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National Innovation System Approach for Promotion of Water in India

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Abstract: Numerous cities and villages alike, throughout India, face issues of water security. The case study based approach of this paper aims to highlight the contribution of various bodies such as academia, government, industries, business incubators, research institutions, NGO's and community-based organizations towards solving these issues and promoting better water management practices in affected regions. The key areas to be focused on, mentioned in the National Water Policy, such as reducing India's dependence on groundwater have been stated. The success of particular methods and techniques in community management proves that implementing a useful framework that connects all these sectors will have the potential to mitigate the water scarcity issues across the nation in the coming years.

Keywords: *Water management, National Water Policy, National Innovation System, Water Security*

I. INTRODUCTION

The growing population of India coupled with problems such as lack of control in the use of water resource across various sectors such as industrial, agriculture and domestic has led to water shortages in numerous states across India. Future predictions by the Ministry of Water Resource of India also state that the over-exploitation of groundwater for agriculture through irrigation will lead to depletion of the resource by 2025 across states such as Punjab, Uttar Pradesh, Haryana and Madhya Pradesh to name a few, as they have a large amount of land under cultivation. Major cities such as Delhi are expected to run out of groundwater by 2020 (CWRM Index, 2018)

In India, the most severe cases of water scarcity are faced by the states of Bihar, Rajasthan, Tamil Nadu, Karnataka and Madhya Pradesh among a few. Chennai, recently, had to import water in the summer of 2019 due to lack of domestic water for the people. This not only affects public health but also the economic sectors profoundly. As states prioritize irrigation and household needs, this leads to a temporary shutdown of industries due to lack of water.

Interlinking different civic communities is one possible way to combat this issue. Through optimal management and allocation of resources on various levels and encouraging activities that benefit the water table of the nation this problem can be reduced.

This paper aims to address the problems involved in the current framework of the water sector in India, promote current practices which benefit the management of this resource and also offer solutions for the sustainable use and management of water in the future.

II. LITERATURE REVIEW

A. Importance of Water as a resource

Water is a fundamental resource which is essential for life, livelihood, food security and sustainable development. With more than 18% of the world's population residing in India, only 4% of the world's renewable water resources are available for the people (MoWR, 2014). Furthermore, an uneven distribution of these resources over time and space poses limits to the utilization of these resources. A growing population and rising needs of a nation developing at a fast pace as well as given indications of the impact of climate change, may put the utilizable water resource under further strain. There is a possibility of deepening water conflicts among different user groups. In addition, there are challenges of frequent floods and droughts across the country. Lack of awareness among the people about the scarcity of water and its life-sustaining and economic value leads to mismanagement, wastage, inefficient use and also pollution.

B. Need for improvement in water management practices:

EFFICIENCIES FOR VARIOUS FACILITIES FOR WATER UTILIZATION

Sl. No.	Water Use and methods	Efficiency (%)
a	Irrigation efficiencies	
	• Conveyance	
	– through unlined canal for surface water	55-60*
	– through lined canal for surface water	70-75*
	• Application for both surface and ground water	
	– Flood irrigation	65
	– Furrow irrigation	80
	– Sprinkler	85
	– Drip	90
	• Overall efficiency for surface water system	30-65
	• Overall efficiency for ground water system	65-75
b	Urban water supply	50-60
c	Rural water supply	60-70
d	Industrial use	80

*Conveyance efficiency of the canal depends on many factors such as length of the canal, type of soil, material used for lining etc.

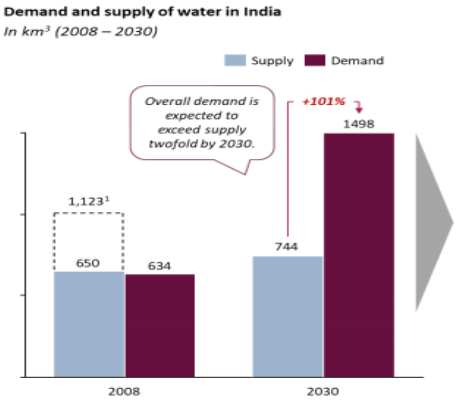
Source: Guidelines for increasing water use efficiency, MoWR

Climate change has resulted in the rise of sea levels causing intrusion of saline water into the groundwater aquifers and surface water, impacting the people and industries such as agriculture, adversely. Access to safe water for drinking and other domestic needs continues to be a problem in several regions. Skewed availability of water between these regions and among the people, coupled with the unreliable water supply system leads to social unrest. The frequency of floods and droughts may increase with time due to variations in the availability of water across different seasons and places. Inter-regional and inter-state disputes in sharing or allocation of water resources strain relationships and hamper the optimization of water through scientific planning.

C. Dependency on groundwater in India

Groundwater is perceived as an individual property leading to its over-exploitation in several areas without any concern towards sustainability. The relative ease and convenience of its decentralized access has meant that groundwater is the backbone of India's agriculture and drinking water security. Groundwater is a common pool resource, utilized by millions of farmers across the country. During the last four decades,

around 84% of the total addition to the net irrigated area has originated from groundwater (Shah, Mihir 2013). India is the largest and fastest growing consumer of groundwater in the world by a large margin. However, groundwater is being exploited beyond sustainable levels with an estimated 30 million groundwater structures currently in use (Shah, Mihir 2013).



Source: Composite water management index

D. Irrigation Sector putting a strain on water resources and risk to food security

Achieving food security for India, with its rising population, will be a significant challenge, and the shortage of water will make the goal tougher to attain. According to the Composite Water Research Management Index, India is expected to host more than 1.5 billion people by 2030, and providing food for the entire population will be a formidable task. Scarcity of water in the country is going to make this task harder. Rice and wheat, the two major crops grown in India, are already being affected by water-related issues. About 65% of the area under rice cultivation and 74% of the area under wheat cultivation faces significant levels of water scarcity. It is estimated that the water demand-supply gap in agriculture could rise to 570 BCM by 2030. Groundwater resources are being used for meeting 62% of irrigation water needs, and are declining in 52% of the cases. This highlights a serious water concern for the agriculture sector.

RELATIVE WEIGHTS FOR DIFFERENT METHODS OF UTILIZATION AND FOR WATER USE FOR VARIOUS PURPOSES

Quantity in BCM

Water uses	Quantity*	Present Level of efficiency (%)^	Full achievable efficiency (%)@	Scope for increase	Quantum of water likely to be saved for full efficiency	Quantum of water likely to be saved by 20% increase or full efficiency	Relative weight for 20% increase
Irrigation							
Surface water	339	30	60	30	102	68	0.53
Ground water	218	55	75	20	44	44	0.34
Drinking water							
Urban water	33	60	90	30	10	7	0.05
Rural water	10	70	90	20	2	2	0.02
Industries (including for Power)	56	80	95	15	8	8	0.06
Others (environment, evaporation etc.)	54	-	-	-	-	-	-
Total	**710**				**166**	**129**	

Source: CWRM Index, Niti Aayog

Inadequate maintenance of existing irrigation infrastructure has resulted in wastage and under-utilization of available resources. The potential for irrigation is higher than the one currently being utilized. Natural water bodies and drainage channels are being intruded upon and diverted for other purposes. Groundwater recharge zones are often blocked. Vast stretches of rivers across the country are heavily polluted and devoid of flow to support the aquatic ecology due to pollution from industrial effluents causing environmental and health hazards. Pollution of water bodies by microbial contamination due to inadequate sanitation facilities and sewage treatment is also a major concern as it causes severe gastrointestinal diseases for the people consuming it. Punjab, which produces more than 10% of India's paddy, utilizes groundwater for meeting 80% of its paddy irrigation needs, thus depleting its own and the country's groundwater resources (CWRM Index, 2019).

The necessary steps to be taken and critical areas to be focused on to ensure sustainable use of the water resources and their management plan is mentioned in the National Water Policy of India.

E. National Water Policy (NWP)

The Ministry of Water Policies of the Government of India has formulated the National Water Policy to govern the planning and development of water resources and their optimum utilization. It was first adopted in 1987 with further revisions in 2002 and later in 2012.

Key features of the policy (2012):

The current water policy acknowledges that availability of utilizable water resources is coming under further strain, with an increasing number of conflicts to be expected in the future. The policy seeks to address such a future, with a growing population and rising needs of a developing nation with the impending uncertainty of climate change. The water allocation priorities were explicitly stated in the first national water policy of 1987, which were then modified in the reformed policy of 2002 to include ecology, navigation and divided the industry into agriculture-related and otherwise. Some of the points mentioned are:

- The need for a national framework law and legislation for the development of inter-state rivers and river valleys.
- Water, be treated as an economic good to promote its conservation and efficient use, after meeting the needs for safe drinking water and sanitation, achieving food security, supporting people dependent on agriculture for their livelihood and high priority allocation for minimum eco-system needs.
- Strategies to be adopted considering climate change for designing and management of water resources structures and review of acceptability criteria has been emphasized.
- A system to evolve benchmarks for water uses for different purposes, i.e., water footprints, and water auditing to be developed to ensure efficient use of water. Project financing as a tool to incentivize efficient & economical use of water has been suggested.
- Water Users Associations should be given statutory powers to collect and retain a portion of water charges, manage the quantity of water allotted to them and maintain the distribution system in their jurisdiction.
- Removal of the large disparity in provisions for water supply in urban and rural areas has been recommended.

- The projects and resources related to water resources should be managed with community participation. Based on the decisions of the state government or local bodies, the private sector can be encouraged to become a service provider in a partnership model with the public to meet agreed terms of service delivery, including penalties for failure.
- Grants provided to the States for updating technology, design practices, planning and management practices, preparation of annual water balances, preparation of hydrologic balances for water systems, and performance evaluation etc.

III. RESEARCH METHOD

The method of research is a case study based approach where the role of the following government and private organizations and institutes in promoting activities such as innovation through research, encouraging management practices, providing sanitation and drinking water facilities, etc. are being studied.

1. Academia: Schools & Universities
2. Role of Research Institutes
3. Entrepreneurship Promotion
4. Role of Government
5. Corporate Social Responsibility (CSR)
6. Role of NGOs & Community Based Organizations

IV. RESULT AND DISCUSSION

A. Academia: Schools & Universities

At present, there is a need not only for the development of water resources but also their efficient management in a sustainable manner. India's population consist of 70 % of youth population. Education and youth empowerment work in collaboration to create more dynamic processes inside International bodies, Governments, Industries, and civil society, thus guaranteeing the development of communities inclined towards sustainable water management.

Schools

The central government has taken the initiative to promote water conservation in schools across the country by starting various programs to make students aware of the need for saving water. The Department of School Education & Literacy (DSEL), which comes under the Union Ministry of HRD, has launched the 'Samagra Shiksha-Jal Shuraksha' drive to promote water conservation activities for school students.

Possible saving in domestic use may be like under:

What we do		What should be done		Saving of water in litres
Activity	Use of water in litres	Activity	Use of water in litres	
Bathing with Shower	100	Bathing with Bucket	18	82
Bathing with running water	40	Bathing with Bucket	18	22
Using old style flush in Latrines	20	Using new style flush	6	14
Shaving with Running water	10	Shaving by taking water in mug	1	9
Brushing teeth with running water	10	Brushing teeth taking water in mug	1	9
Washing cloth with running water	116	Washing cloth with bucket	36	80
Washing Car with running water	100	Washing Car with wet cloth	18	82
Washing floor 15'X 10' with running water	50	Washing floor with wet cloth	10	40
Washing hand with running tap	10	Washing hand with mug	0.5	9.5

Source: Guidelines for increasing water use efficiency, MoWR

Schools should adopt rainwater harvesting practices to satisfy the requirements of water needed for sanitation and gardening. The National Green Tribunal (NGT) has been directing all educational institutions in the Capital to install rainwater harvesting (RWH) systems in their premises at their own cost since 2017. However, schools are unable to implement these due to lack of expertise available. For appropriate RWH implementation, there is a need to provide technical and managerial support to schools, because even the schools that have the system in place have no experience or information regarding its maintenance and operation.

Furthermore, by the promotion of the following water management practices in schools, there is a high scope for reduction in wastage of domestic water in households.

Universities

It is necessary to promote research and development activities at the university level across India to combat the problems of the future. In the past decade, the main research focus has been in the areas computer sciences and information technology in a majority of the universities across India offering undergraduate and postgraduate studies. It would be beneficial for society if there is a shift in focus proposed towards developing these technologies in addressing the various environmental issues mentioned in the national water policy. Innovation and entrepreneurship should be encouraged for offering products and services providing solutions for water treatment and management activities at a household and community level. They should also have the potential to be applied in rural as well as urban areas.

The cause for concern is that barring the top institutions like IIT's and a few private universities, the majority of educational institutions throughout India are lacking in research that works towards India's national water policy. Very few institutions have specific departments for Water Resources or Water management, resulting in low research output related to these fields. Furthermore, there will be a shortage of experienced professionals in the future to tackle various problems that may arise due to climate change and increasing demand for safe water resources for households and industries. Also, there is a shortage in the number of experienced faculty for teaching courses like Wastewater Engineering, Water management, Irrigation and Watershed management, etc. that are available in most of the educational institutes overseas.

(Note: The following tabular data is indicative of the variety of courses and specializations offered in the respective regions. The data does not represent all the universities offering these courses.)

Water specific courses offered for a Master's degree in the UK:

Sr.No.	University	Course
1	Brunel University, London	MSc Water Engineering
2	Cranfield University	Msc Environmental and Water Management Msc Water and Sanitation for Development Msc Water and Wastewater Engineering
3	University of Southampton	Engineering in the Coastal Environment
4	Queen Mary, University of London	Integrated Management of Freshwater Environment
5	University of Bristol	Msc Water and environmental management
6	University of Surrey	Msc Water and environmental engineering
7	University of Oxford	Msc Water Science Policy and management
8	University of Birmingham	River Environments and their Management
9	Bangor University	Wetland Science and Conservation
10	Imperial College London	Hydrology and Sustainable Development Hydrology and Water Resources Management
11	University of Worcester	River Science
12	Swansea University	Desalination and Water Re-use
13	King's College London	Water - Science and Governance
14	University of Chester	Flood Risk Assessment, Modelling and Engineering

Other International Universities:

Sr.No.	University	Course
1	National University of Singapore	Hydraulic Engg and Water Resources Management
2	Delft University of Technology, Netherlands	Water Management
3	University of Texas at Austin	Environment and Water Resource Engineering
4	University of British Columbia, Canada	Integrated water management
5	RWTH Aachen University, Germany	Sustainable management of water and energy
6	Technical University of Denmark	Water Resource engineering
7	Louisiana State University	Oceanography and Coastal Sciences
8	University of Southern California	Water and Waste Management
9	University of California, Davis	Hydrologic Sciences
10	University of Missouri - Columbia	Natural Resources with emphasis in Water Resources
11	SUNY - Buffalo	Water Resources Engineering
12	University of Arizona	Water, Society and Policy
13	Texas A&M University	Water Management and Hydrological Science
14	University of Washington	Hydrology and Hydrodynamics
15	Stanford University	Environmental Fluid Mechanics and Hydrology

Educational Institutes in India:

Sr.No.	University	Course
1	IIT Delhi	Mtech Water Resources Engineering
2	IIT Kharagpur	Mtech Water Resources Engineering
3	IIT Guwahati	Mtech Water Resources Engineering
4	IIT Bombay	Mtech Water Resources Engineering
5	IIT Madras	Mtech Water Resources Engineering
6	IIT Roorkee	Mtech Water Resource Development and mng
7	INSTITUTE OF SCIENCE AND TECHNOLOGY, Hyderabad	Water and Environmental Technology
8	SHRI GURU GOBIND SINGHJI INSTITUTE OF ENGINEERING AND TECHNOLOGY	Water Resource Management
9	College of Engineering, Pune	M.Tech. in Environment and Water Resources Engineering
10	Anna University, Chennai	ME Irrigation and Water Management Engineering ME Integrated Water Resource Management
11	INDIAN AGRICULTURAL RESEARCH INSTITUTE, NEW DELHI	Water Resource Management
12	AMITY UNIVERSITY, NOIDA	Water Resource Management
13	Jaipur National University	Mtech Water Resources Engineering

If we take the example of the University of Oxford course – Water Science, Policy and Management, the course outcome aims to train future decision makers, managers and policy makers in water policy and management. Past graduates go on to obtain policy positions in government departments and international organizations such as World Bank, UNICEF, European Commission and NGO's such as WaterWise.

Students should have ample job opportunities in India after graduating from top institutions such as the IIT's. If the students are expected to put out a high research output, a highly experienced and competitive faculty team is required in these colleges to guide the students so that they can further contribute towards the development of the water sector in India.

B. Research Institutes:

CSIR was established by the Government of India in 1942 as an autonomous body and is currently the largest research and development organization in India. The research and development fields of CSIR include structural engineering, aerospace engineering, ocean sciences, metallurgy, chemicals, mining, food, petroleum, and environmental science.

Scientists at the Council of Scientific and Industrial Research's Lucknow-based Indian Institute of Toxicology Research (CSIR-IITR) have developed a technology that disinfects and provides safe drinking water at the cost of two paise per litre. The technology has been transferred to a Delhi firm, 'Bluebird Water Purifiers'. The technology has a compatible design and can be used both at the domestic and community level.

Source: Bluebird Water Purifiers

The *Interdisciplinary Centre for Water Research (ICWaR)* at the Indian Institute of Science was established in 2015 to address water-related issues that are of significant practical relevance. The Institute has made high impact contributions in the areas related to water science and technology, both at the large (regional, country and river basin) scales and the small (watershed, experimental field and laboratory) scales.

Ongoing research is being funded by agencies such as Ministry of Human Resource Development, Centre for Ecology and Hydrology, Ministry of Water Resource and also international organizations such as the James Hutton Institute.

There are numerous other research organizations with technologies ready for transfer that offer solutions for water related problems, albeit big or small. However, there is a lack of awareness among businesses about the availability of such technologies. A platform for connecting these labs to businesses and NGO's will be fruitful for the environment as well as the economy.

C. Entrepreneurship Promotion

'AquaSense Private Limited' is a startup launched by a group of students from Indian Institute of Technology, Delhi (IITD). Their purpose is developing solutions in the water sector, under the Make in India program of the Government of India. Their products include a groundwater level measurement sensor, which is a patented technology having wide applications in measuring groundwater levels of wells and tubewells.

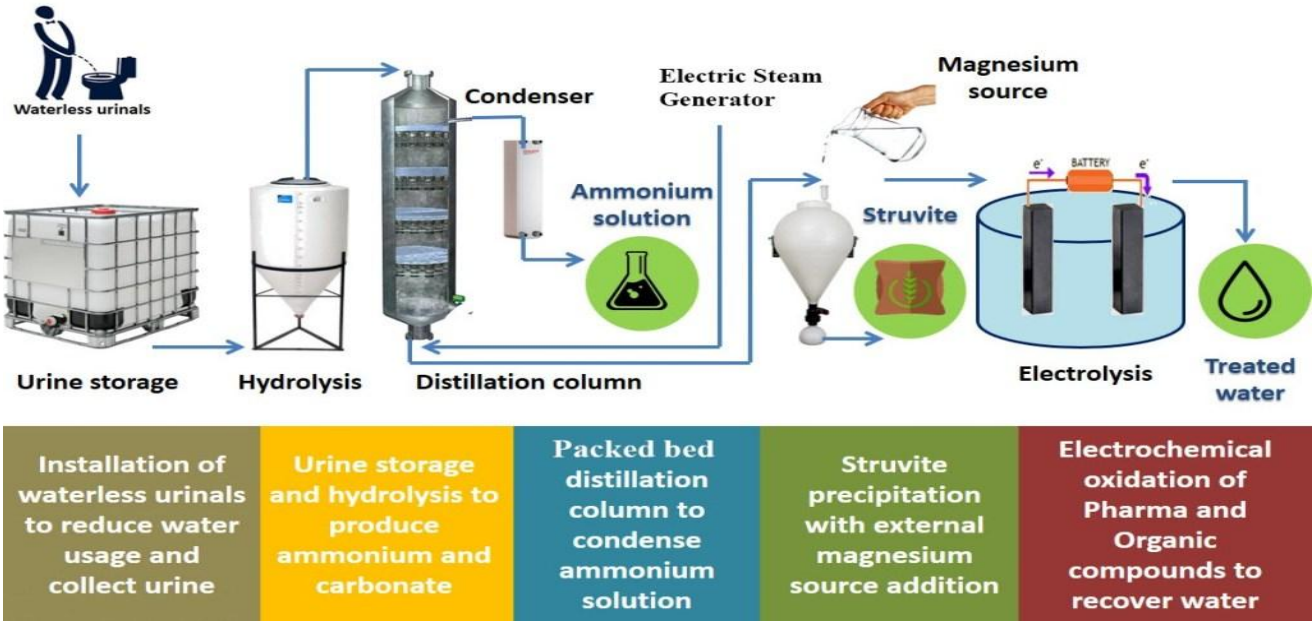
Meanwhile, the water resources department of IIT, Bombay are researching a flood assessment system based on GIS. A model that can predict the amount of flooding in a region will be useful in taking preemptive measures for the same and help to avoid large monetary losses for the people and the government.

Another innovation in the field of sanitation is a product 'Water Chakra' which works on the development of modular on-site toilet treatment system. It recovers about 85 per cent of nitrogen and 96 per cent of phosphorus in the form of commercial-grade ammonia solution and struvite fertilizer, besides recovery of 90 per cent water, according to researchers at the IIT Madras.

The aim was to reduce customer's operation costs and create new products from toilet resources (human urine). It has a wide variety of applications in large institutions and commercial complexes where large amounts of urine can be collected and used for processing to obtain green fertilizers and

water. According to the researchers, 98% of the water recovered can be used for flushing, gardening and fire-fighting purposes among a few.

A majority of business incubators are hesitant in investing in clean-tech ideas due to reasons such as low profitability and unsustainable business models and opt for relatively safer options of service-based e-commerce startups. However, there should be an incentive for entrepreneurs to provide solutions focusing on sustainable development and further working towards achieving the goals set by the NWP.



Source: czeroc.com

D. Role of Government

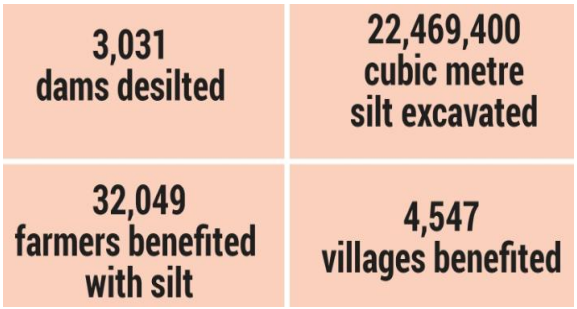
The National Water Mission, established by the government of India, is one of the eight National Missions under the National Action Plan on Climate Change. The Union Cabinet approved the comprehensive Mission Document for National Water Mission (NWM) in 2011. The main objective of NWM is "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management". The five goals set by NWM are:-

1. Building a comprehensive water database in the public domain and assessment of the impact of climate change on water resource;
2. Promotion of citizen and state actions for water conservation, augmentation and preservation;
3. Focusing attention towards vulnerable areas including over-exploited areas;
4. Increasing water use efficiency by 20%; and
5. Promotion of basin level integrated water resources management.

'Gaalmukt Dharan Gaalyukt Shivar Yojana':

Source: Bloomberg Quint

Maharashtra's 'Gaalmukt Dharan Gaalyukt ShivarYojana' is an innovative drought-proofing program by the state's Soil and Water Conservation Department that tackles groundwater recharge issue of silt deposition in water bodies through the creation of non-monetary farmer incentives. Desilting of water bodies is carried out by farmers using excavation machines and allowing them to use this silt to improve soil fertility on their land. Desilting of water bodies restores the water storage capacity and enhances percolation potential for groundwater recharge, while the use of removed silt helps increase soil fertility for the farmer, given its high organic content. The government provides fuel subsidies to operate excavating machines under the program, while the farmer arranges the rental cost either through farmer/community contribution or CSR of philanthropic funding pools. Farmer contribution on average remains at 70-80% of the total price, but is recovered within seven to twelve months.



Source: numerical.co.in

The programme has led to multiple benefits for the state including improved water table in the region, reduced government expenditure on crop compensation, spend on cattle camps for providing water and fodder, and decreased migration for employment opportunities.

During its initial two years of implementation, the scheme has resulted in desilting of about 5,270 water bodies which involved excavation of approximately 32.3 million m3 of silt.

This covers more than 4,600 villages and benefits more than 6.5 million villagers. Removal of silt has increased water storage capacities of water bodies to the tune of about 32,300 thousand m3 which is equivalent to the supply of about 3.2 million water tankers. The silt removed from water bodies have been spread across more than 54,000 acres of farmland and has helped to increase the farm productivity by two to four times which has resulted in improvement in agricultural income by 50% to 100%.

E. Corporate Social Responsibility (CSR)

As per Section 135 of the Act and rules issued thereunder, CSR norms are applicable on companies which have (a) net worth of Rs 500 Crore or more; (b) turnover of Rs 1000 Crore or more; or (c) net profit of Rs 5 Crore or more. The companies, crossing the prescribed threshold, are required to spend at least 2% of their average net profit of the preceding three financial years on CSR activities.

The following companies have had an enormous impact on their neighbouring societies through the implementation of CSR:

Source: ONGC

- ONGC

Oil and Natural Gas Corporation (ONGC), under the Swachh Bharat Abhiyan, had launched a large scale cleanliness campaign in its all work centres, taken up by the Government of India. Through this mission, ONGC took the initiative for the construction of toilet blocks in 2500 government schools in 26 districts spread over 13 states at the cost of Rs 100 crore in the financial year of 2014.

CMD ONGC launched this initiative at MPP School in Pedapalla village in Alamuru Mandal in East Godavari District. The project, named as 'Swachh Vidyalaya Abhiyan' has been implemented in 20 schools by ONGC today. The project has been launched in 2 schools in Ganjam and eight schools in Gajapati districts of Odisha and in 10 schools near ONGC work centres in Gujarat, Andhra Pradesh, Tamil Nadu, Tripura and Assam.

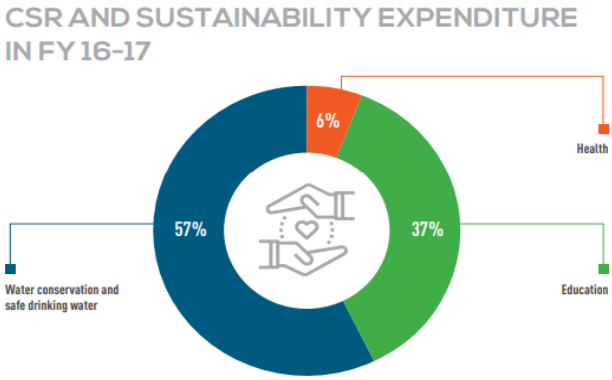
- United Breweries Ltd

In the year 2017-18, a safe drinking water project to reach out to over 44,300 people was launched in 18 villages of Khordha, Odisha. The project would help create livelihood opportunities, as it is an entrepreneur driven model in addition to providing safe drinking water. The project aimed at providing a sustainable solution for drinking water, reducing the number of sick days resulting out of consuming impure water while also promoting entrepreneurship and creating livelihood opportunities in the village.

Source: United Breweries

Water conservation projects have also been initiated in Ludhiana and Patiala. Six ponds are being rejuvenated with community mobilization and awareness being important aspects of the project. The ponds would be managed and maintained by forming water conservation committees in the villages.

UBL has also implemented a project on Rain Water Harvesting and Drinking water facilities at Ganeshapuram, as it has been facing severe drinking water shortage during summer months. The project was implemented to meet the water requirement of 85 families having about 380 members. The quantity of water recharged in the well is equivalent to the quantity of water consumed by the members of these families.



Source: United Breweries

It is possible to connect various such companies to regions nearby with water-related problems and hence direct the CSR efforts towards solving the water crisis in the areas affected.

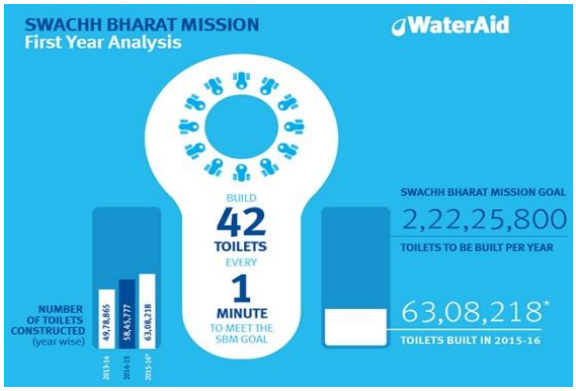
F. Role of NGOs & Community Based Organizations

WaterAid:

WaterAid is an NGO that aims to promote local skills and empower the communities enough to develop, implement and manage water security plans. The different approaches used to manage water security in communities are:

- Building water security and water quality models at the community level.
- Demonstrate processes such as Jal Chaupal to involve the communities to seek solutions for emerging issues.
- Mobilize communities and strengthen mandated institutions, including health care centres, schools, and so on.
- Engage with relevant departments and technical support at the local levels in urban and rural communities.
- Support districts to integrate community-based management of water supply and drinking water security measures as part of the districts' annual plans.

- Monitoring the quality of water through testing the chemical and relevant parameters by labs set up in these districts.



Source: WaterAid

Jal Chaupal (a community level meeting to discuss water issues) is an innovative concept introduced in Bihar and Uttar Pradesh. A participatory approach, Jal Chaupal motivates rural communities to seek solutions for water problems through flagship government programmes on water quality and household level water connections.

Community-Based Organizations (CBOs):

They fill in two important gaps in service that public and private water and sanitation suppliers may not be able to provide adequately. First, from the perspective of participation, public and private water organizations share the limited potential for the active involvement of local communities, especially after the construction of the water project is complete. Second, such organizations are limited in capacity (technical, financial, etc.), in a way that, a significant number of remote villages lie beyond their operational reach. Community-based water supply and management organizations organize themselves as Water Users Associations (WUAs). These organizations can exist on their own but may form larger collectives.

Owners vis-ă-vis Operators		Operators vis-ă-vis Owners	
Responsibilities	Rights	Responsibilities	Rights
• Invest in assets and asset renewal, including, potentially, by taking on debt • Take on a level of risk related to the growth of their investment • In specific cases, fulfill residual obligation/liabilities	• Return on investment • Proceeds in sale of assets • Appoint board of directors • Appoint managers • Supervise the operator	• Maintain assets in good condition • Operate system to fulfill service obligations • Exercise due care in the fulfillment of duties • Increase the return on investment for the owner	• Compensation • Security of tenure in good service, according to the cooperation agreement • Direct the day-to-day operations of system without undue interference

Source: semanticsscholar.org

Community-Based Organizations are adapted to supply for small-pipe water networks, which in general does not comprise for more than 1000 households. Similar to their public or private counterparts, CBOs are involved in all aspects of building the underlying infrastructure for a water supply and sanitation network. Since the beneficiaries own the community-based management model, the maintenance of operations and facilities is managed with oversight of the respective communities themselves. Apart from building and operating the actual water supply network, WUAs can also assist with social service programs, such as disseminating knowledge of national sanitation and hygiene strategies. In rural areas, different kind of farmers' associations along with WUA's have been active in constructing and managing small-irrigation schemes.

ANALYSIS AND CONCLUSION

Considering the vital importance of water for life, for maintaining ecological balance and for economic and developmental activities of all kinds, the planning and management of this resource and its optimal, economic and equitable use has become a matter of urgency.

Inculcating the values of water management in the youth at the school level provides them with a bigger picture of the situation in the country, while also granting them practical knowledge and experience to tackle these issues in the future effectively. Directing projects and research in universities towards water treatment, monitoring or its management should be incentivized to achieve a higher research output in this area.

Linking various communities has proven to be an effective system for water management. There are about 80,000 Community Water Boards operating in Latin America and the Caribbean, showing that community management is an alternative to supply water and sanitation services, especially in rural areas. By implementing a robust framework that benefits from the educational, industrial, corporate and community sectors, it is possible to mitigate the effects of water shortage across the country and work towards a sustainable future.

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