

Webliography of Water Technology and Policy Framework in India and the World

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ABSTRACT

For a long time, knowledge asymmetry has been attributed to uneven growth and development across countries. Today, when issues of access to safe and affordable drinking water are not only a national concern and cooperation across the world are pushing towards sustainable goals, web portals, publication of reports by institutions involved in international and national water technology and policy activities are facilitating knowledge exchange. These platforms have developed indicators to assess the water-related concerns and share best management practices, sustainable approaches and data, making knowledge accessible for all. Also, recently bibliometric and scientometric studies have developed tools to assess research in the area of the water sector. This webliography is an effort to produce a comprehensive list of activities undertaken by institutions participating in the knowledge creation and knowledge dissemination process in the area of water internationally as well as in India.

Keywords: Water and sanitation, Water, India, Indicators, Sustainable development goals

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INTRODUCTION

Over decades water security has emerged as a pressing issue worldwide. Over the past 40 years, the world's population has doubled whereas the use of water has quadrupled.^[1] With the decrease in groundwater level water large parts of Africa, Asia and Europe and southeast of Britain, experience water stress or scarcity. With rising water scarcity across the world, efforts are being taken by several international and national organizations to make safe drinking water available and affordable for all. The Sustainable Development Goal 6 aims at ensuring availability and sustainable management of water and sanitation for all. In order to achieve sustainability, Water technologies have emerged in promoting research and development in the areas of industrial water and wastewater management. This has called in for several science and technological interventions in carrying out processes of water treatment, monitoring, storage, disposal and reuse.

Ensuring access to safe and affordable drinking water is the mandate of UN initiated Sustainable Development Goals (SDGs). In order to achieve this goal several initiatives have been taken at national level and international level

cooperation to encourage "water efficiency and support treatment technologies". This article provides a webliography, which lists the international and national water technology and policy framework to aid this mission. Web portals across the world seek to address the knowledge asymmetry existing in the issues related to water issues by sharing best management practices, promoting sustainable approaches, offering platforms for interactive public data and information and thereby creating awareness. On World Water Day, March 2018, the Water, Peace and Security Initiative (WPSI), was launched. WPSI aims at providing interventions in taking actions on water security. Several datasets and tools have been developed by WPSI to enable appropriate decision making. Bibliometrics have been developed to assess the research performance. These tools have been of immense use in the prediction of future trends. This form of quantitative analysis offers certain advantages in gathering objective information required for decision making. According to Thomson Reuters, there are two ways in which this kind of research works (a) by offering a top-down review, this approach facilitates analysis and data of all the activities in an area, summarizes the data and a comprehensive perspective on activity and achievement and (b) by offering weighted quantitative measures, such as papers per researcher or citations per paper.^[2] While the latter approach, analyzing water-related technology research is very common in the area of water. No study so far has taken the former approach and enlisted the activities and programs to identify indicators surrounding research on water related

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technologies. Webliographies have emerged recently as a tool to offer exhaustive details of activities and programs initiated in an area of concerns. This webliography, thereby, aims at providing a comprehensive picture of activities and achievements in the area of water, both at the global and national level.

For the latter approach to bibliometric studies, the Scopus database¹ (by Elsevier) and Web of Science (by Clarivate Analytics) have been considered rich data sources. Though bibliometric studies have been carried out in the area of water,^[3-6] Hu *et al.* have carried out a historical review of publications on drinking water research between 1991 and 2007.^[4] Hu *et al.* have criticized the bibliometric study as the change in citation and publication counts of a country cannot be held as a true indicator of research or research development or the future research orientation. This study, therefore, takes a closer look at the emphasis laid on water-related research globally and in India by studying the several web-portals, databases, digital libraries and monographs. Studies on water-related technology have been carried out worldwide level as is evident from Table 1, bibliometric studies carried out in the area of the water-related research field. In this Table, we also represent the number of citations each paper has received in Google Scholar, Web of Science and Scopus. L Zhang *et al.* carried out a bibliometric analysis of wetland research during 1991-2008 based on the Science Citation Index (SCI).^[7] The emphasis in these researches was on the water quality, biodiversity, constructed wetland diversity. Fu *et al.* carried out a bibliometric analysis based on the Science Citation Index Expanded from the Web of Science to study the research activities in the area of global drinking water from 1992 to 2011.^[6] Water Research, Environmental Science and Technology and Journal American Water Works Association were the three most common journals in drinking water research. The authors also identified the mainstream research emphases was water treatment methods, disinfection process ozonization and chlorination in disinfection and adsorption was identified to be the most common techniques for treating drinking water. Sun *et al.* carried out a bibliometric analysis on Science Citation Index-Expanded published by the Thomson Reuters of the global estuary pollution research between 1991 to 2010.^[8] Marine Pollution Bulletin was the most active journal publishing in this area. Sediment was the most active research besides heavy metals received a stable focus on a high degree in the field of estuary pollution research. Mostly refractory organic compounds (e.g., PAHs), Biomarkers, bioaccumulation and Eutrophication of estuarine waters received high emphasis in the area of estuary pollution research. Such emphasis on water related research over the

last decade motivates us to take a closer look at the local, national as well as transnational initiatives of resource creation to support the research in the areas. For the study, the paper has been divided into four sections. Section 2 gives a brief outline of what can encompass water technologies. Section 3 we discuss the methodology adopted for the study. In Sections 4 and 5, we discuss the various water related initiatives at both the international and national level.

Defining Water Technologies

UN-Water defines water security as “The capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters and for preserving ecosystems in a climate of peace and political stability”.^[9] In order to achieve this, security countries across the world are investing in scientific R&D to come out with innovative technologies to resolve water-related issues. Besides this, according to UN Water^[9] achieving water security requires good governance practices; and collaboration across sectors, communities, disciplines and political borders; reduced risk of potential conflicts over water resources and innovative sources of financing.

The technology comprises “any systematic, goal-directed procedures that go beyond unstructured, elementary actions”.^[10] Technology in a most simple manner can be comprehended in terms of four closely interlinked elements: technique, knowledge the organization of the production and the product.^[11] In this sense, water technology can be defined as techniques, knowledge, organization and products that can resolve water-related issues. This paper is organized on the basis of different international and national water technologies for industrial water and wastewater management.

Methodology

The Millennium Development Goals and the UN-SDGs identify water as a crucial issue. Following this, nations worldwide have launched water missions and corroborated research on water, sanitation and related subject areas. The objective of this webliography is to highlight the various knowledge resources generated in the areas of water technology-related research and development. We look into the international activities and programs in water research which have aimed at developing indicators for assessing and forecasting. We then take the case of India and highlight the resources and emphasis of research in the last decade as a consequence of the Sustainable Development Goals.

In the year 2005, the Government of India established the National Health Mission and introduced structural reforms to strengthen healthcare and sanitation. The Government consequently launched the Swachh Bharat programme (Clean

1 Scopus covers more than 36000 titles from more than 11000 publishers, including subject area of life sciences, social sciences, physical sciences and health sciences.

Table 1: Top 20 Scientometric and Bibliometric Studies Related to Water

Paper	GSC	WoS	Scopus
Zhang L, Wang MH, Hu J, Ho YS. A review of published wetland research, 1991–2008: ecological engineering and ecosystem restoration. <i>Ecological Engineering</i> . 2010;36(8):973-80.	116	76	86
Fu HZ, Wang MH, Ho YS. Mapping of drinking water research: A bibliometric analysis of research output during 1992–2011. <i>Science of the Total Environment</i> . 2013;443:757-65.	112	74	86
Sun J, Wang MH, Ho YS. A historical review and bibliometric analysis of research on estuary pollution. <i>Marine Pollution Bulletin</i> . 2012;64(1):13-21.	77	43	47
Hu J, Ma Y, Zhang L, Gan F, Ho YS. A historical review and bibliometric analysis of research on lead in drinking water field from 1991 to 2007. <i>Science of the Total Environment</i> . 2010;408(7):1738-44.	76	38	45
Wang MH, Yu TC, Ho YS. A bibliometric analysis of the performance of Water Research. <i>Scientometrics</i> . 2010;84(3):813-20.	75	52	59
Ruaro R, Gubiani ÉA. A scientometric assessment of 30 years of the Index of Biotic Integrity in aquatic ecosystems: applications and main flaws. <i>Ecological Indicators</i> . 2013;29:105-10.	70	29	46
Butcher J, Jeffrey P. The use of bibliometric indicators to explore industry–academia collaboration trends over time in the field of membrane use for water treatment. <i>Technovation</i> . 2005;25(11):1273-80.	67	31	36
Wang MH, Li J, Ho YS. Research articles published in water resources journals: A bibliometric analysis. <i>Desalination and Water Treatment</i> . 2011;28(1-3):353-65.	65	43	46
Ho YS. Bibliometric analysis of biosorption technology in water treatment research from 1991 to 2004. <i>International Journal of Environment and pollution</i> . 2008;34(1-4):1-3.	59	31	35
Khan MA, Ho YS. Arsenic in drinking water: a review on toxicological effects, mechanism of accumulation and remediation. <i>Asian Journal of Chemistry</i> . 2011;23(5):1889.	48	25	32
Tanaka H, Ho YS. Global trends and performances of desalination research. <i>Desalination and Water Treatment</i> . 2011;25(1-3):1-2.	48	29	31
Zhang W, Qian W, Ho YS. A bibliometric analysis of research related to ocean circulation. <i>Scientometrics</i> . 2009;80(2):305-16.	39	32	34
Hassan SU, Haddawy P, Zhu J. A bibliometric study of the world's research activity in sustainable development and its sub-areas using scientific literature. <i>Scientometrics</i> . 2014;99(2):549-79.	34	14	19
Zheng T, Wang J, Wang Q, Nie C, Smale N, Shi Z, Wang X. A bibliometric analysis of industrial wastewater research: current trends and future prospects. <i>Scientometrics</i> . 2015;105(2):863-82.	21	13	0
Yuan J, Yue W, Su C, Wu Z, Ma Z, Pan Y, Ma N, Hu Z, Shi F, Yu Z, Wu Y. Patent activity on water pollution and treatment in China—a scientometric perspective. <i>Scientometrics</i> . 2010;83(3):639-51.	17	9	9
Abejón R, Garea A. A bibliometric analysis of research on arsenic in drinking water during the 1992–2012 period: An outlook to treatment alternatives for arsenic removal. <i>Journal of Water Process Engineering</i> . 2015;6:105-19.	11	6	13
Wang MH, Ho YS. Research articles and publication trends in environmental sciences from 1998 to 2009. <i>Archives of Environmental Science</i> . 2011;5:1-0.	6	0	0
Zhang L, Li S, Loáiciga HA, Zhuang Y, Du Y. Opportunities and challenges of interbasin water transfers: a literature review with bibliometric analysis. <i>Scientometrics</i> . 2015;105(1):279-94.	6	5	4
Jacobs IM, Pouris A, Naidoo D. A scientometric examination of the performance of water research in South Africa. <i>Water SA</i> . 2014;40(4):631-8.	4	3	0
Zare F, Elsayah S, Iwanaga T, Jakeman AJ, Pierce SA. Integrated water assessment and modelling: A bibliometric analysis of trends in the water resource sector. <i>Journal of Hydrology</i> . 2017;552:765-78.	4	2	2

As on 21.06.2018

India Mission) targeting the issue of health and well-being linked with that of adequate water supply and functional sanitation systems. In India, the Mihir Shah Committee Report was placed in July 2016 that recommended the restructuring the Central Water Commission (CWC) and the Central

Ground Water Board (CGWB)² with a function to deal with water policy, data and governance. India over the decade

² The CWC was established in 1945 and is responsible for surface water and creating storage structures such as dams and medium scale reservoirs. Similarly, the Central Ground Water Board (CGWB) has the objective of managing the groundwater resources.

has initiated several water technology-related knowledge resources.

At the national level, we observe several institutions participating in developing indicators for water technology and surrounding issues. Equal access to essential health, clean water and sanitation services continue to be a priority for India, which houses one-sixth of the world's population. Shiao *et al.* argues that India is one of the most water-challenged countries in the world. Groundwater levels are falling.^[12] Whatever water is available is often severely polluted. And the national supply of water predicted to fall 50 percent below demand by 2030. Over the last two decades, we observe a number of movements around water in India. In the section that follows we discuss the institutions engaged in developing indicators and carrying out assessments in water-related technology. Keeping in mind the objectives of the study, several international and national institutions functioning to support the missions surrounding water. While doing so, we look up to (i) the efforts taken by these institutions in publishing findings and reports of their study (ii) publications related to technological development and innovation in the area of water. Many of these institutions have also developed and maintain repositories of data related to water; this study also highlights such databases. Recently the "Composite Water Management Index (CWMI): A Tool for Water Management" was introduced in India in 2018 by the NITI Aayog as a set of indicators for addressing India's suffering from the worst water crisis in its history, to enable data-backed water management and to promote competitive, cooperative federalism in the country.

Global and Country-Specific Initiatives

Databases

The European Environment Agency (eea.europa.eu)

The European Environment Agency (EEA) provides access to datasets, infographics, indicators, interactive data, interactive static maps as well as graphs. It is a prominent repository for indicators on wide range of water related issues such as usage of freshwater resources to urban wastewater treatment and water- and food-borne diseases. Some of its databases are-

- a. **Waterbase:** It is the generic name given to the EEA's databases on the status and quality of Europe's rivers, lakes, groundwater bodies and transitional, coastal and marine waters, on the quantity of Europe's water resources and on the emissions to surface waters from point and diffuse sources of pollution.
- b. **UWWTD (Urban Waste Water Treatment Directive – reported data):** UWWTD concerns the collection, treatment and discharge of urban waste water and the treatment and discharge of waste water from certain industrial sectors.

- c. **Copernicus Land Monitoring Service:** This service provides an EU-Hydro for the EEA member and cooperating countries. It provides a photo-interpreted river network, consisting of surface interpretation of water bodies and a modeled drainage network with catchments and drainage lines.

EEA's web portal is a major information source for those involved in developing, adopting, implementing and evaluating environmental policy and also the general public.

USGS National Water Information System (water.usgs.gov): The United States Geological Survey (USGS) offers real-time open data on Water and historical data through the National Water Information System (NWIS). Some of the assessment tools available here are WaterWatch, GroundWater Watch, WaterQualityWatch, WaterNow, WaterAlert, NWIS Current Water data (Real-Time Data) and USGS Mobile Water Data. The tools can be explored at Usgs.gov/products/data-and-tools/data-and-tools-topics/water.

Atlas of Environmental Justice (EjAtlas.org): The environmental justice atlas documents and catalogues social conflict around environmental issues. This data set is made available under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 license. The EJOLT (Environmental Justice Organizations, Liabilities and Trade, www.ejolt.org) highlights the environmental injustices and conflicts across the world. EJOLT is a global research project bringing science and society together to catalogue and analyze ecological distribution conflicts and confront environmental injustice. Water remains an important issue under consideration and water management as source of conflict. Water-related injustices and conflicts across the world can be found on www.ejolt.org/tag/water. In 2015 the project released "Global Atlas of Environmental Justice" which enables global tracking of ecological conflicts. About 378 cases are reported related to water management issues on EjAtlas.org portal as in March 2019.

Sustainable-Water-Infrastructure (Epa.gov/sustainable-water-infrastructure): The United States Environmental Protection Agency (EPA) provides grants for state environmental programs, non-profits, educational institution. EPA maintains database such as, Drinking Water Treatability Database (TDB), Water Infrastructure Database (WATERiD), Stream-Catchment (StreamCat) Dataset.

- a. The **TDB** presents referenced information on the control of contaminants in drinking water. This database houses performance evaluation data for rehabilitation technologies used in the water and wastewater sectors on a national basis, the databases can also assist utilities to more effectively implement comprehensive asset management, provide reliable service to their customers

and meet their Clean Water Act and Safe Drinking Water Act requirements.

- b. **WATERiD** is a database used for helping utilities choose the best pipe rehabilitation, condition assessment and pipe-location determining technologies for both wastewater conveyance systems and drinking water distribution systems. It includes primary information about individual renewal technologies' cost and performance, case studies for their real-world applications and the list of vendors, consultants and contractors available for a particular technology on a regional basis. The database allows utilities to input their experiences in these areas for the benefit of other utilities.
- c. **Freshwater Biological Traits Database (Traits)** contains traits data for 3,857 North American macroinvertebrate taxa and includes habitat, life history, mobility, morphology and ecological trait data, along with tolerance calculations for temperature and flow. Data types vary and include binary, categorical and text notes entries.
- d. **StreamCat** is an extensive collection of landscape metrics for 2.6 million streams and associated catchments within the conterminous U.S. It includes both natural and human-related landscape features. The data are summarized both for individual stream catchments and for cumulative upstream watersheds.

The dataset also provides metrics for the number of dataset views in catalog.data.gov month by month beginning from 2014.

2. **OECD Studies on Water** (Oecd-ilibrary.org/environment/oecd-studies-on-water_22245081): OECD iLibrary is the online library of the Organisation for Economic Cooperation and Development (OECD) which encompasses books, papers and data. The institution has published reports encompassing indicators on various dimensions of water. Some of these publications include: "Implementing the OECD Principles on Water Governance: Indicator Framework and Evolving Practices" (2018, <https://bit.ly/2Jdpfn>), "Water Utility Performance Indicators (IBNET)" (2011, <https://bit.ly/2CgQpPi>), "OECD Inventory: Water Governance Indicators and Measurement Frameworks" (2015, <https://bit.ly/2Fc3s6s>).
3. **The Alaska Hydrological Survey** (dnr.alaska.gov/mlw/water/hydro/components/water-databases): The Alaska Hydrologic Survey maintains several public information databases, in various formats. These databases are Alaska Groundwater Database, AKWUDS (The Alaska Water Use Data System), WELTS, ARID, STREAMS, LAKES

and Water Quality. We discuss these databases in brief here.

- a. Alaska Groundwater Database provides indicators of groundwater collected by local, state and federal cooperative partners.
- b. The Alaska Water Use Data System (AKWUDS) offers online water use report system/database. This platform offers a two-way space for water right/authorization holders to submit monthly water use data online and at the same time allows them to download data entered here.
- c. The Alaska Well Log Tracking System (WELTS) offers online water use report system/database for water well logs. This platform allows water well drillers to submit water well logs online and at the same time allows them to download data entered in the system.
- d. *ARID* database is a summary of stream characteristics resulting from an initial investigation into navigable streams within the state. The database has continued to grow as new data becomes available.
- e. *Streams* provides a compilation of discrete discharge measurements conducted by Division of Mining, Land and Water personnel.
- f. *Lakes* is a compilation of lake data gathered during specific field projects within the state.
- g. *Water Quality* is an index to water quality data collected by Hydrologic Survey staff.

Programmes

1. **UNESCO's International Hydrological Programme (IHP)** (En.unesco.org/themes/water-security): UNESCO works to build the scientific knowledge base to help countries manage their water resources in a sustainable way through the International Hydrological Programme (IHP), through leading the UN-wide World Water Development Report and through numerous Centres and Chairs on water around the world. UNESCO. The International Hydrological Programme (IHP) is the intergovernmental programme of the UN system devoted to water research, water resources management and education and capacity building. Some of the recent publications of IHP include: "International Glossary of Hydrology" (2012, <https://bit.ly/2u7jAqI>), "HP-VIII: Water Security: Responses to Local Regional and Global Challenges (2014-2021)" (2013, <https://bit.ly/2O2K9zk>), "Water, People and Cooperation: 50 Years of Water Programmes for Sustainable Development at UNESCO" (2015, <https://bit.ly/2O3ev4J>). Water-related Centres under the patronage of UNESCO work on relevant thematic and geographic priorities in their areas of expertise. UNESCO has appointed water-

related UNESCO Chairs on seven key issues namely, (1) Water-related Disasters and Hydrological Changes, (2) Groundwater in a Changing Environment, (3) Water Scarcity and Quality (4) Water and Human Settlements of the Future, (5) Ecohydrology, Engineering Harmony for a Sustainable World, (6) Water Education, Key to Water Security, (7) Water and Gender and (8) Water and Culture.

2. **World Bank Water Program** (Worldbank.org/water | Twitter.com/WorldBankWater): The World Bank Water team is working with partners toward “A Water-Secure World for All”. Some of its recent reports include: “Timor-Leste: Water Sector Assessment and Roadmap” (2018, <https://bit.ly/2UCDwGm>), “Joining Forces for Better Services? When, Why and How Water and Sanitation Utilities Can Benefit from Working Together” (2017, <https://bit.ly/2Hj9Viq>). The World Development Indicators (WDI) is the World Bank’s collection of statistics on global development. WDI offers 1,600 indicators for 217 economies, for over 50 years. Particularly, WDI came along with the monitoring of 27 indicators related to Sustainable Development Goal 6 (Clean Water and Sanitation) (<https://bit.ly/2HjaA3d>).
3. **WHO’s Water, Sanitation and Hygiene (WASH) Programme** (Who.int/water_sanitation_health/en/): The World Health Organization (WHO) works on aspects of water, sanitation and hygiene (WASH) where the health burden is high and where evidence-based interventions could make a major difference. WHO along with WASH has developed indicators for drinking water and for achieving quality water, sanitation and hygiene services in healthcare. Some of the important publications include: “WHO Water, Sanitation and Hygiene Strategy 2018–2025” (2018, (<https://bit.ly/2TKLn7L>), “A Global Overview of National Regulations and Standards for Drinking Water Quality” (2018, <https://bit.ly/2XWzJGc>), “A Practical Guide to Auditing Water Safety Plans” (2015, <https://bit.ly/2Ck1Khv>), “Guidelines for Drinking-Water Quality” (2011, 4th Edition, <https://bit.ly/2FdomlJ>).
4. **The Water Hub Stories** (Thewaterhub.org): The HSBC Water Programme aims to provide and protect water sources, inform and educate communities in need and enable people to prosper, driving economic development across the world. WaterHub is an internationally acclaimed exhibition of select images and stories from across six countries from four continents, depicting the world’s global water crisis.
5. **IUCN Water Knowledge Platform** (Waterandnature.org | Twitter.com/IUCN_Water): The International Union for Conservation of Nature (IUCN) formed the Global Water Programme in 1985 that maintains the

IUCN Water Knowledge Platform. The Mission of the Programme is to be a trusted partner for evidence-based and adaptive change in water resource management that benefits nature and people. This portal offers evidence-based online resources for implementing integrated water resources management (IWRM) using an ecosystems approach and for building partnerships for water infrastructure innovation in the Water-Energy-Food security nexus.

Web-resources and important publications

1. **The Consortium of Universities for the Advancement of Hydrologic Science** (Cuahsi.org | Twitter.com/CUAHSI): CUAHSI is a research organization representing more than 130 U.S. universities and international water science-related organizations. The website is one stop to link to water-related web and data portals. These web portals have developed indicators on a variety of themes, ranging from water resources, water use, irrigation and drainage, waste water to institutional frameworks. Some of their cluster data portals (can be accessed from Cuahsi.org/data-models/portals/) include: Africa Water Sector and Sanitation Monitoring and Reporting, Aquastat, Centre for Ecology and Hydrology: Data (CEH), CUAHSI Data Services (CUAHSI), Earth2Observe Water Cycle Integrator (WCI), Eurostat Water Statistics, beside many others.
2. **Water Supply and Sanitation Collaborative Council** (WSSCC) (Wsscc.org): WSSCC is a United Nations membership organization that advocates for improved sanitation and hygiene for the most vulnerable and marginalized people around the world. This organization has developed various indicators to monitor the Water and sanitation-related WASH programs. Some of its recent publications include “Scoping and Diagnosis of the Global Sanitation Fund’s Approach to Equality and Non-Discrimination” (2017, <https://bit.ly/2F3W23P>), “Public Funding for Sanitation: The Many Faces of Sanitation Subsidies” (2009, <https://bit.ly/2uaJS44>), “Global Sanitation Fund: Sanitation and Hygiene Promotion in Madagascar” (2015, <https://bit.ly/2TCVbBt>).
3. **Water World** (Waterworld.com): Water World facilitates knowledge sharing in three different domains: (a) WaterWorld Magazine, (b) Industrial WaterWorld and (c) Water and Wastewater International. *WaterWorld* Magazine, published monthly, delivers updated information on technology, products and trends in the water and wastewater industry. The editorials cover a wide range of topics covering - energy management, biosolids treatment and disposal, chemicals, pipe maintenance and repairs, stormwater management, computers and automation technology, corrosion control and glances to

industry events. *Industrial WaterWorld* serves management, operation, engineering and consulting professionals in the industrial process water and wastewater industry. Industrial reports generated by this organization provides the news and product and service information necessary for successful planning, designing, operations and maintenance of industrial water systems. *Water and Wastewater International* caters to water industry around the world, reporting on the latest news, technologies and projects of interest to a global water audience.

4. **Water Technology** (Water-technology.net): Water Technology website services entails latest news, views and project information from the water industry across the world, covering industrial and municipal wastewater treatment and water supply and transmission. Water Technology brings together chief engineers and technologists working in the area of water. It also works along with an active network of journalists worldwide to collect information on the emerging issues that could be useful for experts and professionals.
5. **STEPS Centre** (Steps-centre.org): The ESRC STEPS Centre (Social, Technological and Environmental Pathways to Sustainability) in the United Kingdom carries out interdisciplinary global research uniting development studies with science and technology studies to reduce poverty and bring about social justice. The website provides a concept note “Water, Waste and Sustainable Cities in India” (2015, <https://bit.ly/2O2SYJq>), a briefing “Liquid Dynamics: Accessing Water and Sanitation in an Uncertain Age” (2009, <https://bit.ly/2O1nFi6>), a research article “Towards a Peri-Urban Political Ecology of Water Quality Decline” (2016, <https://bit.ly/2TNYoNI>), besides several others.
6. **The Natural Environment Research Council** (NERC) (Nerc.ac.uk): NERC flagship database Water Research Directory UK (Wskp.net/index.php/waterruk/) offers a broad searchable list of individuals active in water research. Also, it elaborates on their expertise and contact details thereby enabling knowledge sharing among actors. NERC also maintains a database called WaterR2B. WaterR2B is a repository of case studies highlighting a significant number of businesses that are benefiting from the UK’s past spending on water-related research. NERC has developed tools for impact assessment around environment and water quality in the public as well as private sector, through an evaluation report titled “Water as a Resource” in 2016. In 2014 UK National Ecosystem Assessment Follow-on’ (UK NEAFO) provided new information and developed tools for monitoring biological effects of fresh and seawater pollution.

7. **The International Water Management Institute** (Iwmi.org): IWMI is a CGIAR center focused on research for development to deliver new evidence-based approaches that address key water-related challenges. The Water Data Portal (WDP, WaterData.iwmi.org), following “one-stop shop” approach, provides access to a large amount of data related to water and agriculture. WDP contains meteorological, hydrological, socio-economic, spatial data layer, satellite images as well as hydrological model setups. Some of the important tool developed by this institute for assessment and forecasting are Drought Monitoring System, Flood Risk Mapping, Irrigated Area Mapping: Asia and Africa, Online Irrigation Benchmark Services and the Water Data Portal. The institution has also developed indicators on water stress that has been published in “Incorporating Environmental Flows into ‘Water Stress’ Indicator 6.4.2: Guidelines for a Minimum Standard Method for Global Reporting” (2019, <https://bit.ly/2ClvV83>). Some of its recent publications include: “Resource Recovery from Waste: Business Models for Energy, Nutrient and Water Reuse in Low- and Middle-Income Countries” (2018, <https://bit.ly/2JbHQez>), “Pricing Reforms for Sustainable Water Use and Management in the Philippines” (2018, <https://bit.ly/2O5SYZd>). Its other categories of publications include research reports, working papers, journal articles and policy briefs.

India-Specific Initiatives

a) Databases

1. **Central Ground Water Board** (www.cgwb.gov.in | [Twitter.com/CGWB_CHQ](https://twitter.com/CGWB_CHQ)): Central Ground Water Board is a statutory organization under Ministry of Jal Shakti, Government of India. The Board releases Ground water year book at State and National level data, State and District groundwater profiles, Ground water assessment reports, maps on major aquifers in India which are important for assessing the water scenario in India.
2. **Water Technology Initiative**, Department of Science and Technology, Government of India (Dst.gov.in/water-technology-initiative-programme-wti): Water Technology Initiative, initiated in August 2007 aims to promote R&D activities aimed at providing safe drinking water at affordable cost and in adequate quantity using appropriate Science and Technology interventions evolved through indigenous efforts. In pursuance of directives of Hon’ble Supreme Court, Technology Mission on Winning, Augmentation and Renovation (WAR) for Water has been launched in August 2009 to undertake research-led solutions, through a coordinated approach, to come out with technological options for various water challenges in different parts of the country.

A national-level think-tank the Technology Information, Forecasting and Assessment Council (TIFAC) is affiliated to DST, which is responsible for carrying out technology impact assessments, aiming to discover the probable implications and consequences. TIFAC is also involved in technology forecasting and assessment of water projects in a systematic and continuing basis.

3. **India Water Portal** (Indiawaterportal.org): India Water Portal is a prominent website, which provides unparalleled resources such as reports, data, news, events, opportunities and discussions pertaining water. The platform encourages sharing experiences and solutions. It highlights the recent publications on the related subjects published in the country. It is a one stop gateway to sanitation portal, school water portal, Hindi water portal and Conflict water portal.
4. **India Environment Portal** (Indiaenvironmentportal.org.in): This open-source platform shares the proprietary information by Centre for Science and Environment (CSE). The statistics provided by this portal aims at portraying the environmental diversity and change in environment condition across time and location.
5. **India Sanitation Portal** (Indiasanitationportal.org): The India Sanitation Portal is an open, inclusive, web-based platform for sharing sanitation knowledge amongst practitioners and the general public. It aims to draw on the rich experience of sanitation-sector experts, package their knowledge and add value to it through technology and then disseminate it to a larger audience through the internet.
6. **Water-related Technologies documented in National Innovation Foundation's Database** (Nif.org.in, Nif.org.in/water_related_technologies): The NIF database encompasses the water-related grassroot innovation technologies for water conservation, waste water treatment, water filtration using indigenous methods. NIF publishes *Award Books* annually, *Festival of Innovation Book* (2015 and 2016), *India Innovates* (2013).
7. **The Energy and Resources Institute** (Teri.in.org): TERI is a leading think tank dedicated to conducting research for sustainable development of India and the Global South. It has an online directory of its recent publications in the area of water. TERI maintains the IndiaEnergyPortal.org, the ENVIS Centre on Renewable Energy and Environment (Terienvic.nic.in), TERI Energy and Environment Data Diary and Yearbook (TEDDY), Teri Information Digest on Energy and Environment (TIDEE), TerraGreen (a monthly magazine on environmental issues). Some of its published books on water include: "Soil and Groundwater Pollution from Agricultural Activities" (2006), "Hydro-politics in

GBM Basin: The Case of Bangladesh-India Water Relations" (2015), "Municipal Water and Waste Water Treatment" (2006) and "Water: Why It Matters" (2012).

8. **Indian Institute of Soil and Water Conservation** (<http://www.cswcrtiweb.org/>): Indian Institute of Soil and Water Conservation is a research network for developing location-specific technologies in the area of soil and water conservation. It provides services like consultancy, training Library and database on the area areas of soil and conservation. Some of the research programs carried by this institute are on water erosion appraisal in different agro-ecological area, watershed hydrology for conservation planning and integrated watershed management for socio economic growth and policy advocacy. The organization releases biannual newsletters in the issues of soil and water conservation.

b. Programs

1. **NITI Aayog** (Niti.gov.in | Twitter.com/NITIAayog): NITI Aayog is a policy think tank of the Government of India, established in 2015, replacing the Planning Commission of India. Here NITI stands for the National Institution for Transforming India (NITI). In June 2018, NITI Aayog released its flagship publication "Composite Water Management Index (CWMI): A Tool for Water Management" (2018, <https://bit.ly/2MARNCP>). CWMI sought to enable data-backed water management in the country and promote competitive, cooperative federalism. The objectives of CWMI are to (i) "Establish a clear baseline and benchmark for state-level performance on key water indicators, (ii) Uncover and explain how states have progressed on water issues over time, including identifying high performers and under-performers, thereby inculcating a culture of constructive competition among states and (iii) Identify areas for deeper engagement and investment on the part of the states".
2. **Ministry of Jal Shakti**, Government of India (Mowr.gov.in): Ministry of Jal Shakti is responsible for formulating the policy guidelines and programs for the development and regulation of country's water resources. Some of the recent national programmes launched by the Ministry include (i) R&D Programme in Water Sector: The organizations involved in R&D in water sector under the Ministry are Central Water Commission (CWC), Central Soil and Material Research Station, Central Water and Power Research Station, National Institute of Hydrology (NIH), Indian National Committee on Surface Water (INCSW) and Indian National Committee on Ground Water (INCGW). (ii) Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), launched in 2016, PMKSY aims at improving water efficiency on farm and expanding

- irrigation ensured water area. <https://pmksy.gov.in/AboutPMKSY.aspx>. (iii) Interlinking of Rivers (ILR) Programme: Under this Programme, the key projects include the Ken–Betwa, Damanganga–Pinjal, Par–Tapi–Narmada, Mahanadi–Godavari, Manas–Sankosh–Teesta–Ganga rivers linking covering Pan India in different phases (<https://bit.ly/2T5dIRJ>). (iv) National Hydrology Project (NHP) (Nhp.mowr.gov.in): The project aims at improving the accessibility and quality of water and lays special emphasis on enhancing the water management institutions. (v) National Mission for Clean Ganga (Nmcg.nic.in | [Twitter.com/cleanganganmcg](https://twitter.com/cleanganganmcg)): National Mission for Clean Ganga launched the Vision Ganga, in December 2017, in collaboration with Centre for Ganga River Basin Management and Studies (cGanga). NMCG accomplishes the mandate of National Ganga River Basin Authority (NGRBA). NMCG aims at ensuring reduction in pollution and rejuvenating the river Ganga. This project also aims at sustaining water quality and environmentally sustainable of the river Ganga. The salient features of “Vision Ganga” include: “Apply modern science and technology in conjunction with traditional wisdom”. National Mission for Clean Ganga recently published several magazines under the section e–patrika titled *Namami Ganga Corporate Social Responsibility* (2017), *Ganga Viskharopan Saptah* (2017) and *Ganga Swach Sankalp Diwas* (2017). Some of the recent reports by MOWR include: *More Crop and Income Per Drop of Water* (2006, <https://bit.ly/2Hz04o0>), *On the Spot Study of Water Situation in Drought Affected Areas of the Country* (2016, <https://bit.ly/2ObqWM9>). CWC has been engaged in activities of collection, storage and dissemination of statistical data along with developing indicators for carrying out assessments of water conditions in India. CWC statistical data on water are published in *Integrated Hydrological Data book* (2015, 2016 and 2017) and *Water and Related Statistics* (2013). NIH, maintains a web based information system and has developed indicators on five different area of water ranging from a) water quality of the Ganga and its tributaries, b) hydrological cycle, c) Himalayan snow cover information system, d) Indus snow cover Information system and e) Web Enabled Ground Water Recharge Estimation Model (WE–GWREM).
3. **National Rural Drinking Water Programme** (NRDWP) (www.mdws.gov.in | [Twitter.com/NRDWP_MDWS](https://twitter.com/NRDWP_MDWS)): The Ministry of Drinking Water and Sanitation (presently Ministry of Jal Shakti), Government of India launched two programs of national significance– the National Rural Drinking Water Program (NRDWP) for rural drinking water supply and the Swachh Bharat Mission (Gramin) [SBM (G)] for sanitation in the country. Indiawater.gov.in/IMISReports/ provides reports on financial progress report, physical progress report of this mission and case studies on water important for decision making.
 4. **UNICEF India’s Water, Sanitation and Hygiene (WASH) Programme** (Unicef.in/Sections/6/WASH | [Twitter.com/ToiletICO](https://twitter.com/ToiletICO)): The UNICEF initiated WASH supports the Indian national and state governments in developing and implementing a range of models for sanitation, hygiene and water supply. Some of the recent reports by UNICEF–WASH include SAWM INDIA and UNICEF partner for stories on adolescents across India (2017).
 5. **India’s Water and Sanitation Crisis** (Water.org/our-impact/india/): Water.Org provides two basic solutions to bridge the water accessibility gap through its two initiatives, (a) WaterCredit Initiative® for those who need access to affordable financing and resources to make household water and sanitation solutions a reality and (b) WaterEquity to provide more funds for water and sanitation loans.
- c. Web-resources and publications**
1. **UN in India: Health, Water and Sanitation** ([In.one.un.org/health-water-and-sanitation/](http://one.un.org/health-water-and-sanitation/)): Under the health water and sanitation mission, UN has taken the initiative to support the Indian government in achieving the goal of National Health policy 2017. Some of its highlighted publications include: “Integrated Approaches for Sustainable Development Goals Planning: The Case of Goal 6 on Water and Sanitation” (2017, <http://bit.ly/2Y08LNZ>) and “Global Strategy for Public Health: Public Health HIV and Reproductive Health–Food Security and Nutrition Water Sanitation and Hygiene (Wash) A UNHCR Strategy 2014–2018” (2016, <https://bit.ly/2VYU6R8>).
 2. **WASH–Legislators’ Forum** (Clraindia.org | [Twitter.com/washlf](https://twitter.com/washlf)): WASH–LF was launched on 28 April 2015 along with the technical support from UNICEF India. It is a unique legislative forum initiated by the Centre for Legislative Research and Advocacy (CLRA) advocating the issue of water, sanitation and hygiene in India. The Forum released publications such as “Sanitation in Maharashtra: A Policy Profile” (2014, <https://bit.ly/2Ckd6SF>) and “Maharashtra City Factsheets on Sanitation” (2014, <https://bit.ly/2TKWQUR>).
 3. **Water Solutions** (a consortium of dedicated scientists, well known for their expertise in groundwater sector for exploration) (Watersolutions.net.in): Water Solutions is an association with expertise in groundwater sector for exploration, assessment, development and management, including artificial recharge and rain water harvesting in

varied hydrogeological environment. The recent posts on its blog include: “Implementation of Sustainable Water Harvesting Techniques is the Need of the Hour”, “Implement Water Management Strategies Now to Avoid Water Anarchy” and “Rainwater Harvesting: Contribute Your Bit for a Bright Future”.

4. **WaterAid India** (Wateraidindia.in): WaterAid works with a vision of creating a “world where everyone has access to safe water and sanitation.” It publishes reports and briefs on policies and practices in water, which include “The Water Gap: The State of the World’s Water 2018” (2018, <https://bit.ly/2VWEZrm>), “State of Urban Water Supply in India” (2018, <https://bit.ly/2F0gTVT>), “Out of Order: The State of the World’s Toilets 2017” (<https://bit.ly/2JcJOLM>), besides others.
5. **India-UK Water Centre** (Iukwc.org | Twitter.com/IndiaUKWater): The aim of the India-UK Water Centre is to promote cooperation and collaboration between NERC-MoES water security research. The virtual India-UK Water Centre (IUKWC) is a brainchild of a collaboration between the two countries and address significant water availability and sustainable water management issues in both the UK and India. Some of its publications include an approach to strategic industry partnerships, guides and leaflets aimed at members of the NERC research and science community. Their publications include a series of “Water Briefs” that aimed at providing a concise overview of the current state of water science in the UK and India. The Centre has several projects under it to map the soil moisture status and mapping and quantification of dominant interactions and feedbacks between human activities. The Centre carries out time to time workshops, research exchange programs, grassroots field exposure sessions, webinars and user engagement activities.
6. **Centre for Science and Environment** (CSE, Cseindia.org | Twitter.com/CSEINDIA): CSE is a leading not-for-profit public interest research and advocacy organisation based in New Delhi, established in 1980. It publishes a fortnightly magazine “Down to Earth” in English and Hindi, an annual “State of India’s Environment” and many occasional monographs on water conservation, water stress and rainwater harvesting. It also maintains three environment-related web portals namely, IndiaEnvironmentPortal.org.in, RainwaterHarvesting.org, GreenClearanceWatch.org and DownToEarth.org.in.
7. **Arghyam India** (Arghyam.org | Twitter.com/arghyamindia): It is a philanthropic organisation working on groundwater and sanitation across India. The organization carries out assessment programs of urban water and sanitation. It has developed indicators for seweraged and non-seweraged cities. Besides this, the organization has also GIS-based Slum Information System Tools for Decision Making. This institution generates sanitation case summaries and reports on waste water treatment plants, urban water management and water quality management. Arghyam maintains the IndiaWaterPortal.org, IndiaSanitationPortal.org, the Schools Water Portal (Schools.indiawaterportal.org) and Water Conflicts Portal (Conflicts.indiawaterportal.org). Some of the important publications of Arghyam include: “A Framework for Rural Drinking Water Quality Management: Collating Experiences from the Voluntary Sector” (2012, <https://bit.ly/1ctRCyD>) and “An Approach to Integrated Urban Water Management (IUWM): The Mulbagal Experience” (2012, <https://bit.ly/2u8nJ6x>).
8. **Sulabh International** (Sulabhinternational.org | Twitter.com/SulabhIntl): Sulabh International aims at improving sanitation in India and globally. It aims at delineating scavengers from the inhuman practices of manually cleaning and carrying human excreta. The organization has also introduced an educational tool for schoolchildren and teachers for providing training for perspective volunteers to pass on the message to communities and educate people about health, hygiene and sanitation. Some of its recent publications include: “Sulabh Swachh Bharat: A Good News Weekly” in English and Hindi languages (since 2016), “Sulabh Sanitation Movement” (2010, <https://bit.ly/2F3Go8E>). It operates the “ENVIS Centre on Hygiene, Sanitation, Sewage Treatment Systems and Technology” that publishes an informative Newsletter and other databases. Some of them are available on its portal <http://sulabhenviis.nic.in>.
9. **Jaldhara Foundation** (www.jaldhara.org | Twitter.com/Jaldhara): The Jaldhara foundation aims at designing and implementing social marketing programs to transform water, sanitation and hygiene practices in communities of India. It publishes news on water-related issues through press releases and media coverage.
10. **Water Collective** (Thewatercollective.org | Twitter.com/WaterCollective): Water Collective is an international nonprofit that secures life-lasting clean water for rural communities in Africa and India. It also highlights that the founding director of Sanitation and health appears in Forbes’ 30 under 30 social entrepreneurs.
11. **SaciWATERS, the South Asia Consortium for Interdisciplinary Water Resources Studies** (www.saciwaters.org | Twitter.com/SaciWATERS): SaciWATERS, the South Asia Consortium for Interdisciplinary Water Resources Studies, is a policy research institute based in Hyderabad, India. To achieve

water security in South Asia through a pro-poor human development approach. Some of its publications include: “Water Security in Peri-Urban South Asia: Adapting to Climate Change and Urbanisation” (2016, ISBN: 9780199464166), “Water Security in Peri-Urban Hyderabad” (2018, <https://bit.ly/2TBjhMJ>), “Climatic Trends and Variability in South Asia: A Case of Four Peri-Urban Locations” (2013, <https://bit.ly/2Hj5tjI>).

12. The Council on Energy, Environment and Water (<http://ceew.in/>): The Council on Energy, Environment and Water (CEEW) is one of South Asia’s leading not-for-profit policy research institutions. The council evaluates water management and security issues in agricultural, industrial, as well as municipal sectors. Their research interests involve assessing collective action for water security mapping of India’s traditional water bodies and modelling of the water-energy nexus. Some of its publications in partnership with the 2030 Water Resources Group (2030wrg.org) in the area of water include: “Circular Economy Pathways for Municipal Wastewater Management in India: A Practitioner’s Guide” (2016, <https://bit.ly/2FbsToH>), “Agri-Water Sustainability in India: Setting the Agenda for the Alliance for Thought Leadership and Action” (2015, <https://bit.ly/2TNRrMG>) and “Collective Action for Water Security and Sustainability: Preliminary Investigations” (2014, <https://bit.ly/1OX39N3>).

13. Interdisciplinary Centre for Water Research (ICWaR, Icw ar.iisc.ac.in): The ICWaR at the Indian Institute of Science is established in April 2015 with an aim to address water-related issues that have formidable scientific challenges and significant practical relevance. The Centre has undertaken studies to assess the impact of climate change on water resources. Some of its recent publications include: “Urban Water Systems: A Framework for Collaboration between ICWaR and UNESCO” (2016, <https://bit.ly/2FeylYd>), “Chennai Floods 2015: A Rapid Assessment” (2016, <https://bit.ly/2u5BZNv>).

14. World Resources Institute (WRI India, Wri-india.org | Twitter.com/WRIIndia): WRI India works with businesses, governments and civil society to ensure a water-secure future. It aims to address both water quantity and quality challenges. The organization has developed India Water Tool where users can find water-related risks and enabling them in decision making for sustainable water management. The tools combine data from Indian government agencies and water stress indicators developed by WRI and Columbia Water Centre. Another WRI dataset ‘Aqueduct Global maps’ creates global water risk maps, allowing stakeholders to assess current and future challenges. WRI also carries out economic and

other analyses to identify the most cost-effective strategies to reduce water pollution. Some of its recent publications include: “Mapping Public Water Management by Harmonizing and Sharing Corporate Water Risk Information” (2018, <https://bit.ly/2Fe7c7H>), “Parched Power: Water Demands, Risks and Opportunities for India’s Power Sector” (2018, <https://bit.ly/2CmEv6G>).

15. KRG India Research Centre for Rainwater Harvesting and Environment (Krgindia.in): The KRG India has over 20 years of experience in providing valuable environmental services to its clients. The surging demand for innovative methods and systems for water conservation to recharge the depleting aquifers of water extraction structures saw the launching of KRG India in the year 2001.

16. Fluoride India (Fluoride Knowledge and Action Network, Fluorideindia.org | Twitter.com/fluorideindia): Fluoride India is engaged in health and better life with safe water and nutrition. Its network fights against toxic water problems such as Fluorosis causing Disability. It also maintains a blog on low-cost water solutions and the *Jal Chaupal* a people’s forum.

17. Water and Sanitation (Twitter.com/WASHIndia): A community of Government and Private stakeholders working towards improving the standards of Water and Sanitation and working towards Swachh Bharat.

18. Water of Life (www.givefreshwater.org | Twitter.com/WaterOfLife): Water of Life serves three countries who desperately need clean water to survive and thrive – Sierra Leone, Liberia and India. Providing access to clean water for every human across the globe is a monumental goal and there are many organizations working to do so. The website shares news on the issue on water-related issues.

19. The Flush Mob (Theflushmob.com | Twitter.com/TFMdelhi): The Flush Mob is an initiative by a group of enthusiastic individuals committed to improve the sanitation and hygiene conditions of India. TFM comes out with press releases on the issues of clean and safe drinking water.

20. The Water Charity (Charitywater.org | Twitter.com/TheWaterCharity): Providing clean water and sanitation to rural communities in Africa, India and South America. Charity water maintains blog on the issue of water.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUMMARY

One of the objectives of this webliography was to produce a comprehensive list of activities undertaken by institutions participating in the knowledge creation and knowledge dissemination process in the area of water at the national and international level. We discussed that scientometric and bibliometric tools have over time emerged as a methodology to assess the research performance in a given area. This approach uses indicators and tools to assess research performances across the field of study. Development of these tools and indicators not only facilitates further research but also assists in the evidence-based decision-making process. While at international level, we observe that a number of indicators tools have been developed in the area of water and sanitation, at the national level recently efforts have been taken by the government of India for development of related indicators and tools for facilitating water-related research encompassing both forecasting and assessment activities. In case of India, the release of recent report “Composite Water Management Index (CWMI): A Tool for Water Management” provides useful information for the Ministries and Departments at the Centre and State level for formulating and implementing strategies suitable for water resource management. It is therefore imperative at country level for Indian institutions to identify the key themes and issues around water to construct meaningful indicators and tools for assessing the water scenarios.

ABBREVIATIONS

CWMI: Composite Water Management Index; **CGWB:** Central Ground Water Board; **DST:** Department of Science and Technology; **WRI:** World Resources Institute; **TFM:** The Flush Mob; **ICWaR:** Interdisciplinary Centre for Water Research; **CEEW:** Council on Energy, Environment and Water; **CSE:** Centre for Science and Environment; **USGS:** United States Geological Survey; **CWC:** Central Water Commission; **CEH:** Centre for Ecology and Hydrology; **CLRA:** Centre for Legislative Research and Advocacy; **TDB:** Drinking Water Treatability Database; **ESRC:** Economic and Social Research Council; **EJOLT:** Environmental Justice Organizations, Liabilities and Trade; **ENVIS:** Environmental Information System; **EPA:** Environmental Protection Agency; **EEA:** European Environment Agency; **INCGW:** Indian National Committee on Ground Water; **INCSW:** Indian National Committee on Surface Water; **IUKWC:** India-UK Water Centre; **IUWM:** Integrated Urban Water Management; **IWRM:** integrated water resources management; **IHP :** International Hydrological Programme; **IUCN:** International Union for Conservation of Nature; **IWMI:** International Water Management Institute; **NGRBA:** National Ganga River Basin Authority; **NIF:** National Innovation Foundation; **NIH:** National Institute of Hydrology; **NITI:**

National Institution for Transforming India; **NMCG:** National Mission for Clean Ganga; **OECD:** Organisation for Economic Cooperation and Development; **PAHs:** Polycyclic Aromatic Hydrocarbons; **PMKSY:** Pradhan Mantri Krishi Sinchayee Yojana; **R&D:** Research and Development; **SCI:** Science Citation Index; **STEPS:** Social, Technological and Environmental Pathways to Sustainability; **Stream Cat:** Stream-Catchment; **SBM (G):** Swachh Bharat Mission (Gramin); **TIFAC:** Technology Information, Forecasting and Assessment Council; **TEDDY:** TERI Energy and Environment Data Diary and Yearbook; **TIDEE:** Teri Information Digest on Energy and Environment; **AKWUDS:** The Alaska Water Use Data System; **WELTS:** The Alaska Well Log Tracking System; **CUAHSI:** The Consortium of Universities for the Advancement of Hydrologic Science; **TERI:** The Energy and Resources Institute; **HSBC:** The Hongkong and Shanghai Banking Corporation; **NERC:** The Natural Environment Research Council; **UNESCO:** The United Nations Educational Scientific and Cultural Organization; **UN-SDGs:** United Nations Sustainable Development Goals; **UWWTD:** Urban Waste Water Treatment Directive; **WCI:** Water Cycle Integrator; **WDP:** Water Data Portal; **WATERiD:** Water Infrastructure Database; **WSSCC:** Water Supply and Sanitation Collaborative Council; **WPSI:** Water, Peace and Security Initiative; **WASH:** Water Sanitation and Hygiene; **WE-GWREM:** Web Enabled Ground Water Recharge Estimation Model; **WAR:** Winning, Augmentation and Renovation; **WDI:** World Development Indicators; **WHO:** World Health Organization.

REFERENCES

- Harrabin R, Shortages: Water supplies in crisis, Science and Environment, 2012, retrieved from <https://www.bbc.com/news/science-environment-18353963> on 15 June 2019.
- Thomson Reuters. Using Bibliometrics: A Guide to Evaluating Research Performance with Citation Data. 2014. Available at http://ips.clarivate.com/m/pdfs/325133_thomson.pdf (on 4 March 2019).
- Wang MH, Yu TC, Ho YS. A bibliometric analysis of the performance of Water Research. *Scientometrics*. 2010 Sep 1;84(3):813-20.
- Hu J, Ma Y, Zhang L, Gan F, Ho YS. A historical review and bibliometric analysis of research on lead in drinking water field from 1991 to 2007. *Science of the Total Environment*. 2010 Mar 1;408(7):1738-44.
- Yi H, Jie W. A bibliometric study of the trend in articles related to eutrophication published in Science Citation Index. *Scientometrics*. 2011 Dec 1;89(3):919-27.
- Fu HZ, Wang MH, Ho YS. Mapping of drinking water research: A bibliometric analysis of research output during 1992–2011. *Science of the Total Environment*. 2013 Jan 15;443:757-65.
- Zhang L, Wang MH, Hu J, Ho YS. A review of published wetland research, 1991–2008: ecological engineering and ecosystem restoration. *Ecological Engineering*. 2010 Aug 1;36(8):973-80.
- Sun J, Wang MH, Ho YS. A historical review and bibliometric analysis of research on estuary pollution. *Marine Pollution Bulletin*. 2012 Jan 1;64(1):13-21.
- UN Water. What is Water Security, 2013. retrieved from <http://www.unwater.org/publications/water-security-infographic/> on 15 March 2019.
- Rapp F. Introduction: General perspectives on the complexity of philosophy of technology. *Philosophy of technology*. Boston, USA: Kluwer Academic Publishers. 1989.
- Li-Hua R. Definitions of technology. A companion to the philosophy of technology. Chichester, UK: Wiley-Blackwell, pp. 18-22. 2009.
- Shiao T, Maddocks A, Carson C, Loizeaux E, 3 Maps Explain India's Growing Water Risks, 2015, retrieved from <https://www.wri.org/blog/2015/02/3-maps-explain-india-s-growing-water-risks> on 8 March 2020.