2018
01

IWMI
International Water Management Institute

IWMI-TATA
Water Policy Program

DISCUSSION PAPER

Reforming India's Water Governance to meet 21st Century Challenges

Practical Pathways to Realizing the Vision of the Mihir Shah Committee

Mihir Shah

TATA TRUSTS

ICAR

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

CGIAR RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

CCAFS

Reforming India's Water Governance to meet 21st Century Challenges

Practical Pathways to Realizing the Vision of the Mihir Shah Committee[i]

Mihir Shah[ii]

1. The Meaning of Reform

Over the last 30 years, not just in India but also all over the globe, reform has acquired a very specific meaning. It is generally used to connote a policy shift in the direction of privatization and reducing the role of the state in the economy. In many respects, this has been a welcome move as the state has handed over sectors of the economy to the private sector and greater competition has led to increases in efficiency and cheaper availability of many goods and services to the consumer, at higher quality.

At the same time, however, the tragic fallout of this blind and dogmatic change in policy has been to further worsen access to basic services to the large mass of the population. Whether it is access to quality health and education or water, sanitation, nutrition, credit etc., a massive reform deficit has afflicted these sectors. For, the reform required here is not the one being proposed under the "Washington Consensus". Indeed, it is not the private sector that is the panacea for these sectors, which suffer from massive market failure. What is required in each of these cases, is reform of government, which would make state systems more efficient and accountable to the people.

It is clear, for example, that falling ill is perhaps the single biggest cause of people slipping below the poverty line in India. Health care remains predominantly private, with India spending among the lowest percentage of GDP globally on public health provision. Similarly, unprecedented farmers' suicides and recent farmers' agitations point to continued lacunae in state intervention in a situation of ginormous market failure. The solution is not to do away with public procurement itself but to decentralize and expand procurement operations to cover a much wider array of crops, such as millets and pulses, to incentivize farmers to diversify their cropping patterns. Again, the functioning of the ICDS and MDMS, the flagship nutrition programs, is highly unsatisfactory in the north Indian Hindi heartland, where malnutrition levels remain among the highest in the world. Adopting more participatory approaches to their implementation is the key reform required, rather than privatization. Learning outcomes in government schools remain abysmally poor, as revealed by the ASER (Annual Survey of Education) reports. Here again, we cannot expect the profit-maximizing private sector to fill in the breach. We will need to profoundly reform the public education system.

Overall, one can say that depending on the specific challenges of each sector, the desired direction of reform could be collectivization (as in agri-marketing), nationalization (as in banking) or reform of functioning of government programs (such as MGNREGA). Reform can, of course, include a greater role for the private sector and liberalization but this must be examined and decided upon on a case-by-case basis. A focus on the question of governance reform in the water sector helps illustrate how critical it is for us to understand precisely the kinds of reforms we need in key sectors of the Indian economy and not to be blinded by a dogmatic adherence to the Washington Consensus. What we need to understand is that each sector of the economy has some very specific features and reform needs to be defined with reference to these *differentia specifica* of each sector. To put it in a word, it is not a question of larger or smaller government: the way forward lies in the maxim "better government is better". When it comes to the question of a natural resource like water, a key specific element of the reforms needed is the recognition that the economy is but a small part of the larger eco-system and that proceeding with a narrow notion of economic development without an adequate recognition of this huge fact, can only lead to disastrous outcomes, as evidenced by the fate of the planet, currently in this age of the Anthropocene (see Rockström 2017).

This paper seeks to answer a set of inter-related questions concerning reforms in the water sector:

- Why has it become necessary to focus on reforming water governance in India today?
- What is it about the nature of the water crisis facing the country that necessitates such an emphasis?
- What are the dimensions that water governance reform needs to cover?
- And in which broad direction must this change occur?

The specific context in which these questions will be answered is of the Mihir Shah Committee Report[iii] submitted to the Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India. There have been

extensive discussions on the Report in the media and in academic journals. These include a number of articles in India's leading social science journal *Economic and Political Weekly*, where the debate continues to this day[iv]. However, this paper seeks to carry the discussion to the next stage, where it will attempt to catalogue possible triggers and catalysts for change, as also outline practical pathways to realizing the vision embedded in the Report. We begin by presenting the basic premises of the Report, somewhat differently from the way they are presented in the Report itself.

2. Water Crisis of Unprecedented Proportions

India faces a major crisis of water as we move into the 21st century. This crisis threatens the basic right to drinking water of our people; it also puts the livelihoods of millions at risk (Shah 2013). The demands of a rapidly industrializing economy and urbanizing society come at a time when the potential for augmenting supply is limited, water tables are falling and water quality issues have increasingly come to the fore. As we drill deeper for water, our groundwater gets contaminated with fluoride, arsenic, mercury and even uranium. Our rivers and our groundwater are polluted by untreated effluents and sewage. Many urban stretches of rivers and lakes are overstrained and overburdened by industrial waste, sewage and agricultural runoff. These wastewaters are overloading rivers and lakes with toxic chemicals and wastes, consequently poisoning water resources and supplies. These toxins are finding their way into plants and animals, causing severe ecological toxicity at various trophic levels. In India, cities produce nearly 40,000 million liters of sewage every day and barely 20 percent of it is treated. Central Pollution Control Board's 2011 survey states that only 2% towns have both sewerage systems and sewage treatment plants (Shah and Kulkarni 2015).

Climate change poses fresh challenges with its impacts on the hydrologic cycle. More extreme rates of precipitation and evapotranspiration will exacerbate impacts of floods and droughts. More intense, extreme and variable rainfall, combined with lack of proper drainage, will mean that every spell of rain becomes an urban nightmare, as roads flood and dirty water enters homes and adds to filth and disease. Our flood management strategies no longer seem to provide an adequate answer to growing flood frequency and intensity. It is no wonder then that conflicts across competing uses and users of water are growing by the day. Water use efficiency in agriculture, which consumes around 80 per cent of our water resources, continues to be among the lowest in the world. At 25-35 per cent, this compares poorly with 40-45 per cent in Malaysia and Morocco and 50-60 per cent in Israel, Japan, China and Taiwan (Shah 2013). The two main sources of irrigation are canals and groundwater. The relative contribution of canal irrigation has been steadily declining over time while groundwater – especially that extracted through tubewells – has rapidly grown in significance over the last 30 years. But the alarming fact is that both these sources of water are now beginning to hit an upper limit.

India has, in recent years, been suffering successive droughts causing great misery to millions of people, even resulting in suicides by farmers. At the epicenter of the present drought is Maharashtra, the State with the highest number of dams in India. Intervening in a debate in the State Assembly on July 21, 2015, the Chief Minister of Maharashtra remarked that the State has 40 per cent of the country's large dams, "*but 82 per cent area of the state is rainfed. Till the time you don't give water to a farmer's fields, you can't save him from suicide. We have moved away from our vision of watershed and conservation. We did not think about hydrology, geology and topography of a region before pushing large dams everywhere. We pushed large dams, not irrigation. But this has to change.*"

3. Governance Reform at the Heart of Change Needed

It is our contention that the crisis that we have just briefly summarized has a very close link with the prevailing paradigm[v] of governance of water in India. Before explicating these links and also suggesting the changes required, let us first summarize the key *features, dimensions and principles* that characterize the existing paradigm, each of which need to undergo urgent transformation:

1. **Command-and-control**: Whether it be rivers or groundwater, the dominant paradigm is of command-and-control. There is no understanding of river systems or their interconnections with the health of catchment areas or groundwater

2. **Bureaucratic Governance**: Large, centralized, decaying bureaucracies are charged with administering water throughout the length and breadth of India

3. **No reference to Hydrological entities such as Aquifers or River Systems**: When I joined the Planning Commission in 2009, the word aquifer could hardly be found within government discourse and the integrity of river systems is still not understood

4. **Uni-disciplinarity**: Since the goal is command-and-control through dam construction and groundwater extraction, the only disciplines evoked are engineering and hydrogeology, that too in their narrowest versions. Water cannot be understood with this narrow disciplinary focus

5. **Uni-dimensionality**: Since the focus is extraction and development, all dimensions of water, other than economic resource use, are ignored. These various other dimensions are however of critical importance to the primary stakeholders of water in India

6. **Water in Silos**: We have divided water into silos of groundwater and surface water, as also irrigation and domestic use, with little dialogue across silos, leading to "hydroschizophrenia" (see Jarvis *et al*. 2005), where the left hand of drinking water does not know what the right hand of irrigation is doing; and the left foot of surface water does not know what the right foot of groundwater is doing

7. **Instrumental View of Water, especially Rivers**: The way we look at our rivers is as water resources to be exploited, ignoring completely the numerous eco-system services provided by living river systems, as also the intrinsic value of rivers for our people and other forms of life.

8. **Supply-side focus**: The entire focus has been on augmenting supplies, with little attention being paid on demand-management of water

9. **No reference to Sustainability**: In the preoccupation with extraction and development, there has generally been an absence of considerations of sustainability, endangering the future of both groundwater and river flows.

10. **Discrimination and Lack of Equity in Access to Water**: Historical forms of discrimination, combine with the impact of growing economic inequalities in the country, to create severe discrimination in access to water on grounds of caste, class, gender, location and community

11. **Lack of Transparency and Access to Water Information:** Over the years, there has been needless secrecy in access to water data and information for researchers and stakeholders that has only meant that the quality of water management has suffered and conflicts have got exacerbated

12. **British Common Law**: The legal framework governing water belongs to the 19th century British common law, which legitimizes and perpetuates inequity in access to water by giving unlimited powers of drawal of water to owners of land

Our central argument is that the present crisis of water in India is a direct consequence of this 12-fold paradigm of governance that needs urgent reform, if we are to find effective solutions to India's multiple water problems. Without a paradigm shift in water governance, we cannot solve the problem of water.

4. CWC: Engineering Command-and-Control over Rivers

The biggest example of centralized command-and control is the construction of large dams on our rivers. Even if we put aside the ginormous human and environmental costs of these structures, the benefits of this kind of engineering supply-centered effort have been underwhelming. Huge public investments over the last 60 years have meant that the irrigation potential created through major and medium irrigation projects has increased nearly five-fold from 9.72 mha in the pre-Plan period to around 46 mha by the XI Plan. But how much of this water have actually benefitted the farmers for whom it was meant is not clear. At the same time, there is incontrovertible evidence that these projects have suffered from massive time and cost over-runs[vi].

The worst offenders are the major irrigation projects where the average cost overruns is as high as 1382 per cent. 28 out of the 151 major projects analyzed, witnessed cost over-runs of over 1000 per cent. Of these, nine had cost overruns of over 5000 per cent. The cost over-runs were relatively lower for medium projects but still unacceptably high, the average being 325 per cent. 23 out of 132 medium projects had cost overruns of over 500 per cent and 10 had cost overruns of over 1000 per cent.

The number of projects awaiting completion peaked in 1980 to 600; then there was decline till 1992 to 460, after which it has again risen to 571, almost touching the 1980 figure. Major irrigation projects are expected to have a gestation period of 15–20 years while medium projects should take 5–10 years for completion. Against these norms, a large number of major as well as medium projects are continuing for 30–40 years or even more. This reflects poor project preparation and implementation, as well as thin spreading of available resources.

Recent scholarship points to definite limits to the role new large dam projects can play in providing economically viable additional water storage (Ackerman 2012). A World Bank study shows that "there is little value to additional storage in most of the peninsular river basins (the *Kaveri*, *Krishna* and *Godavari*) and in the *Narmada* and *Tapti*" (Briscoe and Malik 2006; p.32). Similarly, a study by IWMI (Amarasinghe *et al*. 2007), suggests that Krishna and Kaveri have reached full or partial closure. Another IWMI study shows that in the Krishna river basin, the storage capacity of major and medium reservoirs has reached total water yield (Venot *et al* 2007), with virtually no water reaching the sea in low rainfall years. Concern has also been expressed that "the capture of so much water within the basin and the evaporation of an additional 36 BCM of water has changed the regional climate, increasing humidity and changing temperature regimes, aggravating saline ground water intrusion, and putting at risk the delicate wetland and estuarine ecology which is important not only for aquatic habitats and fisheries, but also for preventing shore erosion" (Ackerman 2012; p.6).

Given these constraints, the trend increasingly is to locate new projects in relatively flat topography that multiplies disproportionately the areas to be flooded and the people to be evicted. It also tends to aggravate already contentious relations between States, as witnessed in the Polavaram dam in Andhra Pradesh, strongly opposed by both Orissa and Chhattisgarh. Water flow in the Himalayan Rivers, particularly the Ganga is, of course, far greater than in Peninsular Rivers but here there are other constraints. In the Ganga Plains, the topography is completely flat and storages cannot be located here. In a study for the Asian Development Bank, Blackmore (2010) has argued that surface irrigation through dams in the Ganga river basin is of low value since water tables are already high. Similarly for the Indus, Blackmore (2010) shows that "*the next major dam (at a cost of USD 12 billion) will yield less than 1.5 per cent increase in regulated flow*". There is also the problem that further up in the Himalayas where we confront one of the most fragile ecosystems in the world. The Himalayas are comparatively young mountains with high rates of erosion. Their upper catchments have little vegetation to bind soil. Deforestation has aggravated the problem. Rivers descending from the Himalayas, therefore, tend to have high sediment loads. A 1986 study found that 40 per cent of hydro-dams built in Tibet in the 1940s had become unusable due to siltation of reservoirs (Pomeranz 2009). Studies by engineering geologists with the Geological Survey of India record many cases of power turbines becoming dysfunctional following massive siltation in run-of-the-river schemes.

Climate change is making predictability of river flows extremely uncertain. This will rise exponentially as more and more dams are built in the region. Diverting rivers will also create large dry regions with adverse impact on local livelihoods (fisheries and agriculture). Dam building enthusiasts also often overlook the fact that the rapid rise of the Himalayas i.e. from 500 to 8000 m gives rise to an unmatched range of ecosystems, a biodiversity that is as enormous as it is fragile. The north-east of India is one of just 25 bio-diversity hotspots in the world (Myers *et al*. 2000). According to Valdiya (1999), and Goswami and Das (2002), the neo-tectonism of the Brahmaputra valley and its surrounding highlands in the eastern Himalayas means that modifying topography by excavation or creating water and sediment loads in river impoundments can be dangerous. Quake-induced changes in the river system can adversely impact the viability of dams as several basic parameters of the regime of rivers and the morphology and behavior of channels may change. "*The last two major earthquakes in the region (1897 and 1950) caused landslides on the hill slopes and led to the blockage of river courses, flash floods due to sudden bursting of landslide induced by temporary dams, raising of riverbeds due to heavy siltation, fissuring and sand venting, subsidence or elevation of existing river and lake bottoms and margins and the creation of new water bodies and waterfalls due to faulting*" (Menon *et al*. 2003). Even more recent research published in *Science* (Kerr and Stone 2009) on Zipingpu reservoir-induced seismicity as a trigger for the massive Sichuan earthquake in 2008, raises doubts about the wisdom of extensive dam-building in a seismically active region.

The ambitious scheme for interlinking of rivers also presents major problems. The comprehensive proposal to link Himalayan with the Peninsular rivers for inter-basin transfer of water was estimated to cost around ₹560,000 crores in 2001 (the cost is officially stated to have risen to ₹11 lakh crore today). Land submergence and R&R packages would be additional to this cost. There are no firm estimates available for running costs of the scheme, such as the cost of power required to lift water. There is also the problem that because of our dependence on the monsoons, the periods when rivers have "surplus" water are generally synchronous across the subcontinent. A recent study further indicates that deficit rainfall years are growing in river basins with surplus water and falling in those with shortages (Ghosh *et al*. 2016). A major problem in planning inter-basin transfers is how to take into account the reasonable needs of the basin states, which will grow over time. Further, given the topography of India and the way links are envisaged, they might totally bypass the core dryland areas of Central and Western India, which are located on elevations of 300+ m above MSL. It is also feared that linking rivers could affect the natural supply of nutrients through curtailing flooding of the downstream areas. Along the east coast of India, all major peninsular rivers have extensive deltas. Damming the rivers for linking will cut down the sediment supply and cause coastal and delta erosion, destroying the fragile coastal eco-systems.

It has also been pointed out that the scheme could affect the monsoon system significantly (Rajamani *et al*. 2006). The presence of a low salinity layer of water with low density is a reason for maintenance of high sea-surface

temperatures greater than 28 °C in the Bay of Bengal, creating low-pressure areas and intensification of monsoon activity. Rainfall over much of the sub-continent is controlled by this layer of low saline water. A disruption in this layer could have serious long-term consequences for climate and rainfall in the subcontinent, endangering the livelihoods of a vast population. Given the emerging limits to further development in the major and medium irrigation sector, we urgently need to move away from a narrowly engineering-construction-centric approach to a more multi-disciplinary, participatory management perspective, with central emphasis on command area development and a sustained effort at improving water use efficiency, which continues to languish at a very low level. Given that nearly 80% of our water resources are consumed by irrigation, an increase in water use efficiency of irrigation projects by 20% will have a major impact on the overall availability of water not only for agriculture but also for other emerging sectors of the economy.

5. Need for Irrigation Management Transfer

The Government of India needs to both incentivise and facilitate states to ensure that they undertake reforms required to ensure that the trillions of litres of water stored in our large dam command areas actually reaches the farmers for whom it is meant. India's irrigation potential created is 113 mha and the potential utilized is 89 mha. This gap is growing by the year. This gap of 24 mha is massive low hanging fruit. By focusing our efforts on bridging this gap we could add millions of hectares to irrigation at half the cost involved in irrigating through new dams (Shah *et al*. 2016).

The way to do this is to move towards Participatory Irrigation Management (PIM), which has been successfully adopted in countries across the globe. This includes advanced nations such as the US, France, Germany, Japan and Australia; East and South Asian countries like China, Sri Lanka, Pakistan, Philippines, Indonesia, Vietnam and Malaysia; Uzbekistan and Kyrgyzstan in Central Asia; Turkey and Iran in the Middle East; African nations such as Mali, Niger, Tanzania and Egypt, as also Mexico, Peru, Colombia and Chile in Latin America.

But even more significant is the successful example of PIM pioneered by States in India such as Dharoi and Hathuka in Gujarat, Waghad in Maharashtra, Satak, Man and Jobat in Madhya Pradesh, Paliganj in Bihar and Shri Ram Sagar in Andhra Pradesh. Of course, there is no question that certain very specific conditions need to be put in place for PIM to be successful. A careful examination of successful PIM projects provides an indication of these conditions:

1. Strong legal status of WUAs and basis for PIM
2. Clear water use rights for WUAs and farmers
3. Leadership and empowerment of women
4. Full decision making authority transferred to WUAs
5. WUAs federate to the main system level
6. Irrigation Service Fees (ISF) determined in participatory manner
7. ISF retained by WUA to finance O&M and repairs and improvements, rehabilitation and modernization

PIM implies that the states only concentrate on technically and financially complex structures, such as main systems up to secondary canals and structures at that level. Tertiary level canals and below, minor structures and field channels, are handed over to Water Users Associations of farmers, which enables the transformation of last-mile connectivity through innovative command area development. What the Centre needs to do is to set up a non-lapsable fund that reimburses to state irrigation departments a matching contribution of their Irrigation Service Feed (ISF) collection from farmers on a 1:1 ratio. In order to generate competition among Major and Medium Irrigation (MMI) staff across commands, States would be allocated the central grant to MMI systems in proportion to their respective ISF collection. To encourage Participatory Irrigation Management (PIM), the Centre should provide a bonus on that portion of each State's ISF collection, which has been collected through Water User Associations (WUAs). And this will be (as mentioned above) on condition that WUAs and their federations are allowed to retain definite proportions of the ISF, which would not only enable them to undertake repair and maintenance of distribution systems but also increase their stakes in water management.

It has been estimated that even without building a single new large dam project, by simply completing ongoing projects we could create new MMI irrigation potential of 7.9 million ha. Again, by simply closing the gap between IPC and IPU we could add 10 million ha by prioritizing investments in Command Area Development and Management (CAD&M) projects. In addition, and we could also restore 2.2 million ha of lost irrigated potential through Extension, Renovation and Modernization (ERM) works in old MMI projects (Shah *et al*. 2016). Sadly, in its current state the Central Water Commission (CWC) is ill-equipped to undertake these kinds of radical reforms.

6. CGWB: Unlimited Extraction of Groundwater

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 used by millions of farmers across the country. Over the last four decades, around 84 per cent of the total addition to the net irrigated area has come from groundwater. India is by far the largest and fastest growing consumer of groundwater in the world. But groundwater is being exploited beyond sustainable levels and with an estimated 30-million groundwater structures in play, India may be hurtling towards a serious crisis of groundwater over-extraction and quality deterioration (Rodell *et al*. 2009). Recent work based on data from NASA's Gravity Recovery and Climate Experiment (GRACE) satellites reveals significant rates of non-renewable depletion of groundwater levels over large areas. The declines were at an alarming rate of as much as one foot per year over the past decade. The study concludes that unsustainable consumption of groundwater for irrigation and other anthropogenic uses is likely to be the cause.

A major contributor to this rapid depletion in water tables is the overwhelming dependence on deep drilling of groundwater through tubewells, which at over 40 per cent is the single largest source of irrigation today. Indeed, we are close to entering a vicious infinite regress scenario where an attempt to solve a problem re-introduces the same problem in the proposed solution. If one continues along the same lines, the initial problem will recur infinitely and will never be solved. This regress appears as a natural corollary of what has been termed "hydroschizophrenia" (Llamas and Martinez-Santos 2005), which entails taking schizophrenic view of an indivisible resource like water, failing to recognize the unity and integrity of the hydrologic cycle. The most striking example of this in India is increased reliance on tubewells both for irrigation and drinking water, not recognizing that one can potentially jeopardize the other. Indeed, the problem of "slippage" in rural drinking water has become a recurrent and serious one. The portents have been visible for some time now. Issues related to water quality have also emerged as a major new concern over the last decade or so. Till the 1970s, quality issues were to do with biological contamination of the main surface water sources due to poor sanitation and waste disposal, leading to repeated incidence of water-borne diseases. But today this has been supplemented by the serious issue of chemical pollution of groundwater, with arsenic, fluoride, iron, nitrate and salinity as the major contaminants. This is directly connected with falling water tables and extraction of water from deeper levels. States continually report an increasing number of habitations affected with quality problems.

According to the Ministry of Drinking Water Supply and Sanitation, out of 593 districts from which data is available, we have problems from high fluoride in 203 districts, iron in 206 districts, salinity in 137 districts, nitrate in 109 districts and arsenic in 35 districts. Biological contamination problems causing enteretic disorders are present throughout the country and are a major concern, being linked with infant mortality, maternal health and related issues. Estimates made for some of these water quality related health problems suggest a massive endemic nature – Fluorosis (65 million) (Susheela 2001) and Arsenicosis (5 million in West Bengal) (WHO 2002) and several magnitudes more, though un-estimated from Assam and Bihar]. Fluorosis caused by high Fluoride in groundwater leads to crippling, skeletal problems and severe bone deformities. On the other hand, Arsenicosis leads to skin lesions and develops into cancer of lung and the bladder (Krishnan 2009). The result is that nearly 60% of all districts in India have problems related to either the quantity or quality of groundwater or both.

7. Sustainable and Equitable Management of Groundwater, the CPR, based on Partnerships

While its decentralized character enables easier last-mile connectivity of groundwater, the problem arises in the inequitable distribution and unsustainable extraction of this common pool resource (CPR). As the work of Nobel Laureate Elinor Ostrom shows, the first design principle in management of a CPR is the clear delineation and demarcation of its boundaries, and an understanding of its essential features, which in the case of groundwater includes its storage and transmission characteristics. About 54 per cent of India (comprising mainly the continental shield) is underlain by formations usually referred to as "hard rocks"[vii]. Groundwater in hard rocks is characterized by limited productivity of individual wells, unpredictable variations in productivity of wells over relatively short distances and poor water quality in some areas.

Initially, the expansion of tubewells following the Green Revolution was restricted to India's 30 per cent alluvial areas, which are generally characterized by relatively more pervious geological strata. From the late 1980s, tubewell drilling was extended to hard rock regions where the groundwater flow regimes are extremely complex. Deeper-seated aquifers often have good initial yields, but a tubewell drilled here may be tapping groundwater accumulated over hundreds or even thousands of years. Once groundwater has been extracted from a deeper aquifer, its replenishment depends upon the inflow from the shallow system or from the surface several hundred meters above it. In general the rate of groundwater recharge is much lower. This poses a severe limit to expansion of tubewell technology in areas underlain by these strata. However, even in the alluvial heartlands of the Green Revolution for which tubewell

technology is relatively more appropriate, we are moving into crisis zone. Three states, Punjab, Rajasthan and Haryana, have reached a stage where even their current level of groundwater extraction exceeds recharge and is therefore unsustainable. Three other states, Tamil Nadu, Gujarat and UP, seem to be fast approaching that stage.

Participatory sustainable groundwater management, recognizing its CPR character is the need of the hour, where management strategies are duly attuned to the specific requirements of each hydrogeological setting, which need to be carefully mapped at a scale that makes possible such participatory management by the primary stakeholders. It is not possible to police 30 million groundwater structures through a license-quota-permits. The challenge of groundwater management arises from the fact that a fugitive, common pool resource is currently being extracted by individuals, millions of farmers in particular, with no effective mechanism to ensure that the rate of extraction is sustainable.

It is this understanding that underpins the National Aquifer Management Program (NAQUIM) initiated by the Government of India in the 12th Plan and its new avatar the *Atal Bhujal Yojana*. This is the largest such program ever initiated in human history. Nothing of this scale has been attempted before: the term scale is used in two senses – one, the *extensiveness* of scale and two, the *fineness* of scale (resolution of the maps). The aquifer mapping program is not an academic exercise and must seamlessly flow into a participatory groundwater management endeavor. This demands strong partnerships among government departments, research institutes, gram panchayats/urban local bodies, industrial units, civil society organizations and the local community. Tragically, so far the program has failed to take off with the requisite momentum. The major reason for this is the huge lack of capacities in the CGWB and the state ground water boards. The institutional mandate of CGWB should be strengthened to enable it to perform its role as the manager of groundwater resource, including hiring from the fields of community institutions, participatory management of resource, political economy and economics, water markets, regulatory systems, alternative uses, opportunity cost of groundwater extraction, energy management and so on.

8. River Basins as Focus of Water Governance

For some time now, policy-makers and scholars alike have emphasized the need to integrate our interventions on surface and groundwater given that the ultimate source of all water on land is precipitation as rain, snow or hail. The need to focus on river basins as the appropriate unit of intervention is evident in the watershed programs initiated by the government over the last 40 years. River Basin Organizations have also been set up. However, it remains true that progress on integrating surface and groundwater has been slow in actual work done on the ground. In recognition of this fact, the recent National Water Framework Law (NWFL) drafted by the Ministry of Water Resources, River Development and Ganga Rejuvenation has placed special emphasis on integrated river basin development and management, as also on river rejuvenation as central pillars of national policy.

The draft bill emphasizes the integral relationship between surface and groundwater. The NWFL recognizes that "water in all its forms constitutes a hydrological unity, so that human interventions in any one form are likely to have effects on others; and that "ground water and surface water interact throughout all landscapes from the mountains to the oceans". This is evident in the fact that "over-extraction of groundwater in the immediate vicinity of a river, destruction of catchment areas and river flood-plains have very negatively impacted river flows in India; such a decrease in river flows, in turn, negatively impacts groundwater recharge in riparian aquifers in the vicinity of the river."

Because "the fall in water tables and water quality, as also the drying up of rivers, has serious negative impacts on drinking water and livelihood security of the people of India, as also the prospects for economic growth and human development in the country", it is vitally important that "each river basin, including associated aquifers, needs to be considered as the basic hydrological unit for planning, development and management of water, empowered with adequate authority to do the same."

The NWFL places central emphasis on river rejuvenation and enjoins the appropriate government to "strive towards rejuvenating river systems with community participation, ensuring:

[a] '*Aviral Dhara*'- continuous flow in time and space including maintenance of connectivity of flow in each river system;

[b] '*Nirmal Dhara*'- unpolluted flow so that the quality of river waters is not adversely affected by human activities; and

[c] '*Swachh Kinara*' – clean and aesthetic river banks."

9. Need of the Hour: National Water Commission[viii]

The CWC and CGWB were created in a very different era, with a mandate appropriate for that era. The challenge today is for us to restructure these agencies so that they can:

[a] work on the new mandate that the nation has placed before them and

[b] work in a manner that overcomes the schism between groundwater and surface water

[c] work with greater presence on the ground at the river basin level

The Committee on Restructuring CWC and CGWB has proposed that a National Water Commission be created that unifies these two apex bodies. Both the CWC as well as CGWB have useful and formidable capabilities for water resource exploration, assessment and monitoring, and planning of infrastructure projects; these must be preserved, nurtured and built upon. These capabilities are no doubt important even today and will remain so in future, too. However, technologies available today are so advanced that these tasks can be performed better and in more cost effective manner than is being done now. The need of the hour is to significantly enhance the effectiveness of assessment, monitoring and planning capabilities and their effective deployment.

The CGWB grew out of a small organization with a narrow, specific purpose, viz., drill exploration wells to assess groundwater resource. The CWC even today views itself as "an apex *technical* organisation in the field of water resources development". Neither agency ever viewed itself as a water governance organization. In the new water resource governance scenario facing the country, we need to envisage a high level central organization that is forward looking, strategic, agile and trans-disciplinary in its skill set. This has to be conceived of as an action organization rather than merely an assessment and monitoring organization, although these too will remain aspects of its mandate. It is true that all the action in the water sector lies with the state governments. Yet a well-designed central organization can deploy and use funds as well as scientific and knowledge resources to influence and support what states do in water governance. This organization should have a compact leadership with a broad range of expertise related to water. Moreover, it has to have a culture of cross-disciplinary team-work rather than different disciplines operating in silos. The need of the hour is a new organizational culture, new skill-mix and new operating style. Both CWC and CGWB are weighed down by their highly specialized but narrow-based skill-structure. These are massive organizations using up huge resources and energies in managing themselves. Their functioning is also mired by a highly dysfunctional organization culture. There is literally a quagmire of hundreds of different designations, which has nightmarish consequences for framing recruitment rules, career progression ladder, promotions, seniority, pay scales etc.[ix] All these limitations constrain the capacity of these agencies to rise to meet major new challenges facing India's water economy. The larger water governance challenge requires a new-age, modern, agile and compact apex organization that is untrammelled by the burden of the irksome internal management complexities of these unwieldy bureaucracies.

What is more, the organisation needs to view both groundwater and surface water in an integrated, holistic manner. CWC and CGWB cannot continue to work in their current independent, isolated fashion. The one issue that brings out the need to unify the two bodies more than any other is the drying up of India's rivers. The single most important factor explaining the drying up of post-monsoon flows in India's peninsular rivers is the over-extraction of groundwater. The drying up of base-flows of groundwater has converted so many of our "gaining" rivers into "losing" rivers. If river rejuvenation is, indeed, the key national mandate assigned to the Ministry of Water Resources, then this cannot be done without hydrologists and hydrogeologists working together, along with social scientists, agronomists and other stakeholders. Both the CWC and CGWB are lacking in the capacities essential for them to respond to the needs of the water sector in 21st century India. Civil engineers (the main discipline overwhelmingly present in the CWC) and hydrogeologists (the main discipline in the CGWB) are crucial for effective water management. But alone they cannot be expected to shoulder the entire burden of the new mandate. There is an acute lack of professionals from a large number of disciplines, without which these bodies will continue to under-perform. These disciplines include, most importantly, the social sciences and management, without which we cannot expect programmes such as Participatory Irrigation Management and Participatory Groundwater Management to succeed; Agronomy, without which crop water budgeting cannot happen and water use efficiency will not improve; Ecological Economics, without which we will not gain an accurate understanding of the value of ecosystem services, which need to be protected in river systems and River Ecology, which is essential to the central mandate of river rejuvenation.

It is, therefore, imperative that:

[a] a brand new National Water Commission (NWC) be established as the nation's apex facilitation organisation dealing with water policy, data and governance;

[b] NWC should be an adjunct office of the Ministry of Water Resources, River Development and Ganga Rejuvenation, functioning with both full autonomy and requisite accountability;

[c] NWC should be headed by a Chief National Water Commissioner, a senior administrator with a stable tenure and with strong background in public administration, and should have full time Commissioners representing Hydrology (present Chair, CWC), Hydrogeology (present Chair, CGWB), Hydrometeorology, River Ecology, Ecological Economics, Agronomy (with focus on soil and water) and Participatory Resource Planning & Management ;

[d] NWC should have strong regional presence in all the major river basins of India;

[e] NWC should build, institutionalise and appropriately manage an architecture of partnerships with knowledge institutions and practitioners in the water space, in areas where in-house expertise may be lacking.

The key mandate and functions that the National Water Commission needs to pursue has following building blocks:

[a] enable and incentivize state governments to implement all irrigation projects in reform mode, with an overarching goal of *har khet ko pani* and improved water resource management and water use efficiency, not just construction of large scale reservoirs, as the main objective;

[b] lead the national aquifer mapping and groundwater management programme;

[c] insulate the agrarian economy and livelihood system from pernicious impacts of drought, flood and climate change and move towards sustainable water security;

[d] develop a nation-wide, location-specific programme for rejuvenation of India's rivers to effectively implement the triple mandate of *nirmal dhara*, *aviral dhara*, *swachh kinara;*

[e] create an effective promotional and regulatory mechanism that finds the right balance between the needs of development and environment, protecting ecological integrity of nation's rivers, lakes, wetlands and aquifers, as well as coastal systems;

[f] promote cost effective programmes for appropriate treatment, recycling and reuse of urban and industrial waste water;

[g] develop and implement practical programmes for controlling point and non-point pollution of water bodies, the wetlands and aquifer systems;

[h] create a transparent, accessible and user-friendly system of data management on water that citizens can fruitfully use while devising solutions to their water problems;

[i] operate as a world-class knowledge institution available, on demand, for advice to the state governments and other stakeholders, including appraisal of projects, dam safety, inter-state and international issues relating to water;

[j] create world-class institutions for broad-based capacity building of water professionals and knowledge management in water.

10. New Paradigm of Water Governance in India: Features, Principles, Dimensions

From the above discussion, we get a clear idea of the fundamental change we need to effect in the paradigm of water governance in India, if we are to meet the challenge of sustainable and equitable access to water and livelihood security for the Indian people. The new paradigm would need to have the following features, principles and dimensions:

1. **Weaving our Interventions into the Contours of Nature:** Rather than command-and-control, our attempt needs to fully appreciate and apprehend the enormous diversity that characterizes this nation and plan our interventions in full cognizance and understanding of this diversity, making them as location-specific as possible, to avoid the pitfalls of indiscriminate centralized planning. Watersheds, aquifers and river systems would be the cornerstones of such planning.
2. **Governance based on Partnerships:** Rather than making governance the sole responsibility of governments, we need to craft a carefully designed architecture of partnerships, where all primary stakeholders get deeply involved in the collective endeavor of participatory water governance.
3. **Multi-disciplinarity:** We must acknowledge that we cannot understand water other than in a deeply multi-disciplinary and trans-disciplinary perspective. This involves not just engineering and hydro-geology but also river ecology, agronomy, soil science, the various social sciences and management, among others.
4. **Multi-dimensionality:** We must adopt the perspective proposed in the current draft of the National Water Framework Law (NWFL), which states that: "water is the common heritage of the people of India; is essential for

the sustenance of life in all its forms; an integral part of the ecological system, sustaining and being sustained by it; a basic requirement for livelihoods; a cleaning agent; a necessary input for economic activity such as agriculture, industry, and commerce; a means of transportation; a means of recreation; an inseparable part of a people's landscape, society, history and culture; and in many cultures, a sacred substance, being venerated in some as a divinity".

5. **Breaking the Silos:** The proposed NWC will hopefully help us taking an integrated view of water, so that the current hydro-schizophrenia can be overcome, ensuring protection of watersheds, river systems and endangered aquifers.
6. **Demand-management and Sustainability as a central Focus:** Rather than seeking to endlessly augment supplies of water, the focus must shift to effectively managing demand so that we recognize the finite nature of the resource and that sustainable use will be impossible without this shift. The supply-side thrust is a vicious infinite regress with no end in sight other than depletion of quantities and quality.
7. **Emphasis on Equity in Access to Water:** We need to centrally emphasize the imperative to end discrimination in access to water on grounds of caste, class, gender, location and community, as emphasized in the NWFL.
8. **Transparency and Easy Access to Water Information:** The issue here is not just access to information, which should have transparency but also availability of information in a manner and form that is useful to and useable by primary stakeholders. The aim must be to pro-actively offer water solutions to problems people face.
9. **National Water Framework Law:** The draft NWFL provides an essential corrective to British Common law by building upon the Public Trust Doctrine enunciated by the Supreme Court, whereby the state at all levels holds natural resources in trust for the community. This would ensure that no one's use of water would be able to deprive anyone of their right to water for life as defined under the NWFL.

11. Practical Pathways to Realizing the Vision of the Mihir Shah Committee

It is our considered view that only through this comprehensive shift in the paradigm of water governance in India can we come to grips with and find sustainable and equitable solutions to the grave crisis of water facing the country. This is the kind of reform, reflecting the specificities of the water sector, which we require, rather than a blind adherence to the agenda embodied in the Washington Consensus. Only through this kind of detailed and comprehensive exercise in each sectoral context, can we begin to get a grip on the real reforms India needs to solve the emerging challenges of the 21st century. It is, therefore, not simply a matter of privatisation, liberalisation and globalisation. That is a lazy dogma, which we must decisively reject, while carefully considering the requirements of change in each sector of the economy.

The changes being proposed in the Report in reforming India's water governance are so fundamental that even the primary step of disbanding the CWC and CGWB and setting up the NWC is itself a huge challenge and is being fiercely resisted even though it is the result of a vast consultative process, which included all relevant stakeholders of India's water sector, from within and outside government. Within the CWC and CGWB there were concerns whether the restructuring suggested would end up undermining them. Such concerns were only natural as prospects of change always generate apprehension. As a Committee, we made a concerted effort to engage both the CWC and CGWB in an intensive and prolonged dialogue to allay these apprehensions. It is our considered view that the thousands of professionals in both the CWC and CGWB will get an even better chance to improve their technical capabilities and career prospects within the NWC.

There has also been a widespread support in favour of this change[x]. And many young and dynamic officers of CWC, who see this change as being in the right direction, are working with a truly extraordinary team of senior-most officers in the Ministry of Water Resources to carefully think through the next steps in implementing these recommendations. This is the first time ever that the Ministry of Water Resources has shown itself open to fundamental reform[xi]. The response so far from the Prime Minister's Office has also been positive. It, of course, remains to be seen how far the government finally goes in acting upon these long-overdue reforms, which should really have been initiated at least two decades ago.

Our more immediate concern, however, is that since the Report was submitted more than two years ago, and there is no action visible on the ground in the direction of implementing its suggestions, we need to propose possible multiple (overlapping) pathways that could lie ahead in realizing the vision of the Report. The possible pathways in this direction could be propelled by many diverse triggers and could also take multiple trajectories. Some conceivable scenarios are briefly sketched below.

12. Possible Catalysts and Triggers

As is well-recognized, crises have historically tended to provide conjunctures that propel processes of reform. This happens when elected governments find themselves completely unable to move even an inch forward in fulfilling their professed mandates and most powerfully when these crises take the form of large-scale agitations on the ground by concerned and impacted stakeholders.

The biggest example of this recent history is the situation that emerged globally in the late 1920s following the Great Depression. When millions were rendered jobless, people were out on the streets and the very future of capitalism seemed to come under threat. It is at that point that a veritable revolution occurred in both economic theory and economic policy world-wide, following the publication of the path-breaking *General Theory of Employment, Interest and Money* by Keynes (1936). This work overthrew the earlier faith of economists and policy-makers in the potency of unfettered free markets in guaranteeing employment. Keynes showed theoretically that there were many situations in which free markets would fail to deliver and argued the case for a policy of government intervention through public investment, without which private capitalists would refuse to invest and generate jobs for the people. Such policies remained the corner-stone of economic policy in all capitalist economies world-wide for another 40-50 years, summarized in the memorable phrase of arch right-wing US President Richard Nixon, who remarked in the early 1970s: "*We are all Keynesians now!*"

In India today, we are witness to farmers' agitations, even in states like Madhya Pradesh, which has never had a history of political mobilization of farmers on the streets. The last 30 years have seen more than 300,000 suicides by farmers, a phenomenon unprecedented in Indian history, which has seen major famines and droughts but not farmers' suicides. There is no question that the wheels have come off the Green Revolution strategy and the responsiveness of crop yields to application of chemical fertilizers and pesticides is at a historic low. Costs of cultivation have spiraled and net incomes of farmers are in the red. In the Central Indian heartlands, the *Adivasis* in many areas, have embarked upon a Maoist insurgency, which in large part can be seen as a reflection of the agrarian crisis afflicting these regions, since farming is the most important occupation of these impoverished small and marginal Adivasi farmers. There is a massive water crisis in all parts of the country, most tragically symbolized by the drought in Sohra (formerly Cheerapunjee), one of the highest rainfall hotspots in the world[xii]. Water conflicts across States, industry and agriculture and town and country, even amongst farmers sharing water from the same aquifer, have broken out through the length and breadth of India.

Politicians of different dispensations have also started eagerly looking for alternative solutions and show themselves open to trying out innovative approaches. We have already quoted the recent speech of the Maharashtra Chief Minister in the State Assembly urging a radically new approach to irrigation. We also have the example of the Chief Minister of Andhra Pradesh, who has resolved to cover the entire cultivable area of 80 lakh hectares in the State with "Zero Budget Natural Farming" by 2027, overcoming the objections of the powerful Green Revolution lobbies, both within and outside the State[xiii]. The Government of Karnataka is seriously considering moving in the same direction. It is also heartening to note that Sikkim is now a "fully organic" State and has set a benchmark in governance on sustainable development, organic farming and eco-tourism. All of these developments can be seen as a powerful vindication of the arguments presented in the Report about the need for a radical paradigm shift in the way we are managing water resources today. If these kinds of initiatives were to gather momentum and gain the requisite popular support among farmers, the largest consumers of water, we could see a situation where the paradigm shift could reach the needed critical mass for it to begin to be actualized in policy and on the ground.

Apart from pressure from farmers and the push from state governments, I believe that Indian industry and the urban consumer could also play a catalytic role in pushing for rapid change in our management of water resources. In my considered view, the crisis of water in urban India is far more serious and even more intractable than the one in the rural hinterlands. Throughout India, industry is more and more in conflict with farmers for their share in scarce fresh water resources. There are growing examples of industrial units being shut down in summer due to a lack of water. As a recent news report (March 29, 2018) states:

> *Just a couple of weeks ago the operators of the 2100 megawatt (MW) coal-fired Farakka power station in West Bengal shut down five of the six turbines due to lack of water. A few days later the 500 MW sixth unit was shut down as well. There wasn't even enough water to supply the taps for workers at the plant or the adjoining township. The 1720 MW Raichur Thermal Power Station in Karnataka state has been hit by lack of water too. Since March 15 it has had to shut down several of its units indefinitely. The 1130 MW Parli power station in Maharashtra state has been shut down since July 2015 due to lack of water. Five years earlier Maharashtra's state-owned utility, MahaGenco, had shut down several units of the 2340 MW Chandrapur Thermal Power Station due to the impact*

of drought. The construction of NTPC's Solapur power plant in Maharashtra has been delayed due to huge question marks about where the plant will get water to run on. Water scarcity could severely undermine the plant's financial viability (Burton and Fernandes 2016).

We have already mentioned the grave lack of capacity in urban areas to treat waste water. In India, cities produce nearly 40,000 million litres of sewage every day and barely 20 percent of it is treated. Central Pollution Control Board's 2011 survey states that only 2% towns have both sewerage systems and sewage treatment plants. Urban flooding has become an increasingly recurrent phenomenon. According to the National Disaster Management Authority (NDMA), there has been an increasing trend of urban flood disasters in India over the past several years whereby major cities in India have been severely affected. Hyderabad in 2000, Ahmedabad in 2001, Delhi in 2003, Chennai in 2004, Mumbai in 2005, Surat in 2006, Kolkata in 2007, Jamshedpur in 2008, Delhi in 2009, Guwahati, Kochi and Delhi in 2010, Srinagar in 2014, Chennai in 2015, Mumbai, Chennai and Thiruvananthapuram in 2017, images of water entering urban homes are becoming more and more common, more and more painful. Chennai had more than 600 water bodies in the 1980s. Today not even a third survive. Hyderabad has lost 3,245 ha wetlands in the last 13 years. The Kashmir valley has lost 50% of its wetlands in the last 30 years. Bengaluru had 262 lakes in the 1960s. Today hardly 10 of them have any water. Water in its Bellandur and Varthur lakes, which is used to grow green vegetables, is laced with cadmium, copper and zinc. Bellandur lake caught fire in 2015, 2017 and 2018 due to the chemically active sludge dumped into it (Shah 2018*b*).

As the National Disaster Management Agency says:

> "*Natural streams and watercourses have formed over thousands of years due to the forces of flowing water in the respective watersheds. Habitations started growing into towns and cities alongside rivers and watercourses. As a result of this, the flow of water has increased in proportion to the urbanization of the watersheds. Ideally, natural drains should have been widened to accommodate higher flows of storm water. On the contrary, there have been large scale encroachments on natural drains and river flood plains. Consequently, the capacity of natural drains has decreased, resulting in flooding. Improper disposal of solid waste, including domestic, commercial and industrial waste and dumping of construction debris into the drains also contributes significantly to reducing their capacities. It is imperative to take better operations and maintenance actions.*" (NDMA *nd*).

It is not entirely clear how much longer urban citizens and corporate India will be willing to wait before pushing for the urgently required reform of India's water sector. Of course, we must not take an entirely sanguine view of the crisis necessarily leading to reform of a positive kind. Harking back to the 1930s, we should not forget that the same crisis, which brought about the Keynesian revolution, also produced the ugly face of Fascism, with Hitler and Mussolini leveraging popular discontent to undermining democracy itself. In India today, we can see how the intensity of the water crisis is leading to calls for high-risk, high-cost responses to the water crisis, such as the mega interlinking of rivers (already critiqued above). They also include extraction of "fossil" water from below the ground, which can be dangerous when extracted from aquifers that receive non-significant recharge, effectively making groundwater in those aquifers a non-renewable resource. It is, therefore, extremely important for a large community of water scholars and activists to continuously raise awareness about the water crisis, as also the real sustainable solutions that are already available and being practiced on the ground, as outlined in the Report, while also cautioning the public and the government about false and dangerous ways forward.

13. Possible Pathways of Change

Let us try now to gaze into the crystal ball a little to try and visualize possible practical pathways towards implementation of the vision embodied in the Report. While various recommendations have been opposed, it is also true that they have (as outlined earlier) resonated with a large number of stakeholders. What is also clear is that there is a very large set of proposals in the report and one way forward is to unbundle these suggestions and try to assess the possible trajectories of their implementation. I present six possible scenarios.

13.1 Reform the CWC

If the proposal for the NWC is found to be overly ambitious and radical in its conception, one way forward could be to limit ourselves to reforming the CWC. Of course, this reform would need to be quite comprehensive, including several elements and could make a huge contribution in reforming the management of India's irrigation commands, as also rejuvenating India's decaying river systems. The CWC reform would need to include several elements and contain many steps:

1. The first step would be to shift the primary goal of the CWC from more and more construction towards

expeditious completion of incomplete irrigation projects and the better management of water. There are fully worked out proposals on how this can be done in the Report. Once the CWC shows the way, all state government irrigation departments could also be incentivized and supported to follow suit.

2. These include radical change in the human resource profile of the CWC to induct professionals from disciplines such as Hydrometeorology, River Ecology, Ecological Economics, Agronomy (with focus on soil and water) and Participatory Resource Planning & Management. This would not only enable the CWC to facilitate States to improve last mile connectivity in irrigation commands as described in the Report but also deal with the socio-ecology of water supply and distribution that has been missing from the CWC's portfolio hitherto.

3. CWC should also include professionals and experts from outside government. Those with long years of experience of working on water issues in academia, and on the ground with village communities, should form a part of the CWC, so that the insights of those within and outside government could come together to give direction to the management of water resources in India.

4. Assiduous and dedicated efforts would also need to be made to build capacities of CWC personnel in several different directions. One, to bring the knowledge of their own disciplines up-to-date with the latest developments in their respective fields. Two, it would be crucial for each professional to understand the need to build a cross-disciplinary understanding of water. Three, they must get a deeper appreciation of the essential links between science and policy, which is currently completely lacking within the CWC.

5. We also need a better alignment between strategy and structure within the CWC for it to be able to deliver on its new mandate. In his classic work, Chandler, Jr. (1962) defined strategy as the basic long-term goals of an enterprise, coupled with the courses of action and allocation of resources necessary to carry out these goals. Structure denotes not only the decision-making hierarchy but also the culture and environment within the organization[xiv]. The relationship between strategy and structure is never unidirectional. Both need to co-evolve. With its new mandate, the CWC must also develop a new work culture, rules and regulations, shedding the rigidities of the past. A carefully crafted organizational reform exercise would be required to arrive at the best alignment between structure and strategy. Once this is done for the CWC, the CWC itself could facilitate such an exercise within all state water resource/irrigation departments. Without such an organizational reform, it would be impossible for the CWC to fulfill its new mandate or implement its new strategy.

6. Reconfigure the organizational design of the CWC on the lines suggested in the Report by creating the following Divisions within the CWC:

    a. Irrigation Reform Division: This division will enable and incentivize state governments to utilize the massive slack created by underutilization of existing irrigation projects and improving their performance factors. It will focus on macro, meso and micro level arrangements with water resource management as the main goal, not just construction of large-scale reservoirs and river development projects. It will operate as a world-class knowledge institution available, on demand, for advice by the state governments and other stakeholders, including appraisal of projects, dam safety, inter-state and international issues relating to water. It will ensure that all dams that are constructed operate in a reform mode from day one, with the overarching mandate of *har khet ko pani*. This includes the most immediate task of completing the 99 on-going projects under AIBP. As the Ministry of Water Resources, River Development and Ganga Rejuvenation's draft Vision Document rightly points out, all these 99 projects must be placed in reform mode and funds for these projects must be made conditional upon reforms being put into place from day one. The Irrigation Reform Division's primary mandate will be to see that it can effectively facilitate the placing of all these projects into reform mode. This is the only way to overcome the endless cycle of time and cost-overruns as also bridge the growing gap between irrigation capacity created and utilized and ensuring that the water reaches the farmers for whom these dams are being built. This division will take care of technical aspects of existing and new water resource projects – appraisal, dams design, operation, safety, repair, etc. The division will monitor selected irrigation projects in order to ensure the achievement of physical and financial targets. At the same time, the division will ensure that the technical aspects of water resources planning and management do not remain in isolation from the work by the other divisions. Therefore, the division will work closely with states to jointly formulate, plan, design and execute their own projects, as per demand. The division will work towards development and strengthening the technical capacity at various levels in different states. The division must therefore become more decentralized so that its presence is strong enough at the river basin scale but also so that it works closely with all the states present in every single river basin in the country.

b. River Rejuvenation Division: This division will develop a nation-wide, location-specific program for rejuvenation of India's rivers to effectively implement the triple mandate of *nirmal dhara*, *aviral dhara*, *swachh kinara*. It will help catalyze participatory institutions at various levels to implement and foster sustainable conjunctive management of surface and groundwater resources. And create an effective promotional and regulatory mechanism that finds the right balance between the needs of development and environment, protecting ecological integrity of nation's rivers, lakes, wetlands and aquifers, as well as coastal systems. The division will be responsible for understanding and conserving river morphology, flows, ecology, bank erosion, floods, assessment and management of environmental flows. The division will need to work in close association with the CGWB in understanding the surface-groundwater interaction, especially in the floodplains and with regard to regions that depend upon springs.

c. Data Management and Transparency Division: This division will create a transparent, accessible and user-friendly system of data management on water that citizens can fruitfully use while devising solutions to their water problems. Data that will be curated and systematically archived into an open-access database will include domains such as hydrometeorology (including rainfall, run-off, temperature, evaporation and transpiration), surface water systems (reservoirs, stream and river gauging etc.), groundwater (aquifers, spring discharge and quality, well water levels, groundwater quality etc.), soil water or soil moisture, additional information on lakes and wetlands etc. The division will be responsible for water resources assessment, analysis and mapping. The division will be responsible for the further development and improvement of the India-WRIS. The aim will be to not only make data transparently available to people, but also to make it accessible in a user-friendly and problem-solving, decision-support mode. The participatory element of data collection must be developed by this division. Drawing upon both formal and informal sources of information at various scales will clearly be the first challenge that the division can try to address. Many organizations, both government and non-government (academic and civil society), collect data at local scales. Reaching out to such organizations for their data and bringing it into the main national data-base with due acknowledgement and standardization to ensure no compromise with quality, can also be one clear role of this division.

7. Regulate the utilization of the National Irrigation Management Fund to incentivize and facilitate reforms by the states in their respective water resource departments and irrigation commands, as described in the Report.

8. Place all AIBP projects compulsorily in reform mode, so that all releases of funds by the Centre would be based on an assessment by the CWC of a movement towards reforms in the state.

9. Radically decentralize the functioning of the CWC by moving more and more multi-disciplinary teams of professionals to the river basins, drastically reducing their presence in Delhi. This would enable the formulation of India's water programs and policies on a river basin basis and help pre-empt many inter-state water conflicts by building powerful river basin organizations, with a bottom-up architecture, which would provide them the necessary strength and credibility.

13.2 Reform the CGWB

Since groundwater is India's most important water resource, there could be nothing more important than strengthening the CGWB and all the state groundwater departments/directorates. The reforms here would include:

1. Placing CGWB at a level on par with the CWC. Today, the CGWB is nothing more than a "poor country cousin" of the CWC, with paltry powers of financial sanction, recruitment, policy-making etc. It is perhaps this lack of parity that has led to a progressive disinterest in the institutional growth of India's premier groundwater agency even as the challenges in controlling groundwater exploitation and contamination have grown. This has to urgently change to reflect the enormous changes on the ground in the facts of water in India.

2. Greatly expanding and enriching the human resource profile of the CGWB and all state groundwater departments/directorates. They must include professionals not merely from hydrogeology but also the social sciences, agronomy, ecology and management. Without these disciplines, programs such as the *Atal Bhujal Yojana* stand no chance of effective implementation on the ground.

3. Bringing in professionals and experts from outside government into the groundwater bureaucracy to serve as standing partners. The aquifer management exercise that the nation has embarked upon is so ginormous that it

cannot be implemented by the government alone. It needs solid and enduring partnerships with academic and research institutions, as also civil society organisations, as has been described in detail in the Report.

4. Building capacities of all CGWB and state groundwater board staff. They must develop an understanding of the fact that managing groundwater sustainably and equitably requires an appreciation of the common pool resource character of groundwater. They must know that merely a knowledge of hydrogeology is not enough to implement the Atal Bhujal Yojana. They must also develop a deeper knowledge of grass-roots realities in different parts of the country through an interaction with diverse stakeholders involved in the management of groundwater, in a learning mode.

5. Organizational reform to bring about a greater alignment between the structure and strategy of the CGWB and henceforth in all state groundwater departments. The role spelt out for the CGWB in the Report represents nothing less than a tectonic paradigm shift, which requires a complete overhaul of the structure of the CGWB and its organizational ethos and modes of functioning. A management reform exercise in this direction would be an urgent necessity to enable the CGWB to be able to play the role of the single most important water management agency in the country.

6. Reconfigure the organizational design of the CGWB on the lines suggested in the Report by creating the following Divisions within the CGWB :

    a. Aquifer Mapping and Participatory Groundwater Management Division: This division will lead the *Atal Bhujal Yojana* (ABHY). It will work hard to build a new and unique architecture of partnerships with credible institutions across the country, which will become formal partners in this program. These will include, other than state groundwater departments, other water-related government departments, academic and research institutions, civil society organizations, Panchayati Raj Institutions and others as per requirement so that the largest aquifer mapping and management exercise in human history, can be completed within a decade. It will have to work closely at the village and watershed levels, given the highly decentralized nature of groundwater usage in all the river basins. This division will also take on the role of surveys, assessment and monitoring of groundwater to estimate (and in a limited way predict) the status of groundwater resources at the national scale.

    b. Water Security Division: The overarching national goal in the water domain is water security. This includes ensuring the right to water for life as per the draft National Water Framework Bill, as also insulating the agrarian economy and livelihood system from pernicious impacts of drought, flood and climate change. This is the mandate of this division: to devise policies and programs for tackling these challenges. It will coordinate activities of the National Water Mission related to impacts of climate change. The division will need to work in close co-ordination with the CWC, as also the Ministries of Drinking Water and Sanitation, Rural Development, Agriculture and Environment, along with state governments.

    c. Urban and Industrial Water Division: Historically, urban and industrial water has not come under the purview of the Ministry of Water Resources. However, given the enormous challenges of a rapidly urbanizing and industrializing India, there is an urgent need to not only address these issues but to do so in a manner that takes a holistic view of the often competing and conflicting demands of urban and rural areas, as also agriculture and industry. This division will take care of the highly neglected areas of appropriate, cost-effective treatment, recycling and reuse of urban and industrial waste water to meet the challenges of rapid industrialization and urbanization in India. It will also work closely with the Aquifer Mapping and Groundwater Management Division to map the aquifers of urban India and devise effective strategies for sustainable and equitable groundwater management in India's towns and cities. This division will be an intellectual and strategic resource for the Ministry of Urban Development to draw upon.

    d. Water Quality Division: This division will work to develop and implement practical programs for controlling point and non-point pollution of water bodies, the wetlands and aquifer systems. Water quality has emerged as a key neglected area in the water sector in India. There are complaints of water being contaminated with fluoride, arsenic, mercury and even uranium in some areas. Many urban stretches of rivers and lakes are overstrained and overburdened by industrial waste, sewage and agricultural runoff. These wastewaters are overloading rivers and lakes with toxic chemicals and wastes, consequently poisoning water resources and supplies. These toxins are finding their way into plants and animals, causing severe ecological toxicity at various trophic levels. The division will work in close co-ordination with all other divisions and also with the Central Pollution Control Board to address these issues.

13.3 Reform both the CWC and CGWB (as above) without forming the NWC

Since the very idea of disbanding the CWC and CGWB and merging them to form the NWC appears to have become the main hurdle preventing acceptance of the reforms suggested in the Report, one way forward could be to institute the proposed reforms within the CWC and the CGWB, even without disbanding and merging them into the NWC. Much would be gained by reforming both the CWC and CGWB as described above. They would have the much-needed capacities, the required focus and direction, as per the conditions on the ground, the multi-disciplinary understanding of water, the multiplicity of stakeholders without which effective implementation of government programs would be impossible and the parity of status and power, which the CGWB must be accorded with the CWC.

13.4 Form the NWC without a River Basin Presence

However, it is clear that keeping the CWC and CGWB as separate entities would still not allow the holistic vision required to address the "hydroschizophrenia" that characterizes water management and all water programs in India. It would also make the rejuvenation of rivers a distant dream, as the unitary vision of the hydrologic cycle would still remain elusive. There would also be a degree of both overlap and incompleteness if they were to continue to work as separate entities, as can be seen from the functions of the divisions described above, which would work best if they were to come under a unified NWC. What is more, the entire conception of the NWC as a knowledge institution would not be realized.

The Knowledge Management and Capacity Building Division of the NWC is a critical element in the Mihir Shah Committee Report. This division is to be in-charge of creating world-class institutions for broad-based capacity building of water professionals in integrated water and land management. The division would work towards restructuring and strengthening the existing NWA and RGI into institutions of excellence. The two institutions should together impart training to a wide range of stakeholders, and the training should be structured on the basis of a one-year cycle that includes an effective combination of practical, field-oriented and multi-disciplinary modules. Capacity building courses should be run by a faculty drawn not only from within NWA-RGI but also from sister institutions across the country, who would become formal partners in this overall exercise, so that a multidisciplinary approach to water management can become possible across river basins. This Division would be responsible for creating mass awareness regarding water resource programs and policies and initiatives in which people have a central role. Most importantly, this division would try and develop modalities for common recruitment of officers through UPSC – for a separate water related service – so that the officers can move across divisions and help follow an integrated, participatory river basin approach to water. The selection would be open to all water related disciplines, not only Engineering and Geology. The division would also be the one responsible for the research and knowledge management within the NWC on water-related issues, in a multi-disciplinary, integrated river-basin perspective. It will be the one to advise the Government of India on water-related disputes between different states. It will carry out morphological studies to assess river behavior, bank erosion/coastal erosion problems and advise the Central and State Governments on all such matters. It will promote modern data collection techniques and development of related computer software for the water sector in India. The division will prepare guidelines for Integrated River Basin Development and Management Plans as prescribed under the draft National Water Framework Law.

Today, the CWC and CGWB, as also their corresponding avatars at the state level, rarely even speak to each other, let alone working together in a holistic manner as recommended in the Report. One way forward could, therefore, be to go ahead and form the NWC as suggested in the Report but, at least in the initial period, be somewhat less ambitious and let it remain primarily based in Delhi, without necessarily having an NWC presence in each river basin.

13.5 Form Government-centric NWC with Presence in Major River Basins

An alternative pathway could be for the NWC to indeed move into major river basins of the country but not necessarily open itself out to professionals and experts from outside government as proposed in the Report. There would be a great loss in capacity and capability, especially to implement difficult programs such as ABHY, which it would be almost certainly impossible for the Centre and the states to implement without support from academia and civil society, with feet on the ground. But at least we would have an NWC, with strong multi-disciplinary capacities and a holistic way of working on water, with a decentralised presence in each river basin, which would be a massive step forward from where we are now. This could pave the way to opening up a participatory partnership model for the integrated management of surface and groundwater on one hand, but also of ensuring equity of allocation across different needs – domestic, agriculture and industry.

13.6 Form the NWC as proposed by the Mihir Shah Committee

Constituting a NWC which builds enduring partnerships with academia and civil society, and functions on a river-basin structure, exactly as visualized in the Mihir Shah Committee Report, would completely realize the mandate of the Report.

These are thus six different scenarios and pathways for realizing the vision embedded in the Mihir Shah Committee Report. They have been proposed in the hope that at least some progress can be made in the direction of implementing the recommendations of the Report, which have now been widely acknowledged, including within the government, as being of vital importance to achieving the overarching national goals in the water sector.

References

Ackerman, R. 2012. New Directions for Water Management in Indian Agriculture. *Global Journal of Emerging Market Economies*, 4 (2): 227-288.

Amarasinghe, U.A., Shah, T., Turral, H. and Anand, B.K. 2007. *India's Water Future to 2025-2050: Business-as-usual Scenario and Deviations*. Colombo, Sri Lanka: International Water Management Institute, 47p. (Research Report 123). Available online: http://www.iwmi.cgiar.org/Publications/IWMI_Research_Reports/PDF/PUB123/RR123.pdf

Blackmore, D. 2010. *River Basin Management: Opportunities and Risks*. eWater CRC and Asian Development Bank, October.

Briscoe, J. and Malik, R.P.S. 2006. India's Water Economy: Bracing for a turbulent future. World Bank, New Delhi: Oxford University Press. Available online: https://openknowledge.worldbank.org/handle/10986/7238

Burton, B. and Fernandes, A. 2016. Drought hits Indian coal plants and plans. 23 March, EndCoal.org Website. https://endcoal.org/2016/03/drought-hits-indian-coal-plants-and-plans/

Chandler, Jr. A.D.1962. *Strategy and Structure: Chapters in the History of the Industrial Enterprise*. Cambridge: MIT Press, 490p.

E.T. 2016. *Mihir Shah report brims with sense*. *Economic Times (E.T.)*, 3 September. Available online: https://economictimes.indiatimes.com/blogs/et-editorials/mihir-shah-report-brims-with-sense/

Fligstein, N. 2008. Chandler and the Sociology of Organizations. *The Business History Review*, 82 (2), A Special Issue on Alfred D. Chandler Jr.

Ghosh, S., Vittal, H., Sharma, T., Karmakar, S., Kasiviswanathan, K.S., Dhanesh, Y., Sudheer, K.P. and Gunthe, S.S. 2016. Indian Summer Monsoon Rainfall: Implications of Contrasting Trends in the Spatial Variability of Means and Extremes. PLoS ONE 11 (7). Available online: http://doi.org/10.1371/journal.pone.0158670

GoI. 2013. *Twelfth Five-Year Plan (2012-2017): Faster, More Inclusive and Sustainable Growth, Volume I*. Planning Commission, Government of India (GoI). Available online: http://www.nationalplanningcycles.org/sites/default/files/country_docs/India/nhp_india.pdf

Goswami, D.C. and Das, P.J. 2002. *Hydrological impact of earthquakes on the Brahmaputra river regime*. Proceedings of the 18th National Convention of Civil Engineers, Guwahati.

Guha, R. 2017. Water: The resource that will determine our future. *Hindustan Times*, 25 March. Available online: https://www.hindustantimes.com/columns/water-the-resource-that-will-determine-our-future/story-8eQOY2rrC5AAFzxfmpKwtJ.html

Harsha, J. 2018. Thwarting Water Sector Reforms. *Economic and Political Weekly*, September 22, LIII (38): 82-85.

Jarvis, T., Giordano, M., Puri, S., Matsumoto, K. and Wolf, A. 2005. International borders, ground water flow and hydroschizophrenia. *Ground Water*, 43 (5): 764-70.

Kerr, R.A. and Stone, R. 2009. A human trigger for the Great Quake of Sichuan? *Science*, 323 (5912), 16 January.

Keynes, J.M. 1936. *The General Theory of Employment, Interest and Money*. London: Macmillan.

Krishnan, S. 2009. The silently accepted menace of disease burden from drinking water quality problems. Report submitted to the Planning Commission.

Kuhn, T.S. 1962. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

Kumar, M.D., Prathapar, S.A., Saleth, R.M., Reddy, V.R., Narayanamoorthy, A. and Bassi, N. 2017. New 'Water Management Paradigm': Outdated Concepts? *Economic and Political Weekly*, December 9, LII (49): 89-94.

Llamas, R. and Martinez-Santos, P. 2005. Intensive Groundwater Use: Silent Revolution and Potential Source of Water Conflicts. *Journal of Water Resources Planning and Management*, 131 (5). https://doi.org/10.1061/(ASCE)0733-9496(2005)131:5(337)

Menon, M., Vagholikar, N., Kohli, K. and Fernandes, A. 2003. Large Dams in the Northeast: A Bright Future? *The Ecologist Asia*, 11 (1).

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. and Kent, J. 2000. Biodiversity Hotspots for Conservation Priorities. *Nature*, 403, pp. 853–58.

NDMA. *nd*. Plan Budget: Guidelines. National Disaster Management Authority (NDMA), Government of India. https://ndma.gov.in/en/about-ndma/budget/plan-budget/71-citizens-corner/natural-disaster/urban-flood/552-guidelines.html

Pomeranz, K. 2009. The Great Himalayan Watershed: Agrarian Crisis, Mega-Dams and the Environment. *New Left Review*, No. 58, Jul-Aug. Available online: https://newleftreview.org/II/58/kenneth-pomeranz-the-great-himalayan-watershed

Rajamani, V., Mohanty, U.C., Ramesh, R., Bhat, G.S., Vinayachandran, P.S., Sengupta, D., Kumar, P. and Kolli, R.K. 2006. Linking Indian Rivers vs Bay of Bengal monsoon activity. *Current Science*, 90 (1): 12-13.

Rockström, J. 2017. *Beyond the Anthropocene*. Talk at the World Economic Forum 2017. Available online: https://www.stockholmresilience.org/research/research-news/2017-02-16-wef-2017-beyond-the-anthropocene.html

Rodell, M., Velicogna, I. and Famiglietti, J.S. 2009. Satellite-based Estimates of Groundwater Depletion in India, *Nature*, 460, pp. 999-1002.

Shah, M. 2013. Water: Towards a Paradigm Shift in the 12th Plan. *Economic and Political Weekly*, January 19, XLVIII (3): 40-52.

Shah, M. 2018*a*. Resistance to Reforms in Water Governance. *Economic and Political Weekly*, February 10, LIII (6): 60-63.

Shah, M. 2018*b*. *Bringing the Science back into Water*. Lecture delivered at the International Centre for Theoretical Sciences, Bengaluru.

Shah, M. and Kulkarni, H. 2015. Urban Water Systems in India: Typologies and Hypotheses. *Economic and Political Weekly*, July 25, L (30): 57-69.

Shah, M., Gopal, B., Tare, V., Bhal, K.T., Shah, T., Kulkarni, H. and Rajendra, B. 2016. *A 21st Century Institutional Architecture for India's Water Reforms*. Report submitted by the Committee on Restructuring the CWC and CGWB. July 2016, Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India. Available online: http://mowr.gov.in/sites/default/files/Report_on_Restructuring_CWC_CGWB_0.pdf

Susheela, A.K. 2001. *A Treatise on Fluorosis*. Delhi: Fluorosis Research and Rural Development Foundation.

Valdiya, K.S. 1999. *A Geodynamic Perspective of Arunachal Pradesh*. Keynote address at workshop organized by G.B. Pant Institute of Himalayan Environment and Development.

Venot, J-P., Turral, H., Samad, M and Molle, F. 2007. *Shifting waterscapes: Explaining basin closure in the Lower Krishna Basin, South India*. Colombo, Sri Lanka: International Water Management Institute, 60p. (Research Report 121). Available online: http://www.iwmi.cgiar.org/Publications/IWMI_Research_Reports/PDF/PUB121/RR121.pdf

WHO. 2002. *An overview: Gaps in health research on Arsenic Poisoning*. 27th Session of WHO South-East Asia Advisory Committee on Health Research, 15-18 April, Dhaka, Bangladesh.

Endnotes

i. The Mihir Shah Committee submitted its Report on *Restructuring the CWC and CGWB* to the Ministry of Water Resources, Government of India in July 2016 (Shah *et al*. 2016).

ii. I am grateful to Tushaar Shah for suggesting I write a paper on this topic and to Himanshu Kulkarni for his inputs into it. Both were Members of the Mihir Shah Committee.

iii. Referred to henceforth in this paper as Report and Committee

iv. *Economic and Political Weekly* devoted a whole issue (December 24, 2016) to a symposium on the Report, with 12 renowned water scholars commenting on it and Mihir Shah giving a response (http://www.epw.in/water-governance). Later a fresh critique of the report was proposed by Kumar *et al*. (2017) to which response was given by Shah (2018*a*) and Harsha (2018).

v. A paradigm is a comprehensive way of seeing a whole, a framework that profoundly alters the way we see the parts within the whole. Paradigms are the lenses through which we see reality, which can at times appear incommensurable. As Kuhn (1962: 123) famously wrote, "*the historian of science may be tempted to exclaim that when paradigms change, the world itself changes with them*".

vi. This section is heavily drawn from the Twelfth Five Year Plan chapter on Water (see GoI 2013).

vii. 'Hard rock' is a generic term applied to igneous and metamorphic rocks with aquifers of low primary inter-granular porosity (e.g., granites, basalts, gneisses and schists).

viii. This section draws heavily on Shah *et al*. (2016).

ix. For example, CGWB has as many as 125 different designations (Scientific-71, Engineering-20, Ministerial / Administrative-34). Rampant increase in court cases and representations related to seniority, promotions, FCS etc. bear testimony to the fact that there is a link between number of designations and court cases / representations.

x. See, among many examples, ET (2016) and Guha (2017), which states, "*Rigorously researched and closely argued, this report displays a deep familiarity with social and economic life across India, and offers a set of forward-looking recommendations as well*".

xi. Even as Member, Planning Commission, from 2009 to 2014, I faced fierce resistance from the Ministry of Water Resources when I proposed the paradigm shift.

xii. Recently, a whole team from Sohra visited my organization *Samaj Pragati Sahayog* in Madhya Pradesh to learn about possible solutions to the water crisis in their area.

xiii. A critical assessment of ZBNF as a strategy is beyond the scope of this paper. What is noteworthy for us, however, is the extraordinary fact that a major politician like the Chief Minister of Andhra Pradesh is willing to risk such a dramatic paradigm shift in agriculture at such a significant scale. This clearly indicates the urgency that is being felt by policy-makers of resolving the farming and water crisis on the ground, as also the willingness to move towards radically new solutions.

xiv. For a critical assessment of Chandler's work, see Fligstein (2008).

About IWMI-Tata Water Policy Program

The IWMI-Tata Water Policy Program (ITP) was launched in 2000 as a co-equal partnership between the International Water Management Institute (IWMI), Colombo and Sir Ratan Tata Trusts (SRTT), Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as Sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations.

Through this program, IWMI collaborates with a range of partners across India to identify, analyse and document relevant water management approaches and current practices. These practices are assessed and synthesized for maximum policy impact and published as IWMI-Tata Policy Papers, Water Policy Research Highlights and IWMI-Tata Comments. The research underlying these publications was funded with support from IWMI, Tata Trusts, CGIAR Research Program on Water, Land and Ecosystems (WLE) and CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). The views expressed in the publications are of the author/s alone and not of ITP's funding partners. All IWMI-Tata publications are open access and freely downloadable from the Program's blog: http://iwmi-tata.blogspot.com

IWMI Headquarters
127 Sunil Mawatha, Pelawatte, Battaramulla, Colombo, Sri Lanka
Mailing Address
P. O. Box 2075, Colombo, Sri Lanka
Tel: +94 11 2880000, 2784080 **Fax:** +94 11 2786854
Email: iwmi@cgiar.org
Website: www.iwmi.org

IWMI-Tata Water Policy Program
"Jal Tarang"
Near Smruti Apartments, Behind IRMA Gate
Mangalpura, Anand 388001, Gujarat, India
Tel: +91 2692 263816, 263817
Email: iwmi-tata@cgiar.org
Blog: http://iwmi-tata.blogspot.in

IWMI
International Water Management Institute

IWMI is a CGIAR Research Center and leads the:

CGIAR

RESEARCH PROGRAM ON
Water, Land and Ecosystems