-encompassing Open Science Framework will be built under the STIP 2020. DST's decision to adopt an open-science approach to publicly funded research is a good step for better innovation. Additionally, such a framework will enforce open scientific inquiry, bring transparency, promote new research areas, and even encourage exploration of topics not seen by the initial researchers. Under this framework, all the data used in and generated from publicly funded research will be made available to all under the FAIR (findable, accessible, interoperable, and reusable) terms [9].

Indian scientific diaspora, including academicians, thought leaders, stakeholders, members of Science India Forum, and distinguished community leaders from gulf countries deliberated on open science policy, fellowships in India, opportunities for innovators, young researchers at the post-draft STIP consultation with Indian diaspora from the Gulf Cooperation Council (GCC) countries viz., Saudi Arabia, Qatar, Kuwait, Bahrain, UAE and Oman on, 22nd January 2021 (dst.gov.nic.in).

Historically, the interaction between universities/research institutes and industries has been low in India, resulting in poor uptake of university research by industry. Furthermore, low levels of innovation in India are caused by a lack of synergy between universities and industries.
Adopting an open science policy can serve as a research accelerator for India, encouraging collaborations between universities and industries, leading to innovation and technological development. Open science will facilitate rapid access to novel data and code from universities to their industrial counterparts, resulting in new collaborations [11].

On a more serious note, India's recently released Science, Technology, Innovation Policy (Draft), boldly declares that "science" will be a key driver for economic growth and human development in the country.

Interestingly, the new policy is the fifth of its kind since Independence. The first science policy resolution (SPR) came just two years after the country became a republic, in 1958. The second Technology Policy Statement (TPS) arrived in 1983; the third Science and Technology Policy (STP) in 2003; and the fourth new Science, Technology and Innovation (STI) policy came out in 2013. The latest edition has hogged headlines for a slew of initiatives it has proposed for enhancing India's science-scape. Arguably the most interesting among them is the proposal to promote "open science". The STIP 2020 says the "public will have the right to access all outputs" from government-funded research. People can access such research directly or via funding agencies or government institutions. The policy says the "publicly funded research" that people can access freely include scholarly publications, research data and research infrastructures, instruments, computing facilities, libraries, learning spaces, etc.

The government move to promote open science comes at a time when a global debate rages around allowing the public to have free and unrestricted access to scientific information. The draft policy defines Open Science as an act or movement that promote "more equitable participation in science". This can be achieved through various measures. And they include increasing access to research output, more transparency and accountability in research, inclusiveness, better resource utilisation through minimal restrictions on "reuse of research" output and infrastructure, and ensuring constant exchange of knowledge between producers and users of knowledge [12].

The draft science and tech policy say that to promote open science a "future-looking, all-encompassing Open Science Framework" will come in force very soon. This framework will be "largely community-driven". The government will make sure that the framework will have the necessary "institutional mechanisms and operational modalities". Quite interestingly, the STIP says in order to make accessibility ubiquitous and egalitarian, supporting tools and applications will come in local languages, from Hindi to Tamil. This, the draft policy believes, will help "widen the scope of accessibility and for meaningful use of data."
The other interesting features of the open science programme India is going to adopt include interoperability and shared-ownership of data and research among "national stakeholders and international partners". The government also plans to create a National Science, Technology and Innovation (STI) Observatory. This would function as a central repository for all the data that the STI ecosystem generates. The observatory will have a central hub for coordination. It will be available in all the regional centres and it can be available on all platforms (interoperable). Another noteworthy plan is to build a dedicated portal called Indian Science and Technology Archive of Research (INDSTA). This portal will help the public access all publicly-funded research. But what exactly can they access here? This lot includes manuscripts, research data, supplementary information, research protocols, review articles, conference proceedings, monographs, book chapters, etc. This will be an open-access portal, which will be interoperable with other repositories. It will facilitate interactions between researchers and users [12].

The emergence of various open movements globally has had an impact in India. Most of these initiatives focus primarily on the consumption side of science and therefore may not encompass all aspects of open science. Most of them fall within the contours of open movements like open access and open data.
In this context, it may be useful to note that owing to the varying usages of the term 'open science', even the few Indian initiatives which are referred to as 'open science initiatives' may not be envisaging the term as broadly as we do.
For a broader picture of the open initiatives in India, one of the potential approaches could be to analyse the initiatives taken within specific spheres of different open movements. While it is not feasible to provide an exhaustive account of all open initiatives taken in India in just an article, discussing a few prominent initiatives, and examining the content and implementation of existing policies and mandates may help in getting a better picture of the broader contexts in which the open movements operate, and the diverse challenges faced by them. This would also help in offering appropriate policy recommendations for a stronger and sustainable open science movement in India, as it encompasses all the other open movements.
Presently, India has registered 18 open access mandates or policies on registry of open access repositories, mandates and policies (ROARMAP). The last one registered in 2019 before the upcoming of open science concept by United Nations Educational, Scientific and Cultural Organization (UNESCO) in 2020. Looking into the UNESCO initiatives in 2021 a framework in upcoming STIP was recommended for open science initiative.

*iv. Initiatives by UNESCO and way ahead*

The United Nations Educational, Scientific and Cultural Organization (UNESCO) have 195 Members and 8 Associate Members and are governed by the General Conference and the Executive Board. The Secretariat, headed by the Director-General, implements the decisions of these two bodies. The Organization has more than 50 field offices around the world and its headquarters are located in Paris.

UNESCO's mission is to contribute to the building of a culture of peace, the eradication of poverty, sustainable development and intercultural dialogue through education, the sciences, culture, communication and information [13].

UNESCO assembly of 193 member states would be approving in its 41st meeting of General Conference in November 2021 a set of Recommendations on Open Science. The rationale for these recommendations, as agreed to by member states, is to promote science which is open to the well-being of society, locally and globally. The

first draft of these Recommendations has highlighted several principles: science as public good, open access to data and scientific knowledge, open access to practitioners and principles of inclusion, equity and diversity [14].

To build a global consensus on Open Science, the development of the UNESCO recommendation on Open Science relies on an inclusive, transparent and consultative process involving all countries and all stakeholders, including Member States, the scientific community as a whole, the key scientific international and national institutions and entities, other relevant United Nations agencies; citizens and traditional knowledge holders.
As of December 2019, UNESCO held a series of online and face to face consultations to support an open debate on Open Science awareness, understanding and policy development to feed into the UNESCO Recommendation on Open Science.
In view of including inputs from all regions and all actors into the Recommendation, an electronic consultation on Open Science, in the form of an online survey, was conducted between February and July 2020. Open to all, the survey collected information from a broad range of interested contributors, individuals and institutions from across the world[14].
UNESCO Recommendation on Open Science will be prepared through a regionally balanced, inclusive and transparent consultation process. An Open Science Advisory Committee is established by the Director-General of UNESCO to guide the consultative process leading to the Recommendation by:
providing expert and strategic advice;
ensuring delivery of the process milestones;
providing support with fundraising.
Four representatives of Member States from each the UNESCO electoral groups and six representatives of key scientific bodies and institutions dealing with open science, are selected by taking into account geographical and gender balance as well as expertise and competence in the field of open science [4](https://en.unesco.org/sites/default/files/tor-open_science_advisory_commitee-en.pdf).

According to UNESCO, Open Educational Resources (OERs) are learning, teaching and research materials in any format and medium that reside in the public domain or are under copyright that have been released under an open license, that permit no-cost access, re-use, re-purpose, adaptation and redistribution by others [4].

## II. DISCUSSION & ANALYSIS

The benefits of open science are many folds. It fosters transparency and efficiency of research and encourages collaborations and maximum resource utilisation. Overall, open science stimulates economic growth and meaningful scientific interventions in public lives. If we can adapt the practices of open science, it will be beneficial to guide the Indian research system towards higher competitiveness and quality. Researchers from the publicly funded Universities should share research publications and more importantly, research data, which includes negative results as well. More engagement/ dialogue between researchers and the public must be encouraged to make research more societal-need driven. There is an urgent need to stop relying on a "one-sided evaluation system" based on research articles and journal impact factors for research evaluation, funding. More importantly, the very fundamental of research projects must be the need of the society, not driven by the research choices of high impact commercial journals.

Free flow of science will help promote a transparent, collaborative and inspirational research process. The advancement of digital technologies has created online platforms to organise and publish the results of research projects, scientific publications and large data sets and make them available to a broader scientific community, potential users from the MSME sectors and the public in general. Cross-discipline learning and collaboration became a reality with the advancement of technologies. However, only a smaller section of the scientific community has woken up to support the causes of open science. We need wider participation to make open science

a reality. It is very much true for India as well. We are far behind in adopting the open science practices. Nurturing open science will need some push from the system to make the researchers adopt open science practices. It's high time for us to embrace the concepts of open science. Open science can potentially navigate the current research ecosystem from publications driven to societal need driven [15].

It must be mentioned here that in the context of India, where most of the population does not have access to the internet, there is a crucial need to look at implementing open science beyond the contours of online networks.
Lack of transparency is one of the major challenges in the production stage of science. This manifest itself in many ways including non-disclosure of details like source of funding, methodology/ data, and negative results.
Different factors influence participation in the production of science. In the Indian context, some of the important socio-economic factors that affect participation are gender, urban-rural divide, language, caste, disability, and economic status.
Like most other parts of the globe, the research culture in India faces a widespread problem - research is publication-driven, and not driven by desire for scientific/social progress. This is born out of immense pressure faced by researchers to publish consistently to progress in their careers [16].

The alignment of Indian open access or open science policies should have with Horizon 2020 is important.
So, what is Horizon 2020? Horizon 2020 was the EU's research and innovation funding programme from 2014-2020 with a budget of nearly €80 billion. Horizon 2020 is succeeded by Horizon Europe [17].
Although data shows a good forward match of the country towards achieving the aims of Horizon 2020. This can be reflected well in the Table 1.

**Table 1**: Open access policies registered by India and percentage of alignment with Horizon 2020

| Policymaker Name | Avg. Percentage policy alignment with Horizon 2020 |
|---|---|
| National Knowledge Commission | 30.76923077 |
| National Institute of Technology, Rourkela | 53.84615385 |
| National Institute of Oceanography | 53.84615385 |
| Mahatma Gandhi University | 53.84615385 |
| Madurai Kamaraj University | 23.07692308 |
| M S University | 30.76923077 |
| Indian Institute of Horticultural Research Bengaluru | 46.15384615 |
| Indian Council of Agricultural Research | 61.53846154 |
| IITH Indian Institute of Technology Hyderabad | 46.15384615 |
| ICRISAT International Crops Research Institute for the Semi-Arid Tropics | 46.15384615 |
| Department of Biotechnology and Department of Science & Technology, Ministry of Science & Technology | 84.61538462 |
| Council of Scientific & Industrial Research | 53.84615385 |
| CGIAR | 69.23076923 |
| Bharathidasan University | 38.46153846 |

*Legend: Adopted and reproduced from ROARMAP in July 2022*

Table 1 clearly indicate that scientific funding agencies of Indian under the Ministry of Science and Technology, Government of India like Department of Science and Technology and Department of Biotechnology along with Council of Scientific and Industrial Research is doing an incredible job in making publication come on open access platform that are funded by them.

Starting from the policy registered by Indian Council of Agriculture Research (ICAR), we see that all the institutes of ICAR are instructed by the mandate or policy registered that they need to setup open access institutional repository using free and open-source software, which is of open archive initiative (OAI-MAP) compliant. ICAR has also committed to set up a central harvester to harvest the metadata and full-text of all the records from all the OA repositories of the ICAR institutes for one stop access to all the agricultural knowledge generated in ICAR. All research and technical publications viz., research articles, popular articles, book chapters, books, monograms, catalogues, conference proceedings, success stories, case studies, annual reports, newsletters, pamphlets, brochures, bulletins, summary of the completed projects, class/lecture notes, presentations, photos,

videos, speeches, key note addresses, other digital objects and all the grey literatures available with the institutes to be placed under Open Access.

The authors of the scholarly articles produced from the research conducted at the ICAR institutes have to deposit immediately the final authors version manuscripts of papers accepted for publication (pre-prints) in the institute's Open Access repository.

Scientists and other research personnel of the ICAR working in all ICAR institutes or elsewhere are encouraged to publish their research work with publishers which allow self-archiving in Open Access Institutional Repositories and required to submit final manuscript of paper accepted for publication (pre-print) in the ICAR institute's Open Access repository.

Scientists are advised to mention the ICAR's Open Access policy while signing the copyright agreements with the publishers. And the embargo if any should not be later than 6 months.

Final reports of completed research projects and M.Sc. and Ph.D. thesis/dissertations to be deposited in the institutes open access repository after completion of the work was made mandatory. The metadata (e.g., title, abstract, authors, publisher, etc.) be freely accessible from the time of deposition of the content and their free unrestricted use through Open Access can be made after an embargo period not more than 12 months.

All the journals published by the ICAR have been made Open Access. All the books published by ICAR and journals and books published by the ICAR institutes are to be made Open Access [18].

India's new science policy – Science, Technology and Innovation Policy 2020 – wants to make scholarly knowledge openly accessible to all.

An expert group consulting the government on the new policy has recommended a 'one nation one subscription' formula for India. This means the government will aim to negotiate with leading publishers of science journals a country-wide open access policy. Under the scheme, a single, centrally-negotiated payment will be made to publishers of scholarly journals in return for access to all published literature by every individual living in India [19].

Mahatma Gandhi University (MGU) of Kerela has also adopted open access and open science policies and registered some mandates for its open library operation.

The University Library was started in 1989. MGU Library and Information System consists of University Central Library, more than 30 libraries of the departments/schools and 4 Study Centres situated in different campuses. MGU has won the State IT Award during the year 2009 in the e-learning category for its University Online Theses Digital Library. With the launching of the Mahatma Gandhi University Online Theses Digital Library, it has become the first Indian University to adopt Open Access of its doctoral research Open Access theses to the academics worldwide through www.mgutheses.in.

The University Library has a collection of 57,350 books, 2,500 e-books, 2,050 theses and 7,500 bound volumes of journals. In addition to this, the library subscribes 253 current Indian (169) and Foreign (84) journals, 4 Online Databases and 4 Online Journal Archives [20].

Open Access policy of scientific institution and body under the Ministry of Science and technology, that is, CSIR is brief but very effective. Points highlighted in the mandate are as follows:

1. All research papers published from all CSIR laboratories and supported by a grant from CSIR will be made open access by depositing the full-text and the metadata of each paper in an institutional repository.
2. Each CSIR laboratory will set up its own interoperable institutional open access repositories for research papers, electronic thesis and dissertations. CSIR-URDIP will set up a central harvester which would harvest the full-text and metadata of all these papers/documents.
3. CSIR and its constituent laboratories publish number of journals. All the CSIR journals published by erstwhile NISCAIR and presently CSIR-NIScPR have been made open access. Progressively, all CSIR publications will be made open access.
4. CSIR-NISCAIR presently CSIR-NIScPR will organize training programmes: (a) for scientists to change their perceptions towards open access (b) for editors and journal production officers of CSIR and other scientific agencies and (c) for personnel from CSIR laboratories who would be setting up institutional repositories.
5. Every year each CSIR will celebrate "Open Access Day" during the International Open Access Week (http://www.openaccessweek.org/) by organizing sensitizing lectures, programmes, taking new OA initiatives, publicizing the statistics of downloads, etc.
6. If the publishers do not follow transparent models of subscription/licensing the content, CSIR scientists will not publish in the journals, will not review the papers and will not join the editorial boards of the journals of those publishers.

7. CSIR will lead the Open Access Movement within the country and take on board other scientific agencies to form a National Open Access Policy including legislation if necessary to mandate the availability of output of publicly funded research in public domain [21].

National Spatial Data Infrastructure has also published its mandate regarding open data for moving ahead in having democratisation of education as well as science. According to their mandate it is expressed that evidence-based planning of socio-economic development processes rely on quality data. There is a general need to facilitate sharing and utilization of the large amount of data generated and residing among the entities of the Government of India. The objective of the open access policy put forth by this body is to facilitate the access to Government of India owned shareable data and information in both human readable and machine-readable forms through a network all over the country in a proactive and periodically updatable manner, within the framework of various related policies, acts and rules of Government of India, thereby permitting wider accessibility and use of public data and information [14].

Bharathidasan University from India has also adopted good open access mandate. It has good open educational resources (OERs) like open distance learning, E-learning and mock test. All the e-learning materials have been made open access by the university and in is freely available on its website. It can be accessed and read by anyone free of cost [22].

According to the Research Archive of Indian Institute of Technology, Hyderabad it has registered its open access policy on ROARMAP database in the year 2014. Some of the mandates of its policies are as follows:

Metadata Policy **for information describing items in the repository**

1. Anyone may access the metadata free of charge.
2. The metadata may be re-used in any medium without prior permission for not-for-profit purposes provided the OAI Identifier or a link to the original metadata record is given.

Data Policy **for full-text and other full data items**

1. Anyone may access full items free of charge.
2. Single copies of full items can be:
    - reproduced, and displayed or performed in any format or medium
    - for personal research or study, educational, or not-for-profit purposes without prior permission or charge.
3. Full items must not be sold commercially in any format or medium without formal permission of the copyright holders.

Content Policy **for types of document & data set held**

1. This is an institutional or departmental repository.
2. The repository holds all types of materials.
3. Deposited items may include:
    - working drafts
    - submitted versions (as sent to journals for peer-review)
    - accepted versions (author's final peer-reviewed drafts)
    - published versions (publisher-created files)
4. Items are individually tagged with:
    - their peer-review status.
    - their publication status.
5. Principal Languages: English

Submission Policy

Concerning depositors, quality & copyright

1. Items may only be deposited by accredited members, academic staff, registered students, and employees of the institution, or their delegated agents.
2. Authors may only submit their own work for archiving.
3. The administrator only vets' items for the eligibility of authors/depositors, relevance to the scope of the repository, valid layout & format, and the exclusion of spam
4. The validity and authenticity of the content of submissions is the sole responsibility of the depositor.
5. Items can be deposited at any time, but will not be made publicly visible until any publishers' or funders' embargo period has expired.
6. Any copyright violations are entirely the responsibility of the authors/depositors.
7. If the repository receives proof of copyright violation, the relevant item will be removed immediately [23].

International Journal Online of Humanities (IJOHMN) has well defined open access policy, which has also been archived on ROARMAP. IJOHMN follows an Open Journal Access policy. Authors retain the copyright of the original work and grant the rights of publication to the publisher with the work simultaneously licensed under a Creative Commons CC BY License that allows others to distribute, remix, adapt, and build upon your work, even commercially, as long as they credit you for the original creation. Authors are permitted to post their work in institutional repositories, social media or other platforms [24].

The National Institute of Oceanography, India adopted its open access policy on 6th December 2010. The policy was the result of administrative and management decision to adhere to open access policy. The institution presently has online public access catalogue and institutional repositories [25].

National Institute of Technology, Rourkela had registered its open access policy on ROARMAP back in 2006. It has its repository in place as well and the link of its repository is http://dspace.nitrkl.ac.in/dspace/.

National Knowledge Commission has also registered its open access policy on ROARMAP database. According to ROARMAP the open access policy adopted by commission was in 2006 and last revised in 2007 but presently the website of the commission in not working [26].

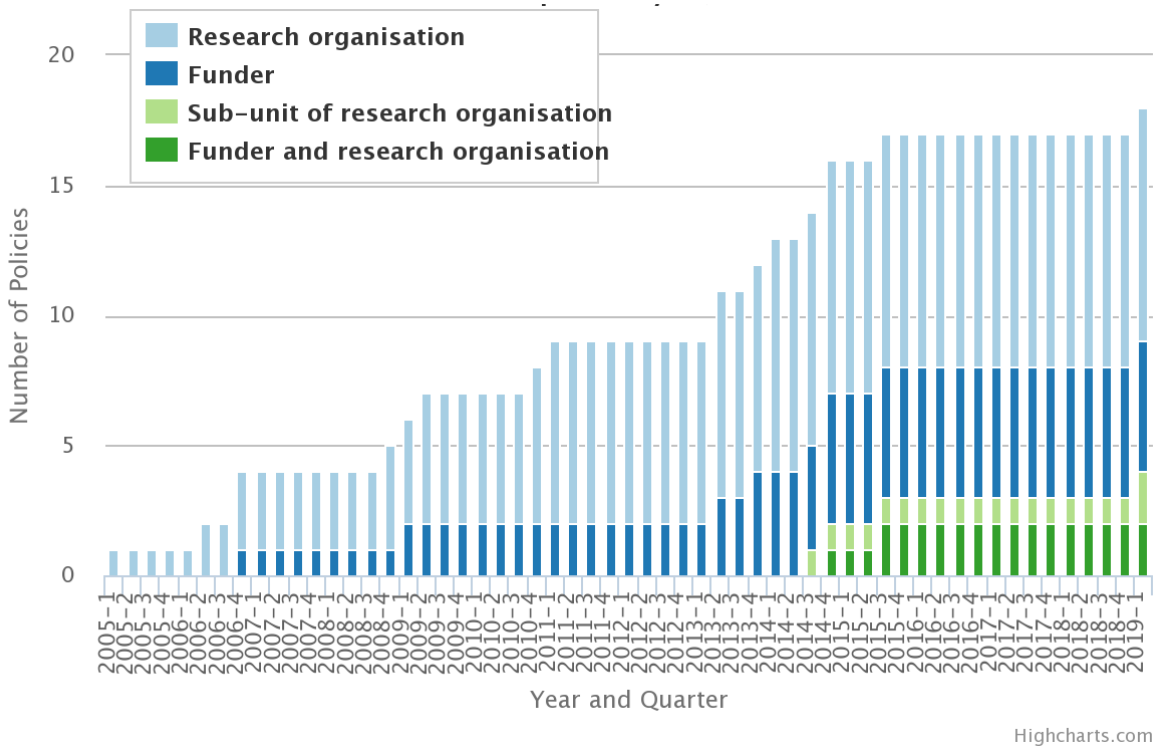
Society of Science registered its open access policy on ROARMAP in 2015. They have their e-journal publication, which is available in open access mode. The link of journal of advanced laboratory research in biology was found its website. All the volumes and issues of this journal are found in open access starting from 2010 till date [27].

Thus, discussing in details all the open access, open data and open science policies registered by various policy making bodies of India it is found through analysis that India is matching towards sustainability and democratisation of science as mandated and propagated by UNESCO.

Unfortunately, India's record in the arena of open science remains poor in spite of its undeniable benefits. Though, it is increasingly becoming a global practice in the sphere of science and innovation, due recognition elided in India.

Presently as per data on ROARMAP database there are all together 18 open access policies registered by India. Figure 1 very well reflects this

**Figure 1** Number of Open Access policies registered by India on ROARMAP




*Legend: Adopted and reproduced from ROARMAP in July 2022*

The Figure 1 indicates that in 2005 first open access policy was registered by India and in 2019 the last open access policy was registered. In 2005, the first policy was registered by a research organisation and in 2019 India stands at a total of 18 open access policies with 9 registrations by research organisation, 5 by funding agencies, 2 by funders & research organisation together and 2 by subunits of research organisations.

At this juncture, it is important to mention that some of the renowned data providers nationally and internationally are as follows:

1. Data.gov: https://www.data.gov/
2. Open science design (NASEM): https://www.nationalacademies.org/
3. Australian Research data infrastructure: https://ardc.edu.au/about_us/
4. G7 Open science working groups: https://www.investopedia.com/terms/g/g7.asp
5. OECD Enhance Access to data & models: https://www.oecd.org/india/
6. African Research Cloud: https://www.uwc.ac.za/Faculties/NS/IDIA/Pages/African-Research-Cloud.aspx
7. UNESCO: https://en.unesco.org/
8. Horizon 2020: https://ec.europa.eu/programmes/horizon2020/en
9. EOSC- European open science cloud: https://www.eosc-portal.eu/
10. Data.gov in: https://data.gov.in/
11. Kaggle Datasets: https://www.kaggle.com/datasets
12. World Bank Open Data: https://data.worldbank.org/
13. SPARC Open Data: https://sparcopen.org/open-data/
14. Open Science Journal: https://osjournal.org/

15. The Royal Society: https://royalsociety.org/
16. BMJ Open Science: https://openscience.bmj.com/
17. Stanford Large Network Dataset Collection: https://snap.stanford.edu/data/
18. https://roarmap.eprints.org/

## III. CONCLUSION AND POLICY RECOMMENDATIONS

With the increasing efforts by the Government of India and the international initiative by UNESCO, it is felt that the dream of open access and open science is slowly but steadily becoming true. Thus, the spear of democratisation of science and knowledge will be seen here in India on large scale. Presently, even the scenario is not bad. As per the data accessed from the Directory of Open Access Journal (DOAJ) we find that in April 2022 India registered 233 open access journals and international number was 326. So, we can confidently say that India is strongly marching towards open access and open science policy. The 233 journals registered had no demand of article processing charge, which makes the scenario even good for the authors. In 2005, we had only one open access policy and presently there are 18 strong policies registered in the country and STIP 2021 has strongly advocated creating the open science environment in India. This can be seen with well adherence of Department of Science and technology and Department of Biotechnology, GoI adherence to Horizon 2020 being around 84 percent, which is a good percentage. When coming to availability of scientific resources the CSIR-NIScPR erstwhile CSIR-NISCAIR has made its entire journal available in open access. Thus, promising no dearth of science resources or science journal created or published in the country be freely available to all.

Recommendation to the government of India after conducting this study is as follows:

1. Alignment of most of the registered policies with Horizon 2020.
2. According to UNESCO recommendation funding agencies should make hundred percent availability of their research on public domain.
3. Bodies and institutions those who publish less than 50 percent of their publications and researches available to public should be issued alert and followed up strictly to make the research work available to the public.
4. Scientific development can only happen when science is done in the country for the welfare and sustainability of the masses.
5. Last but not the least an open and affordable / free of cost scientific resources should be available to the citizen to inculcate a scientific temperament among citizens.

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