Technology Mission: “Winning, Augmentation and Renovation”

Technology Mission: WAR for Water

Plan Document

Prepared by

Union Ministry of Science and Technology

Government of India

On the directive of

Supreme Court of India

Order on Writ Petition (C) No 230 of 2001

Dated 28th April 2009

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1. Background of the Mission WAR for Water

While awarding judgment on a Public Interest Litigation Writ Petition (C) No. 230 of 2001 titled Shri M. K. Balakrishnan and Others versus Union of India and Others filed by Shri Balakrishnan, Supreme Court of India directed the Government of India to constitute a Committee of Eminent Scientists and provide all resources necessary to address and solve the problem of water scarcity in the country through recourse to research and technology on 26th March 2009. Subsequently, through an order dated 28th April 2009, the Supreme Court appointed Secretary, Union Ministry of Science and Technology as the Chairman and Secretary, Union Ministry of Water Resources as member and directed the Committee to find out solutions to problem of water scarcity on a war footing through an order dated 28th April 2009. The court directed that the said Committee should be given all financial, technical and administrative help by the Central and State Governments for this purpose.

The order dated 28th April 2009 directed the Committee under the chairmanship of Secretary, Union Ministry of Science and Technology

- To find out inexpensive methods of converting saline water into fresh water
- To find out methods of harnessing and managing the monsoon rain water
- To manage the flood waters
- To do research in rain water harvesting and treatment of waste water and also recommend
- Any other methods or suggestions including for matters for protection and preservation of wet lands and related issues.

2. Action Report

An Action Taken Report on the directives of the Supreme Court is presented in **Table 1**.

Table 1: Action Taken Report on the directives of the Supreme Court

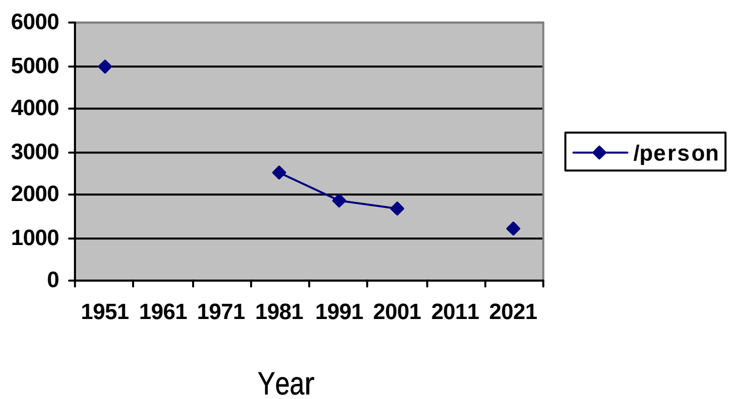
S No	Directive	Action Planned	Action Taken
1	Constitution of Expert Committee	• Selection of members • Seeking consent of members • Constitution of the Technical Expert Committee (TEC) • Issue of order on the constitution of TEC	• Completed • Completed • Completed • Completed
2	To find out inexpensive methods of converting saline water into fresh water	• Spotting and scouting feasible solutions from national and international technology sources	• A Consultative Group consisting of lead organizations was set up to act as a feeder channel to the TEC on availability of technologies in their respective departments as also outside their system. • A compilation of reports on Indian Water Technology systems (**Annexure 1**)
3	To find out methods of harnessing and managing the monsoon rain water and also to manage the flood waters and also to do research in rain water harvesting and treatment of waste water	• Data collection on floods and rainfall. • Scouting and sourcing of technologies for rain water harvesting. • Spotting and sourcing of technologies on waste water treatment • Interaction with the Ministry of Water Resources on technical issues regarding management of flood and rain water	• A Consultative Group consisting of lead organizations was set up to act as a feeder channel to the TEC on availability of technologies in their respective departments as also outside their system • A compilation of reports on Indian Water Technology systems (**Annexure 1**)
4	Any other methods or suggestions including for matters for protection and preservation of wet lands and related issues.	• Organisation of National and International Conferences and workshops to evolve guidelines/ recommendations	• Actions planned during September – December 2009

3. Concept and Approach Plan Proposed

The Union Ministry of Science and Technology recognized the need for imminent technical solutions to the problems of water scarcity in the country. Challenges relating to water scarcity can be traced to several causes. Some such reasons are a) decreasing per capita availability of fresh water, b) loss of quality of available fresh water on account of contamination and poor management practices, c) inadequate harvesting of rain water resources, d) excessive and inefficient use of water in some human activities, e) inability to use available water on account of natural contamination, for example, with arsenic, fluoride, iron etc, f) non-potability on account of salinity, g) non-viability of some available technologies like reverse osmosis and distillation in several socio-economic environments, h) inadequate water body management practices including lakes, reservoirs, rivers, ground water sources etc, i) inadequate flood water management systems, j) non judicious use of water without renovations and recycling and k) urbanization with insufficient infrastructure for sourcing, delivering and recovery of water for multiple use.

It is widely known that the per capita availability of water (in cubic metres) in India is decreasing gradually as shown in **Figure 1**.

Figure 1.: Per capita availability of Water per annum



Global database on various sources of water are presented in **Table 2.**

Table 2 : Share of various sources of water in global supply

S No	Sources of water	Share in global supply (%)
1	Oceans and seas	96.2688
2	Ground water (saline + fresh)	1.68
3	Ice, snow, glaciers	1.72

Table 2 (Continued)		
S No	Sources of water	Share in global supply (%)
4	Lakes (saline)	0.0062
	Others • Lakes (fresh) • Rivers • Biological water • Marshes • Atmospheric moisture • Soil moisture • Other ice and snow	0.325

Table 2 : Share of various sources of water in global supply

Oceans as Sources of Water: It seems logical to draw water supply from oceans in coastal areas on account of oceans serving as an abundant source. However, on account of high salinity, water from oceans is not readily useful. Technologies for sourcing drinking water from oceans through reverse osmosis, distillation and low temperature thermal distillation methods have been reported. Viabilities and management of rejects from reverse osmosis and distillation techniques have posed challenges in wider applications of such technologies. Inexpensive and viable methods for sourcing water from oceans for population in coastal areas are necessary.

Ground and Surface Water: While the urban water supply predominately uses surface and ground water, nearly 70% of drinking water requirements in rural India are met by ground water. The quality of ground water, is variable and often does not meet the drinking water requirements. Often ground water is either brackish or saline or contaminated with excess fluoride, arsenic, iron etc or microorganisms. At few locations, contamination is due to multiple species. As the origin of most of the groundwater contamination is geological, it is quite likely that locations in contiguous areas are affected by similar contaminants. Water challenge in such areas may be similar in character.

In order to augment the available /accessible water, it is necessary that suitable treatment technologies may be implanted to make contaminated water suitable for drinking. More often, hybrid solutions would be required to provide solution to the problem.

Desalination of sea water for meeting requirements of different end users such as agriculture, municipal and drinking using low Temperature thermal desalination, reverse osmosis etc, need to be explored and examined for their social and economic viabilities. The innovative approaches for adapting known but hitherto unexplored and unexploited technologies would be necessary.

Themes and Topics for Research: Recognizing that research on water is being undertaken in several institutions and agencies in a non-coordinated manner currently, the Supreme Court has issued a directive to mount on war footing a research on water for finding out technical solutions to the water related challenges. The court has challenged the research and development agencies to come out with research based solutions to the problem.

Importance of Non Technical Issues in Water Challenge: While majority of the problems associated with water may be on account of in- sufficiency of availability of research-led technology solutions to water body managers and the community, there are also other serious social and community issues which contribute to the aggravation of the problem.

Concept of Technology Mission WAR for Water

Problems associated with water can be broadly grouped as a) availability of water, b) poor quality of water for the intended use and c) indiscriminate use of a valuable natural resource namely water. The technological approaches for solving the problems may therefore emanate from a) Winning water from sustainable resources, b) Augmentation of quality of water from available and accessible sources and c) Renovation for recycle. A Technology Mission on Winning, Augmentation and Renovation (WAR) for water is proposed to address the directives of the Supreme Court of India to the Union Ministry of Science and Technology. The proposed mission is to undertake research-led solutions on war footing through national and coordinated approach.

The Technology mission WAR for Water is developed on the principle that timely, urgent, cost effective, socially viable and sustainable techno-management solutions are required for solving problems of water scarcity.

Approaches needed for Timely and Urgent Solutions

Problems of water challenge require immediate solutions. Therefore, the Technology Mission WAR for water should explore scouting and sourcing of technologies available and accessible from the global experience under real life situations while developing in parallel, home grown solutions through laboratory research. Various approaches planned for finding out viable solutions for water related challenges faced by the community are depicted in **Table 3.**

Table 3: Approaches planned for finding out viable solutions for water related challenges faced by the community

Step	Function	Activity required	Priority actions
1	Mapping the scale, scope and seriousness of the problem in select regions	Mapping a wide range of water related real life challenges in different social environment based on real life data	Data collection. Quantification of water challenges. Assessment of impacted population. Enrollment of the community in selecting likely solutions.
2	Priority profiling and setting	Study of water challenge related problems and their socio economic impact	Selecting criteria for priority selection based on feasibility of solutions and their impact potentials.
3	Spotting and scouting feasible solutions from national and international technology sources	Global and wide national search seeking expression of interest	Global and National advertisement for expression of interest to provide viable solutions to selected water challenge.
4	Expert Study and Evaluation	Scientific and technical Assessment and quantitative ranking of offered solutions	Interactions with technology providers and offers of solutions.

Table 3 (Continued)			
Step	Function	Activity required	Priority actions
5	Matching of solution with problems in real field locations	Research and analysis of offered solutions for solving the selected specific problem	Extensive research and bench study for solution selection.
6	Resource planning and flow arrangements	Project planning and implementation document for every single site	Fund mobilization and allocation for intervention in each location.
7	Pilot under trial examination under real life conditions	Enrollment of the community leaders for rooting the selected solution(s)	Internalizing a study group for every solution selected for pilot trial.
8	Data analysis and scope for applications of technical solutions	Expert assessment and economic and social viability analysis	Cost and social viability ranking of solutions found out.
9	Finalization of selection of options of technical solutions for each water related challenge along with site specificity	Finalization of solution methodologies for each type of water challenge for subsequent replication	Finalization of research report on solutions found out.

4. Formation of Technical Expert Committee (TEC)

In pursuance of the directives of the Supreme Court through order on writ petition (C) No. 230 of 2001 dated 28th April 2009, a Technical Expert Committee with Secretary, Union Ministry of Science and Technology as the Chairman has been formed and notified.

The copy of the order is presented in Annexure 2. The CVs of the technical experts included in the TEC are appended in Annexure 3. A panel of 20 experts has also been prepared for wider consultation on specific technical matters from time to time. The panel is presented in Annexure 4. This panel can be enlarged, as and when need arises. The Technical Expert Committee will be serviced by the Department of Science and Technology. The Technical Committee will meet as frequently as needed and it will form the main committee for finding out research and development solutions directed by the Supreme Court.

The Technical Committee will also be assisted by various executive systems as shown in the Chart 1.

Chart-1: Executive Systems for assisting TEC

** Successful Outputs from research on war footing will be delivered to the National Water Mission and other programmes being proposed by the Government for possible scale up and replication

5. Approach plan for selecting and Demonstrating Technical Solutions through research

The selected approach plan includes selection of about 25 different water related challenges in select locations and matching most appropriate technology solutions within the capacity of the local community to apply the solution in a sustainable manner followed by technical scale evaluation and proving of viabilities in credible sizes.

Total of eight steps have been recognized under Technology Mission: WAR for water which are presented in Chart 2. Many successful innovations in coping with water challenges have been reported. A special effort to identify such successful examples and include further research for their replication in other locations forms also a strategy and the approach plan. Some of the plausible technology solutions emanating from the research already completed have been captured and presented in Annexure 1. Several hard and long term options may need to be evaluated for locations where the current per capita availability of water is already below 1000 M^3 .

Agriculture and irrigation form some the most water demanding use in the country. Water saving agriculture, renovation of waste water for multiple uses will have to emerge necessarily as integral part of the Technology Mission: WAR for water. Countries like Israel and Russia have adopted non-conventional technologies to cope with their water challenges. Some valuable lessons can be learnt from the experience of other countries. Certain solutions for water challenges will involve management more than technology. Scientific approaches to management will become the priority of dealing with such challenges.

Twenty-five water related challenges being identified will include a) low per capita availability, b) quality deficit of available water for specified uses, c) geological contamination through arsenic, d) contamination through fluoride, e) contamination through iron, f) contamination through multiple species, g) biological contamination, h) alkali metal ion salinity i) alkaline earth metal salt salinity and hardness, j) storage capacity for seasonally available water, k) surface run-off on account of nature of geological terrain, l) water body disuse, m) mismatched rates withdrawal and recharging capacity, n) non-optimal use of water in agriculture, o) non-optimal use of water in industrial sector, p) unplanned water use and demand, q) contamination of water on account of pesticide and other use-derived residues, r) deficit of assurance for drinking water quality, s) sea water intrusion in coastal areas, t) evaporation loss from water bodies, u) non-sustainable water cycle management, v) reject management from water related technologies, w) water winning and mining in water starved areas, x) river flood management and y) wetland management.

Water related challenges may arise out of multiple causes and scientific solutions may demand several and innovative approaches. It is likely that multiple technology solutions may be found out. It is therefore preferable to scout for possible solutions for the diverse water related problems in the country through globally available opportunities. Since water is an essential need for living systems, sustainability and viability of recommended solutions will form a crucial part. Therefore, solutions emanating from research should be practically proved for their viability and sustainability in a convincing manner in credible scales before the claims of feasibility of solutions are made.

Since urgent solutions are required, application research on convergent water technology solutions has been prioritized over developmental research for on water technologies in the laboratories. Technology Mission WAR for water will therefore focus on adaptation and absorption of technologies in differing social contexts. Selected research plan detailing the work elements for finding out viable technical solution for various water challenges in the country is presented in Chart-2.

Chart-2 : Research plan detailing the work elements for finding out viable technical solution for various water challenges

6. Methodology Planned

- Identification of two contiguous villages having a population ~10000 (2000 families) with similar water challenge.

- Expression of interest from solution providers to provide 40 lpd water for municipal and 3 lpd water for drinking purposes per person at a cost of Rs 125 p.m. per family (Rs 1500 per annum per family) i.e. a revenue of Rs. 30 lakh per year for catering to a population of 10000 complete with reject management. Indicative cost will vary for locations affected by heavy metal contaminants, brackishness, excess salinity etc.

- Standardization of initial investment and two years operation and maintenance cost by Technical Expert Committee.

- Evaluation of performance of system by a Committee of Experts data to be collected on quality of water, operation and maintenance requirement, power consumption, back washing, media replacement/ regeneration etc as per standard protocols.

- Up scaling of system to meet requirement for population of 1 lakh at two locations.

- It is proposed that the above methodology would be adopted to develop solution model for 25 diverse water scarcity problems in different geographical region of the country covering a population of 50 lakh.

7. Research Packages planned under Technology Mission WAR for Water

Under the directives of the Supreme Court, research on War footing is being undertaken to find out viable solutions to various water related challenges in different locations in the country employing a dis-aggregated approach. Winning, Augmentation and Renovation (WAR) for recycle will form the basic concepts under Technology Mission WAR for water. Total of seven research packages are envisaged under Technology Mission WAR for Water.

Article I.

Research Package on Data Gathering

- Selection of water related challenge and likely technical solutions
- Collection of site specific data on various locations of India with differing water challenges
- Collection of information on impacted population including the economic status for building internal revenue and recovery models

Article II.

Research package for Development of Transparent Criteria

- Research on available and emerging technologies for water technologies
- Desk studies on techno-economic feasibility of various available technology solution options based on site specific conditions
- Drawing up of transparent criteria for assessment and ranking of technology options

Article III.

Research Package on Scouting for Feasible Global Technical Solutions

- Drawing up technical specifications for inviting global tender for technical and viable solutions for each type of water challenge
- Seeking expression of interest from technology solution providers with preparedness for Build-Operate and Transfer capability for serving a human population of 10,000
- Assessment of various technical offers made through transparent criteria by technical experts

Article IV.

Research Package on Least cost and best Revenue model of Technology solution

- Pilot level evaluation of various selected options of technology solutions under different site specific conditions for commercial level operations
- Techno economic assessment of various pilot level trials and listing of least economic cost options
- Social audit of various least cost technology options and social impact study for sustainability

Article V.

Research Package on sizing of economy of scale and scoping for least cost solutions

- Field level assessment of the selected site specific technology solutions for scoping and scaling up for serving a habitat of 100,000 human people in an area contiguous to the successful sites
- Socio economic impact assessment of credible technology solutions complete with revenue model for sustainability
- Research on fiscal policy support measures needed, if any, for sustainability assessment

Article VI.

Research package on site neutrality of selected solutions

- Technology solutions with internal revenue model for sustainable use for a human habitat of 100,000 in non-contiguous areas for replication
- Research on the impact of socio economic conditions on the sustainability of selected solutions
- More precise definition of boundary conditions for usability of technical solutions found out for serving the needs of habitat with 100,000 population

Article VII.

Research package on Hybrid options of technology Solutions for Urban/ Metro use

- Research on hybrid options of technology solutions for large communities with matching purchasing power
- Technology solutions with provisions for renovation and multiple use of water in high demand areas
- Laying technology spread sheet for techno economically viable options as a function of a) quality of available water b) socio economic conditions of the region and c) socio cultural
- Research on feasibility of drawing up water standards
- Research on technology –policy interface for decision makers

8. Implementation Strategies and Activities planned

Once the technological options and other related issues are finalized, a few water stressed villages are identified. The following broad activity is drawn up for implementing the scheme:

- Set up pilot plants for convergent technology solutions for water challenge in each region covering a total population of approximately 10,000 to prove the concept at ground level and undertake research on sustainability.

- Upscale the facility to cover about 100,000 people in the same contiguous region and then for meeting the needs of a similar population in a different geographical terrain and raw water sources for assessing site neutrality of the solution found out.

- Documentation and dissemination of knowledge for replication.

9. Mechanisms envisaged for speedy decision making and implementation of the Supreme Court Directive

Technical Expert Committee constituted will execute the directives of the Supreme Court and find out solutions for countering the problems of water scarcity. The Committee will submit its final report before August 2011. The final set of research reports for different types of water challenges would include technology solutions complete with revenue models, boundary conditions for applications and technology –policy reports for onward submission to state and central Governments.

The Chairman of the Technical Expert Committee has already approached the Government of India to constitute an empowered committee of secretaries with adequate administrative and financial powers to ensure the availability of resources required for the implementation of WAR for water under the directives of the supreme court in finding out research solutions for water problems. Committee of Secretaries will help in implementing the recommendations of Technical Expert Committee and report to the Union Government of the various stages of development of the technology mission.

The proposed arrangement of Committee of Secretaries is expected to link the Technology Mission: WAR for water to state and other central government departments. The implementation and replication of solutions will require the support and resources available with the various state Governments. Various and suitable mechanisms available to different departments of the Government of India to involve the state governments will be employed for spreading economically and socially viable solutions emanating from the research coordinated by the Technical Expert Committee.

10. Programme Management

The activities and the progress of the mission will be monitored by the TEC as mentioned earlier, and also the TEC will report the progress to the Hon. Supreme Court. In addition to the TEC it is proposed to constitute 2 more Committees as follows:

- Committee of Eminent Scientists
- National Consultative Group

It is also proposed to create a Technical and Management Secretariat to service all the committees. Following are the details of these committees along with their broad terms of reference:

The Committee of Eminent Scientists (CoES)

The Committee of Eminent Scientists (CoES) is an advisory body and will consist of members with global eminence drawn both from India and abroad, including NRIs. Secretary DST will serve as its Member – Convener.

This Committee will be the Advisory Council to the Ministry of Science and Technology and to the Technology Mission WAR for water on all matters pertaining to technology mission for meeting the challenges with regard to finding solutions to water shortage problems faced by the country.

The Committee would also review the overall performance of the S&T Mission and recommend pro-active measures for mitigation of water shortage issue. The Committee would also advise on mid-course changes and trajectories during the mission period based on the R&D outputs and technological changes in the external environment.

National Consultative Group (NCG)

A National consultative group comprising of representatives from various departments who have a stake in the area of water management has been formed to :

- Link and connect their parent departments and the autonomous institutions with the Water Technology Mission
- To serve as the single window for facilitating two way information flow between the mission secretariat and their parent agencies

- To effectively coordinate with TEC, Thematic Working groups, mission secretariat and their parent agencies
- Suggest suitable projects / technologies in the theme area for consideration by the TEC.

The meeting of Consultative Group was convened on 2nd May 2009 wherein it was transpired that addressing the scarcity of water necessitated

Scouting of the existing water related technologies available nationally and internationally.

- Implementation of such technologies for examining their effectiveness and appropriateness under various socio-economic contexts.
- Chanellising the technologies so examined for research under real life conditions.
- Large scale application of successful technologies across the country and finding the solutions to the existing problems.

Technology Mission Secretariat

The programme envisages a nationally coordinated effort involving more than a few hundred researchers, academic and research institutions, industry and the NGOs of the country. There is also a need to gather and evaluate information on technological solutions becoming available globally by a team of technical experts. Therefore, a lean and dedicated Mission Secretariat comprising of an administration and a technical wing is proposed to be constituted for serving the administrative, technical and financial requirements to execute the Mission. This secretariat will serve the above committees and also will be responsible for filing progress reports to the Supreme Court and the Government periodically.

The Mission Secretariat would:

- Serve as a full time technical secretariat to the Chairman and the Technical Expert Committee
- Establish and liaise effectively with the Ministry of Science and Technology and Ministry of Water Resources for water Technology and management mission components
- Provide opportunities to solution providers for making presentations and shortlist possible and viable solutions for review by the TEC
- To coordinate with all the Principal Investigators involved in the mission mode projects and prepare technical reports on bi-monthly basis
- To ensure the availability of timely and adequate financial resource inputs for all the technical teams involved in the mission mode projects
- To serve as an online link between the principal investigators and the implementation committees and prepare technical progress reports
- To prepare suitable technical reports for advising the field teams and personnel for implementation of solutions.
- To connect with partners and alliances on technical matters and
- To serve any other necessary function recognized by the Chairman of the TEC

11. Time Scheduling

Table 4 : Time Scheduling

S No	Activity planned	Start date	Completion date	Output expected
1	Notification of the Technical Expert Committee		29 June 2009	Order Notification
2	Finalization of Concept plan	April 2009	30 July 2009	Work plan document
3	Constitution of all Committees	May 2009	August 2009	Committee notification
4	Report of Progress of work to the Supreme court		11 August 2009	First progress report (April – July 2009)
5	First meeting of the Technical Expert Committee (TEC) and formation of sub committees for technical evaluation and selection of technologies	August 2009	31 August 2009	Technology selection report and minutes of the meeting
6	Collection of data on water challenges in various and possible sites for research on technology solutions	July 2009	September 2009	Identification of about 25 water challenged sites with 10,000 human population for intervention
7	Selection of sites for research solutions	August 2009	October 2009	Specific work plan for each selected site with revenue models
8	Report of Progress to the Supreme Court		20 October 2009	Second Progress Report (Aug-Sep 2009)
9	Finalization of tender specifications for pilot level demonstrations of convergent solutions	August 2009	October 2009	Tender and selection criteria for assessment of technical merits
10	Issue of tender for global solutions for each specific water challenged site		October 2009	
11	Second Meeting of the Technical Committee and various sub committees		November 2009	Assessment of the Expression of interest and technical evaluation report
12	Report of Progress to the Supreme Court		December 2009	Third progress report (Oct-Nov 2009)
13	Presentations by the technology solution providers to sub committees of the TEC	November 2009	Ongoing for about four months	Technical evaluation and selection of solutions
14	Selection of first set of solutions for about ten sites of 10,000 population	January 2010	March 2010	Pilot study plan report complete with financial investment statements
15	Report of Progress to the Supreme Court		February 2010	Fourth Progress report (Dec 09-Jan 10)

Table 4 (Continued)

S No	Activity planned	Start date	Completion date	Output expected
16	Selection of second set of solutions for about additional water challenged sites	January 2010	April 2010	
17	Commencement of pilot research studies in different locations	March 2010	July 2010	
18	Report of Progress to the Supreme Court		April 2010	Fifth progress Report (Feb-Mar 2010)
19	Performance evaluation of technical solutions for 10,000 population	April 2010	June 2010 September 2010	Sixth Progress Report (April- May 2010) and Seventh Progress Report (June- July 2010) on technical solutions
20	Ranking of various solutions based on performance	August 2010	October 2010	Eighth progress report (Aug- Sept 2010) listing ranking of technologies
21	Selection of cost effective and feasible solutions for different water uses and various input water quality	June 2010	June 2011	Short-listing of Purpose specific and source specific technological solutions in
			Dec 2010	Ninth Progress Report (Oct – Nov 2010)
			March 2011	Tenth Progress Report (Jan – Feb 2011)
			May 2011	Eleventh Progress Report (March- April 2011)
22	Submission of final research report complete with details of solutions found out		July/ August 2011	Set of research reports for different types of water challenges complete with revenue models, boundary conditions for applications and technology –policy reports for onward submission to state and central Governments Submission of twelfth and final report to the Supreme Court

12. Reporting systems

The technologies suggested for providing safe drinking water and experiences gained at the field level on implementation of various schemes adopting appropriate technology suitable to specific locations will be documented. Viability of the schemes and its social acceptability will be assessed for sharing with various stake-holders. Criteria of selection based on feasibility of solutions and priority will be assessed and listed out. Management information systems and exception reports, detailing critical progress parameters in spreading the initiative, will be compiled and presented at regular intervals, for review and mid-term course correction by the concerned authorities.

Technical Expert Committee, represented by its Chairman will be the body reporting to the Supreme Court of the progress of work. TEC will receive suitable advice from time to time from the Committee of Eminent Scientists and support from an empowered Committee of Secretaries for administrative and technical decisions.

Minutes of the meetings of all the committees viz. CoES, TEC, WG, CoS and their sub committees will be recorded and reported to appropriate agencies depending on the technical merit.

A dedicated mission secretariat will be constituted within the Department of Science and Technology which will compile periodically and every two months technical reports of progress of work. Totally twelve technical reports are planned for submission to the Supreme Court during the 24 month project period.

The mission secretariat will also prepare a technology solution report for every water challenge addressed and make the reports available to the concerned user departments as and when a viable technical solution is found out through research. These reports will be submitted to the Committee of Secretaries for its information and Committee of Eminent Scientists for its advice.

The mission secretariat will evolve a system for publishing a News letter for wider circulation among the civil society, state Governments and other user agencies for ensuring wider reach and dissemination of successful outputs of research. Successful research solutions will be reported in a special portal developed for Technology Mission WAR for water.

Half yearly reports on the Technology Mission on WAR for water will be prepared and submitted to various agencies in the Central and State Governments for possible implementation of successful research outcomes through their own internal programmes.

At the end of the project period, an outcome report will be prepared. A project management and lessons learnt report will also be submitted to the Government of India.

13. Planned Deliverables

- Research Package on Data Gathering
- Research Package for Development of Transparent Criteria
- Research Package on Scouting for Feasible Global Technical Solutions
- Research Package on Least Cost and Best Revenue Model of Technology Solution
- Research Package on Sizing of Economy of Scale and Scoping for Least Cost Solutions
- Research Package on Site Neutrality of Selected Solutions
- Research Package on Hybrid Options of Technology Solutions for Urban/ Metro Use

There have been several innovations under real field conditions in India already. Some of those innovations will be evaluated for replication under similar social conditions. Global best practices will be captured. Some successful case studies from global examples will be captured and adapted to the Indian conditions.

The project activity would finally conclude with the production a project document indicating the nature of water problem in different parts of India and will have the matching technologies / management prescriptions for solving the identified problems. This document will be transferred to the respective line ministry for further popularization amongst the different stake holders including the community and the Zilla Parishad to adopt and become self reliant in solving the water problem in their area with minimal support from the government.

14. Concluding Remarks

Water is a fundamental need for human civilization. Although conservation of mass principle would stipulate that the total quantum of water will remain unchanged over time, the availability of usable quality water per person is changing adversely in the world. The Supreme Court of India has recognized that science and technology could provide viable solutions to the mounting water related challenges. Since water challenge is a result of several social and managerial conflicts, resolution of conflicts might need more tools than what science and technology can offer. However, science and technology can certainly provide viable and innovative tools for managing the net water demand and supply. The proposed "Technology Mission WAR for water" has been prepared by the Department of Science and Technology with a commitment to show case what Indian research and development community can do to the country through solution science and scientific approaches in a time bound manner.

The final output of the Technology Mission WAR for water will be some technology solutions found out through careful research by a large group of Indian researchers. These solutions will be captured in the form of reports of successful solutions pilot demonstrations in select locations in the country, perhaps benefiting about 5 million people. The outputs of the Technology Mission WAR for water will quite likely form inputs to other national initiatives on water for possible study and replication.

ANNEXURES

TECHNOLOGICAL APPROACHES FOR PROVIDING SAFE DRINKING WATER FOR RURAL AND REMOTE AREAS

Introduction:

The Government of India has been vigorously pursuing with all necessary efforts to provide safe drinking water in a reliable and cost effective manner in the last few decades through a variety of channels including Rajiv Gandhi National Drinking Water Mission (RGNDWM) and Bharat Nirman Yojana. Every scientific organisation has also been working towards development of suitable devices for mitigating some of the perennial problems related to salinity, fluoride, nitrate, iron, arsenic and microbial contamination of groundwater. The causes for deteriorating situation are many including the population growth, increase in per capita requirement with change in life style, cross contamination of fresh water sources with effluents, overexploitation of groundwater resources, etc. It is difficult to quantify the affected habitations as new ones are getting added. An integrated approach involving means to conserve the existing resources, reduce the demand by promoting a quality based use pattern and imbibing responsibility to operate and maintain the technological devices of water purification is the need of the hour. This can perhaps be achieved through education, participation and simple technological devices.

Several national laboratories are involved in the development and evaluation of technologies suitable for desalination and water purification under rural environment. The efforts have resulted in innovative ideas for the deployment of the technologies in tune with the local environment. The experience in the last two decades has revealed a variety of problems and local constraints, requiring more emphasis on technology adoption and absorption involving community participation. Inherent constraints include the rapidly depleting natural groundwater resources and safe disposal of the contaminated reject streams. The major operational problems are the erratic power availability and economics. It is necessary to formulate a balanced strategy so as to fulfil the desired objectives within the constraints. The role of desalination and water purification technologies is very important, besides conservation of the natural resources, as a part of the balanced strategy for providing safe drinking water.

Water Quality Problems:

The major problems that constraint the availability of safe drinking water are:

- Excess salinity due to geological conditions.
- Contamination of surface sources mainly by bio-organisms.
- Contamination of groundwater due to fluoride, arsenic, nitrate, iron and of late chromium from the geological sources.

Technological Approaches

Two philosophies are normally adopted depending on the treatment stage. Point of entry treatment refers to the treatment carried out at the source of distribution while in the point of use devices the treatment is carried out at the user point. Point of entry treatment is economical and convenient but becomes the responsibility of supplier and is vulnerable to contamination across the distribution channel. Ensuring equitable distribution is difficult and results in higher percentage of wastage. On the other, the point of use devices have to be maintained and operated by the individual assuring him of his supply but is subjected to the availability of suitable device and adequate contaminated water in the premises. The per capita capital expenditure may be more compared to community treatment plants. The technological devices should be simple and wherever possible should be suitable for household operation, with minimum chemical or physical intervention. Also the device should be less dependent on external energy sources. Dead end devices, which reject the contaminants as solids are preferable to ensure maximum conservation of water resources. A number of national laboratories have developed technologies for the removal of arsenic, fluoride, etc. by sorption techniques and for iron removal by aeration – filtration sequence. Some household gadgets also have been reported based on similar methodologies. Some of the community devices are under trial operation. The basic difficulties are the disposal of the sludge and monitoring of the quality of water, which depends on the operating parameters.

Membrane Processes:

Membrane processes are eco-friendly processes and operate on physical or physico-chemical mechanisms and hence require minimal chemical intervention. Depending on the chemical structure and surface morphology, a variety of membranes can be made varying in pore-size and chemical nature.

Bio-contamination is a major problem as the entry route is not confined to geo-hydrological parameters or industrial effluents alone but also can arise while transportation or in the distribution system. With all the micro-organisms being larger than 3 nm, bio-decontamination can be achieved using ultra-filtration (UF) membranes. UF based devices could be useful where other contaminants are absent. Since the average pore sizes are larger compared to RO & NF, the requisite pressure is much less to force pure water through the pores. In fact, the device developed by BARC can operate between 3 to 20 meters of water column without the need for external power source. Since iron removal mechanism involves oxidation – filtration, the same can be achieved using the domestic filters with minor modification to allow aeration. The device developed and transferred to many parties for commercial exploitation has been doing very well. The membranes made of poly-sulphone can produce crystal clear, micro-biologically safe water in capacities above 40 litres/day. Being a dead end device, operation is simple. It is almost maintenance free except occasional cleaning of membrane cartridge.

Reduction of Salinity & removal of Fluoride, Arsenic and Nitrate:

Salinity reduction has to be achieved by any of the desalination technologies. Selection of the process is purely a site specific decision. Islands like Lakshadweep have wasted heat from DG sets (in cooling water) and seawater can be easily sourced. Therefore, thermal technologies using waste heat could be deployed. In these islands the depth of sea increases suddenly increases after a few hundred meters from the coast, thus providing conducive environment for thermo-cline desalination which has less maintenance problems. The unique conditions of the island with paucity of land and inadequate infrastructure, this technology could be more suited compared to SWRO Plants albeit at a higher technological defined water cost. However, the situation is different for a vast majority of inland villages constrained by inadequate infrastructure, poor logistics and less general awareness amongst the local habitants.

Salinity problems or salinity associated with fluoride or nitrate or arsenic can be treated with reverse osmosis. However, the design may have to be done carefully particularly with respect to recovery so that both permeate and the reject streams can be utilized albeit for different end uses. For a decent quality of living , one needs about 100 litres per capita day out of which only about 10 litres are required for drinking, cooking and mouth & face washing. The remaining is required for washing of clothes, flushing, etc. Operating the plant at low recoveries would lead to less energy consumption, less maintenance and better permeate quality. This combined with partial recirculation of reject, depending on the feed salinity can lead to less exploitation of the groundwater.

When the water is contaminated with As or F but without any salinity problems it may be possible to use RO at very high recovery with tap water/ low solute rejection brackish water membranes with treatment of reject through sorption technologies to prevent the contaminant slopping back to the environment. As far as nitrate is considered, there is no established method to remove it and the present strategy is to blend the water with other sources of fresh water and distribute maintaining the nitrate content below the desirable limits.

Ultrafiltration coupled with aeration mechanism shall be adequate for the removal of iron. Complexation ultrafiltration is a novel idea where the contaminants sizes are increased by complexing with some organic ligands so that they are rejected by the UF membrane.

Conclusions:

Membrane based devices could be the future trend in providing safe drinking water. Already ultrafiltration based devices have been successful for the removal of bio-contaminants and iron. Further efforts would lead to point of use devices for other contaminants also. For point of entry treatment for communities, total dedicated participation by the local habitants will be the key to the success of the programme.

Technologies for Recycling of Wastewater

The Population of India is likely to be stabilized by 2050 at the level of 1700 million people. The urban population for the year 2051 is likely to be of the magnitude of 850 million when about 50% population will live in cities. The per capita wastewater generation shall be around 981 lpcd (by the conservative estimate) based on the average wastewater generation observed during the four studies carried out by CPCB. However the actual measurement of drains carried out in National Capital Territory of Delhi on monthly basis indicates the per capita wastewater generation over 220 lpcd. The development process has gained momentum and the basic infrastructure is the priority that includes piped water supply and sewerage system for management of wastewater. In these circumstances wastewater generation from urban population will be enormous.

Recycling is defined as the internal use of wastewater by the original user prior to discharge to a treatment system or other points of disposal. The term `reuse' applies to wastewaters that are discharged from municipalities, industries and irrigation, and then withdrawn by users other than the dischargers. After treatment, reclaimed waters are generally used for irrigation, cooling water, algal cultivation and pisciculture, apart from other industrial applications.

- Municipal wastewater generation is about 75% of the supply. Only a part of this can be recycled.
- Industrial applications such as thermal power plants can have higher (~98%) recyclables, but other industries generally have less recyclable water.
- But since the projected industrial requirement (~193 km^3/ yr) for 2050 is more than the domestic requirement (102 km^3/ yr) that includes drinking and potable needs, the overall recyclable water may be ~60% of the supply.
- At 60% of the supply, estimated recyclable water is between 103 and 177 km^3/ yr for low and high population projections respectively.

Municipal/ Domestic sewage Water recycling is possible by using advanced aerobic, anaerobic process, membrane process and membrane bioreactor. Membrane Processes using combination of ulta-filtration , reverse osmosis etc have also been used for treatment of industrial effluents.

WATER SCENARIO IN INDIA

Introduction

India is the 2nd country in the world having the highest precipitation. In our country 85% of water is used for farming, 10% for industry and 5% for domestic use. The competition between these is increasing day by day. Due to increasing population and pollution due to human activity, the supply of water is reducing. As per the World Watch Institute, India will be a highly water stressed country from 2020 onwards. The meaning of water stress is that less than 1000 cubic metre of water will be available per person per annum.

Water Scenario

On an average the rainfall received in our country is 1200mm, with maximum of 11000mm in Cherrapunji and the minimum average rainfall in West Rajasthan of about 250-300mm.

Urban Water Scenario

Even though the rate of urbanization in India is among the lowest in the world, the nation has more than 250 million city-dwellers. Experts predict that this number will rise even further, and by 2020, about 50 percent of India's population will be living in cities. This is going to put further pressure on the already strained centralized water supply systems of urban areas.

The urban water supply and sanitation sector in the country is suffering from inadequate levels of service, an increasing demand-supply gap, poor sanitary conditions and deteriorating financial and technical performance. According to Central Public Health Engineering Organisation (CPHEEO) estimates, as on 31st March, 2000, 88 per cent of urban population has access to a potable water supply. But his supply is highly erratic and unreliable. Transmission and distribution networks are old and poorly maintained, and generally of a poor quality. Consequently physical losses are typically high, ranging from 25 to over 50 per cent. Low pressures and intermittent supplies allow back siphoning, which results in contamination of water in the distribution network. Water is typically available for only 2-8 hours a day in most Indian cities. The situation is even worse in summer when water is available only for a few minutes, sometimes not at all.

According to a World Bank study, of the 27 Asian cities with populations of over 1,000,000, Chennai and Delhi are ranked as the worst performing metropolitan cities in terms of hours of water availability per day, while Mumbai is ranked as second worst performer and Calcutta fourth worst.

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In most cities, centralized water supply systems depend on surface water sources like rivers and lakes. Chennai, for instance, has to bring in water form a distance of 200 km whereas Bangalore gets its water from the Cauvery river, which is 95 km away. Where surface water sources fail to meet the rising demand, groundwater reserves are being tapped, often to unsustainable levels.

Delhi: The nation's capital is perpetually in the grip of a water crisis, more do during the dry season, when the situation gets particularly worse. As the demand-supply gap widens, more groundwater is being exploited. Of the water supplied by the municipality, approximately 11 per cent comes from the groundwater reserves and remaining from the Yamuna river. It is, however, difficult to establish the total quantity of groundwater extracted because a large number of tubewells (owned by individuals, industries and bottled water companies) remain unregistered.

Chennai: The main sources of public water supply in the city are the three reservoirs – Poondi, Redhills and Cholavaram – with an aggregate storage capacity of 175 MCM. Even when the reservoirs are not full, they get inflows from intermittent rains, which is then drawn. On the other hand, losses due to evaporation from the reservoirs result in the effective availability being lower than the storage.

The other major resource is groundwater from the well fields in the Araniar-Kortaliyar basin and the southern coastal aquifer, and a large number of wells and tubewells spread all across the city.

Over-extraction of groundwater in the north western coastal belt resulted in a rapid ingress of seawater, which extended from 3 km inshore in 1969 to 7 km in 1983 and 9 km in 1987. Groundwater levels within the city also fell and brackish water began to appear even in localities which earlier had good quality groundwater sources.

Bangalore: With a population of 5,686,000, Bangalore is India's fifth largest city. As per the estimates of the Bangalore Water Supply and Sewerage Board (BWSSB), the total demand of water is 840 million litres per day (MLD) (assuming a population of 6 million and a supply rate of 140 litres per capita per day [lpcd]). The demand works out to be 1200 MLD, at the standard rate of 200 lpcd set by the Bureau of Indian Standards (BIS) for water.

Water Conflicts

Severe water shortages have already led to a growing number of conflicts across the country. Some 90 per cent of India's territory is drained by inter-state rivers. The lack of clear allocation rules, and uncertainty about what water each State has a right to, imposes high economic and environmental costs. The conflict over the Cauvery river water between Karnataka and Tamil Nadu, the Godavari river conflict between Maharashtra and Karnataka and the Narmada water conflict between Madhya Pradesh and Gujarat are all ongoing conflicts which are being fought in the Supreme Court of our country. On the international front, India has clearly demarcated water rights with Pakistan through the Indus Waters Treaty. However, we still have a problem with Bangladesh when it comes to the distribution of the water of the Ganges.

Climate change worsens the scenario

Sewage and waste water from rapidly growing cities and effluents from industries have turned many rivers, including major ones, into fetid sewers. Massive investments are needed in sewers and wastewater treatment plants to protect people's health and improve the environment.

Climate change projections show that India's water problems are only likely to worsen. With more rain expected to fall in fewer days and the rapid melting of glaciers – especially in the western Himalayas – Indian will need to gear up to tackle the increasing incidence of both droughts and floods.

There is clearly an urgent need for action. First, India needs a lot more water infrastructure. Compared to other semi-arid countries, India can store relatively small quantities of its fickle rainfall. Whereas, India's dams can store only 200 cu.m. of water per person, other middle-income countries like China, South Africa, and Mexico can store about 1000 cu.m. per capita.

New infrastructure needs to be built especially in underserved areas such as the water-rich northeast of the country where investments can transform water from a curse to a blessing. Furthermore, India desperately short of power in peak periods, has utilized only about 20 per cent of its economically viable hydropower potential, as compared to 80 per cent in developed countries. The country needs to invest in water infrastructure at all levels from large multipurpose water projects to small community watershed management and rainwater harvesting projects.

River Basins

India has a large potential for utilization of water resources as it contains large number of rivers. In addition to this there are numerous water reservoirs in the form of lakes and ponds, both natural and man-made.

India is also bordered by Bay of Bengal, Arabian Sea and Indian Ocean and has a coastline of more than 7,000 km. The total navigable length of inland waterways is 14,500 km. With regard to this, India now requires efficient water resource planning and management.

Water Resource Planning and Management

The water resources is going to be the most serious problem that the country will be facing in the 21st century. The total demand for water has been projected as 400 km^3. Total annual precipitation in India is about 4000 km^3. Groundwater contributes70-80% of agriculture produce in India, about four-fifths of the domestic water supply in rural areas and about 50% of urban and industrial uses. From the estimated utilizable freshwater resources of about 1130 km^3, only less than 600 km^3 has been put to use at present. Climate changes account for 20% increase in water scarcity and balance 80% is due to population increase and economic developments resulting in water pollution. Demand for freshwater by the industrial sector rose from 3% in 1990 to 4% in 2000 and will be up to 11.5% in 2025. The share of irrigation demand is projected to decline from 84% in 2000 to 73% in 2025.

According to the latest census, India's population is about 1020 million, which is projected to go up to 1333 million by AD 2025 and further to 1640 million by AD 2050. It is projected that the per capita water availability in India may reduce to about 1200 m^3/year by 2047.

The change in human attitude towards water resources is also important as the resources are not unlimited and moreover they must be preserved for future generations. Another important step can be the interlinking of all rivers flowing within the Indian territory. Unless we take into cognizance the intensity of the water scarcity, nothing will happen. States with flowing rivers must behave with a level of maturity and the Centre should act as a mediator. In this way water could reach every part of the country and droughts may be prevented.

Technologies for Desalination

Desalination refers to the process by which pure water is recovered from saline water by the application of energy. It is energy intensive process. Most of the commercial desalination plants as on date use thermal, mechanical or electrical energy. The amount of energy required for separating 1000 litres of desalinated water from seawater varies from about 3 kWh to about 16 kWh depending on the type of process and design constraints even through the thermodynamic requirement is only about 0.7 kWh. The commercially relevant desalination processes are broadly classified as thermal and membrane processes. Multistage Flash (MSF), Multi-Effect Distillation (MED) and Vapour Compression (VC) are the proven thermal desalination processes which utilize heat energy for seawater desalination. Reverse osmosis (RO) and Electro-Dialysis (ED) are the proven membrane processes. RO uses neutral membrane and mechanical energy (pressure) for achieving the separation of relatively pure water from the saline water while ED uses ionic membranes and utilize electrical energy (potential). The total installed seawater desalination plant capacity in the world is about 17 million m^3/day. Thermal desalination processes account for 55% of total production capacity compared to 45% by membrane processes . However, membrane processes have about 77% of the number of installed plants of which thermal processes account for 22% . This implies that large capacity plants are normally based on thermal process whereas small capacity plants are based on membrane processes.

Desalination Indian Context

All kinds of land based desalination plants in the country including seawater and brackish water desalination produce more than 500,000 m^3/day (500 MLD) fresh water.

Seawater Desalination

Seawater desalination generates a new source of fresh water rather managing the existing source of water. Table 1 gives some of the thermal seawater desalination plants (operating/under construction) in India. A list of some of the membrane based seawater desalination plants (operation/under construction) in India is given in Table 2. Indian presently has about 200,000 m^3/d (200 MLD) seawater desalination plants in the country. The developments in desalination are directed towards reducing the overall cost of desalinated water through technological innovations.

Table 1: Some of the Thermal Desalination Plants in India
(Operating/ Under Construction)

S.No.	Place	Capacity (MLD)	Process	Supplier
1.	Reliance Industries, Jamnagar	48+15	MED	IDE,Israel/Technochem
2.	Cement Plant, Kutch	2.2	MED	L&T/SIDEM
3.	Eid-Parry, Chennai	1.5	MED	IDE, Israel/Technochem
4.	NDDP, Kallpakkam	4.5(a part of hybrid)	MSF	BARCH
5.	NPCIL, Kudankulam	7.5	MVC	IDE, Israel/Technochem

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Table 2: Some of the Membrane Based Sea Water Desalination Plants in India (Operating/under construction)

S.No.	Place	Capacity (MLD)	Process	Supplier
1.	TWAD, Chennai	3.8	SWRO	BHEL
2.	GEB, Sikka	4.0	SWRO	Ion Exchange
3.	NDDP, Kalpakkam	1.8 (a part of hybrid)	SWRO	BARC
4.	NPCIL, Kudankulam	2x1.2	SWRO	Tata Projects /Doshi Ion
5.	CMWSSB, Chennai	100	SWRO	IVRCL/BEFESA, Spain
6.	CPCL, Chennai	26	SWRO	Ion Exchange.

Desalination and power plants at some location has the benefit of sharing the resources such as common seawater intake system, common outfall system and other infrastructural facilities. The concept of hybrid desalination is picking up for large capacity desalination plants in water scarce coastal cities. It takes into account product water quality requirements for different uses, such as distilled quality water for industries and potable water for drinking use. Interest in using nuclear energy for producing desalinated water has been growing worldwide. Low grade and waste heat utilisation for seawater desalination appears promising and has been demonstrated in BARC by coupling a Low Temperature Evaporation (LTE) plant using waste heat of nuclear research reactor CIRUS for seawater desalination. Ocean energy can also be utilized for seawater desalination and has been demonstrated successfully. Coastal cities in the country face about 100-1000 MLD water short fall. BOOT concept is emerging as an attractive option for setting up large size desalination plants. Apart from big cities many coastal villages & islands also face acute water problem which requires urgent attention. For water scarce coastal areas, large size seawater desalination plants (100 MLD capacity) for big cities and small size desalination units of few thousand litres per day capacity for remote coastal villages and islands appears promising. Barge mounted and trailor mounted desalination plants have been developed by BARC. Mobile desalination plants can be taken from one place to another place and appear attractive for the remote villages/islands along the coast.

Brackish Water Desalination

In our country, several areas have salinity problem besides the presence of harmful elements like fluoride, arsenic, nitrate, iron etc. In order to provide safe drinking water, membrane processes are being used at domestic level as well as large capacity plants. There are several advantages of brackish water desalination by membrane process. It has short start and stop facility. It is easier to integrate with renewable energy sources like solar wind, tidal etc. Lower power requirement per cubic meter of product water, use of energy recovery system selection of low pressure advanced membranes, use of Variable Frequencey Drives (VFD) for HP pump motor to vary membrane feed pressure makes it attractive. The energy consumption per m^3 of permeate in brackish water RO has been brought down through technological development. Large volume of production of membrane material and usage of low cost chemicals for cleaning the modules has resulted into cost reduction. The incorporation of advanced pretreatment technology like Micro-Filtration (MF) & Ultra-Filtration (UF) has the potential of increasing the plant recovery, reducing membrane cleaning frequency and increasing membrane life. R&D sectors like Bhabha Atomic Research Centre (BARC), Central Salt & Marine Chemicals Research Institute (CSMCRI) and Defence Research Laboratory Jodhpur in India are actively engaged in the development work in this field. Several companies like Ion Exchange, ROCHEM Separation, Permionics (India) Ltd., Aqua Plant Equipment Pvt. Ltd., Aqua Treat Engg. etc. are active in supplying brackish water desalination plants in the country.

Conclusion

It has been well recognized in India that the availability of water for domestic, agricultural and industrial requirement is going to be a serious constraint in the coming years. It may adversely effect economic development and human health. Hence the growing need for developing and introducing science and technology based desalination system, which are economically and environmentally sustainable, is very important.

Various methods for Rain Water Harvesting

There are two methods for rain water harvesting namely- Traditional and Contemporary

Traditional Methods

Talabs/Bandhis: These are reservoirs. They may be natural, such as the ponds (pokhariyan) at Tikamgarh in the Bundelkhand region. They can be human made, like the lakes in Udaipur. A reservoir area of less than five bighas is called a talai; a medium sized lake is called a bandhi or talab; bigger lakes are called sagar or samand. The pokhariyan serve irrigation and drinking purposes.

Saza Kuva: It is the most important source of irrigation in the Aravalli hills in Mewar, eastern Rajasthan. Saza Kuva construction is generally taken up by a group of farmers with a adjacent landholdings.

Johads: These are small earthen check dams that capture and conserve rainwater, improving percolation and groundwater recharge. Starting 1984, the last sixteen years have seen the revival of some 3000 johads spread across more than 650 villages in Alwar district, Rajasthan. This has resulted in a general rise of the ground water level by almost 6 metres and a 33 percent increase in the forest cover in the area.

Naada/ Bandha: Naada/bandha are found in the Mewar region of the Thar desert. It is a stone check dam, constructed across a stream or gully, to capture monsoon runoff on a stretch of land. Submerged in water, the land becomes fertile as silt deposits on it and the soil retains substantial amounts of water.

Rapat: A rapat is a percolation tank, with a bund to impound rainwater flowing through a watershed and a waste weir to dispose of the surplus flow. If the height of the structure is small, the bund may be built of masonary, otherwise earth is used. Rajasthan rapats, being small, are all masonry structures. Rapats and percolation tanks do not directly irrigate land, but recharges well within a distance of 305 km downstream. Silting is a serious problem with small rapats and the estimated life of a rapat varies from 5 to 20 years.

Chandela Tanks: These tanks were constructed by stopping the flow of water in rivulets flowing between hills by erecting massive earthen embankments, having width of 60m or more. These hills with long stretches of quartz reefs running underneath them, acted as natural ground water barrier helping to trap water between the ridges. The earthen embankments were supported on both sides with walls of coarse stones, forming a series of stone steps. These tanks served to satisfy the drinking water needs of villagers and cattle.

Bundela Tanks: These tanks are bigger in size as compared to Chandela tanks. These tanks had solidly constructed steps leading to water in the tank; But these structures had chabootaras, pavilions and royal orchards designed to show off the glory of the kind who built them. These tanks are not as cost effective and simple as Chandela tanks.

Jhalaras: These were human-made tanks, found in Rajasthan and Gujarat, essentially meant for community use and for religious rites. Often rectangular in design, jhalaras have steps on three or four sides. Jhalars are ground water bodies which are built to ensure easy & regular supply of water to be surrounding areas. The jhalars are rectangular in shape with steps on three or even on all the four sides of the tank, the steps are built on a series of levels. The jhalaras collect subterranean seepage of a talab or a lake located upstream.

Ahar Pynes: This traditional floodwater harvesting system is indigenous to south Bihar. In south Bihar, the terrain has a marked slope – 1 m per km – from south to north. The soil here is sandy and does not retain water. Groundwater levels are low. Rivers in this region swell only during the monsoon, but the water is swiftly carried away or percolates down into the sand. All these factors make flood water harvesting the best option here, to which this system is admirably suited. An ahar is a catchment basin embanked on three side, the `fourth' side being the natural gradient of the land itself. Pynes are artificial channels constructed to utilize river water in agricultural fields. Starting out from the river, pynes meander through field to end up in an ahar. Most pynes flow within 10 km of a river and their length is not more than 20 km. In 2000 the ahar irrigates 80 ha of land. The people grow two cereal crops and one crop of vegetables every year.

Cheruvu: Cheruvu are found in Chitoor and Cuddapah districts in Andhra Pradesh. They are reservoirs to stone run-off. Cheruvu embankments are fitted with thoomu (sluices), alugu or marva or Kalju (floor weir)and kalava (canal).

Bhandaras: These are check dams or diversion weirs built across rivers. A traditional system found in Maharashtra, their presence raises the water level of the rivers so that it begins to flow into channels. They are also used to impound water and form a large reservoir.

Kuls: They are water channels found in precipitous mountain areas. These channels carry water from glaciers to villages in the Spiti valley of Himachal Pradesh. Where the terrain is muddy, the kul is lined with rocks to keep it from becoming clogged. In the Jammu region too, similar irrigation system called kuhls are found.

Naula: It is a surface-water harvesting method typical to the hill areas of Uttaranchal. These are small wells or ponds in which water is collected by making a stone wall across a stream.

Contemporary Methods

Check dams: A check dam is generally constructed on small streams and long gullies formed by the erosive activity of water. Ideally a check dam is located in a narrow stream with high banks. While constructing a series of check dams on a long stream course, the spacing between two check dams should be beyond their water spread. The height of the check dam should be such that even during the highest flood, water does not spill over the banks

Contour trenches: Contour trenches are used both on hill slopes as well as on degraded and barren waste lands for soil and moisture conservation and forestation purposes. The trenches break the slope and reduce the velocity of surface runoff. It can be used in all slopes irrespective of rainfall conditions (i.e. in both high and low rainfall conditions), varying soil types and depths. Trenches can be continuous or interrupted. The interrupted one can be in series or staggered, continuous one is used for moisture conservation in low rainfall areas and require careful layout. Intermittent trenches are adopted in high rainfall areas. The trenches are to be constructed strictly on contours irrespective of the category.

Bunding: Bunds are small earthen barriers provided an agricultural lands with slopes ranging from 1 to 6%. They control the effective length of slope and thereby reduce the gain in velocity of run-off flow to avoid gully formations. Types of bunds are:

a) Graded bunds: Graded bunds are constructed in medium to high rainfall area – having annual rainfall of 600 mm and above – and in soils with poor permeability or those having the crust formation tendency.
b) Contour bunds: Contour bunds are constructed in relatively low rainfall areas- having annual rainfall of less than 600 mm ; particularly in the areas having light textured soils. They are essentially meant for storing rainwater received during a period of 24 hours at 10 years recurrence interval. The major considerations are maximum depth of water to be impounded, design depth of flow over waste weir and desired free board.

Contour Stone Wall: It is constructed with stones across the hill slopes thereby intercepting the surface runoff. These terraces help in retarding the soil loss and conserving soil moisture. Spacing of such stone walls are not rigid. Spacing raging from 10 m to 30 m can be adopted depending upon slope of the terrain. For the construction, a shallow trench has to be dug and the stones collected and packed directly on to the foundation and in the super structure to form the terrace. The stones should be properly inter-locked. The soil excavated to form the foundation for the terrace is used for forming a small bund on the upstream side of the terrace. Terrace is stabilized by planting suitable vegetation on the bund.

Gully control: Gully erosion generally starts as small rills and gradually develop into deeper crevices. Ravines are a form of extensive gully erosion. Gully erosion not only damages the land resources but the same time contribute larger amount of sediment load to river system. For the purpose of gully control measures gullies are classified based on several factors. One method takes into consideration the gully depth and catchment area.

Table 2: Classification of Gullies

Description	Gully depth	Catchment area
Small	1m or less	2 ha. Or less
Medium	1 to 5 m	2-20 ha
Large	Greater than 5 m	Greater than 20 ha

Gully plugs are earthen embankments usually constructed for blocking the active and erosion prone gullies for their stabilization

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Sub-Surface Dams: Groundwater dams are structures that intercept or obstruct the natural flow of groundwater and provide storage for water underground. They have been used in several parts of the world, notably India, Africa and Brazil. Their use is in areas where flow of groundwater varies considerably during the course of the year, from very high flows following rain to negligible flows during the dry season. The basic principle of the groundwater dam is that instead of storing the water in surface reservoirs, water is stored underground. The main advantage of water storage in groundwater dams is that evaporation losses are much less for water stored underground. There are to main types of groundwater dam: the sub-surface dam and the sand storage dam. A sub-surface dam intercepts or obstructs the flow of an aquifer and reduces the variation of the level of the groundwater table upstream of the dam. It is built entirely under the ground. The sand storage dam is constructed above ground. The reservoir is recharged during the monsoon period and the stored water can be used during the dry season. Excess water flows over the top of the dam to replenish aquifers downstream. Water may be obtained from the underground reservoir either from a well upstream of the dam or from a pipe, passing through the dam, and leading to a collection point downstream. The best sites for construction of groundwater dams are where the soil consists of sands and gravel, with rock or a permeable layer at a depth of a few meters. Ideally the dam should be built where rainwater from a large catchment area flows through a narrow passage.

Percolation ponds: A percolation pond, like an irrigation tank, has a structure to impound rainwater flowing through a watershed, and a waste weir to dispose of the surplus flow in excess of the storage capacity of the lake created. The section of the bund is similar to that of an irrigation tank, except that the cut-off trench is taken to a depth equal to half the height of the bund. The purpose of the cut-off in the case of the percolation tank is just to prevent erosion of the downstream slope of the bund due to piping. The cut-off should be shallow enough to permit the percolating water to pass downstream into the aquifer. The percolation tank bund has a hearting and a casing, and is provided with stone pitching on the upstream face and turfing on the downstream slope. A masonry waste weir is also necessary to pass surplus water. Drains are provided under the bund to lead water percolating into the bund safely downstream. The percolation tanks of Maharashtra have of around 30 to 60 million litres.

No.T.1(5)/TIFA/2008
Government of India
Ministry of Science and Technol0gy
Department of Science and Technology

Technology Bhavan, New Mehrauli Road, New Delhi
Dated the 29th June, 2009

ORDER

In pursuance of the directions contained in order dated 28th April, 2009 in Writ Petition (C) No.230 of 2001 titled Shri M.K. Balakrishnan and Others Versus Union of India and Others, a Technical Expert Committee on Water Solutions is hereby constituted with the composition, terms of reference and tenure as indicated below:-

(a) Composition

(i)	Dr. T. Ramasami, Secretary, Department of Science and Technology	Chairman
(ii)	Shri U.N. Panjiar, Secretary, Ministry of Water Resources Shram Shakti Bhawan, Rafi Marg, New Delhi – 110 001	Member
(iii)	Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences, Block-12, C.G.O. Complex Lodhi Road, New Delhi-110003.	Member
(iv)	Prof. S.K. Brahmachari, Secretary DSIR and DG, CSIR, Anusandhan Bhawan, Rafi Marg, New Delhi.	Member
(v)	Shri A.K. Bajaj, Chairman, Central Water Commission, West Block, R.K. Puram, New Delhi.	Member
(vi)	Shri B.M. Jha, Chairman, Central Ground Water Board, Man Singh Road, New Delhi.	Member
(vii)	Dr. P.K.Ghosh, Director, Central Salt and Marine Chemicals Research Institute, Gijubhai Babhika Marg, Bhavnagar, Gujarat – 364 002	Member

(viii)	Dr. V. Jayaraman, Director, National Remote Sensing Center, Indian Space Research Organisation, (Dept. of Space, Govt. of India), Balanagar, Hyderabad - 500 625	Member
(ix)	Shri R.D. Singh, Director, National Institute of Hydrology, Roorkee – 247 667	Member
(x)	Shri V.B.Patel, Formerly Chairman of Central Water Commission, Vice Chairman, IWRS, Gujarat Water Resources Management, Saket Projects Limited, Saket House, Panchsheel, Usmanpura, Ahmedabad – 380 013	Member
(xi)	Prof. A.K.Gosain, Department of Civil Engineering, Indian Institute of Technology, Hauz Khas, New Delhi – 110 016	Member
(xii)	The Chairman, Central Pollution Control Board, Ministry of Environment & Forests, Parivesh Bhawan, East Arjun Nagar, Delhi –110032	Member
(xiii)	Dr. N. Sharan, Indian Entrepreneur, Chairman, ECI, IMC, USA	Member
(xiv)	Dr. C.D.Thatte, Former Secretary General ICID, C-16, Parnali Housing Society, Damle path, Off. Law College Road, Erandwane, Pune – 411 005	Member
(xv)	Dr. M.Gopalakrishnan, President, Indian Water Resources Society, Secretary General, ICID, 48, Nyaya Marg, New Delhi	Member

(xvi)	Prof. A.K.Biswas, Third World Center for Water Management, Avenida Manantial Oreinte, No. 27, Las Clubs, Atizapan de Zaragoza, 52958 – Mexico	Member
(xvii)	Dr. Tushar Shah, International Water Management Institute, 2nd Floor, Office Block "B", National Agricultural Science Center Complex, DPS Marg, Pusa, New Delhi – 110 012	Member
(xviii)	Representative of The Energy Resources Institute, Darbari Seth Block, India Habitat Center, Lodhi Road, New Delhi – 110 003	Member
(xix)	Dr. Sunitha Narain, Center for Science and Environment, 41, Tughlakabad Institutional Area, New Delhi – 110 062	Member
(xx)	Shri Venu Srinivasan, President, Confederation of Indian Industries, Mantosh Sondhi Center, 23, Institutional Area, Lodhi Road, New Delhi – 110 003	Member
(xxi)	Other specialists (both national and international) who could provide technical expertise whom the chairman may consider valuable	Members
(xxii)	Special invitees representing community Groups (about four), state Governments (four relevant areas), agro, municipal and industrial groups (about six water user groups)	Members
(xxiii)	Dr. Laxman Prasad, Adviser, DST	Convener

(b) Terms of Reference

(i) The function of the Technical Expert Committee will be to find technical solutions, test validate and prove the feasibility of implementation of these technical solutions in different social contexts.

(ii) The Chairman of the Committee will approach the Government for constituting an Empowered Committee of Secretaries under his Chairmanship to serve as the decision making body of the mission and to monitor and review the progress of the activities by the Technical Expert Committee.

(iii) The Committee shall undertake its task on war footing and shall comply with the guidelines issued by the Honorable Supreme Court.

(c) Tenure

The tenure of the TEC shall be for a period of two years from the date of issue of this order.

Sd/-
(Sanjiv Nair)
Joint Secretary to the Government of India

Copy forwarded for information and necessary action to:-

1. The Chairman and members of the Technical Expert Committee.

2. All Heads of Departments/Directors/Deputy Secretaries in the Department of Science and Technology.

3. AdI.(A)/Ad.I(B)/Ad.II(A)/Ad.II(B)/EC Sections of Department of Science and Technology.

4. Guard file

DR. PUSHPITO K. GHOSH

Dr. Pushpito K. Ghosh (dob May 29, 1954) is the Director of Central Salt & Marine Chemicals Research Institute, Bhavnagar. He obtained his Bachelor's degree in 1974 from St. Stephen's College, Delhi, Master's Degree from IIT Kanpur in 1976 and Ph. D. degree from Princeton University, USA in 1981. All of these degree were in the area of Chemistry. He has served in various R&D capacities of Imperial Chemical Industries (ICI) including as Section Manager of Strategic Research in UK and as Head of Alchemie Research Centre which he established as a leading laboratory of ICI globally. He took over as Director of CSMCRI in March, 1999 and the Institute has gained international recognition under his leadership. He pioneered important concepts and project including the world-renowned Jatropha biodiesel project which was featured in Nature, integrated sulphate of potash and magnesia technology presently under commercialization, "green bromine" technology, 2-stage seawater desalination technology and development of novel products such as spherical common salt which featured in New York Times. Besides publishing a large number of papers in prestigious journals, Dr. Ghosh has more than 25 granted U.S. patents to his credit and serves as member of many committees including Chairmanship of the Chemical Division Council of Bureau of Indian Standards and Chairmanship of the Programme Advisory Committee of Department of Science & Technology, GOI in the areas of Inorganic Chemistry and Water Technology Initiative. He is also a member of the Advisory Committee of Ministry of New of Renewable Energy. Dr. Ghosh has been bestowed with several awards in recent years including the Dr. Vikram Sarabhai Award (2005-2006; 2006-2007), the DaimlerChrysler Environment Leadership Award (2005), the Chemtech Award for Outstandin Contribution in Research (2007), the Nayudamma Distinguished Speaker Award (2006) and the CSIR Rural Technology award (2008). Dr. Ghosh has delivered a large number of invited lecturers over the years including the National Science Day Oration Lecture in DRDO in 2007, the Plenary Lecture at the International Jatropha Congress in 2008 and the P.C. Mahalanobis Memorial Lecturer in 2008.

SHRI V.B.PATEL

Shri V B Patel Former Chairman, Central Water Commission and Ex-officio Secretary to Government of India is Fellow of various professionals and societies like Institution of Engineers (India), Indian National Academy of Engineering, International Water Resources Association USA, Indian Water Resources Society, Indian Association of Hydrologists and Indian Water Works Association. In his professional career of over 50 years he has worked in various positions like Secretary to Government of Gujarat and Chairman Gujarat Water Supply and Sewerage Board. He handled challenging assignments in design and construction of River Valley Projects. His pioneering efforts in involving the farmers in water management are well known. He worked as member on Committee appointed by Planning Commission on Pricing of Irrigation Water. He chaired the working group of Planning Commission for Formation of X Five Year Plan on Privatizations and Participatory Irrigation Management. Shri Patel enjoys reputation as trouble shooter and a visionary providing unconventional solutions. He has to his credit several such tasks. This includes departmental construction of Kadana dam; conceiving and installing emergency scheme of water supply of 300 MGD for Ukai Thermal Power Plant. He handled the herculean task of dewatering the city of Porbander, which is in depression and was flooded by about 3 meters. During 1987-88, when the Gujarat State was facing third consecutive draught, he successfully handled the drinking water crisis, holding three key positions as Secretary Water Resources Department, Secretary Water Supply and Chairman, Gujarat Water Supply and Sewerage Board. Again in the year 2000, when monsoon failed in Gujarat and the State was facing threat of large scale migration of human beings and cattle, he conceived an emergency water supply scheme of 700 MGD, which was implemented in record time of 5 months and which served domestic water to 2 million people of Gujarat. This was the largest emergence water supply system ever conceived. Shri V B Patel has worked on several committees of State Governments and Government of India and participated in National and International events, on Water Resources planning practices and policies. Chairman, Water Management Forum, Institution of Engineers (India); Chairman, Communication Core Group of Task Force on Inter Linking of Rivers. Presently he is Member, Gujarat Ecology Commission and Member, Development Support Centre, which is a NGO, working on developing and supporting New NGOs in Participatory Irrigation Management as well as Watershed Development Programmes. He is President of Multi Mantech International Pvt Ltd, which is providing consultancy in infrastructure planning and development, in the areas related to water, Waste Water and Oil & Gas sectors

PROF. A.K.GOSAIN

Prof. A. K. Gosain has been working with the Department of Civil Engineering, IIT Delhi since 1997. His Educational Qualifications include B.Sc. Engg, Civil Engineering, 1974, PEC Chandigarh, M.Tech., Water Resources Engg., 1976, IIT Delhi, Ph.D., Inter-comparison of models for real-time flood forecasting in River Yamuna, 1984, IIT Delhi. His main areas of interest are Hydrological modelling using distributed models, Urban Hydrological modelling; Databases, Management Information Systems (MIS), Geographical Information Systems (GIS); Expert Systems; Hydraulic modeling; Irrigation water management, Water resources management; Real-Time River flood forecasting; Snowmelt modeling, Development of computer models for water resources management and impact assessment, Climate change impact assessment on water resources. Before joining IIT Delhi in 1986 has worked with School of Systems and Management Studies, IIT Delhi and Applied Mechanics Department of IIT Delhi as well. He has also worked as Principal Investigator and consultant on many prestigious Indian/international collaborative projects. He is also working on various committees/societies as member currently.

His Special skills involve Modelling using C^{++} and FORTRAN compilers, Use of GIS technologies, Database design and implementation, Formulation and implementation of MIS, Use of Expert System, Conducting workshops and special purpose training programs. He has published Seventy five research papers in journals, conferences, symposia and workshops, six research reports which have been widely circulated within the technical community of the country and delivered lectures at seminars, workshops and training courses conducted by various organisations. He has been awarded the 11th 'MAUSAM' award for his paper 'Application of Deterministic Conceptual Models for Water Balance Studies', in the Journal 'MAUSAM', published by the India Meteorological Department. He developed Video course on 'Water Management', in collaboration with Centre for Education Technology, IIT Delhi, in 1993. It consists of 40 lectures of one-hour duration. Back-up material for the lecture series has also been prepared and is distributed with the videos. The material has been procured by many organisations in the country. In addition to this he also developed course on 'Geographical Information System (GIS)' in 1997, this course is offered at the B. Tech and the M.Tech level and is a very popular with the students of various programmes.

He had an instrumental rule in the establishment of the Water Resources Simulation and Management Laboratory, which was initiated in 1981 and was reinforced in 1984 through the procurement of HP-1000 computer system as well as Computational Laboratory, which is a central computational facility in the Civil Engg. Department. Besides equipping it with the latest systems including the workstations and Pentiums, the Local Area Network with 50 nodes spread over the department was also established.

MR NIRAJ SHARAN

Mr. Niraj Sharan is the Chairman and CEO of Aura Inc, San Dimas, CA - USA since 1996. After completing his Bachelor of Science in Electronics and Communication Engineering in 1980 from B I T Mesra, Ranchi, he moved on to Stevens Institute of Technology, Hoboken, NJ, USA to pursue his Masters in Computer Science.

He has been involved in Technologies related to Environmental Compliance in the Process Manufacturing Industry like Oil and Gas, Fertilizer and Chemical and Power Generation. These Technologies involve Sulphur Removal from Acid Gas and Diesel and Gasoline up to 99.99% and complying to Bharat IV and beyond. Other Technologies relate to Elemental Analysis of Coal, Petroleum Coke and Minerals so that more efficient Combustion happens in Boilers thus reducing NOx, SOx and Stack Emissions.

Later, he has been involved in Business Development of Water Desalination Plants based on Electrodialysis and Zero Bacteria using UV approach – adopting the Russian technology.

His company Auro Inc., serves markets in North America, Europe Union and Asia.

DR. C.D.THATTE

Born in September, 1935, Dr. Chandrakant Damodar Thatte, graduated in Civil Engineering from Pune University in 1956. He has done Post Graduate Courses in the subject of Soil Mechanics. Foundation Engineering, Ground Water Hydrology and others and Ph.D in hydraulic modeling. From the beginning of his career with the Government, he has held several posts such as Executive Engineer, Superintending Engineer, Director and Chief Engineer in the State of Gujarat and then joined the Central Water Commission, the apex water organisation of the Government of India as Member (Design and Research). After three years, he became the Chairman of the Commission and later took over as Secretary to the Government of India in the Ministry of Water Resources, from where he retired in September, 1993.

Dr. Thatte was thereafter conferred the position of Scientist Emeritus of the Council of Scientific and Industrial Research to work for the National Environmental Engineering Research Institute, Nagpur and other water resources related National Institutions. He served on various Government of India Expert Committees, viz. landslides, land and water systems analysis, Himalayan Glaciers etc. He is working as Task Leader for Evaluation of Irrigation through Indira Gandhi Nehar Project Stage 1 Studies which cover environmental concerns besides problem of O&M, settlement, waterlogging and economic analysis. He also worked as an expert for UNDP and UNEP on certain issues relating to international river water sharing and Global Freshwater programme. He has been closely associated with several NGOs in the country.

Dr. Thatte has published more than 125 technical papers in India and abroad. He is a recipient of several awards such as CBIP's Anand Award, Cash Your Ideas Award, Nehru Centenary Award, Certificates of Merit for the Technical papers etc. He has also been honoured by several Indian Professional Societies.

ER. M. GOPALAKRISHNAN

Engr. M. Gopalakrishnan (born 28.1.1943) holds Master of Engineering (Honours) in Water Resources Development from University of Roorkee (now, IIT-R). His remarkable academic performance yielded him both Khosla Gold Medal and University Gold Medal for the top position in both P.G.Dip (Hons) and M.E levels with record breaking scores. He entered the Central Water Engineering Services (1966 batch) as the topper of his batch in the then Central Water & Power Commission. He retired on 31 January 2003 as a Member Central Water Commission (CWC. Mr. Gopalakrishnan served as the Coordinator of a Government of India's multi-disciplinary high level Task Force on Interlinking of Rivers in 2003 later and helped formulating two Action Plans on Interlinking of Rivers that were to submitted as per the ToR set for the Task Force by the Government of India. With over four and a half decades of rich experience in the field of Water Resources Development and Management in India and abroad Mr. Gopalakrishnan continues to serve his profession in many forms.

Er. Gopalakrishnan served as one of the Governors of the World Water Council during 2003-06. He is a member of Technical Advisory Committee of UNESCO who brings out World Water Development Reports once in three years with the last one WWDR 3, released in March 2009 during the World Water Forum 5. Er. Gopalakrishnan serves as a member of the Committee constituted by the Indian Ministry of Water Resources on "National Mission on Water" and is also a member in the sub committee on surface water under the main committee.

Mr. Gopalakrishnan holds several distinguished honorary positions like the President, Indian Water Resources Society (since 2004), President of the New Delhi Associate Centre of World Water Council (since 2006), Co-Chairman of the Institution of Engineers (India)'s special Committee on Interlinking of Indian Rivers (since 2005). He is a Life Member of several leading Indian Professional Bodies like IWRS, IAH, ISET, IGS.

A member of several Expert Committees constituted to advise on hydro projects in Himalayas by Developers, both public and private, (in three cases, he is the Chairman Chairman of the Group) he guides water sector in India remarkably. Mr. Gopalakrishnan is the Chairman of the Dams and Seismicity committee of Indian National Committee on Large Dams for over a decade and represents the country in the ICOLD committee on the subject.

Mr Gopalakrishnan has been associated with GWP bridging the interests of both organisations. He had also been closely associated with World water Council when he was one of the Governors (2004-06) by contributing to their Committee on Legal and Financial matters.

He has published about hundred papers (or other contributions) touching upon many water related issues, design aspects and policies, in seminars, workshops, Congresses, Journals and other publications.

PROF. ASIT K. BISWAS

Prof. Asit K. Biswas is an Indian born Canadian citizen and president of Mexico City based Third World Centre for Water Management and also is advisor for the International Centre on Water and Environment (CIAMA-La Alfranca).

He believes that water is a source of collaboration and not conflict. He has distinguished himself in solving global water supply problems and in enhancing water economy research and teaching at TKK. Prof. Biswas received the Honorary Degree of Doctor of Science in Technology from the Helsinki University of Technology (TKK) in its 20th solemn doctoral degree ceremony on April 2, 2008.

The University of Strathclyde, Glasgow, has conferred upon Prof. Asit K. Biswas the Honorary Degree of Doctor of Science in Technology for Major international initiatives and outstanding achievements, in June 2007.

He is the 2006 Stockholm Water Prize Laureate.

During 2005, Prof. Biswas promoted the policies and best practices for water resources management in Aragon in the Human Development Report, giving Aragon a global exposure and was conferred with Aragon Environment Prize, 2006.

SHRI TUSHAAR SHAH

Tushaar Shah joined IWMI in 1999 as leader of the program on Policy, Institutions and Management. In 2001, he took over the leadership of IWMI's new theme on Sustainable Groundwater Management. Shah also built and led the IWMI-Tata Water Policy Program in India--the first ever collaboration between an international center and an Indian foundation. In 2005, Shah created two IWMI research projects funded under the Challenge Program for Water and Food: "Groundwater Governance in Indo-Gangetic and Yellow River Basins" and "Strategic Analyses of India's National River-Linking Project". In 2002, Shah was selected for the CG award for 'Outstanding Scientist of the Year'.

Shah obtained his doctorate from the Indian Institute of Management at Ahmedabad and specialized as a development economist and strategic management specialist. He was formerly the Director of the Institute of Rural Management at Anand during 1987-95. Before his IWMI years, Shah consulted with scores of NGOs, government and lending institutions including the World Bank, Ford Foundation, Swiss Agency for Development Co-operation, Swedish International Development Agency. He also consulted extensively with private Indian foundations including Sir Ratan Tata Trust and Sir Dorabji Tata Trust. He has also served on the boards of some 25 Indian NGOs and research centers including as the chairman of IDE, India and PRADAN. He also serves on the Academic Council of the Chinese Center for Agricultural Policy (CCAP).Most recently, Shah served on several committees of the Government of India for developing the irrigation component of India's 11th Five-Year Plan as well as a committee of the Indian Planning Commission on Sustainable Groundwater Management. He was also invited to make submissions to the Finance Minister in pre-budget briefings. Shahs research at IWMI contributed to the formulation of US $

450 m groundwater recharge scheme for hard-rock districts by the Government of India and a US $ 270 m investment by the government of Gujarat in improved farm power infrastructure for sustainable groundwater management. Shah works out of Anand in Western India, primarily on water policies and institutions.

SMT. SUNITA NARAIN

Sunita Narain has been with the Centre for Science and Environment from 1982. She is currently the director of the Centre and the director of the Society for Environmental Communications and publisher of the fortnightly magazine, Down To Earth. In her years at the Centre, she has worked hard at analysing and studying the relationship between environment and development and at creating public consciousness about the need for sustainable development. Over the years, she has also developed the management and financial support systems needed for the institution, which has over 100 staff members and a dynamic programme profile. She is currently in charge of the Centre's management and plays an active role in a number of research projects and public campaigns

Her research interests are wide-ranging - from global democracy, with a special focus on climate change, to the need for local democracy, within which she has worked both on forest-related resource management and water-related issues. She began her career by writing and researching for the State of India's Environment reports and then went on to study issues related to forest management. For this project she travelled across the country to understand people's management of natural resources and in 1989 co-authored the publication Towards Green Villages advocating local participatory democracy as the key to sustainable development. In the early 1990s she got involved with global environmental issues and she continues to work on these as researcher and advocate

In 1991 she co-authored the publication Global Warming in an Unequal World: A case of environmental colonialism and in 1992 Towards a Green World: Should environmental management be built on legal conventions or human rights? Since the Kyoto Protocol in 1997, she has worked on a number of articles and papers on issues related to flexibility mechanisms and the need for equity and entitlements in climate negotiations. In 2000, she co-edited the publication Green Politics: Global Environmental Negotiations, which looks at the emerging ecological globalisation framework and puts forward an agenda for the South on global negotiations.

In 1997, pushing the concern for water harvesting, she co-edited the book Dying Wisdom: Rise, fall and potential of India's water harvesting systems. Since then, she has worked on a number of articles on the policy interventions needed for ecoregeneration of India's rural environment and poverty reduction. In 1999, she co-edited the State of India's Environment, The Citizens' Fifth Report and in 2001, Making Water Everybody's Business: the practice and policy of water harvesting.

Narain remains an active participant, both nationally and internationally, in civil society. She serves on the boards of various organisations and on governmental committees and has spoken at many fora across the world on issues of her concern and expertise.

MR. VENU SRINIVASAN

Mr Venu Srinivasan, Managing Director, Sundaram-Clayton Ltd and Chairman & Managing Director, TVS Motor Company Ltd, has been elected as the President of CII for the year 2009-10.

An engineer with a Masters' Degree in Management from Purdue University, USA, Mr Srinivasan is the Honorary Consul General of Republic of Korea, Chennai, and a Member of the Prime Minister's Council on Trade & Industry.

Mr Srinivasan has also held positions as President of The Automotive Research Association of India and President, Society of Indian Automobile Manufacturers.

Mr Srinivasan was chosen as a 'Star of Asia' by Business Week International, along with the Chairman of Toyota, Japan. He is the first Indian industrialist to receive an honorary 'doctorate degree in science' from the University of Warwick, UK, for excellence in manufacturing and contribution in the field of technology and R & D. He also received the Jamshedji Tata Life Time Achievement Award 2004 from the Indian Society for Quality.

Under his leadership, both Sundaram-Clayton Ltd and TVS Motor Company have been awarded the prestigious Deming Prize by the Union of Japanese Scientists and Engineers, Japan.

S. No	Name and Designation	Address of Serving Organisation
1	Bothale Rajashree Dr. (Mrs.)	Scientist / Engineer – SE RRSSC / ISRO CAZRI Campus Jodhpur 342003, Rajasthan
2	Chadha D. K. Dr.	Global Hydrological Solutions G-66, Vikaspuri New Delhi – 110 018
3	Chaudhari Sanjeev, Dr.	Professor, Centre for Environmental Science & Engg, Indian Institute of Technology (IIT-Bombay), Powai, Mumbai, Maharashtra 400 076
4	Ghosh N. C. Dr.	Scientist "F", National Institute of Hydrology, Roorkee – 247 667, Uttarakhand
5	Gopal Ram, Dr.	Director (DRDO Retd.) and UGC Professor & Visiting Faculty, A-66 Krishna Nagar, Pali Road, Basni, Jodhpur, Rajasthan 342 005
6	Gupta A. B. Prof.	Department of Civil Engineering, Malaviya National Institute of Technology, Jaipur, Rajasthan
7	Gupta Kapil Prof.	Associate Professor, Department of Civil Engineering, Indian Institute of Technology, Powai, Navi Mumbai Mumbai – 400 076, Maharashtra
8	Gupta S. K. Dr.	Physical Research Laboratory (PRL) Navrangpura, P.O. Box 4218, Ahmedabad, Gujarat., PIN 380 009
9	James E.J., Dr.	Director, Water Institute, Karunya University, Coimbatore 14
10	Mehrotra Indu Prof. (Ms.)	Department of Civil Engineering, Indian Institute of Technology- Roorkee, Roorkee – 22 47 667, Uttarakhand
11	Maiti H.S. Dr.	Director, Central Glass and Ceramics Research Institute (CGCRI), 196 Raja S.C. Mullick Road, P.O. Jadavpur, Kolkata West Bengal 700 032

12	Majumdar P. P. Dr.	Associate Professor, Department of Civil Engineering, Indian Institute of Science, Bangalore – 560 012, Karnataka
13	Majumder Arunabha, Dr.	Head, Department of Sanitary Engineering & Visiting Faculty, All India Institute of Hygiene & Public Health & Jadavpur University, 110 CR Avenue,