Open Data Resources for Clean Energy and Water Sectors in India

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ABSTRACT

With the wave of digitalisation, institutions across countries are pushing for the creation of open data and their governance. FAIR Data Principles have initiated the publishing of open research data to the key stakeholders and practitioners in the low- and middle-income countries to meet their developmental goals through practical usage in problem-solving. Open Data, which is part of the Open Science movement, has transformed the regime structure at a transnational level for the governance of critical issues surrounding water and energy. This paper provides a baseline survey to look into the various open data initiatives in the areas of water and clean energy across countries in general and India in particular. Given the multifaceted challenges around the water-energy nexus existing in India, it is critical to identifying the open data initiatives and studying their governance at the country level. Since governance requires the participation of various institutions and multiple stakeholders, the research aims at highlighting the various initiatives such as participation of institutions and the application of Creative Commons (CC) licensing terms in the open data governance for clean energy and water sectors in India.

Keywords: Open data; Open data resources; FAIR data; Data governance; Water; Energy; Clean energy; Water-energy nexus; India, South Asia.

1. INTRODUCTION

Access to information is considered a fundamental right by the European Commission, UNESCO, and many other intergovernmental agencies, which includes the right to receive and impart information[3]. Open data captures a scenario of making data available for free use, repeated use, and share with everyone. Open data has been argued to play an essential role in 'promoting social engagements, and aiding new services' based on new ways to make use of information. The available research data can be used to deal with issues that are of concern in society. Research data may include statistics, outcomes of experiments, observations from the fieldwork, recordings of the interviews, and images. Open data not only enables enhancing the quality of research but also prevents the duplication of research. It has been viewed as a means to expedite scientific advancements and eventually contributing to innovation as well as economic growth and development. The European Commission has been emphasising on the dissemination of research data by making them Findable, Accessible, Interoperable, and Reusable (the FAIR principles). These FAIR data principles add greater value to the data and increase their usability by both human beings as well as machines. The vision of attaining FAIR data usage can be achieved through two major activities: (a) through development, enhancement, and adoption of shared language to support interoperability, and reuse at different scales and (b) provision for improvements in data management and services. According to Chen, et al.[1], the openness of the data can be achieved through the support of software, workflow, and explanation of the research life cycle and the parallel development of services and tools as a goal in itself. This is to be noted that FAIR Data and Open Data are not one and the same. Data complying FAIR may not be open; in such a scenario, the data might be shared under some restrictions.

While on the one hand, globalisation has improved communication, it has also reduced the power and autonomy of the national government. The change of the regime structure has transformed at international, national, and even at the local level, leading to the emergence of a new structure of governance extensively[5]. Water is a major global public good, where traditionally, water governance has been visualised at local level issues, as it encompasses managing local rights, and addressing the needs of the local users of the resources. The emergent global issues of management of water resources have pushed for the development of a global perspective on water governance and the need for a coordinated effort of governance of water[12]. At the same time, Holley and Lecavalier[7], Dubash and Florini[2], and Florini and Sovacool[4] have highlighted the emergence of energy sustainability as an important aim of global energy governance. Thereby, energy security can be achieved through a global governance mechanism, which can promise reliable, affordable, and efficient access to energy services. Governments across countries are adopting open data as a strategy to increase transparency, participation, and effectiveness[8, 10]. However, no study has been carried out so far to identify the role of open data access in the governance of water

and energy at the national and international levels. The study, therefore, aims at identifying the open data initiatives taken by institutions at national as well as global level for effective governance of water and energy sectors. For the purpose of the study, this paper has been divided into five section. In section two, attempted to locate the need for access to open data in the governance of the water and energy sector. In section three, the methodology adopted for this research is discussed. In section four, findings, and in section five, conclusions are highlighted.

2. OPEN DATA AND GOVERNANCE

Since data governance requires a blended approach, including fulfilling the requirements of data availability, usability, consistency, integrity, security, and interoperability, governance of the research data ecosystem, thus, requires well-defined pathways involving the key stakeholders in order to achieve the FAIR data principles and related challenges. The Sustainable Development Goals of the United Nations also have emphasised on data-driven decision making for fulfilling different development goals and their respective targets. In 2016 the FAIR Data Principles were introduced by the international scientific community to ensure sustained approaches to open research data and data stewardship. The FAIR stands for the scientific data which meet standards of Findability, Accessibility, Interoperability, and Reusability (FAIR). The open research data is now centred on the FAIR Data Principles and supported by intergovernmental and international organisations such as the Committee on Data for Science and Technology (CODATA), Research Data Alliance (RDA), Association of European Research Libraries (LIBER), besides many CODATA National Committees, including Indian and Chinese National Committees, and other scientific societies. However, building research data repositories or publishing open research data compliant with FAIR data principles requires a huge capacity building exercise across the world involving the key stakeholders and practitioners. Skills development of the future data stewards and data scientists, who will build up national and institutional open data ecosystems across the world, including in the developing countries, needs to be strengthened. The first-ever CODATA-RDA School of Research Data Science was held in ICTP, Trieste, Italy, in August 2016. There were a series of CODATA-RDA schools held in different countries since then. An International Network of 'Data Schools' is also established for better governance of open research data. The primary focus of this network is to cater to the needs of young researchers or data stewards in Lower- and Middle-Income Countries (LMICs). Access to clean water and energy have been the prominent focus of sustainable development goals. While some societies possess the capabilities and means because of their experiences, working knowledge, and availability of resources, other societies face challenges in achieving those goals. Good governance has emerged as a way to empower the public to participate in decision making at the local level, facilitating good governance at the local level and developing the capacities[14].

While arguing for governance as a more inclusive concept than the government, Rogers and Hall[13] propose that governance involves mediating behaviour by establishing institutions and government policies between a society and its government. Establishment of these institutions reduce transactions cost in coordinating their actions in resource management. Effective governance is also fundamental for developing cooperation among the stakeholders. Florini and Sovacool[4] define governance as a 'myriad processes through which a group of people set and enforce the rules needed to enable that group to achieve desired outcomes.' In such a scenario, water governance has been defined as "the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society"[13]. Thereby, openness and transparency have emerged to be an important principle for effective water governance as it enables stakeholders that participate in the governance process to use a singular language that is open and transparent, building trust in the system. Studies have highlighted the dynamic nature of governance, where the actors and their agendas have shaped the developments in urban water governance in the case of Bangladesh[15]. At the energy front, Holley and Lecavalier[7] have argued for the development of governance arrangements along with the availability of updated data for pathways for sustainability in case of Hong Kong access to open data is one movement, which has tremendously facilitated the governance pursuits.

Berlin declaration defines open access as a source of human knowledge and cultural heritage where the authors and the contributors of this knowledge grant to all users "a free, irrevocable, worldwide, right of access to, and a license to copy, use, distribute, transmit and display the work publicly and to make and distribute derivative works, in any digital medium for any responsible purpose, subject to proper attribution of authorship (community standards, will continue to provide the mechanism for enforcement of proper attribution and responsible use of the published work.". The declaration of open access to knowledge proposes that the dissemination of knowledge is half complete if the information is not made 'widely and readily available to society'. The movement on Open Access has opened up new modes of knowledge dissemination. Consequently, public organisations are experiencing pressure to release their raw data. Open access to this data has practical usage in problem solving[9].

Molloy[11] argues that data assists in the progress of scientific knowledge. Its availability not only increases transparency but also the scientific processes eventually turn out to be beneficial for society. Also, Gurstein[6] emphasises on the 'use' of data, which reflects the realisation of the objective of access to data that goes beyond the creation of opportunity. At the same time, transparency in data enables enhanced public engagement in the analysis and assessment of policy. Given the fact that not everyone has access to supporting infrastructure, effective use of open data remains a challenge. Open access data movement, therefore, aims to ensure the availability of digital resources.

3. METHODOLOGY

This paper reviews the various national and international web resources that partake in the open access movement.

Table 1. Availability of open research data from India

Name of Data Repository	Website	Year of Launch	Key Organisations involved	Whether indexed with Re3Data.org	Whether CC-licensed Contents
Clean Energy					
India Energy Portal	www.indiaenergyportal.org	2005	The Energy and Resources Institute (TERI)	Yes	No
All About Renewables	www.allaboutrenewables.com	2018	Sustainable Energy Foundation (Shakti), World Institute of Sustainable Energy (WISE), Indian Renewable Energy Federation (IREF)	No	No
Renewable Energy Data Portal	www.prayaspune.org/peg/re.html	2016	Prayas Group	No	No
India Energy Dashboards	www.indiaenergy.gov.in/edm/	2018	Niti Aayog	No	No
TERI ENVIS Centre on Renewable Energy and Environment	http://terienvis.nic.in	1996	The Energy and Resources Institute (TERI), supported by ENVIS Programme of MoEF&CC	No	No
Water and Sanitation					
India Water Portal	www.indiawaterportal.org	2005	Arghyam, a public charitable trust	Yes	Yes
India Environment Portal	www.indiaenvironmentportal.org.in	2005	Centre for Science and Environment (CSE)	Yes	Yes
India Sanitation Portal	www.indiasanitationportal.org	2008	Water, Sanitation and Hygiene (WASH) Institute	No	No
World Resources Institute, India	www.wri-india.org	2014	World Resources Institute (an international NGO operating in India)	No	Yes
Hydrology and Water Resources Information System for India	http://117.252.14.242/rbis/rbis.htm	1978	National Institute of Hydrology, Ministry of Jal Shakti, Government of India.	No	No

Since the objective of this research is to enlist the open data initiatives across countries in facilitating governance in the area of water and energy, we review the open data initiative specific to India and well as at the global level. Since no institution functions in isolation and requires other supportive institutions to carry out its functions, in this research paper, we also list the supporting institutions which participate in the governance activities commenced by these institutions. An internet search has been carried on online databases, data portals and data sources to identify the institutions participating in the open data. The sources are then validated for CC contents through Re3Data.org. Re3Data.org is a directory of open data repositories drawn across the world. Re3Data.org supports the culture of accessibility and visibility of research data and provides an exhaustive inventory of institutions that have been actively participating in the open data movement. These processed research data are made open access to the researcher, policymakers, as well as entrepreneurs to carry out analysis and assessment. In the sections that follow, we compare and report the web resources that have not been listed on the Re3Data.org portal.

4. RESULTS AND DISCUSSION

At the national level, we have identified five major open data initiatives in the area of water and energy. From Table 1, we observe that in the case of energy, only one of five resources are listed in Re3Data.org directory. In contrast, in the area of water, we can observe two of the web resource portals are linked to Re3Data.org directory.

At the international level, from Table 2, we observe that two out of five data portals are enlisted with Re3Data.org in the case of energy. In the case of water, three out of five data portals are indexed with Re3Data.org. In the last column of Table 2, we identified whether the respective information and data portal has any provision of contents made available with the CC open licenses.

Table 2. Regional open research data systems in Asian region/ global South

Name of Data Repository	Website	Year of Launch	Organizations involved	Whether indexed with Re3Data.org	Whether CC-licensed Contents
Clean Energy					
Open Energy Information	https://openei.org/wiki/Data	2012	National Renewable Energy Laboratory, USA	Yes	Yes
The National Renewable Energy Laboratory	https://www.nrel.gov/gis/	2013	U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Alliance for Sustainable Energy, LLC.	Yes	No
Open Data Impact Map	https://www.opendataimpactmap.org/index	2015	Center for Open Data Enterprise, Open Data for Development (OD4D) program, International Development Research Centre (IDRC), the World Bank, Department for International Development (DFID), and Global Affairs Canada (GAC)	No	Yes
International Energy Association (IEA)	https://www.iea.org/	1974	International Energy Association (IEA)	No	No
African Energy	https://www.africa-energy.com/live-data/data-catalogue	1998	Cross-border Information (CBI)	No	No
Water and Sanitation					
Food and Agriculture Organisation of United Nations	http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en	1961	United Nations	Yes	No
The United States Geological Survey (USGS)	https://waterdata.usgs.gov/nwis	1879	Plymouth Marine Laboratory Remote Sensing Group	Yes	No
EartH2Observe	http://www.earth2observe.eu/	2016	European FP projects DEWFORA, GLOWASIS, WATCH, GEOWOW	Yes	No
Conservation Gateway	https://www.conservationgateway.org/Pages/default.aspx		The Nature Conservancy	No	No
The European Environment Agency	https://www.eea.europa.eu/data-and-maps	1994	European Union; EIONET: European Environment Information and Observation Network	Yes	Yes
Sustainable Development Goal 6 (SDG6) Data Portal	www.sdg6monitoring.org	2019	UN-Water	No	Yes

4.1 Open Data in the Clean Energy Sector at National Level

4.1.1 India Energy Portal

On behalf of the National Knowledge Commission, TERI instituted the India Energy Portal (IEP) (Indiaenergyportal.org) for effectual assimilation and consolidation of knowledge. The IEP is put together upon public-private partnerships. It offers admittance to knowledge and information on a range of aspects associated with energy in a comprehensive manner to a variety of stakeholders. The section on energy in the portal offers exhaustive information on resources and positions of the sectors like coal, natural gas, petroleum, and power (including hydro, thermal, nuclear power with transmission and distribution considerations). Further, there is in-depth coverage

of the trends in research, development, and deployment. The applications of renewable energy resources such as wind, solar, biomass/ biofuels, small hydro, hydrogen, waste to energy, etc. together with the rural electrification and distributed generation are also addressed in detail in the portal. Moreover, there are details on the 'application of solar energy in the building sector, through solar passive architecture' in the section. The relevance of measures towards energy conservation in buildings, agricultural, industrial, transportation sectors, and rural/community is also adequately addressed in the section.

4.1.2 All About Renewables

All about renewable is an online platform (Allaboutrenewables.com) which provides access to around

200+ policies and regulations, 800+ project locations/capacities of Renewable Energy (RE) IPPs/Investors on the map of India, 250+ list of RE manufacturers, over 100+ links of central and state/UT government organisations, 50+ NGOs, electric utilities, 350+ national and international reports, and journals/magazines in the renewable energy sector. It also provides 'easy-to-read' outline tables of central/state/UT policies and regulations on renewable energy. With this online portal, on just a 'click of a button', one can access the daily/weekly/monthly electricity generation figures of conventional and renewable electricity generation in the country. The portal further provides daily news updates, orders and amendments, latest events, etc. The flagship report of this portal is "Renewables India 2017: Towards Grid Parity", released in 2017 for portraying Status of RE development in India in 2016-17. The key organisations involved in the creation and maintenance of the Allaboutrenewables.com portal are the World Institute of Sustainable Energy (WISE) (www.wisein.org), the Shakti Sustainable Energy Foundation (http://shaktifoundation.in), and Indian Renewable Energy Federation (www.iref.net.in).

4.1.3 Renewable Energy Data Portal

Renewable energy data portal (Prayaspune.org/peg/re.html) "is a comprehensive and granular data made available for the public in a user-friendly way. The data portal offers data on capacity, generation, prices, renewable energy certificates, rooftop solars, solar and non-solar targets and compliances and data on other renewable energies. The three major initiatives of Prayas Energy groups are (a) The electricity governance initiative, (b) Transport governance initiative, and a blog series by Prayas (Energy Group) and Centre for Policy Research (CPR).

4.1.4 India Energy Dashboards

India energy dashboards portal (Indiaenergy.gov.in/edm/) has been developed by Prayas (Energy Group) for NITI Aayog. The portal intends to provide a single platform for different energy-related data and research from across the country. The portal serves stakeholders such as the public and researchers and policymakers to get access to Indian energy databases and reports.

4.1.5 India Energy Security Scenarios 2047

India energy security scenarios (IESS), 2047, (IESS2047.gov.in) is a scenario building tool for renewable energy to observe the future potential of the energy scenario in India. The users can explore data on energy demand and supply in energy sub-sectors. The portal provides data on energy security, energy emissions, energy flows, land requirements, grid balancing, and energy costs.

4.1.6 TERI ENVIS – Centre on Renewable Energy and Environment

The Energy and Resources Institute (TERI) (Terienvis.nic.in) was able to envisage a future with a renewable energy-rich prospect in as early as the early 1980s. Subsequently, it was developed as a pioneering institute in policies, market designs, and technologies towards promoting renewable energy. TERI

focuses on establishing quality standards and performance benchmarks for renewable energy technologies. It also creates research programmes and partnerships with academia and industry, to build up new solutions in the wind, solar, and biomass energy. TERI Library hosts the ENVIS Centre on Renewable Energy and Environment since July 1984. Some of the online databases created and maintained by this ENVIS Centre include: 'Directory of R&D Organisations', 'Articles Database', 'Directory of Experts', 'Bibliographic Database', and 'Database of Ph.D. Theses' that are inundated with well-grounded literature on renewable energy, environment, and climate change. Other flagship databases published by TERI Press, include (i) TERI Energy & Environment Data Diary and Yearbook (TEDDY) (an annual periodical), and (ii) TERI Information Digest on Energy and Environment (TIDEE) (a quarterly abstracting periodical).

4.2 Open Data in the Clean Energy Sector at International level

4.2.1 Open Energy Initiative

Open Energy Initiative (OpenEI.org) is a leading source of energy data, specifically for renewable energy and energy efficiency. This platform enables users to view, edit, add, and download data for free. The most sought data on open energy data are (a) Open Energy Data Initiative (OEDI), b). Dept. of Energy Open Data Catalog (DOE Data), (c) International Utility Rate Database (IURDB), (d) OpenEI Datasets, and (e). U.S. Utility Rate Database (URDB). Besides this, OpenEI also offers a web application for data analysis such as the collaborative data management system (Collab), Life cycle assessment harmonisation, Map of wind farms, and many more.

4.2.2 African Energy

African Energy (Africa-energy.com) provides access to data and news and consultancy services with an aim to support decision making. Two of the major initiatives by African Energy are the Africa Energy Atlas and Africa Energy Live Data. The Africa Energy Atlas provides up to date information on energy. The atlas was first published in 2007 and has become an important source for energy professionals, academicians, and policymakers. The African Energy Live data is a huge database, which encompasses more than 5500 project reports. This platform was launched in 2017 to assist the stakeholders of the power industry with statistical tools and support.

4.2.3 International Energy Agency

International Energy Agency (IEA) is the most influential Inter-Government organisation (IGO) in the area of water. IEA has been successful in coordinating responses among the government of countries. As for many IGOs, IEA is the guardian of the world's statistical data and provides data on energy research and development. IEA has also been responsible for publishing on energy statistics reports. It has been considered as an important actor in energy governance and a leading source of information for the government as well as the private sector. IEA objectives support a sustainable energy future. It has been responsible for conducting research, analysis, and

making policy recommendations. In the year 2008, the IEA proposed recommendations for sustainable energy policies for clean energy based on the dialogues with Brazil, China, India, Russia, and South Africa sustainable.

4.2.4 National Renewable Energy Laboratory

National Renewable Energy Laboratory (NREL) is a leading national laboratory under the U.S. Department of Energy for research and development in the areas of renewable energy and energy efficiency. In 2013, NREL launched an open-source integrated time series data on energy. NREL also introduced Energy DataBus for tracking and analysing energy use on its campus. This software can store a large amount of data collected at high frequency. NREL has made this software freely available for software developers to test and implement.

4.2.5 Open Data Impact Map

Open Data Impact Map (Opendataimpactmap.org) is a project of the Open Data for Development Network (OD4D). It is a public database of organisations that use open government data from around the world. The Map pushes for governments, international organisations, and researchers to realise the demand for open data. The Maps provided by this website facilitate governance among organisations, including companies, non-profits, academic institutions, and developer groups that utilise open government data. The availability of such data has assisted advocacy, to develop products and services, improve operations, inform strategy, and conduct research in the area of water.

4.3 Open Data in the Water Sector in India
4.3.1 India Water Portal

India Water Portal (Indiawaterportal.org) shares documented knowledge and builds communities around water and related issues in India. The portal provides incomparable resources, working papers, reports, data, articles, news, events, opportunities, and discussions on water. This interface enables stakeholders to share experiences and solutions. India Water Portal was encouraged by the National Knowledge Commission, which proposed the need for knowledge portals in various areas back in 2005. Ever since its inception, it is involved in open data sharing and relevant source data on water and sanitation in India.

4.3.2 India Environment Portal

India Environment Portal (Indiaenvironmentportal. org.in) provides information on developments, policies, and resources. The India Environment Portal is built on an open-source platform; proprietary information held by Centre for Science and Environment (CSE) has been made available and open, and government documents are carefully sourced and put out for public scrutiny.

4.3.3 India Sanitation Portal

India Sanitation Portal (Indiasanitationportal.org) aims to bridge the knowledge asymmetry amongst the various stakeholders participating in the discourse on water and

sanitation in India. The Portal was launched at the South Asian Conference on Sanitation (SACOSAN) in November 2008, by Shri Somnath Chatterjee (then the Speaker of the Lok Sabha) to bring together stakeholders and resources working in the area of sanitation. It offers an open, inclusive, web-based platform. The issues covered by this institution include health, solid waste, water, technology, and wastewater. The value added by this institution is reflected through the publication of reports on groundwater, rainwater harvesting, water quality, and water supply.

4.3.4 National Institution of Hydrology

National Institution of Hydrology (NIH), established in Roorkee in 1978, is a leading institution in India actively engaged in hydrological research aimed at achieving sustainable development and self-reliance in the water sector. To carry out significant studies, the institution is continuously developing new techniques, procedures, software packages and field instrumentation. NIH is also engaged in development of web-based information systems (NIHRoorkee.gov.in/web-based-information-system) in different areas of water sector, viz., (a) Ganga Kosh (water quality of the Ganga and its tributaries), (b) hydrological cycle, (c) Web GIS-based snow cover information system for Himalayas, (d) Web GIS-based snow cover information system for Indus basin, and (e) Web-enabled groundwater recharge estimation model (WE-GREM). These web-based information systems are beneficial for the students, researchers, and practitioners working in the related subject areas.

4.3.5 World Resources Institute, India

World Resources Institute, India (WRI-India.org) is an international NGO operating in India and providing the technical information needed for equitable and sustainable development. It is continuously engaged in activities related to dissemination of knowledge through the publication of reports, working papers, issue briefs, and fact sheets. WRI-India is also involved in water governance programs where it works with the government bodies, private sector enterprises, civil societies, and citizens to address the issues of the vulnerable communities and facilitating the decision-making process. WRI-India participates in capacity building and resilience-building along with civil societies to introduce bottom-up change. In the endeavour to make data accessible to assist policymakers and corporate executives, WRI-India, in collaboration with WRI global created open, accessible data portals, namely, Prepdata (visualising data to build climate resilience, Prepdata.org) and LandMark (Global platform of indigenous and community lands, Landmarkmap.org).

4.4 Open Data in the Water Sector at International Level
4.4.1 Food and Agriculture Organisation of the United Nations

Food and Agriculture Organisation of the United Nations (FAO.org) works on several regional issues related to water governance. Its prime focus has been on the water in the area of agriculture, which aids the Sustainable Development Goals 1

and 2 of providing food security and poverty alleviation. FAO is involved in an understanding context-specific governance system, providing support to stakeholders, establishing dialogues at local as well as the national level for creating a conducive environment for a sustainable governance system. The key areas around which FAO structures its water governance activities are (a) Water governance in river basins and watersheds, (b) Water tenure, (c) Governance of irrigation, (d) Groundwater governance, e) Governance of water for pollution control and water quality management and (f) Putting food security at the centre of the international water debate. FAO provides software models and other tools which can be downloaded for free. The key databases and software modules include (a) AQUASTAT, a global water information system, (b) AQUACROP, an industry-leading crop–water productivity software model, (c) AQUAMAPS, a global spatial database on water and agriculture, (d) GAEZ, Global Agro-Ecological Zones and (e)The Harmonised World Soil Database, includes 15000 soil mapping units combining existing regional and national updates of the soil information worldwide.

4.4.2 The United States Geological Survey

The United States Geological Survey (USGS.gov) provides data for all 50 American States. The website maintains diverse categories of data such as surface water, groundwater, or water quality, and by geographic area. This site is the public web interface to the USGS National Water Information System, a system that is based on several development efforts that were established in our water science centres. This institution continuously involved in the development of innovative methods and tools to introduce useful information on water.

4.4.3 EartH2Observe.eu

Involved in developing datasets and models, in offering global water resources reanalysis. The website provides a list of functions through the Water Cycle Integrator data portal (WCI). The data is open and freely accessible data. The portal brings together findings from European Funded projects Drought Early Warning and Forecasting (DEWFORA), GLOWASIS, WATCH, GEOWOW, and others.

4.4.4 Conservation Gateway

Conservation Gateway (Conservationgateway.org) offers open data relevant for practitioners, scientists, and policymakers. This institution works with formal and informal partners located worldwide. The major activities of the institution are related to conservation planning and practices. For conservation planning, the institution provides a wide array of tools and data for various kinds of planning efforts. The gateway also provides conservation activities by geography, which covers four major regions of Asia Pacific, Africa, Latin America, and North America.

4.4.5 European Environment Agency

European Environment Agency (EEA.europa.eu) is an agency of the European Union. It provides sound, independent information on the environment. The agency provides access to datasets, infographics, indicators, interactive data,

interactive maps, static maps, and static graphs. The agency is a repository of indicators on the use of freshwater resources, urban wastewater treatment, water- and food-borne diseases, water intensity of crop production, and water temperature. EEA offers an open data product, titled Waterbase-UWWTD (Urban Waste Water Treatment Directive reported Data), which is also accessible from the Pan-European and global Copernicus Land Monitoring Service (Land.copernicus.eu).

4.4.6 Sustainable Development Goal 6 (SDG6) Data Portal

Sustainable Development Goal 6 (SDG6) Data Portal (Sdg6monitoring.org) was launched in August 2019 in Stockholm during the World Water Week by the UN-Water. This integrated monitoring initiative for SDG6 brings together data on all the SDG6 global indicators and other key social, economic and environmental parameters. The portal tracks overall progress towards SDG6 at global, regional and national levels.

In the case of clean energy data repositories in India we observe, none confer to CC. TERI ENVIS has pioneered in creating repositories in this field and is the oldest data repository, while NITI Aayog and All About Renewables are the most recent platforms. In case of water however, we can observe that the oldest data repository is Hydrology and water Resources Information System (operational since 1978) and the most recent addition is the World resource Institute. If we compare the data repositories of Water and Energy in India, we can observe that water has been identified as a concern quite early as compared to the concerns surrounding energy sustainability. Moreover, we can also observe that many of the data repositories comply to the CC. Perhaps such compliance also depicts the thrust and interest for data sharing in the area of water, as compared to energy where the need has not yet been realised.

In the case of the international clean energy data repositories we can observe that International Energy Association is the oldest institution (operational since 1974), whereas open data impact map is the most recently introduced data repository. At this point we can also infer that while energy issues have been identified as critical issue at international level quite early, in case of India, related policies have taken time to roll out. In case of water, we observe that USGS created first of its kind of data repository in 1879, but has failed to comply to CC.

5. CONCLUSIONS

International institutions have laid emphasis on the role of open data in creating local capabilities and facilitating good governance. However, the translation of these strategies into pathways for sustainability has remained a challenge because of varying experiences and capabilities across countries. From the discussion above, we can observe that various organisations are participating in water and energy governance through open data initiatives. We observe that most of these web portals are working in collaborations with institutions, both private and public in nature. In the case of India, we observe that none of the energy portals participate in the CC, whereas in the case of water, three out of five institutions have participated in the

movement of CC. Since open data facilitates social engagement and enhances the scientific advancements, in the case of Water and Energy, we fail to observe efforts from institutions in the global South to participate in the open data initiatives. It is, therefore, imperative to have thrust on open data and to FAIR principles, where the data can be used by researchers and the public to derive meaningful scientific evidences and arrive at sustainable solutions. At the global level, we observe that only two out of the five institutions participated in the CC, whereas in the case of water, only one out of five institutions participating in the CC initiative. Here too, we observe that the potential of open data for developing capacities has not been realised.

Indian open data resources available online are far from the compliance with the FAIR data principles, as most of them are not findable from any international directory of open data repositories, such as Re3Data.org. Most of the datasets are also not interoperable, and some of them are not available with a suitable open licensing term. Also, there is an urgent need for feeding information about new data repositories into the database of Re3Data.org. Although this is happening at a languid pace, leaving many potentially useful data repositories to remain unlisted on this directory. The creators of new data repositories should be proactive. They should enlist themselves with the Re3Data.org and other global directory services for open research data for better utilisation of their open data resources by the end users.

REFERENCES

1. Chen, X.; Dallmeier-Tiessen, S.; Dasler, R.; Feger, S.; Fokianos, P.; Gonzalez, J.B. & Rodriguez, D.R. Open is not enough. *Nature Physics*, 2019, **15**(2), 113-119. doi: 10.1038/s41567-018-0342-2.
2. Dubash, N.K. & Florini, A. Mapping global energy governance. *Global Policy*, 2011, **2**, 6-18. doi: 10.1111/j.1758-5899.2011.00119.x.
3. European Parliament (2019). Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on Open Data and the Reuse of Public Sector Information. *Off. J. Eur. Union*, L172, 56-83.
4. Florini, A. & Sovacool, B.K. Who Governs Energy? The Challenges Facing Global Energy Governance. *Energy Policy*, 2009, **37**(12), 5239-5248. doi: 10.1016/j.enpol.2009.07.039.
5. Franks, T.R. & Cleaver, F.D. Water governance and poverty: A framework for analysis. *Prog. Dev. Stud.*, 2007, **7**(4), 291-306. doi: 10.1177/146499340700700402.
6. Gurstein, M.B. Open data: Empowering the empowered or effective data use for everyone?. *First Monday*, 2011, **16**(2). doi: 10.5210/fm.v16i2.3316.
7. Holley, C. & Lecavalier, E. Energy governance, energy security and environmental sustainability: A case study from Hong Kong. *Energy Policy*, 2017, **108**, 379-389. doi: 10.1016/j.enpol.2017.06.010.
8. Huijboom, N. & Van den Broek, T. Open data: An international comparison of strategies. *Eur. J. ePract.*, 2011, **12**(1), 4-16.
9. Janssen, M.; Charalabidis, Y. & Zuiderwijk, A. Benefits, adoption barriers and myths of open data and open Government. *Inf. Syst. Manage.*, 2012, **29**(4), 258-268. doi: 10.1080/10580530.2012.716740.
10. McGrew, A. & Held, D. Governing globalisation: Power, authority and global governance. Cambridge: Polity Press. 2002.
11. Molloy, J.C. The open knowledge foundation: Open data means better science. *PLoS Biol.,* 2011, **9**(12): e1001195. doi: 10.1371/journal.pbio.1001195.
12. Pahl-Wostl, C.; Gupta, J. & Petry, D. Governance and the global water system: a theoretical exploration. *Global Governance: A Rev. Multilateralism Int. Org.*, 2008, **14**(4), 419-435. doi: 10.1163/19426720-01404003.
13. Rogers, P. & Hall, A.W. *Eff. Water Governance* (Vol. 7). Stockholm: Global water partnership, 2003.
14. United Nations. *Good Governance Sustainable Dev*. Retrieved from https://sustainabledevelopment.un.org/partnership/?p=1545, 2019.
15. Yasmin, T.; Farrelly, M.A. & Rogers, B.C. Evolution of water governance in Bangladesh: An urban perspective. *World Dev.*, 2018, **109**, 386-400. doi: 10.1016/j.worlddev.2018.05.003.

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In this study, he conceptualised the paper, collected the data from Re3data.org and related databases, and wrote jointly with the co-author.