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Contribution by India

to the CSTD 2022-2023 priority theme on "Ensuring safe water and sanitation for all: a solution by science, technology and innovation"

Government of India's Inputs on Priority Theme 2: Ensuring safe water and sanitation for all: a solution by science, technology and innovation

1. Water Technology Initiative:

Water Technology Initiative (WTI), is a demand-oriented user centric initiative which includes development research in laboratories as well as application research in field. The scope of the scheme was enhanced in pursuance of directives of Hon'ble Supreme Court undertake research-led solutions, through a coordinated approach, to come out with technological options for various water challenges in different parts of the country.

Objectives

- Promote national, bilateral and multilateral developmental research related to water quality, quantity and recycling
- Capacity building of research professionals, water managers and stakeholders
- Promote application research for techno- economic assessment of scientific interventions for their suitability in social context
- Promote upscaling and replication at credible scale for last mile connectivity outcomes of research outcomes.

Deliverables

- Research outputs including publications, patents, technology leads, best practices, invention disclosure, application specific technology classification etc.
- Methodology for development of customised solutions suited to social context.
- Best practices for addressing water challenges with stakeholders involvement.
- Impact assessment Studies, Research Packages, Technology Status Reports, Policy inputs to stakeholders (including users).

B. *Description of WTI, its components, approach/strategy for implementation, etc*

Description of Scheme

The scope of the scheme includes development research in laboratories and application research in field. The overarching goal of the scheme is to promote RD&D activities which enable winning of water from sustainable sources, augmentation of water quality for specific applications and recycling and reuse of water. This is a need based demand oriented thematic initiative encompassing the

entire technology development chain to successively progress to higher technology readiness levels culminating into sustainable solutions.
The scheme directly caters to furthering the Sustainable Development Goal #6 (***Clean water and sanitation***) which aims to ensure availability and sustainable management of water and sanitation for all. The scheme is also relevant to national mission on "Swachh Bharat" and "Namami Gange". The target partners for scheme implementation include Academic Institution; Public funded R&D Organisation; SIRO Recognised Industrial units; Academic Institution; Local Bodies (Urban & Rural); Voluntary Organisation & Trusts; State S&T Council and Department; Autonomous Bodies at State & Central Level Dealing in subject area and Public Sector.

Components of the Scheme:

Research Stream

- Oriented fundamental & applied research to promote high quality, cutting edge breakthrough research innovation.
- 'Proof of Concept' for technology development endeavour.
- Capacity building through national/ international fellowship and trainings in the area of water.
- Bilateral and Multilateral Cooperation through various models suitable for national needs.
- Centres of Excellence on various themes related to water research.

Technology Stream

- Assessment of existing technology option and evolving promising alternatives.
- Pre-competitive technology development.
- Pilot demonstration of technology leads emanating from R&D.

Solution stream : Demand driven Convergent solutions for water challenges mounted in field

- Scientific methodology for referencing of technologies to socio-economic context.
- Holistic assessment of water requirement to address prevalent and emerging water challenges.
- Techno-economic analysis of technology options to evolve sustainable convergent technological solutions.

Implementation Approach

1. Pro-active Identification of Water challenges and mobilisation of thematic proposals;
2. Design of activities through stakeholders' consultation;

3. Coordinated effort through linkage with line ministries/ state department/ local bodies/ user etc;
4. Facilitation of scientific endeavour through technical and financial support;
5. Gainful collaboration aimed at creation of knowledge networks through tapping the country's collective scientific strengths in industry, academics etc. and linking global expertise, wherever essential.
6. Designing of solution tailored to location specific need
7. Pilot implementation at a credible scale, enrolling community and stakeholders

C. Monitoring/ Evaluation mechanism in place:

Evaluation Mechanism

1. Defining evaluation criteria (e.g. Demand and need for work, perceived superiority over existing alternatives, scientific merit, competence and synergies, Project formulation, sustainability etc.)
2. Peer review by Experts
3. Feedback of Stakeholders
4. Evaluation by composite group of Experts, users, line ministries
5. Recommendations on support worthiness

Monitoring Mechanism

- Six monthly technical and financial progress report
- Institutional/ Consortium level Monitoring (for high cost high impact projects)
- Periodic field visits by Expert Teams
- Annual Review by DST appointed Peer Review Committee
- Recommendations on progress including course correction, if needed

D. The prioritized Water challenges are:

- Integrated water management for water sensitive cities and sustainable water balance for urban cities.
- Renewable energy powered Sustainable Desalination technologies
- Detection and mitigation of Geogenic and anthropogenic contaminants in water such as Arsenic, Flourides , Coliform, Iron, Nitrates , Chromium etc.
- Balancing water demand and use utilizing technological tools.
- Near Zero Liquid Discharge (ZLD) Options for effluents (including energy savings).
- Technological solutions for optimal use of water in industry.
- Flood Management technologies for utilization of unexpected or suddenly available water for agriculture and drinking purposes.

- Addressing pesticides and other use derived residues in selected clusters.
- Technological solutions for optimal use of water in agriculture.
- Technological solutions for Wetland preservation and management.

E. ***Output/Outcome analysis of the deliverables including social impact of the scheme:***

- ❖ 23 convergent solutions and upscaling of 2 proven technologies addressing various water challenges.
- ❖ Application research for 9 site specific water challenges benefitting more than 100 hamlets in 11 states.
- ❖ Water Quality Monitoring Networks in 2 States in partnership with stakeholders.
- ❖ More than 450 national and collaborative technological endeavours to develop research leads for addressing prevalent and emerging water quality and quantity related problems.
- ❖ Water Advanced Research Innovation (WARI) fellowship with US Collaboration and Bilateral research and Capacity Building programme with UK, France and Netherlands.
- ❖ 7 Water Innovation Centres on urban water management, waste water treatment, drinking water and irrigation water, desalination, water conservation, agriculture and irrigation established.
- ❖ 11 Mission projects in identified clusters to develop methodology & best practices related to flood, drought, storage, distribution, wetland and salinity.
- ❖ Autonomous water quality monitoring of rivers.

The scheme has vast social impact and field interventions have benefitted two lakh people so far. Several initiatives have been replicated by community in the vicinity and upscaled to larger population level. The programmes on natural treatment and water conservation in arid areas are two most successful impactful initiatives. The technology developed for arsenic removal is an example of sustained R&D support leading to field deployable technology.

F. National level initiatives :

(i) Demand Driven Mission mode projects: In year of 2017, DST had implemented a call for field extensive proposal under WTI to find research and field level interventions to demonstrate technical, social, environmental and eventually economic sustainable solution for water challenges. In this exercise, DST had launched WTI Call 2017 on Demand Driven convergent Water solution in mission mode in March 2017. Under this call 11 Demand driven Mission projects were recommended and supported in the area of Renewable powered desalination, IoT enabled water sensing and distributions systems, Flood

management, water conservation and groundwater recharge, optimal water use in agriculture and wetland systems.

(ii) Water Technology Research and Water Innovation Centres : Division had also launched the Water Technology Research and Innovation Centres (WATER-IC) theme based Call-WTI 2017 in 201. Considering the prevalent and emerging water challenges in Indian scenario, Virtual Networked Centres were envisaged to develop knowledge base to cater to the various water relevant issues through supporting R&D for water quality, quantity and recycle & reuse. These centres are expected to nurture knowledge, innovation, expertise through institutional and human capacity building of water researchers, professionals, community etc and to address the gap areas in Water Technology research, development, demonstration, adaptation, adoption and commercialization of water. Under this intervention, 7 Centres of Excellence have been set up in premier research organisations in the country for concerted and synchronised research in the area of Desalination, Agri-Water nexus, Heavy metal water treatment technologies, Water Disinfection and decentralised waste water treatment technologies and natural water treatment techno options. These 7 centres are multi institutional hubs that also envisage to identify the global best practices and be the knowledge dissemination focal points at the national level on a thematic area in water.

(iii) Water Energy Food Health Nexus (WEFH-Nexus) : In year of 2019, DST had launched a novel and cross sectoral call on " Water Energy Food Health" Nexus. The objective of the call was to mobilize study, research, innovation and technology proposals to explore, understand and address nexus of water issues with the sectors e.g. energy, food, health, infrastructure etc. in the context of existing and emerging water challenges in the country especially with reference to reliable availability of water drinking, municipal, and agricultural requirements. The cross sectoral call envisaged to support thematic lab based Research Development and Demonstration (RD&D) on Water quality sensing, analysis, treatment and management for addressing issues related to Water-food, Water-Energy, Water-Health, Water-Energy-Food-Health and other cross sectoral Nexus. WTI got an overwhelming response against the above call in 5 different streams of the call and 396 full proposals were received by premier institutions and groups working on the nexus of Water with Energy, Food, Health (WEFH). 64 proposals that envisage to work on the WEFH nexus under the Applied research, Action research, Technology development, Technology assessment and Convergent solution streams under the call have been provided financial support.

G. Bilateral Collaboration on Water :

(1) Indo-UK Water Quality Research Programme:

DST had launched an initiative on Water Quality Research Programme in collaboration with NERC and EPSRC inviting proposals for a new 3-year research programme to improve water quality by providing a better understanding of the sources and fate of different pollutants and by supporting the development of management strategies and technologies to reduce pollution levels. **Eight** Indo UK projects have been finally supported under the bilateral program. In an India- United

Kingdom collaborative programme, Yamuna river in the north (in the most polluted stretch, contributing to 70% of Delhi's water supply needs) and the Cauvery river in the south (the most abstracted river in India) are being studied for prevalence of emerging contaminants. Investigations will also be made on the fate of ECs and use of bio-solids during wastewater and sludge treatment line at 10 Waste Water Treatment Plants (WWTPs) in India. The attempt is to develop evidence based wastewater discharge standards and guidance for safe use of contaminated sludge:

1. Existing Water Quality Research Projects between India and UK and their major outcomes:

S.no.	Title of Project	Organisations involved	Major outcome achieved
1.	Secular changes and Remediation of grounds water arsenic in the Ganga River Basin	National Institute of Hydrology, Roorkee	Field laboratory intervention for detailed hydrogeochemical studies have been done. A reactive transport model has been installed in Nadia, West Bengal. Installation of piezometer nests for 6 sites at Varanasi, Patna, Bhagalpur, Behrampur, Nadia, South 24 Parganas (headwater of Sunderbans) has been achieved to study contaminant transport and river groundwater interactions. Based on the Water quality results collected from Ballia & Bahraich, clusters of arsenic contaminated areas has been identified. Selection of MAR site to study positive/negative impacts of MAR
	The development and implementation of sensors are treatment technologies for freshwater systems in india	Bose Institute, Kolkata	The relevant target gene(s) of EDC-degrading operon has been amplified and confirmed using the genomic DNA of EDC-degrading isolates. Catabolic genes of the degradative operon(s) including relevant

			regulatory modules of strains has been identified.
	Fate and Management of Emerging Contaminants	Indian Institute of Technology Madras, Chennai	The pilot plant PPT reactor capacity of 1 m3/day has been designed and fabricated and is to be installed at IIT Madras. The seasonal distribution of emerging contaminants and pollutants in the River Cauvery. Has been quantified. The IIT Madras study showed that it was essential to regularly monitor rivers and their tributaries for contamination by pharmaceutical products. There was also a need to upgrade wastewater treatment systems to reduce the levels of emerging contaminants in the rivers. The results of the study have recently been published in the reputed peer-reviewed journal Science of the Total Environment,
	AMR Pollutants: interactive studies and novel sensor technologies	Indian Institute of Technology Madras (IITM), Chennai.	The novel strategy for low cost fabrication of the robust Laser Printed- Microfluidics Paper Based Analytical Sensors has been developed which will help detecting antimicrobials easily in the parts per million range. It will also help understand the relationship between AMR and AMR triggering pollutants and assist policymakers in framing

			solutions to tackle grand societal AMR challenge. The project team has also carried out the paper based sensors for the detection of ciprofloxacin by complexation with eosin-yellow, triclosan using diazotization reaction, chromium using diphenyl carbazide, copper using silver nanoparticles and lead using sodium rhodizonate has been also developed.
	Innovation low-cost optical sensor platform for water quality monitoring	Indian Institute of Science, Bengaluru.	Fabrication of Etched Fiber Bragg Grating (eFBG) sensor has been done. This sensor has the advantage of high sensitivity, selectivity, real time detection, low cost and portability properties. The Long Period Grating (LPG) sensors (fabricated by the UK group) has been tested for MoS2 coating and the spectral response were also monitored in each step.
	Rehabilation of vibro infested waters of vembanAd Lake: pollution and solution (REVIVAL)	CSIR-National Institute of Oceanography, Kochi.	The database on spatio-temporal vibration in the phyto and zooplankton community in the lake has been prepared. Development of prototype of Secchi disc for collecting data on turbidity and colour of Vembanad lake using a Secchi disc and a mobile application (TurbAqua). More than 400 isolates of Vibrio spp have been isolated from the Vembanad lake.

			Drone system has been developed for collection of hyperspectral optical data over water. An epidemiological model of cholera in Vembanad Lake has been also prepared.
	Impact of Rainwater Harvesting on Groundwater Quality in India with specific Referance to Fluroide and Micropollutants	National Institute of Hydrology, Roorkee	Field experiments pertaining to soil properties has been completed. The soil maps has been procured and digitization of soil maps on GIS has been also completed. The project team has also carried out the installation of piezometers at three sites, mounting of two AWLRs in two piezometers has been also done and gauge board assessment of prevailing surface water and groundwater chemistry has also been completed. Evaluation of surface water chemistry to prepare synthetic infiltrate for lysimeter studies has been also achieved.
	PATHWAYS & evolution of pollutants: interaction between physical controlling effects, microbial community composition and pollutants biodegradation rates	Indian Institute of Technology, Bombay.	A dye trace study has been carried out in Ulhas River. Estuary. pH, DO, and BOD for the Ulhas River Estuary has been studied.

(2) Bilateral Indo- Netherlands collaboration on Water:

- DIWALI is envisaged as a platform where all stakeholders from both countries A Programme of cooperation (POC) was signed between Netherlands and India in water sector 'Dutch Indian Water Alliance for Leadership Initiative (DIWALI) in 2013'. (academic institutions and industries) could participate and form a consortium for designing solution for water challenges to meet the utility price envelop of countries similar to India and for tapping business opportunities in global markets. The specific activities emerged from the outcome of the interactions helped to embark upon Indo-Dutch Water Cooperation journey to develop the bilateral collaboration in the sector.
- A concrete start has already been made under a series of Joint calls; NWO-DST call on Urban Water Systems evolved the Indo-Dutch consortia - Water4Change being led by IIT Roorkee, India and Delft University, The Netherlands that envisages to develop context specific fit for purpose smart and water sensitive guidelines for planning, design, governance, infrastructure and socio ecological aspects of fast growing secondary cities with Bhopal, Bhuj and Kozhikode as pilots representing different climatic conditions which is in line with the National Mission of Smart Cities.

- NWO – DST Jointly launched a call on Cleaning Ganga and Agri-Water which envisaged to improve surface and groundwater quality along with availability in the catchment area of the Hindon basin. Under this call, DST-NWO is working on evolving Indo-Dutch collaboration to reduce agricultural water extraction and improve the water use efficiency through improved irrigation technologies or other water conservation methods. The call addressed several SDG's, in particular 2 (Zero Hunger), 6 (Clean Water and Sanitation) and 13 (Climate Action). In The Netherlands this topic links to the top sectors Water & Maritime, Horticulture & Starting Materials and Agro & Food and one of the 4 societal missions defined in the new Mission-Oriented Research and Innovation Policy, 'Agriculture, water and food'. This call in Indian context was in line with the significant National Missions such as "Namami Ganga" and "Swatch Bharat".
- DST-NWO has jointly supported three Indo-Dutch (DST-NWO) bilateral consortia projects under the above Bilateral call on Cleaning the Ganga and Agri Water Nexus. The Hindon sub- basin region has been selected as a case area. The consortia supported under this call are led by premier research Institutions from the Indian and Dutch side with the following envisaged activities dealing with the collaborative research for studying the impact of agriculture on water quality and quantity in the Hindon basin of the Ganga river system;

    - The Indo Dutch consortia focusing on "***Hindon Roots Sensing HIROS River Rejuvenation through Scalable Water and Solute Balance Modelling and Informed Farmers' Actions***", led by the Indian Institute of Science, Bangalore and Wageningen University (WU), The Netherlands has been suppored. The project envisaged working on in-situ remote sensing and eco-hydrological modelling at field/river basin scale including farmers involvement to develop a package of agri-water interventions and solutions that will reduce the significant

groundwater over-exploitation and aims to improve the surface water quality in the Hindon Basin.

- Other Indo-Dutch consortia supported by DST and NWO jointly that focuses on "***Co-creating Sustainable Agri-Water Use in the Hindon sub-basin - A Multi-Scale Participatory Approach"*** led by Indian Institute of Science & Education and Research (IISER), Kolkata and Wageningen University & Research, Wageningen, The Netherlands. The consortia envisaged to assess the contribution of agricultural practices to water depletion and pollution in the Hindon basin and also proposes to work on identification and development of agricultural pathways in a participatory fashion which can reduce the pressure on the river system while remaining productive and competitive for sustainable agriculture and land- and water-use in the Hindon sub-basin.

- DST-NWO has also supported a third Indo-Dutch consortium that proposes to work on "***Changing the fate of the Hindon river by evaluating the impact of agriculture on the water balance Developing a template for a cleaner Ganga river"*** against the DST- NWO Cleaning Ganga and Agri Water call. The consortia are led by IIT Kanpur from the Indian side and WUR, Hydrology and Quantitative Water Management Group, Wageningen from the Netherlands. This consortium aims to work on developing a hydrological model that will provide a scientific understanding of the hydrological functioning and the impact of agricultural water management of the Hindon sub-basin of the Ganges river.

(3) Indo – French CEFIPRA programme : A bilateral Indo-French joint initiative was launched for networking proposals in the area of waste water treatment and natural water treatment systems. The French Embassy in India and the Department of Science & Technology (DST) had joined hands for Indo-French Scientific Networking Programme in the field of water. The Indo-French Joint call was launched initiating a good response and two networking Indo-French proposals in the area of Waste Water treatment and Natural Water treatment were supported.

(4) DST-INTEL-IUSSTF WAQM programme DST had jointly launched call for DST-Intel-IUSSTF Joint research programme on 'River Water Quality and Air Quality Monitoring" for conceptualization of a Indo US Collaborative research programme on River Water and Air Quality Monitoring in PPP mode. The program is a joint initiative of the Department of Science and Technology, Government of India and Intel with an aim to develop key technologies for sensing, communication and analysis of large scale data collected from autonomous networks of perpetual/ long lived sensor nodes, followed by integration and deployment for water and air quality monitoring in real time.

(5) Indo US Water Advanced Research & Innovation (WARI) Fellowship:

Recognizing that water is of fundamental importance for human development, the environment and the economy, and therefore needs to feature prominently in the development agenda of both India and the United States, the Department of Science and Technology (DST), the Indo-US Science and Technology Forum,

the University of Nebraska-Lincoln (UNL) and the Daugherty Water for Food Global Institute (DWFI) partnered to foster cooperation between scientists and students from both countries through the Water Advanced Research and Innovation (WARI) Program, a dynamic reciprocal visitation program. The program was envisaged to provide opportunity to best and brightest Indian students and scientists to gain exposure and access to world class research facilities at the University of Nebraska-Lincoln; Daugherty Water for Food Global Institute. After successful completion of three years of I phase of the program, the program was extended for II phase in 2018 with both student internship and post-doc fellow modules. Till date, the program has witnessed a total of 25 student interns and 13 Postdoctoral fellows. WARI alumni have authored or co-authored 13 papers in international journals, are preparing or have submitted 23 other papers, given 16 poster presentations and 10 oral presentations, written 5 book chapters, and have been awarded 4 of the 6 collaborative grants applied for. Also one of the WARI Fellow alumni from BHU has been inducted as a Fellow of the National Academy of Agricultural Sciences, New Delhi. Due to the growing popularity and success of the program, three U.S. universities viz Purdue University, Texas Tech University and University of Idaho also came on board in the second phase for hosting Indian fellows and interns in their labs under the WARI program.