A 21st Century Institutional Architecture for India's Water Reforms

Report submitted by the Committee on Restructuring the CWC and CGWB

July 2016

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Preface

India faces unprecedented challenges of water management in the 21st century. As the water crisis deepens by the day, the old 20th century solutions appear to be distinctly running out of steam. These solutions were devised in an era when India had yet to create its irrigation potential, which was a basic requirement for food security. It was these investments in irrigation that powered India's Green Revolution and brought the country food self-sufficiency.

But today the situation on the ground has changed. While big dams played a big role in creating a huge irrigation potential, today the challenge is to effectively utilise this potential, as the water that lies stored in our dams is not reaching the farmers for whom it is meant. At the same time, groundwater, which truly powered the Green Revolution, faces a crisis of sustainability. Water levels and water quality have both fallen creating a new kind of crisis, where the solution to a problem has become part of the problem itself. The new challenge is to mange our aquifers sustainably so that we make sure we do not kill the goose that lays the golden eggs. At the same time, India faces new challenges and demands on water posed by rapid urbanisation and industrialisation. Conflicts over water, across uses, across town and country, and across industry and agriculture, have become more and more common.

Addressing these new challenges requires a new strategy. And this strategy demands a new institutional architecture. Both the Central Water Commission and the Central Ground Water Board played a stellar role in shepherding India's water sector over several decades. But these were institutions set up in a different era, serving a different mandate and manned by particular kind of personnel. Today there is an urgent need to strengthen, restructure and redesign these institutions so that the kind of leadership India's water sector requires can be provided.

This report tries to suggest a way forward in which this change can be brought about. The report is the result of a vast consultative process, which included all relevant stakeholders of India's water sector, from within and outside government. Among the CWC and CGWB there were concerns whether the restructuring suggested would end up undermining these institutions. 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. The suggestions contained in our report only seek to strengthen the governance of India's water resources and it is our considered view that the professionals involved in both the CWC and CGWB will get an even better chance to improve their technical capabilities and career prospects within the proposed new set-up.

I wish to place on record the heartfelt thanks of the Committee to Hon'ble Minister for Water Resources, River Development and Ganga Rejuvenation, Sushri Uma Bharti ji for her extraordinary support and encouragement to the Committee at every stage of our deliberations. I also wish to thank Secretary, MoWR, RD & GR, Shri Shashi Shekhar for his intellectual inputs and support to the work of the Committee. Finally, I thank all the Members of the Committee for their painstaking efforts in addressing a hugely complex task that demanded high levels of intellectual input and strategic thinking in arriving at the recommendations of our report. A final word of thanks to Shri SK Sharma, SJC (PP), MoWR, RD & GR, for all his administrative support to the Committee.

Dr. Mihir Shah
26th July 2016

Executive Summary

1. India's Water Crisis

- If the current pattern of demand continues, about half of the demand for water will be unmet by 2030
- Water tables are falling in most parts of India
- There is fluoride, arsenic, mercury, even uranium in our groundwater
- Recent droughts and persistent farmers' suicides underscore the gravity of the situation
- Climate change poses fresh challenges as more extreme rates of precipitation and evapo-transpiration exacerbate impacts of floods and droughts
- Cities produce nearly 40,000 million litres of sewage every day and barely 20 percent of it is treated
- Only 2% of our urban areas have both sewerage systems and sewage treatment plants
- More intense, extreme and variable rainfall, combined with lack of proper drainage, means that every spell of rain becomes an urban nightmare as roads flood and dirty water enters homes and adds to filth and disease.
- It is no wonder then that conflicts across competing uses and users of water are growing by the day

2. Twentieth Century Solutions Not Working

- We have invested Rs. 400,000 crore in major and medium irrigation projects since Independence
- Irrigation potential created is 113 mha and potential utilized is 89 mha. The gap is growing by the year
- Vast storages of water not reaching the farmers

- We have focused only on expenditure of vast sums of money for construction of dams and main canal systems, not on enduring outcomes
- Average cost over-run is as high as 1382% in major irrigation projects and 325% in medium projects
- Basin closure in most rivers implies reduced scope for fresh dam building
- India is the world's largest user of groundwater
- Groundwater provides 80% of India's drinking water and nearly two-thirds of irrigation needs
- Over the last four decades, around 84% of the total addition to irrigation has come from groundwater
- Groundwater is the foundation of India's food security
- But today we face a crisis of sustainability
- The solution to the problem (tubewell irrigation) has become part of the problem itself
- 60% of India's districts face groundwater over-exploitation and /or serious quality issues
- We must not kill the goose that lays the golden egg

3. Need for a Paradigm Shift

- PMKSY focus on incomplete projects is better than going in for new projects
- But what is to prevent the problems of the past from recurring again
- To bridge the growing gap between irrigation potential created (IPC) and irrigation potential utilised (IPU), we need to operate in *reform* mode
- By focusing on low-hanging fruit we could add 35 mha to irrigated area over next 10 years at very low cost
- Move from 45% irrigation to 65% at 1.5 lakh/ha as against present strategy which would cost 3-5 lakh/ha

- For this we need to shift focus from construction to management and maintenance

Irrigation Management Transfer (IMT)

- States should 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 should be handed over to Water Users Associations of farmers
- Need to transform last-mile connectivity through innovative command area development
- States have not adequately focused on water management
- Centre must incentivise-facilitate States to move in this direction
- MoWR now accepts this should be the central focus of PMKSY
- Make farmers primary stakeholders in managing command areas – irrigation management transfer
- All over the world, countries are moving to IMT
- This has also been the basis for the Gujarat agrarian miracle of 2000-10 (11% rate of growth) and for the dramatic rise in Madhya Pradesh irrigated area from 6 to 30 lakh ha during 2009-14
- IMT Improves equitable access to water by all farmers (*har khet ko paani*)
- Leads to sustainable operation and maintenance of the irrigation systems
- Results in 20% saving in water use
- Creates a healthier link between farmers and irrigation department
- Gives more crop per drop
- Increases predictability of irrigation
- Farmers actively participate to
    - contribute towards the physical rehabilitation of the system
    - undertake crop planning and
    - resolve conflicts amicably

- MoWR is activating the National Irrigation Management Fund (NIMF) that facilitates States to adopt reform
- Rs. 6000 crore has been approved for the NIMF in the 12th Plan, to be notified
- MoWR to provide matching grant to States equal to Irrigation Service Fees (ISF) collection and build their capacities
- Reform here refers to
    - Pass Participatory Irrigation Management (PIM) Act (only 15 States have and that too remains largely on paper)
    - Set up Water Users Associations (WUAs)
    - Empower WUAs to charge ISF and take independent decisions on planning, implementation and management of irrigation systems free of bureaucratic control
    - Allow WUAs and their Federations to retain at least 50% of the ISF to take care of last mile O&M
- Pushing these reforms forward, facilitating the States to undertake them requires a new institutional architecture in place at the Centre

Participatory Groundwater Management

- Need to recognise that groundwater is a common pool resource
- Cannot continue its unbridled competitive extraction
- Cannot police 30 million groundwater structures through a licence-quota-permit raj
- The way forward is participatory aquifer management initiated in the 12th Plan (NAQUIM)
- MoWR review reveals CGWB completely unable to undertake this task without serious restructuring

4. India faces New Challenges

- Many of India's peninsular rivers are facing a serious crisis of post-monsoon flows

- The single most important factor explaining the drying up of 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
- Left hand of surface water does not know what right hand of groundwater is doing: hydro-schizophrenia
- Need greater and more integrated presence of water professionals at river basin level
- The recent National Water Framework Bill (NWFB) 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 emphasises the integral relationship between surface and groundwater. The NWFB recognises 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"
- And 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 NWFB 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"
- In India, the number of people living in urban areas is expected to more than double and grow to around 800 million by 2050.
- This will pose unprecedented challenges for water management in urban India.
- The demands of a rapidly industrialising 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.
- Both our rivers and our groundwater are polluted by untreated effluents and sewage dumped into them.
- 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.
- These new national goals and challenges require a reformed institutional architecture to lead the effort towards attaining them

5. Case for Restructuring CWC and CGWB

- The paradigm shift required in both surface and ground water, as also new national challenges in the 21st century, demand major reforms in the CWC and CGWB
- CWC set up in 1945 and CGWB in 1971 have continued unreformed over several decades
- Even as objective conditions on the ground, demands of the economy and society, as also our understanding of water, have all undergone a sea change
- Their mandate belongs to an old era when dam construction and tubewell drilling was the prime need of the hour
- Capacities and Structure reflect that mandate
- Mainly comprise civil engineers and hydrogeologists
- Very weak presence on the ground in river basins
- Need to work closely together within a holistic river basin perspective
- Need greater and more effective presence at river basin level
- CWC and CGWB suffer from a lack of professionals from a large number of disciplines
- The paradigm shift of moving toward Irrigation Management Transfer to ensure *har khet ko paani*, as also participatory groundwater management to implement NAQUIM,requiresprofessionals from Social Sciences and Management
- If we are to tackle demand-side management issues and implement crop water budgeting and improve water use efficiency, we need professionals from Agronomy
- We need professionals from Ecological Economics for an accurate understanding of the value of ecosystem services
- And to attain the national goals of *nirmal dhara, aviral dhara, swachh kinara*, we need professionals specializing in River Ecology
- Several State Governments testified that huge delays in techno-economic appraisal by CWC had become a matter of concern

- Most large states have developed requisite expertise in the past 2 decades (BODHI). IIH, Roorkee, CWPRS, Pune, IIT Roorkee, IISc, IITs and RECs have expertise which State Governments can avail
- Appraisal can be a demand-based exercise, a partnership between the central and state governments

6. National Water Commission (NWC)

The Committee recommends 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 and development 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

Mandate and Functions of the NWC

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

i. enable and incentivize state governments to implement all irrigation projects in reform mode, with an overarching goal of *har khet ko paani* and improved water resource management and water use efficiency, not just construction of large scale reservoirs, as the main objective;
ii. lead the national aquifer mapping and groundwater management programme;
iii. insulate the agrarian economy and livelihood system from pernicious impacts of drought, flood and climate change and move towards sustainable water security;
iv. 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;*
v. 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;
vi. promote cost effective programmes for appropriate treatment, recycling and reuse of urban and industrial waste water;
vii. develop and implement practical programmes for controlling point and non-point pollution of water bodies, the wetlands and aquifer systems;
viii. 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;
ix. 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;
x. create world-class institutions for broad-based capacity building of water professionals and knowledge management in water

NWC: Structure

Since the NWCs mandate is based on the concept of integrating various disciplines into a river basin framework, as also to guide participatory water resource planning and management at different scales, integrating upwards into a river basin framework, its structure must find a resonance between various disciplines represented by its 'commissioners' and the key functions of the Divisions described below. Each Division may be headed by a Deputy Director General (DDG: Additional Secretary rank; some may be drawn from the existing Members of CWC and senior positions of CGWB). Each such Division would include sub-divisions called 'directorates'.

At present CWC has three technical wings, each headed by a Member, Designs and Research Wing, Water Planning and Projects Wing, River Management Wing. CGWB operates through four technical wings, each headed by a Member, Exploratory Drilling & Material Management Wing, Sustainable Management & Liaison Wing, Survey, Assessment & Monitoring Wing and Training and Technology Transfer Wing. There are also the NWA and RGI tasked with capacity building. We believe the work of all these remains very important but it needs to be restructured and strengthened as proposed below, in order for them to more effectively fulfil their new mandate.

Divisions of the NWC

1. Irrigation Reform Division

This Division will take care of the NWC mandate to 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* and not just construction of large scale reservoirs and river development projects as the main goal. 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 paani***.

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 utilised and **ensuring that the water reaches the farmers for whom these dams are being built**.

2. River Rejuvenation Division

This Division will answer to the mandate of the NWC to 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.* It will help catalyse 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

3. Aquifer Mapping and Participatory Groundwater Management Division

This Division will lead the National Aquifer Management Programme (NAQUIM). 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 programme. These will include other than state groundwater departments, other water-related government departments, academic and research institutions, civil society organisations, Panchayati Raj Institutions and others as per requirement so that NAQUIM, the largest aquifer mapping and management programme in human history, can be completed within a decade. It will have to work closely at the village and watershed levels, given the highly decentralised 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.

4. 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 meeting the NWC mandate of 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 programmes for tackling these challenges. The Division will provide flood-forecasting services to all major flood prone inter-state river basins of India. 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 all other NWC Divisions, as also the Ministries of Drinking Water and Sanitation, Rural Development, Agriculture and Environment, along with State Governments.

5. Urban and Industrial Water Division

Historically, urban and industrial water has not come under the purview of the CWC. However, given the enormous challenges of a rapidly urbanising and industrialising 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 industrialisation and urbanisation 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.

6. Water Quality Division

This Division will work to fulfill the NWC mandate to develop and implement practical programmes 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 CPCB to address these issues

7. Data Management and Transparency Division

This Division will take care of the mandate of the NWC to 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.

8. Knowledge Management and Capacity Building Division

This Division will be in-charge of creating world-class institutions for broad-based capacity building of water professionals in integrated water and land management.

The Division will 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 will be responsible for creating mass awareness regarding water resource programmes and policies and initiatives in which people have a central role.

Management of Partnerships

- For the NWC to be able to play its mandated role will require the organisation to build strong partnerships with a wide range of organisations across the country in the water sector.
- We are not advocating that all the capacities required should be housed within the NWC.
- A lot of the professionals needed by the NWC would become available through a carefully crafted architecture of partnerships with world-class academic and research institutions, of which there are many in India, as also civil society organisations with a strong presence in the field and a track record of excellence over many years.

- The key here is how these partnerships are managed.

NWC: Strong Regional Presence in River Basins

- River basins must form fundamental units for strategic planning and management of water resources
- For this we need to correct the currently inadequate presence of CWC and CGWB in the river basins
- There are 11 river basins where neither CWC nor CGWB has a regional centre
- We propose a reorganisation of CWC-CGWB offices in a way that incorporates their current presence and only adds offices where they are both missing
- But by unifying them, we also save huge admin costs in terms of land, buildings and personnel

Chapter One

Challenges of Water Management in 21st Century India

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 citizens; it also puts the livelihoods of millions at risk.

The demands of a rapidly industrialising 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 and uranium. Our rivers and our groundwater are polluted by untreated effluents and sewage, which continue to be dumped into them. 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 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.

Climate change poses fresh challenges with its impacts on the hydrologic cycle. More extreme rates of precipitation and evapo-transpiration 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% of our water resources, continues to be among the lowest in the world. At 25-35 percent, this compares poorly with 40-45 percent in Malaysia and Morocco and 50-60 percent in Israel, Japan, China and Taiwan. 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 epicentre 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."

Making this change happen, which both the Hon'ble Prime Minister and Chief Minister have emphasised, is what we regard as the central mandate of our Committee. This report outlines in brief the challenges of water management facing 21st century India, how the supply-centred approach we have followed over the past 6-7 decades has reached palpable limits and outlines the paradigm shift that India needs in water. The report argues that we need to move beyond the approach to water embodied in techno-centric supply-side interventions implemented top-down by fragmented bureaucracies, involving mostly technology, engineering, and public investment in water infrastructure, towards a more people-centred approach to water management that leads to rejuvenation of rivers and aquifers, so that we can sustainably meet the needs of water security[1] of our people and move towards comprehensive drought-proofing.

This new approach has three crucial elements:

1. Demand-side management entailing the formulation and application of incentives or quantitative restrictions aimed at limiting the demand for water by increasing efficiency and reducing waste;

2. Recognizing nature as an important stakeholder, emphasizing the criticality of maintaining required environmental flows and minimizing adverse eco-system impacts of water development interventions;

3. Participatory resource management, as an approach to water resource development and management as superior to top-down techno-centric approach both for the former's intrinsic and instrumental value.

The report concludes by describing the new institutional arrangement that is needed through a restructuring and strengthening of the CWC and CGWB, so that this paradigm shift can be effectively put in place on the ground, in a way that truly benefits the people of our country.

1.1 Demand and Supply of Water in India

Estimates of India's water budget i.e., annual flow of water available for human use after allowing for evapo-transpiration and required ecological flow – vary considerably. Here too we need to bring the best science to bear on the estimates of demand and supply of water in India.

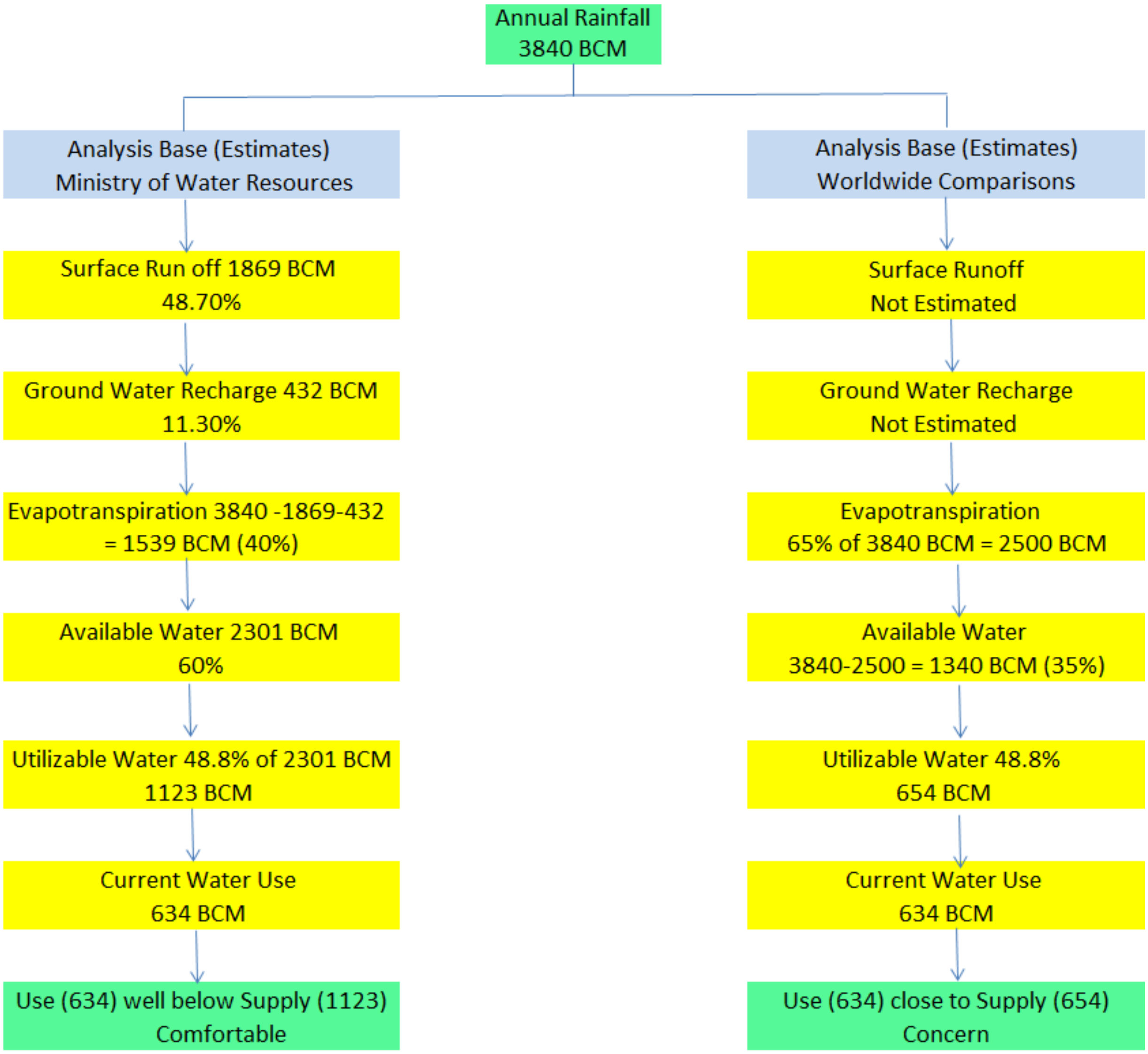
The water budget derived from Ministry of Water Resources estimates (summarised in the first column in Figure 1.1 shows utilizable water of 1123 BCM against current water use of 634 BCM suggesting more than adequate availability at the aggregate level given current requirements.

[1]Water security is understood as ensuring "availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies" (Grey and Sadoff, 2007).

This is based on the Central Water Commission's estimate of India's water resource potential as 1869 billion cubic metres (BCM). The Standing Sub-committee of the Ministry of Water Resources estimates total water demand rising to 1093 BCM in 2025, thus reaffirming a comfortable scenario. However, more recent calculations based on higher estimates of the amount of water lost to the atmosphere by evapo-transpiration are less comforting. Narasimhan (2008) [2] has recalculated India's water budget, using an evapo-transpiration rate of 65 per cent, which compares with worldwide figures ranging from 60 per cent to 90 per cent instead of the 40 per cent rate assumed in the official estimates. The result also summarised in Figure 1.1 is sobering. After allowing the same 48.8 per cent for ecological flows, his estimate of water utilizable for human use comes to only 654 BCM, which is very close to the current actual water use estimate of 634 BCM. The 2030 Water Resources Group (2009)[3] estimates that if the current pattern of demand continues, about half of the demand for water will be unmet by 2030.

[2] Narasimhan, T.N. (2008): 'A Note on India's Water Budget and Evapotranspiration', *Journal of Earth System Science*, **117**

[3] The 2030 Water Resources Group (2009): *Charting Our Water Future*



Source: Narasimhan, T.N. and V.K. Gaur (2009): *A Framework for India's Water Policy*
National Institute for Advanced Studies, Bangalore

Figure 1.1

In addition to the fact that aggregate estimates suffer from data infirmities and arbitrary assumptions and are still being debated and contested, it is also important to emphasise that in a country of such immense physiographic, hydrogeological and demographic diversity, and also vastly different levels of economic development (hence water use), water balances for the country as a whole are of limited value since they hide the existence of areas of acute water shortage or even problems of quality. What is required is a much more disaggregated picture, accurately reflecting the challenge faced by each river basin. But the overall picture does alert us to the grave water crisis facing the country. Even more sobering is the fact that supply-side solutions are now running out of steam.

Around 80% of India's water is consumed by the irrigation sector. For the first two decades after independence, this water was mainly supplied through large and medium irrigation dams constructed on our major river systems. However, over the last four decades it is groundwater that has been the main source of water.

Figure 1.2 summarises sources of water for irrigation in India and shows how groundwater, especially irrigation largely carried out through tubewells, has become the main source in recent decades.As shown in Figure 1.2, groundwater today provides more than 60 per cent of net irrigated area. The area irrigated by canals and tanks has actually undergone a decline even in absolute terms since the 1990s.

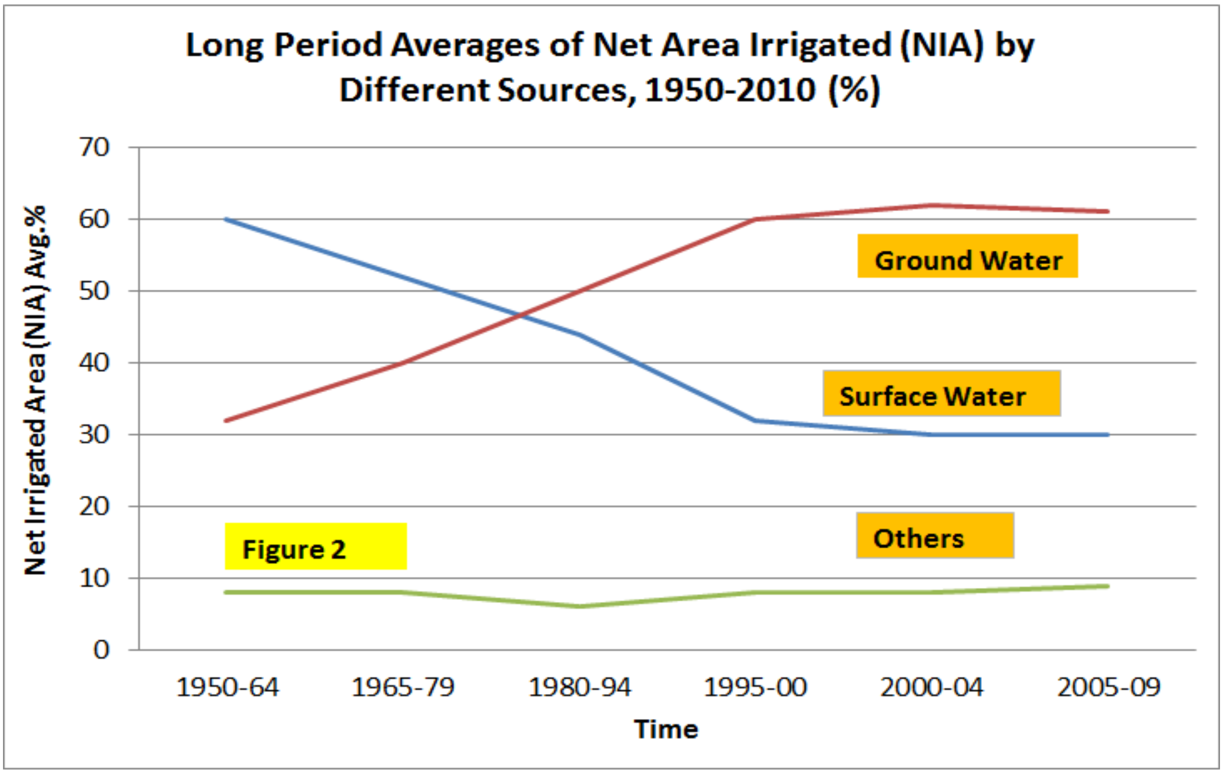


Figure 1.2

1.2 Emerging Limits to Supply-side Solutions

1.2.1 Large Dams

Recent scholarship points to definite limits to the role new large dam projects can play in providing economically viable additional water storage (Ackerman, 2011). 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 the International Water Management Institute (IWMI) (Amarsinghe *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, 2011, 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 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” (ibid).

There is also the problem that further up in the Himalayas 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 (K. 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). Rapid rise of the Himalayas (from 500 to 8000 metres) 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), as also 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 behaviour 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 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 Rs. 5,60,000 crores in 2001. 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 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+ metres 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 degrees 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.

1.2.2 Groundwater

As far as the possibilities of further groundwater development are concerned, the situation is perhaps even more difficult in large parts of the country. Unfortunately the growing dependence on groundwater has taken the form of unsustainable over-extraction, which is lowering the water table and adversely impacting drinking water security.

While public investments since Independence have focused largely on surface water, over the last three decades, groundwater has emerged as the main source of both drinking water and irrigation, based almost entirely on private investments by millions of atomistic decision-makers.[4]

The relative ease and convenience of its decentralised 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.

Figure 1.3 provides a comparison between India and other countries on the annual abstraction rates for ground water.

[4]Of course, it must be acknowledged that the massive investments in public electrification hugely contributed to groundwater development

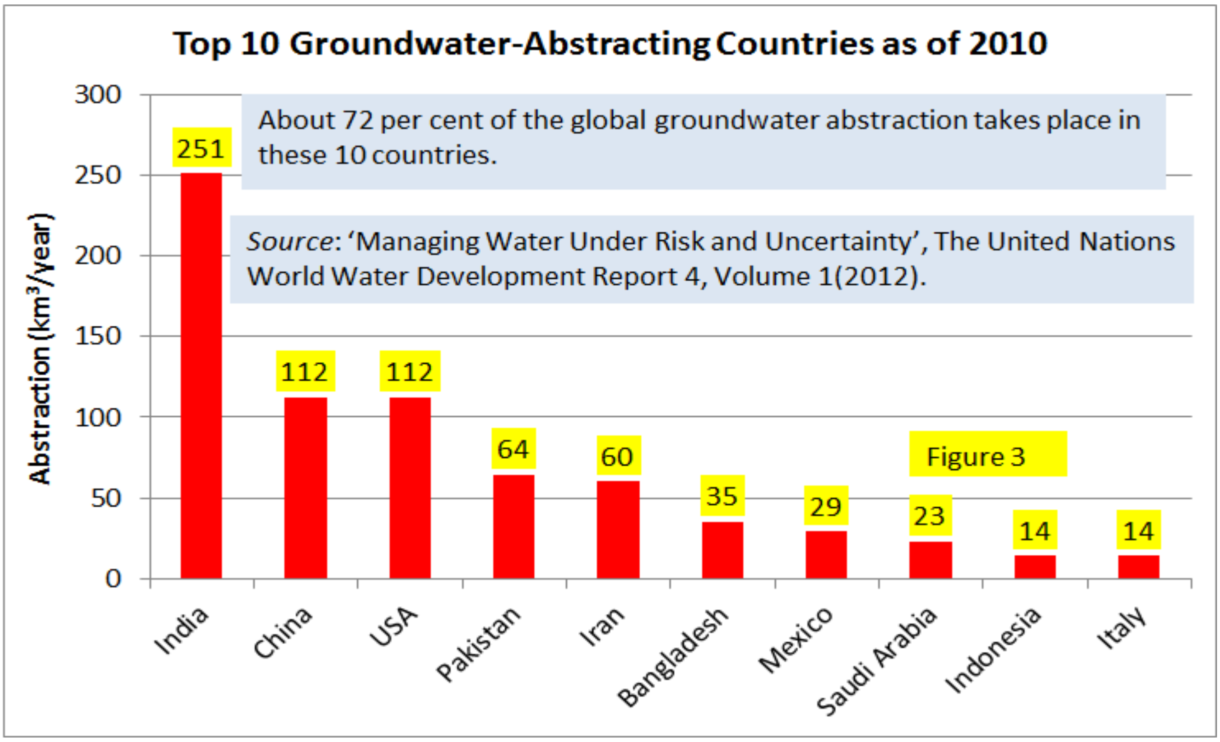


Figure 1.3

Recent work based on data from NASA's Gravity Recovery and Climate Experiment (GRACE) satellites[5] 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. During the study period of August 2002 to October 2008, groundwater depletion in Rajasthan, Punjab, Haryana and Delhi was equivalent to a net loss of 109 cubic km. of water, which is double the capacity of India's largest surface-water reservoir. Annual rainfall was close to normal throughout the period and the study shows that other terrestrial water storage components (soil moisture, surface waters, snow, glaciers and biomass) did not contribute significantly to the observed decline in total water levels. The study concludes that unsustainable consumption of groundwater for irrigation and other anthropogenic uses is likely to be the cause.

[5]Rodell, M., Velicogna, I., and J.S. Famiglietti (2009): 'Satellite-based Estimates of Groundwater Depletion in India', *Nature,* dci10.1038

When the annual withdrawal rate of ground water is compared with the annual recharge of ground water the picture that emerges is not very rosy. The withdrawal rate expressed as a percentage of the net ground water available per year (termed level of Ground water development) exceeds 100 % in some states and is far from satisfactory in other states.

Tables 1.1 and 1.2 present the changes in the level of ground water development at the state level from 2004 to 2011.In Punjab, Haryana, Rajasthan and Delhi, this level has crossed 100 percent, closely followed by Tamil Nadu (77%) and UP (74%). The crisis has also clearly deepened over the last decade

Table 1.1
Groundwater Availability, Net Draft and Level of Development, 2004[6]

States	Net Annual Groundwater Availability (BCM/yr)	Net Draft (BCM/yr)	Impact on Ground Water Stocks (BCM/yr)	Level of GW Development (%)
Punjab	21.4	31.2	(-) 9.8	145
Rajasthan	10.4	13.0	(-) 2.6	125
Haryana	8.6	9.5	(-) 0.9	109
Tamil Nadu	20.8	17.7	3.1	85
Gujarat	15.0	11.5	3.5	76
Uttar Pradesh	70.2	48.8	21.4	70
INDIA	398.7	230.4	168.3	58

Source: CGWB (2006)

Table 1.2
Groundwater Availability, Net Draft and Level of Development, 2011

States	Net Annual Groundwater Availability (BCM/yr)	Net Draft (BCM/yr)	Impact on Ground Water Stocks (BCM/yr)	Level of GW Development (%)
Punjab	20.32	34.88	(-)14.83	172
Rajasthan	10.83	14.84	(-)4.01	137
Haryana	9.79	13.05	(-)3.31	133
Tamil Nadu	19.38	14.93	4.39	77
Gujarat	17.59	11.86	5.87	67
Uttar Pradesh	71.66	52.78	19.64	74
INDIA	**398.16**	**245.05**	**154.71**	**62**

Source: CGWB (2014)

[6]The Level of Groundwater Development is the ratio of annual groundwater withdrawal (groundwater draft) and the net annual groundwater available in the assessment unit (block/taluka/mandal). Net annual groundwater availability is defined as the annual groundwater recharge (total annual recharge from monsoon and non-monsoon seasons) minus the natural discharge during non-monsoon season (estimated at 5-10%) of the total annual groundwater recharge).

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 today the single largest source of irrigation. 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",[7] 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 recognising 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

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[7] Llamas, R. and P. Martinez-Santos (2005): 'Intensive Groundwater Use: Silent Revolution and Potential Source of Water Conflicts", *American Society of Civil Engineers Journal of Water Resources Planning and Management*, 131, no.4; Jarvis, T. et al (2005): 'International Borders, Ground Water Flow and Hydroschizophrenia', *Ground Water*, Vol.43, No.5

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)[8] and Arsenicosis [5 million in West Bengal (WHO 2002)[9] and several magnitudes more, though unestimated 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.[10]

A recent assessment by NASA showed that during 2002 to 2008, India lost about 109 cu.km. of water, leading to a decline in water table to the extent of 3-5 cm per annum (Tiwari et al, 2009)[11]. In addition to depletion, many parts of India report severe water quality problems, causing drinking water vulnerability. *The result is that nearly 60% of all districts in India have problems related to either the quantity or quality of groundwater or both.*

1.3 Challenge of Demand Management and Last-Mile Delivery

1.3.1 Large Dams

Given the emerging limits to further development in the major and medium irrigation (MMI) 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

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[8]Susheela AK, 2001, *A Treatise on Fluorosis*, Fluorosis Research and Rural Development Foundation, Delhi

[9]*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 2002, Dhaka, Bangladesh

[10] S. Krishnan (2009): *The Silently Accepted Menace of Disease Burden from Drinking Water Quality Problems*, Submission to the Planning Commission

[11] VM Tiwari *et al* (2009):'Dwindling groundwater resources in northern Indian region, from satellite gravity observations', *Geoph. Res. Lett.*, 36, L18401, doi:10.1029/2009GL039401.

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 sectors of the economy.

Huge public investments over the last 60 years have meant that the irrigation potential created through MMI projects has increased nearly five-fold from 9.72 mha in the pre-Plan period to around 46 mha by the 11th Plan. At the same time, it is clear that these projects have suffered from massive time and cost overruns.

The worst offenders are the major irrigation projects where the average cost overrun is as high as 1382 per cent. 28 out of the 151 major projects analyzed witnessed cost overruns of over 1000 per cent. Of these, nine had cost overruns of over 5000 per cent. The cost overruns 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 (460), after which it has again risen to 571, almost touching the 1980 figure again.

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. There is a spillover of 337 projects—154 major, 148 medium and 35 Extension, Renovation, Modernisation (ERM) projects into the Twelfth Plan from previous Plan periods.[12]

The Accelerated Irrigation Benefits Programme (AIBP) was launched in 1996 to fast-track the implementation of ongoing major and medium irrigation projects which were in an advanced stage of completion. Central

[12]Around 56 per cent of these 337 projects have not been approved by the Planning Commission and are not eligible for central assistance.

assistance worth Rs. 54251 crores has been provided to the States between 1996 and 2012 under AIBP. The AIBP has been successful in accelerating the rate of creation of additional irrigation potential in the MMI sector, which increased from 2.2 mha per Plan till the Eighth Plan to 4.10 mha during the Ninth Plan following the introduction of AIBP and further rose to 5.30mha during the Tenth Plan and 4.28 mha during the Eleventh Plan.

Box 1.1 IIM Lucknow Evaluates AIBP

To assess the impact of the Accelerated Irrigation Benefit Programme (AIBP), the Programme Evaluation Organization of the Planning Commission initiated an evaluation of the AIBP. This exercise, conducted by the Indian Institute of Management, Lucknow, carried out sample surveys in 10 different states covering 10 irrigation projects (4 Major, 4 Medium and 2 ERM). The study completed in late 2011 reveals that the gap between the irrigation potential created and utilized in these projects is substantial and growing. Major reasons are low water discharge, insufficient water distribution mechanism, unequal water distribution across farmers located at different points, loss of water during distribution, incorrect recording of irrigated area and diversion of cultivable land to other purposes within the command area.

State governments are finding it difficult to finance recurring costs of irrigation and to collect economic water charges from the farmers. Majority of the farmers do not pay irrigation charges on time in major irrigation projects of U.P., Karnataka, and Assam. These financial constraints not only affect the maintenance of assets under AIBP i.e. water outlets and distribution channels, which was found to be inadequate, but also the sustainability of these irrigation systems with adverse impact on water use efficiency and equity. Importantly, more than 50 per cent of the farmers in major irrigation projects are willing to pay extra charge for assured water supply indicating that access to water is more important than its cost.

Source: Planning Commission (2012)

The real difficulty is that while we have done well in creating additional irrigation capacities, their utilization has been less than satisfactory. From being almost equal in the pre-Plan period, the gap between the two has only grown wider over the years. Improved utilisation of these capacities can dramatically add to irrigated area and also lead to a major improvement in water-use efficiency.

Studies by four Indian Institutes of Management (Ahmedabad, Bangalore, Kolkata and Lucknow) of 34 states and Union Territories (UTs) completed in 2009 show that the IPC–IPU gap reflects implementation issues such as faulty project designs, poor lining and desilting and shoddy maintenance of distribution channels.

Another reason is that irrigation potential is defined on the basis of a certain volume of water expected in the reservoir, which is divided by a presumed depth of irrigation required for a presumed cropping pattern. However, the actual values of these variables differ from their presumed values because of a switch to water-intensive crops at the upper end of the command.

Institutional weaknesses are also important. There is lack of coordination between concerned department officials (resulting in delays in implementation and implementation without proper technical assessment) as also inadequate technical and managerial capacity of irrigation department staff. The absence or ineffectiveness of Water Users Associations (WUAs), is also mentioned as a significant contributor to the IPC–IPU gap.

The most important initiative for bridging the gap between IPC and IPU is the Command Area Development Programme (CADP) that has been running since 1974–75. The difficulty is that the CADP has been both divorced from the AIBP and not received the emphasis it deserves. The mode of implementation of the CADP has also left much to be desired in terms of the complement of human resources provided for the programme as also an inadequate understanding of participatory and devolutionary approaches. At times the supporting legal framework in the form of

Participatory Irrigation Management (PIM) Acts has been lacking. Only 15 States have enacted PIM Acts and/or amended the existing Irrigation Acts. As many as 13 States are yet to do so. Although a large number of WUAs are reported to have been formed in various States, only a few have actually been handed over the system. Successful functioning of WUAs is reported only in a few projects in Maharashtra, Gujarat, Andhra Pradesh and Orissa.

The Central Water Commission (CWC) has studied the water use efficiency in 30 completed major and medium irrigation projects. Nine projects have a water use efficiency of less than 30 per cent. The average across 30 projects is 38 per cent. Among the factors explaining the low water use efficiency levels identified by the CWC are:

- Poor maintenance of canal and distribution network resulting in growth of weeds and vegetation within them;
- Siltation of canals, damage of lining in lined canals, distortion of canal sections due to siltation or collapse of slopes, leakages in gates and shutters;
- Non-provision of lining in canals, field channels and water courses passing through permeable soil strata has resulted in high seepage losses.
- The lack of regulation gates on head regulators of minors has led to uneven distribution of water;
- Cases of over-irrigation due to non-availability of control structures in the distribution system have also been reported;
- Poor management practices and lack of awareness among farmers have contributed to an adverse performance overall.

The key bottleneck so far has been that capacities of irrigation departments in many States to deliver quality services have failed to keep up with growing MMI investments. While States compete for capital investments in new MMI projects, they are not always able to manage them efficiently. In 2005, the World Bank estimated that to minimize deferred maintenance on Indian MMI systems, we need to spend Rs. 19,000 crore on annual maintenance, which is nearly 20 times more than what States actually spend. State irrigation departments generate enough revenue only to meet their establishment costs, which many do from the water charges they recover by selling a small proportion of MMI water to industries. But this just covers salaries and leaves little or nothing for regular maintenance and upkeep of systems, especially canals and distribution systems. This has an adverse impact on irrigation. This is also closely linked to the fact that in many States the Irrigation Service Fee (ISF) to be collected from farmers has been abolished or is as low as 2-8 percent of dues. In this way, the accountability loop between farmers and irrigation departments is broken. Wherever ISF gets regularly collected, irrigation staff shows greater accountability and responsiveness to farmers. There is greater contact between the two, there is greater oversight of water distribution and farmers expect at least a minimal level of service if an ISF is demanded of them. When governments abolish ISF or fix it at a token rate or fail to undertake regular collection, farmers forfeit their right to demand service and irrigation staff can afford to neglect service provision.

Thus, a vicious cycle is set up which results in the fact that despite creation of millions of hectares of irrigation capacity, farmers continue to be starved of water in the absence of good last-mile connectivity.

1.3.2 Groundwater

As for groundwater, we have a different kind of management problem. While its decentralised character enables easier last-mile connectivity, the problem arises in the inequitable distribution and unsustainable extraction of this common pool resource (CPR).While groundwater resources are perceived as a part of a specific cadastre—watersheds, landscapes, river basins, villages, blocks, districts, states—aquifers are seldom considered. Aquifers are rock formations capable of storing and transmitting groundwater. A complete understanding of groundwater resources is possible only through a proper understanding of such aquifers. As the work of Nobel Prize winning economist ElinorOstrom shows, the first design principle in management of CPRs 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.Table1.3 provides an overview of the various underlying hydro-geologic settings that characterize India. Figure 1.4 shows these in pictorial form.

Table 1.3: Typology of Hydrogeological Settings in India

Hydrogeological setting	**Area (km^2)**	**States**	**Share in Total Area (%)**
Crystalline (Basement) Systems	1023639	Andhra Pradesh, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Pondicherry, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal	31
Alluvial (Unconsolidated) Systems	931832	Arunachal Pradesh, Assam, Bihar, Delhi, Diu & Daman, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Kerala, Madhya Pradesh, Maharashtra, Orissa, Pondicherry, Punjab, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh, Uttarakhand, West Bengal	28
Mountain Systems	525067	Arunachal Pradesh, Assam, Haryana, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Mizoram, Rajasthan, Sikkim, Uttar Pradesh, Uttarakhand, West Bengal	16
Volcanic Systems	525036	Andhra Pradesh, Bihar, Dadra & Nagar Haveli, Diu & Daman, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, West Bengal	16
Sedimentary (Soft Rock) Systems	85436	Andhra Pradesh, Chhattisgarh, Gujarat, Madhya Pradesh, Maharashtra, Orissa	3
Sedimentary (Hard Rock) Systems	194798	Andhra Pradesh, Bihar, Chhattisgarh, Jharkhand, Karnataka, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh	6
Total	**3285808**		**100**

Source: Kulkarni et al, 2015

About 54 percent of India (comprising mainly the continental shield) is underlain by formations usually referred to as "hard rocks". 'Hard rock' is a generic term applied to igneous and metamorphic rocks with aquifers of low primary intergranular porosity (e.g., granites, basalts, gneisses and schists). Groundwater resource in hard rocks is characterised 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 (setting 2), 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 metres 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.

Similarly in the mountain systems (setting 3 in Table 1.3), which comprise 17 per cent of India's land area, effects of groundwater overuse do not take very long to appear.

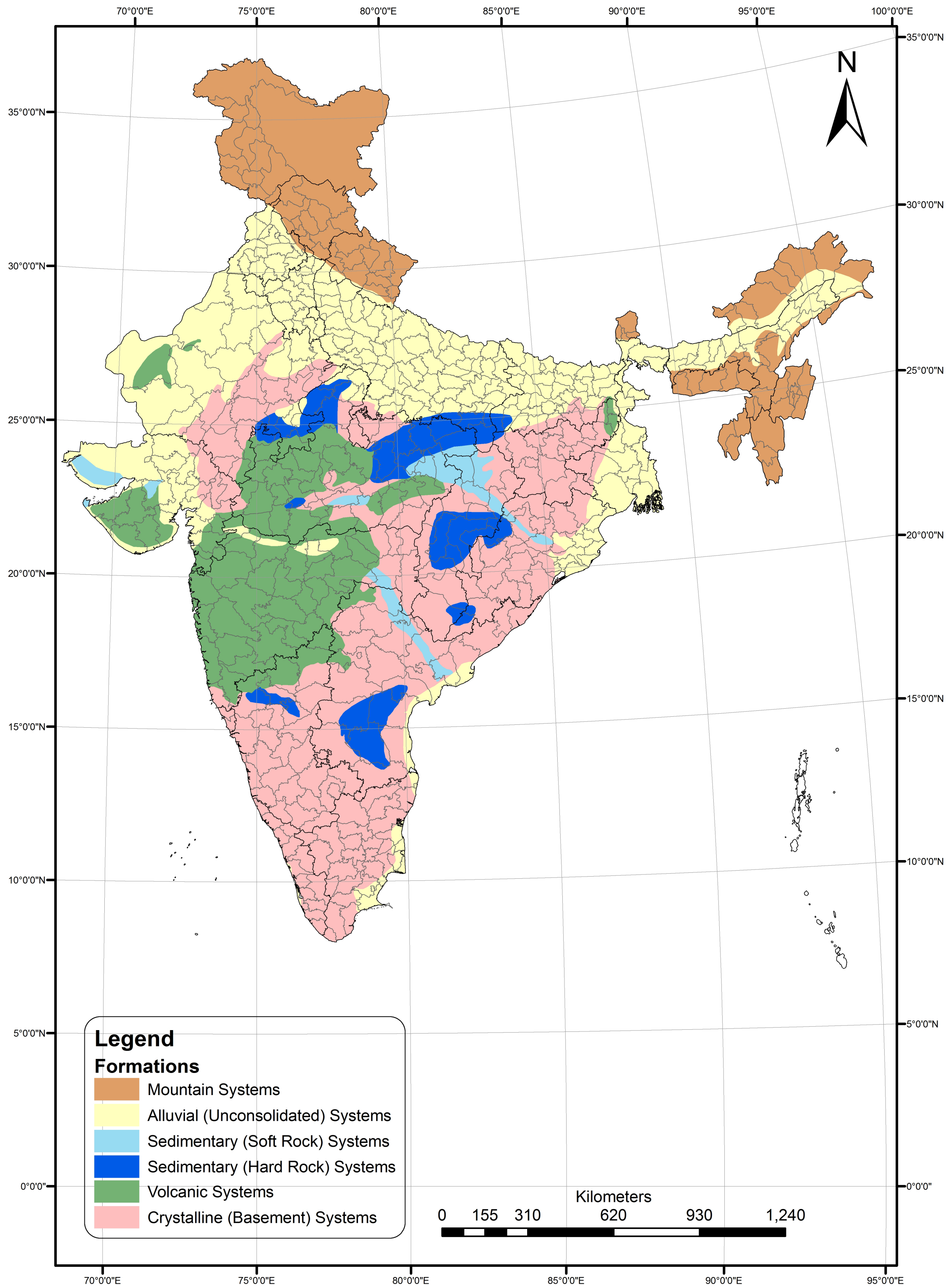

Figure 1.4

As the processes of groundwater accumulation and movement are vastly different in different geological types, the implications of any level of groundwater development (GD) will vary significantly across types of geological settings. A much lower level of GD (defined as draft on groundwater as a percentage of net annual groundwater availability) in settings 3-6 in Table 1.4, which account for 71 per cent of India's land area, could be as "unsafe" as a comparatively higher level in settings 1 and 2. Thus, we need to exercise far greater caution in settings 3-6 as soon as the level of GD crosses 50 per cent.

However, even in the alluvial heartlands of the Green Revolution (i.e., setting 1 in Table 1.3) 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 exceeding recharge and is therefore unsustainable. Three other states, Tamil Nadu, Gujarat and UP, seem to be fast approaching that stage.

Participatory, sustainable groundwater management, recognising 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 abundantly clear, therefore, that without a radical change in our understanding and approach to both surface and groundwater management in India, we will not be able to tackle the acute water crisis facing the nation. The paradigm shift required in water is outlined in the next chapter

Chapter Two

Need for a Paradigm Shift in Water

2.1 Ensuring Water in Commands Reaches the Farmers

The Government of India needs to both incentivise and facilitate States to ensure that they undertake reforms required to ensure that the millions of hectares 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 a new dam.

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.

Box 2.1 Success Story of PIM

One of the most successful examples of PIM in India is being implemented jointly by the Government of Gujarat and Development Support Centre, Ahmedabad since 1994 on the right bank canal of the Dharoi project on the Sabarmati river covering about 48,000 hectares. 175 WUAs and two Branch Level Federations have been formed.Each WUA services a command area of about 300 to 500 hectares and has about 200 to 350 members. The Branch Level Federations service an area of 7,000-14,000 hectares. The WUAs in Dharoi are registered as co-operatives. Each farmer within the command area has purchased a share to become a member. There are about 35,000 members. They have carried out canal rehabilitation works worth Rs.55 million wherein the members have contributed about Rs.10 million. They have appointed their own President, Secretary and Canal Operators who ensure that the WUA financial and administrative systems as well as the physical system are in shape before the irrigation season. These operators and the secretary are paid by the WUA itself without any grants from the Government. They have installed gates at the outlet level with their own funds and devised a system of water distribution wherein no member is given water without a pass. They prepare an annual budget and decide the water charges which are often over and above the Government rate. The office bearers collect the water charges in advance from the farmers and pay them to the Irrigation Department. The WUAs charge penalties to members in case they break the rules finalized at the Annual General Body meeting and this penalty is double for office bearers. Some of them have also carried out pilots on volumetric supply of water and water use efficiency. They have built up reserve funds that serve as a contingency during scanty rainfall years. Source: Planning Commission (2010)

But even more significant are the successful examples 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.

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. In the following respects:

- Improves equitable access to water by all farmers (*harkhetkopaani*)
- Leads to sustainable operation and maintenance of the irrigation systems
- Results in at least 20% saving in water use
- Creates a healthier link between farmers and irrigation department
- Gives more crop per drop
- Increases predictability of irrigation
- Farmers actively participate to
    - contribute towards the physical rehabilitation of the system
    - undertake crop planning and
    - resolve conflicts amicably

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 allocate 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 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. Similarly, to encourage volumetric water deliveries, an additional bonus should be provided on that portion of a State's ISF collection, which accrues through volumetric water supply to WUAs at the outlet level. The clear understanding is that empowering WUAs is the key to making the process of pricing of water and ISF collection more transparent and participatory.

Our huge investments in irrigation have yielded much less than what they should have mainly because command area development (CAD) has been consistently neglected and divorced from building of irrigation capacities. The Centre must stipulate that all irrigation project proposals (major, medium or small) will henceforth include CAD works from the very beginning as an integral part of the project. Thus, each proposal will plan for irrigation water from the reservoir to the farm gate and not just the outlet as at present. No investment clearance will be provided to any irrigation project devoid of CAD integration. There will be *pari passu* action in each irrigation command wherein works in the distributary network and software activities of CAD will be undertaken simultaneously with head works and main canal work, leading to a seamless integration of work in the head-reaches and tail-end of the command. Recognition of potential creation at the outlet of distributary will be discontinued. Potential creation will be recognised only after complete hydraulic connectivity is achieved from reservoir to farm-gate. In this manner, creation of irrigation capacities will be better matched by their utilisation, farmers will truly benefit from these investments and water use efficiency will improve.

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. And we could also restore an additional 2.2 million ha of lost irrigated potential through Extension, Renovation and Modernisation (ERM) works in old MMI projects.

Sadly, in its current state the Central Water Commission (CWC) is ill-equipped to undertake these kinds of radical reforms. Later in the report we will outline institutional restructuring that is needed to enable the Government of India to play the necessary role in this respect.

2.2 Moving Towards Participatory Groundwater Management

Equally urgent is a reform of groundwater management in India. It is not possible to police 30 million groundwater structures through a licence-quota-permit raj. We need a participatory approach to sustainable and equitable groundwater management based on a knowledge of the underlying aquifers. It is this understanding that underpins the National Aquifer Management Programme(NAQUIM) initiated recently by the Government of India. The aquifer mapping programme is notan academic exercise and must seamlessly flow into a participatory groundwater management endeavour. This demands strong partnershipsamong government departments, research institutes, gram panchayats/urban local bodies, industrial units, civil society organizations and the local community. The interface of civil society and research institutes with government needs to be encouraged across all aspects of the programme, ranging from mapping India's aquifers, large-scale capacity building of professionals at different levels, action-research interface with implementation programmes and development of social-regulation norms around groundwater.

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. Over the last few years innovative approaches across the country have blazed a trail on how this paradox might be resolved (Box 3).

Box 2.2

Success Stories of Participatory Groundwater Management in India

- The FAO-supported APFAMGS programme in Andhra Pradesh aimed at involving farmers in hydrologic data generation, analysis and decision-making, particularly around crop-water budgeting.
- Social regulation in groundwater sharing under the AP Drought Adaptation Initiative (APDAI) involving Watershed Support Services and Activities Network (WASSAN), in parts of AP.
- Experiences from Barefoot College, Tilonia, with a water budgeting tool known as JalChitra.
- Foundation for Ecological Security (FES) taking a micro-watershed unit for water balance and planning groundwater use along with communities in Rajasthan, MP and AP.
- Experiences of Advanced Centre for Water Resources Development and Management (ACWADAM) with Samaj Pragati Sahayog in MP and with the Pani Panchayats in Maharashtra on knowledge-based, typology-driven aquifer-management strategies.
- Training programmes and drinking water initiatives by ACT in Kutch training local youth as para-professionals in their quest for improved groundwater management.
- Research on documenting local groundwater knowledge in Saurashtra and Bihar by INREM Foundation.
- The Hivre Bazar model of watershed development and social regulation to manage water resources in Maharashtra.

Source: Planning Commission (2012)

The efficient management of this Common Pool Resource requires an understanding of the following aspects:

- Relationship between surface hydrologic units (watersheds and river basins) and hydrogeological units, i.e. aquifers;
- The broad lithological setup constituting the aquifer with some idea about the geometry of the aquifer – extent and thickness;
- Identification of groundwater recharge areas, resulting in protection and augmentation strategies;
- Groundwater balance and crop-water budgeting at the scale of a village or watershed.
- Groundwater assessment at the level of each individual aquifer in terms of groundwater storage and transmission characteristics, including the aquifer storage capacity.
- Regulatory options at community level, including drilling depth (or whether to drill tube wells or bore wells at all), distances between wells (especially with regard to drinking water sources), cropping pattern that ensures sustainability of the resource (aquifer) and not just the source (well/tubewell), comprehensive plan for participatory groundwater management based on aquifer understanding, bearing in mind principles of equitable distribution of groundwater across all stakeholders.

Each of these are the central foci of the National Aquifer Management Programme launched in the 12th Plan with a budgetary allocation of Rs. 3,539 crore. 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).

Tragically, so far the programme has failed to take off with the requisite momentum. With four years of the 12th Five Year Plan period already over, the actual expenditure is hardly one-tenth of the allocated amount. The major reason for this is the huge lack of capacities in the CGWB and the state ground water boards. Effective management of groundwater requires changes in the nature of coordination among the government ministries related to groundwater (water resources/irrigation, drinking water, rural development, agriculture, environment and forests, urban development, pollution control and industrial effluents). These agencies must be required to assess the impact of their decisions on groundwater and report to CGWB, on issues concerning groundwater. For this to be effective, 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. The Environmental Impact Appraisal conducted by the Ministry of Environment and Forests needs to include impact on groundwater based on inputs from CGWB. MoEF must be required to seek the opinion of CGWB in all groundwater stressed regions as well as in cases where a negative impact on water quality is anticipated. CGWB may develop protocols for conducting assessment of impact of major (industrial/urban/hydrological) interventions on groundwater and strengthen its own internal capacities to widen its scope of work.

A quick review of NAQUIM shows that the program is lagging behind its stated goals. We provide below a summary view of the targets and achievements thus far of NAQUIM:

- A priority area of 8.89 lakh sq.km has been taken up for data generation, aquifer map preparation and preparation of aquifer management plan, out of the total mappable area of 23.25 lakh sq.km in the country.
- Till now the data collection, data compilation, data gap analysis has been completed for a targeted area of 8.89 lakh sq.km. The data generation is in progress
- Aquifer mapping has been completed in NCR area of Uttar Pradesh, Haryana and Delhi encompassing an area of 25000 sq.km.
- The pilot projects on Aquifer Mapping covering an area of 3000 sq.km. in the states of Bihar, Rajasthan, Maharashtra, Karnataka and Tamil Nadu have been completed. The Pilot Project reports have been submitted and uploaded on the website of CGWB.

- During September/ October 2015, areas were reprioritized based on severity of resource constraints with an objective to take areas in clusters in a compact mode. The priority States are Punjab, Haryana, Rajasthan Gujarat, Andhra Pradesh, Telangana, Karnataka and Tamil Nadu and Bundelkhand constituting an area of about 5 lakh Sq. Km.
- Aquifer mapping for potable water and delineation of arsenic affected aquifer in selected blocks of UP, West Bengal, Bihar and Jharkhand has been initiated.

The challenges facing the program are summarised below:

- NAQUIM was approved finally only in September2013 and various activities proposed for data generation got delayed accordingly.
- In order to complete the aquifer mapping as per targets set by government, a number of activities were envisaged to be done through outsourcing, but due to delays the process of engaging the agencies for outsourcing, the same could not take place in time.
- Central Ground Water Board is working with much less than the sanctioned strength in almost all the disciplines and cadres.
- CGWB is working with old and limited number of drilling machines, field vehicles, ancillary equipment etc. including drilling, geophysical, hydrogeological and chemical equipment. Limited availability of machinery and equipment and their frequent breakdowns also hampers the pace of in house data generation.
- For some of the data/information on thematic layers such as topography, geological maps, geomorphological maps, land use etc. CGWB is dependent on other organizations like GSI, SOI, NRSC etc.
- Limited exposure of the officers to the latest technological and knowledge developments and global best practices.
- CGWB needs to have a multi-disciplinary approach drawing members form all associated disciplines to understand the entire gamut of ground water management issues.

- Empowerment of the officers of CGWB in terms of administrative and financial powers to enable smooth execution of activities under NAQUIM.

The new 6-year program that has just been initiated with World Bank assistance for Groundwater Development and Management with a total financial outlay of Rs. 6000 crore is a step in the right direction, with each of its components exactly reflecting the paradigm shift outlined by our Committee in this report

Table 2.1 Components of World Bank assisted Groundwater Development & Management Programme

Project Component	Project Cost by Component and Financer (Crore INR)		
	World Bank	Government	Total
A. Decision support Tools for Ground Water Management A.1 – Enhancing groundwater databases, data sharing and collaboration A.2 – Groundwater monitoring and water audit A.3 – Groundwater studies and research	750	750	1500
B. Area specific framework for sustainable groundwater management B.1 - Analytical Framework for Groundwater Management B.2 – Conjunctive Management of Surface and Groundwater B.3 –Aquifer Protection Measures	500	500	1000
C. Enhance groundwater recharge and improve water use efficiency C.1 – Restoration of groundwater recharge areas C.2 –Interventions in groundwater recharge C.3- Interventions in efficient water using technologies	750	750	1500
D. Strengthening Institutions to foster Community Based Management	1000	1000	2000

D.1 Establishment and development of State and Local level institutional capacity D.2 Establishment of community based "Bhujal-Card" D.3 Community/Farm level capacity building, training curriculum on water budget D.4 Establishment of CPMUs and PMUs for implementation of the project			
TOTAL	**3000**	**3000**	**6000**

Table 2.1

Each component of this ambitious project requires huge enhancement of capacities in the CGWB and state boards, as also a large architecture of partnerships with other institutions across the country, with high technical and social capacities. Some partnerships are already in place. Many more are needed. This will be elaborated in the next chapter

2.3 Rejuvenating Rivers: Focus on River Basins

For some time now, policy-makers and scholars alike have emphasised 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 programmes initiated by the government over the last 40 years. River Basin Organisations 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 Bill (NWFB) 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 emphasises the integral relationship between surface and groundwater. The NWFB recognises 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”

And 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 NWFB 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”

The entire area from which the precipitation is directed into a river until it meets another river (and ultimately the ocean), is referred to as its basin or watershed. A common feature of all river basins is the topography that influences the pattern of stream network forming a river. Steep slopes such as in the mountains cause rapid runoff and erosion and allow lesser infiltration into groundwater. In the plains as the slope decreases considerably, the runoff exceeding the capacity of the river channel periodically spills over the river-banks into areas lying laterally to them. These periodically flooded areas – the floodplains – play a vital role in the groundwater recharge, water quality of the river, biodiversity and several other benefits to humans.

River basins differ in their water resources depending upon a variety of factors such as the climate (precipitation and temperature), geology, soils, vegetation cover and even their size. A river basin may however cover several different geologies and climate zones. The river flowing downslope may pass through dry deserts (e.g., Indus) or high rainfall regions (e.g., Ganga). A large river basin comprises of several sub-basins of their tributaries which often differ in many respects of soil, geology, climate, vegetation, human interaction and these tributaries do influence the rivers they join (downstream of their confluence) (Figure 2.1). In case of such large river basins, it maybe necessary to treat sub-basins separately keeping in view their distinctive characteristics.

The dynamics of water resources of a river basin along with their human use are conceptualised in Figure 2.2. This representation is however oversimplified as the network of tributaries and diversity of human interventions create enormous complexity in the web of water resources. The river basin approach is expected to consider multiple diverse human uses of water throughout the basin (including health, recreation and livelihoods as well as upstream-downstream linkages), along with the natural ecosystem functions of the aquatic ecosystems, in order to maximize the economic and social benefits equitably and sustainably.

It is important to note that river basins (= watersheds) do not follow human-defined administrative/political boundaries but are determined by the physical features of the land surface. Similarly, the boundaries of the aquifers (groundwater storages) also do not necessarily coincide with those of the surface waters as they are determined by subsurface geological features.

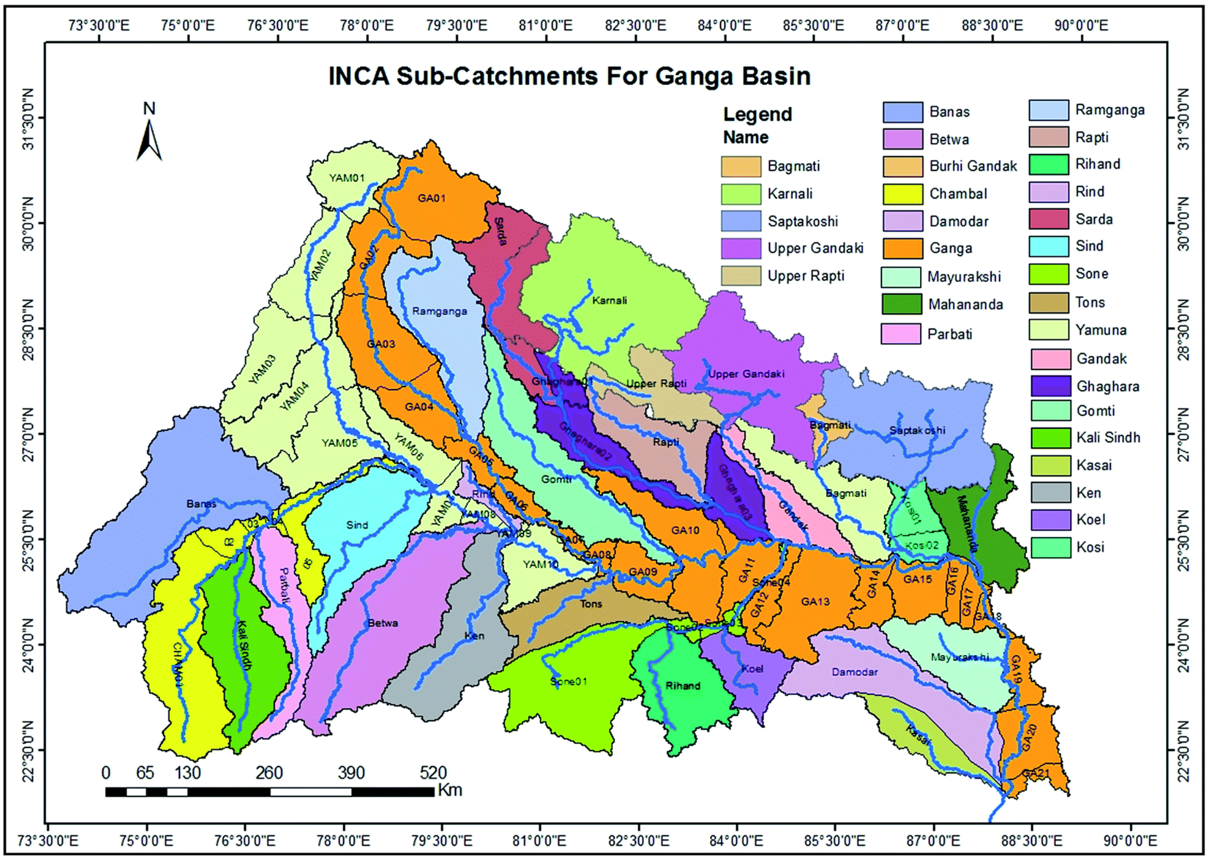

Figure 2.1

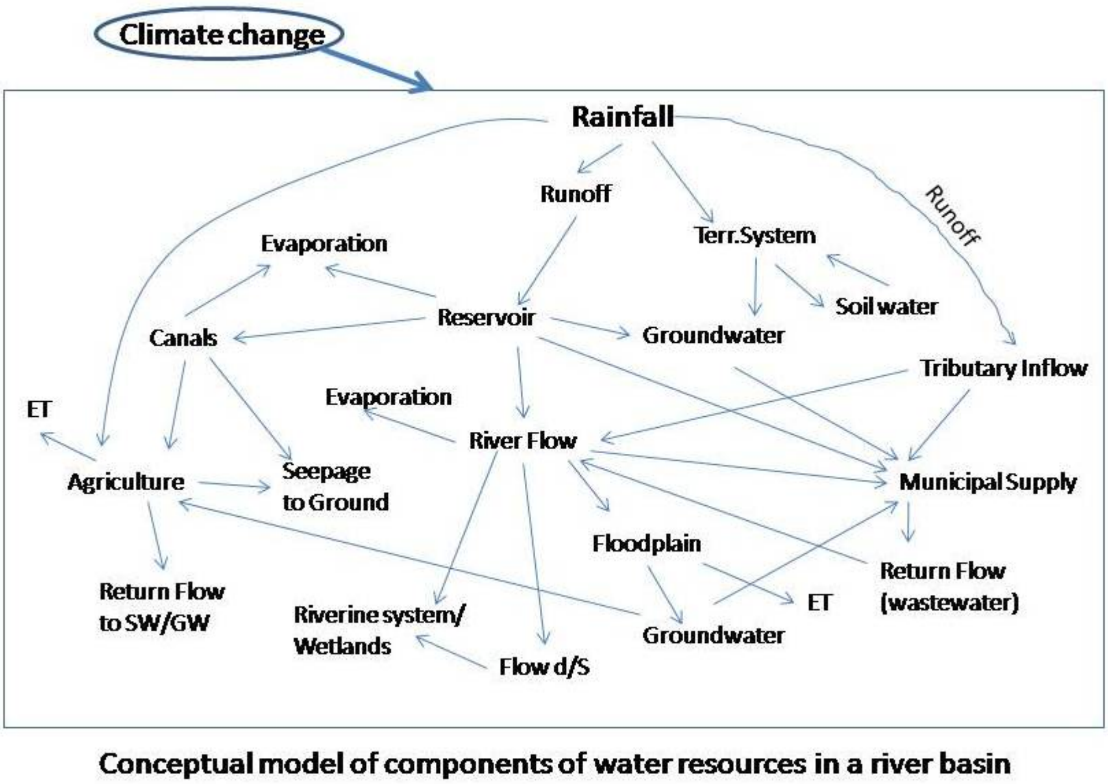

Figure 2.2

The development of the river basin concept, its changing focus, strengths and weaknesses have been discussed in many publication (e.g., Molle 2006, 2009, Cohen and Davidson 2011)[13].

River basin management encompasses two sets of complementary activities undertaken in conjunction with each other: those related to the development of natural resources for promoting economic growth, and those concerned with the conservation, protection and restoration of the natural resources. Because the water resources are intimately and intricately linked with the land resources, the management of water resources at the basin scale cannot be divorced from that of the land resources. These considerations bring into play a large number of stakeholders, institutions, policies and processes making the governance highly complex. Non-stationarity of hydrological cycle as well as the shifts in hydrological regimes and changes in extreme events with the climate change make it necessary to consider their impact on water resource management for an effective response.

Numerous discussions about the institutional arrangements and decision making for river basins have revolved around two approaches: a centralised regulatory system with a single "apex authority that seeks hydrometric data and nationally agreed standards and procedures in decisions over water quality and allocation" and a polycentric river basin management that "is institutionally, organisationally and geographically decentralised, emphasising local, collective ownership and reference to locally agreed standards" (see Lankford and Hepworth 2010[14]). Pahl-Wostl

[13]Molle, F. 2006. Planning and managing water resources at the river-basin level: Emergence and evolution of a concept. Colombo, Sri Lanka: International Water Management Institute. 38 p. (IWMI Comprehensive Assessment Research Report 16); Molle, F. 2009.River-basin planning and management: The social life of a concept. Geoforum 40 (3): 484–494; Cohen, A. and Davidson, S. 2011. An examination of the watershed approach: Challenges, antecedents, and the transition from technical tool to governance unit. Water Alternatives 4(1): 1-14

[14]Lankford, B. and Hepworth, N. 2010. The cathedral and the bazaar: Monocentric and polycentric river basin management. Water Alternatives 3(1): 82-101

et al. (2012)[15] discuss many examples of water resource governance and suggest that polycentric governance regimes characterized by a distribution of power but effective coordination structures perform better. They also state that 'the ability to respond to challenges from climate change is strongly related to polycentric governance and innovative ways for dealing with uncertainty'. They further show that 'economic and institutional development often focuses on and leads to fulfilling needs of the human population at the expense of the environment' and point out the need for effective water governance structures in parallel to economic development.

Keeping these considerations in mind, we will propose in Chapter 4, the appropriate institutional architecture required for river basin management across the country.

2.4 A 21st Century Approach to Flood Management

In addressing the problem of floods, the central focus over the years has been on engineering/structural solutions. Apart from the massive investments in large dams, India has already constructed over 35,000 km of embankments. But these are rapidly reaching their limits. Recent studies show, for example, that "the existing storage infrastructure in Peninsular rivers is mostly designed to smooth out the southwest monsoon flows in, say, 9 out of 10 years. There may still be the 1 in 10 year flood, for which, however, there is no economic justification to invest in substantial additional infrastructure. Instead, better weather and flood forecasting is required, along with flood insurance and possibly the designation of flood diversion areas, whereby farmers are asked to temporarily (and against compensation) set aside embanked land to accommodate flood overflow. . . for the Ganges system, out of 250 BCM of potentially utilizable water, about 37 BCM are presently captured, and a

[15] Pahl-Wostl, C., Lebel, L., Knieper, C., Nikitina, E. 2012. From applying panaceas to mastering complexity: Toward adaptive water governance in river basins. Environmental Science & Policy 23: 24 – 34

total of at most 50 BCM would be captured if all possible dams under consideration were to be built. These would add little in the way of irrigation or flood prevention benefits. Tributaries at risk are already fully embanked, and floods have occurred not because water has flown over the embankments, but because embankments have been repeatedly breached as a result of poor maintenance (e.g., Kosi in Bihar) or inappropriate dam management (e.g., Hirakud in Orissa)" (Ackerman, 2011).

Evidence from floods in the Ghaggar river basin, both in 1993 and 2010, clearly shows the damage caused in Punjab and Haryana by breaches in embankments and unused, poorly designed and maintained canals, as also because settlements have been encouraged on flood plains and drainage lines. In 2008, a breach in an upstream embankment of the Kosi led to the nearly thousand deaths and the displacement of around 3.35 million people (Government of Bihar, 2008). In North Bihar, despite the continued construction of embankments, the flood-prone area has increased 200 percent since independence, at times because embankments end up obstructing natural drainages and impede the natural building up of river deltas and flood plains.

Once again, the problem is that in pandering to short-sighted populism, we have ignored the lessons of science, as also history. Rohan D'Souza (2002) traces the origins of the dominant approach to flood management to the colonial period. He has studied the experiments with flood control in the delta regions of eastern India over the period 1803 to 1956. He suggests that in this time, this region was transformed from a flood dependent agrarian regime to a flood vulnerable landscape. The colonial administration developed the idea of flood control to secure its property regime and its revenue collection strategies. Embankments designed to insulate lands from inundation were the first flood control works deployed by the British in the Orissa delta, based on the learnings from adjoining Bengal. D'Souza provides a fascinating account of the struggle between the revenue administration and the military engineers over the wisdom of the embankment construction programme, a narration that actually does a great deal of credit to the engineers, who at least at that point in time, were very clear that the embankments were aggravating the flood line by clogging drainage and causing the river beds to rapidly deteriorate. But the engineers were gradually subdued and the myopic vision of the revenue authorities won the day. All engineers from that point in time were zealously committed to a rapid expansion in the embankment construction programme, under the guidance of the revenue department! There were those who pointed to the damage being caused by the embankments but during the same period, powerful sectional and proprietary interests, dependent on flood protection structures, drowned out these voices of sanity and ecological wisdom. Even so, the hydraulic crisis that had overwhelmed large swathes of the delta cried out for a resolution.

The iconic Arthur Cotton was called upon to survey the delta in 1858 and came up with another one of those classic pronouncements, which have guided water policy in India till today: "all deltas require essentially the same treatment", which meant that their rivers needed to be controlled and regulated into an invariable and constant supply. Over the years it has been hard to break with this tradition of embankments and dams and move to an alternative 'room for the river' approach, based on best international practice.

In acknowledgment of the limits to further possibilities of building large storages and embankments, some State governments (such as Bihar) have decided to broaden their strategy of tackling floods by placing greater emphasis on rehabilitation of traditional, natural drainage systems, leveraging the funds available under MGNREGA (Samaj Pragati Sahayog and Megh-Pyne Abhiyan, 2012). Since this involves a process of complex social mobilisation and social engineering, civil society organisations will work in close partnership with the State government in this endeavour. We strongly advocate such a paradigm shift in flood management away from building more and more embankments and towards a "room for the river"[16] kind of approach.

It is now understood that embankments reduce the flow carrying capacity of the channel and cause aggradation of channel bed, thereby increasing flood intensity and frequency. Increasing height of embankments only aggravates these problems. The problem with embankments is also that they undermine the ecological and economic functions of floodplain, including groundwater recharge, water quality improvement, natural resource production, fisheries support, waste removal, biodiversity support, recreation, etc. Creation of embankments leads to settlements and industries close to them and they result in consolidation of ground – reduction in groundwater recharge – blockage of drainage network – and pollution of both surface and groundwater. Floodplain-associated water bodies (including lakes and wetlands) should also be seen as water storages that help groundwater recharge and water quality improvement. Restoration and creation of on-floodplain storages along the rivers should be a part of water management strategies.

Thus, far greater priority will be given to non-structural measures such as the efficient management of flood plains, flood plain zoning, disaster preparedness & response planning, flood forecasting & warning, along with disaster relief, flood fighting including public health measures and flood insurance.

Many reservoirs were initially constructed without any flood cushion but with development and population growth, habitations have come up very close to the downstream of these reservoirs and operation of such reservoirs needs to be done carefully. The existing flood forecasting network of Central Water Commission (CWC) is not sufficient to cover the entire country adequately. There is urgent need for extension of CWC's flood forecasting network in consultation with the State Governments and IMD to cover A, B-1, B-2 and C-class Cities located near rivers under the

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[16]This is the name of the new Dutch approach to flood management that shifts focus from dike reinforcement to river relief (Government of Netherlands, 2007, ClimateWire, 2012).

network of automatic data collection, transmission and flood information dissemination. At present, the CWC provides inflow forecast to 28 reservoirs in the country. This needs to be extended to an additional 160 reservoirs, which will cover 80–90 per cent of the total live storage capacity.

Moreover, a majority of the flood warning systems in India are not timely, primarily due to poor transmission. Delays cause enormous damage to property and lives every year. Models used for flood forecasting and its influence zones are not rigorous enough due to lack of integration of hydrology and the weather forecasting systems. The lead-time for flood forecasting can be improved through the use of hydraulic and hydrologic models which are linked to the weather forecasting system, the real time data acquisition system, and the reservoir operation system. It is possible to improve the current forecasting methods by using satellite based information for better estimates of rainfall and snowmelt.

The National Water Academy (NWA) located at Pune is presently involved in providing training to the engineers / officers of the Central / State Governments. The NWA needs to be developed as a Centre of Excellence for international training programmes on matters pertaining to flood mitigation so that up-to-date globally available know-how could be shared under such training programmes. The NWA, Pune must also be suitably strengthened to meet the requirement of the NDMA for conducting trainings on disaster risk reduction programmes. Project-specific planning and implementation is to be ensured by the State Governments. The present structure of the State flood control departments needs to be revamped so that they can discharge their role as prime flood managers in the State. The specific needs of human resources and their skill development need to be addressed.

Digital Elevation Models (DEM) along major river systems including area falling in the flood affected zone in the range of 0.5–1 m need to be prepared for all river basins. Use of NRSC’s flood hazard zonation maps, close contour information, river configuration & bank erosion studies, geo-spatial tools and flood mapping and flood damage assessment should be encouraged. The Disaster Management Support Programme should be expanded to include more river basins and the NDMA will provide necessary support to NRSC in this regard. Basin-wise flood management models including ALTM technology based Digital Elevation Models, Inundation Forecast Models, Bathymetric Surveys and Cubature Study Models should be undertaken jointly by NRSC, CWC and concerned States. Development of integrated mathematical models should be undertaken jointly by IMD and CWC for flood / runoff forecasting using weather parameters, rainfall observed and rainfall forecast.

2.5 Urban and Industrial Water Management

In India, the number of people living in urban areas is expected to more than double and grow to around 800 million by 2050. This will pose unprecedented challenges for water management in urban India. The demands of a rapidly industrialising 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. Both our rivers and our groundwater are polluted by untreated effluents and sewage dumped into them. 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 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.

Averaged for 71 cities and towns, groundwater constitutes 48% of the share in urban water supply. In India, 56 per cent of metropolitan, class-I and class-II cities are dependent on groundwater either fully or partially. Unaccounted water in urban areas exceeds 50% according to the CGWB's report on the groundwater scenario in 28 Indian cities. Privately driven, individualistic pumping of groundwater in large parts of urban India has provided benefits for filling out the gaps in public water supply schemes. However, it has also led to problems of co-terminal depletion and contamination of aquifers. There are huge gaps in our knowledge about urban aquifers, their characteristics, the significance of their service value and a comprehensive understanding of the competition and conflicts around groundwater resources. Sustainable management of groundwater is impossible without a much deeper understanding of the types of aquifers within which it is located.

Aquifers in large regions of India act as both sources and sinks for various loads, ranging from sullage to sewage and from industrial waste to agricultural residues like pesticide and fertilizer. Groundwater resources in growing urban centres are therefore likely to become contaminated as much by residual contaminants from erstwhile agricultural activities and poor rural sanitation as by contamination from more current haphazard waste-water disposal. Only 33% urban Indians are connected to a piped sewer system and 13% – roughly 50 million urban Indians – still defecate in the open (Census of India, 2011). Large parts of the modern cities remain unconnected to the sewage system as they live in unauthorised or illegal areas or slums, where state services do not reach. Surveys of groundwater quality in many cities, therefore, reveal a large magnitude of water-borne pathogenic contamination – commonly referred to as bacteriological contamination – clear signs of groundwater contamination by sewage.

The following key steps could form the building blocks of an urban aquifer management programme in India:

1. Identifying status of existing groundwater resources in cities through participatory mechanisms, involving citizens, educational institutions and urban utilities;
2. Assessment of the groundwater resources through a participatory 'aquifer mapping' approach coupled with systematic studies by institutions with appropriate capacities to identify natural recharge areas, groundwater discharging zones and quantification of aquifer characteristics, namely transmissivities, storativities and groundwater quality;
3. Profiling stakeholders, including users, tanker operators, drilling agencies and developing mechanisms for registering water sources;
4. Ascertaining quantitative and quality-related groundwater security, including groundwater recharge, which is allied to the protection, conservation and upkeep of water bodies;
5. Hydrogeology must be considered during waste-disposal, sewage and sullage management and design of sewerage and sewage-treatment;
6. Developing a framework of regulatory norms around urban groundwater use and protection of urban aquifers by preserving natural recharge areas;
7. Understand changes in river flows and quality and the precise relationship between aquifers, aquifer systems and the river flowing through a town or city;
8. Finally, developing an institutional structure required for mapping the aquifers, and initiating groundwater management as an integral part of urban governance.

Currently, according to estimates of the Central Pollution Control Board, the country has installed capacity to treat roughly 30 per cent of the excreta it generates. Just two cities, Delhi and Mumbai, which generate around 17 per cent of the country's sewage, have nearly 40 per cent of the country's installed capacity. What is worse, some of these plants do not function because of high recurring costs – electricity and chemicals and others because they do not have the sewage to treat. In most cities, only a small (unestimated) proportion of sewage is transported for treatment. And if the treated sewage – transported in official drains – is allowed to be mixed with the untreated sewage – transported in unofficial and open drains – then the net result is pollution.

Decentralised wastewater management systems can overcome many of these problems by

- catering to the un-served areas and minimize the pressure of transporting to a single location.
- reducing the cost of treatment and O&M costs
- adopting site-specific treatment technologies based on the land use.
- minimising land requirement for treatment.

What is more, with basic level treatment of sewage, the water can be reutilised in industries and power plants. The water sludge after treatment can also be used as manure in agriculture; this measure may result in revenue generation to ULB. It is in the interest of the city to find ways to find buyers and users for its sewage. In this way it can work out the effluent profile of its treated effluent and segregate its waste to meet the needs of the end-user.

A rapidly emerging element of urban water, which requires much greater focus on recycling and reuse, is industrial water. Indian industry is currently excessively dependent on fresh water and tends to dump its untreated waste into our rivers and groundwater. Overall, the water footprint of Indian industry is too high, which is bringing industry into conflict with other parts of the economy and society. There is huge scope for reducing the industrial water footprint and this can be done through technologies and investments, which have a very short pay back period.

Coal-based thermal power plants need massive amounts of water, both for cooling and ash disposal. In case of coastal power plants, the water requirement is normally met from the sea, but for inland TPPs, water is a far more critical issue. Out of the 192,804 MW with environmental clearance, about 138,000 MW or 72% are inland. TERI has estimated that in 1999–2001 out of a total of about 83,000 million litres per day (MLD) of water discharged by all the industries in India, about 66,700 MLD (~80 per cent) is cooling water discharge from thermal power plants. CSE puts the figure closer to 90%. During the same period, it was estimated that for every MW of power produced, Indian thermal power plants consumed about 8 times more water than those in developed nations. This is mainly attributed to the once-through cooling system (open loop system). Cooling towers and ash handling are the major water consuming areas and account for about 70 per cent of the water use within the plant. Comprehensive water audits conducted by TERI at some of India's largest thermal power plants revealed immense scope of water savings in the cooling towers, and ash handling systems. Once-through systems are becoming uncommon in the world. However, in India, many plants still operate the once-through cooling system. A rough estimate suggests that by converting all the thermal power plants in India to closed-cycle cooling systems, about 65,000 MLD of fresh water can be saved.

The payback period for the proposed wastewater treatment and recycling system is less than 3 years. From a national perspective, where a large number of power plants other than NTPC still function on the once-through cooling system, there is considerable scope to improve water-use efficiency and conserve water resources

The first step in this direction will be to make comprehensive water audits a recurring feature of industrial activity so that we know what is being used by the industrial sector at present and so that changes can be monitored and the most cost-effective basket of water efficiency technologies and processes designed and implemented to reduce water demand and increase industrial value added per unit of water consumed. We must make it mandatory for companies to include every year in their annual report, details of their water footprint for the year. Simultaneously, we must develop benchmarks for specific water use in different industries and would ensure their application in the grant of clearances for industrial projects.

2.6 Transparency and Accessibility of Water Data

Keeping this imperative requirement for high quality data for scientific water management, our Committee would like to highlight serious gaps and inadequacies in the scope, coverage and quality of data currently used for assessing India's potential and utilisable water resources from different sources, their actual utilisation for, and impact on, various end uses:

- Collection of data is fragmented between different agencies. The agencies responsible for collection of the 'physical data' (to use precipitation and stream gauging as examples) are administered by differing Ministries, while the user data come under such diverse classifications as public health and sanitation, irrigation and urban planning. There is a consequential absence of a coherent and internally consistent conceptual framework and protocols for data collection and validation.
- The fact that 'water' is a 'State' subject leaves the Central Government agencies that are responsible for the national data with little choice but to rely on the State agencies for such data. Agencies of the Central Government – India Meteorological Department (IMD), Central Water Commission (CWC), (CGWB), Central Pollution Control Board (CPCB)—do collect a considerable amount of data, but most of the information at the regional and project levels is collected by the State agencies. As a result, much of the data are not readily accessible even within and between Government agencies concerned with water resources development, leave aside in the public domain.
- The Hydrology Project has expanded the physical infrastructure and equipped it with improved measuring and recording devices. The idea was to collate them into a national data network (called HIS) to facilitate easier access to users. But accomplishments have fallen far short of

expectations because of the reluctance of the States to send all the information they collect fully and promptly to the national data pool.

Data improvement is a national effort of the Central and the State government agencies that requires active involvement of specialised government agencies and scholars in universities, research institutions and non-governmental organisations in a way that fragmentation of focus and effort is minimized. This calls for a common agreed framework of concepts. The Central Government must take the lead in creating appropriate institutional arrangements to ensure independent and professional conduct of the surveys, providing financial and technical support to the States and ensuring that all agencies follow prescribed protocols and transmit the data to the central pool. For this purpose the MoWR, RD & GR must engage with knowledgeable and reputed experts on water related issues from relevant disciplines within and outside government to work out

- the strategy, modalities and funding for building a comprehensive, technical and scientific data base on potential and utilisable water from different sources;
- details of the scope, content. methodology and mechanisms of the surveys to assess performance and impact of programmes through sample surveys of users and specific projects; and
- the design of an integrated and digitised National Water Resources Information System

All of this must result in data becoming much more transparently accessible to common users in a user-friendly form.

This chapter provided a brief overview of the paradigm shift required in water management in India. In the next chapter, we assess how far CWC and CGWB would be able to put into effect this paradigm shift given their present structure and resources available to them.

Chapter Three

New Paradigm within the Old Structure?

In this chapter, we will examine the present structure and functions of the CWC and CGWB and assess how far it is possible for these institutions to deliver on the paradigm shift in water that this nation needs so urgently.

3.1 Present Structure and Functions of CWC

Central Water Commission (CWC) came into existence as "Central Waterways, Irrigation and Navigation Commission (CWINC)" vide Department of Labour Resolution No. DW 101(2) dated April 5, 1945. In the year 1951, it was renamed as "Central Water and Power Commission" (CW&PC) after its merger with the "Central Electricity Commission". Following the changes in the Ministry of Agriculture and Irrigation, in the year 1974, water wing of CW&PC was separated as "Central Water Commission", which continues till date. At present Central Water Commission functions as an "Attached Office" of the Ministry of Water Resources and is its main technical arm.

3.1.1 Functions of CWC

CWC in its annual report of 2013-14 has stated that the organisation is charged with the general responsibility of initiating, coordinating and furthering in consultation with the State Governments concerned, schemes for the control, conservation and utilization of water resources in the respective State for the purpose of flood management, irrigation, drinking water supply and water power generation. The Commission, if so required, can undertake the construction and execution of any such scheme.

In exercise of the above responsibilities, CWC considers following as its main functions (CWC Annual Report, 2013-14):

- Techno-economic appraisal of irrigation, flood control & multipurpose projects proposed by the State Governments;
- Collection, compilation, publication and analysis of the hydrological and hydro-meteorological data relating to major rivers in the country, consisting of rainfall, runoff, temperature, etc.;
- Collection, maintenance and publication of statistical data relating to water resources and its utilization including quality of water;
- Provide flood forecasting services to all major flood prone inter-state river basins of India through a network of flood forecasting stations;
- Monitoring of selected major and medium irrigation projects, to ensure the achievement of physical and financial targets. Monitoring of projects under Accelerated Irrigation Benefit Program (AIBP), and Command Area Development (CAD) program has also been included in its field of activities;
- Advise the Government of India and the concerned State Governments on the basin-wise development of water resources;
- Carry out necessary surveys and investigations as and when required, to prepare designs and schemes for the development of river valleys in respect of power generation, irrigation by gravity flow or lift, flood management and erosion control, anti-water logging measures, drainage and drinking water supply;
- Providing Design Consultancy including Hydrological Studies in respect of Water Resources Projects, when so requested, by the state governments concerned/project authorities.
- Carry out construction work of any river valley development scheme on behalf of the Government of India or State Government concerned;
- Advise and assist, when so required, the State Governments (Commissions, Corporations or Boards that are set up) in the investigation, surveys and preparation of river valley and power development schemes for particular areas and regions;

- Advise the Government of India in respect of Water Resources Development, regarding rights and disputes between different States which affect any scheme for the conservation and utilization and any matter that may be referred to the Commission in connection with river valley development;
- Imparting training to in-service engineers from Central and State Organizations in various aspects of water resource development;
- Initiating studies on socio-agro-economic and ecological aspects of irrigation projects for the sustained development of irrigation;
- Conduct and coordinate research on the various aspects of river valley development schemes such as flood management, irrigation, navigation, water power development, etc., and the connected structural and design features;
- Promote modern data collection techniques such as remote sensing technology for water resources development, flood forecasting and development of related computer software;
- Conduct studies on dam safety aspects for the existing dams and standardize related instrumentation for dam safety measures;
- Carry out morphological studies to assess river behaviour, bank erosion/coastal erosion problems and advise the Central and State Governments on all such matters;
- Promote and create mass awareness regarding the progress and achievements made by the country in the water resources development, use and conservation.

3.1.2 Organisational Structure of CWC

CWC is primarily manned by the Central Water Engineering Services (CWES) cadre, the only organised service of the Ministry of Water Resources. CWC is headed by a Chairman, with the status of Ex-Officio Secretary to the Government of India. The work of the Commission is divided among 3 wings namely, Designs and Research Wing (D&R), Water Planning and Projects Wing (WP&P) and River Management Wing (RM). Allied functions are grouped under respective wings and each wing is placed under the charge of a full-time Member with the status of Ex Officio Additional Secretary to the Government of India. Each wing comprising of a number of Organizations is responsible for the disposal of tasks and duties falling within the scope of functions assigned to it. In the discharge of these responsibilities, officers of the rank of Chief Engineer, Director/Superintending Engineer, Deputy Director/Executive Engineer, Assistant Director/Assistant Executive Engineer and other Engineering and Non-Engineering officers and supporting staff working in various regional and headquarter organizations, assist the Members. There is a separate Human Resources Management Unit headed by a Chief Engineer, to deal with Human Resources Management/Development, Financial Management, Training and Administrative matters of the CWC.

National Water Academy (NWA) located at Pune is responsible for training of Central and State in-service engineers and functions directly under the guidance of Chairman.

Chairman: Head of the Organization – Responsible for overseeing the various activities related to overall planning and development of surface water resources of the country and management of the Commission as a whole.

Member (Water Planning & Projects): Responsible for overall planning and development of river basins, national perspective plan for water resources development in accordance with the National Water Policy, techno-economic appraisal of Water Resources Projects and assistance to the States in the formulation and implementation of projects, monitoring of selected projects for identification of bottlenecks to achieve the targeted benefits, preparation of project reports for seeking international assistance, environmental aspects, issues related to construction machinery of projects, application of remote sensing technologies in water resources, etc.

Member (Designs & Research): Responsible for providing guidance and support in planning, feasibility studies, standardization and designs of river valley projects in the country, safety aspects of major and medium dams, hydrological studies for the projects, coordination of research activities, etc.

Member (River Management): Responsible for providing technical guidance in matters relating to river morphology, flood management, techno-economic evaluation of flood management schemes, collection of hydrological and hydro-meteorological data, formulation of flood forecast on all major flood prone rivers and inflow forecasts for selected important reservoirs, investigation of irrigation / hydro-electric / multipurpose projects, monitoring of major and medium projects with regard to Command Area Development, etc.

3.1.3 Headquarters

There are eighteen organizations, each headed by a Chief Engineer at CWC headquarters, New Delhi. Out of which, nine organizations are under WP&P wing, six organizations are under D&R wing and two organizations are under RM wing. In addition, Human Resources Management (HRM) Unit headed by Chief Engineer (HRM) is also located at headquarters. The details of the organizations are given in the organogram.

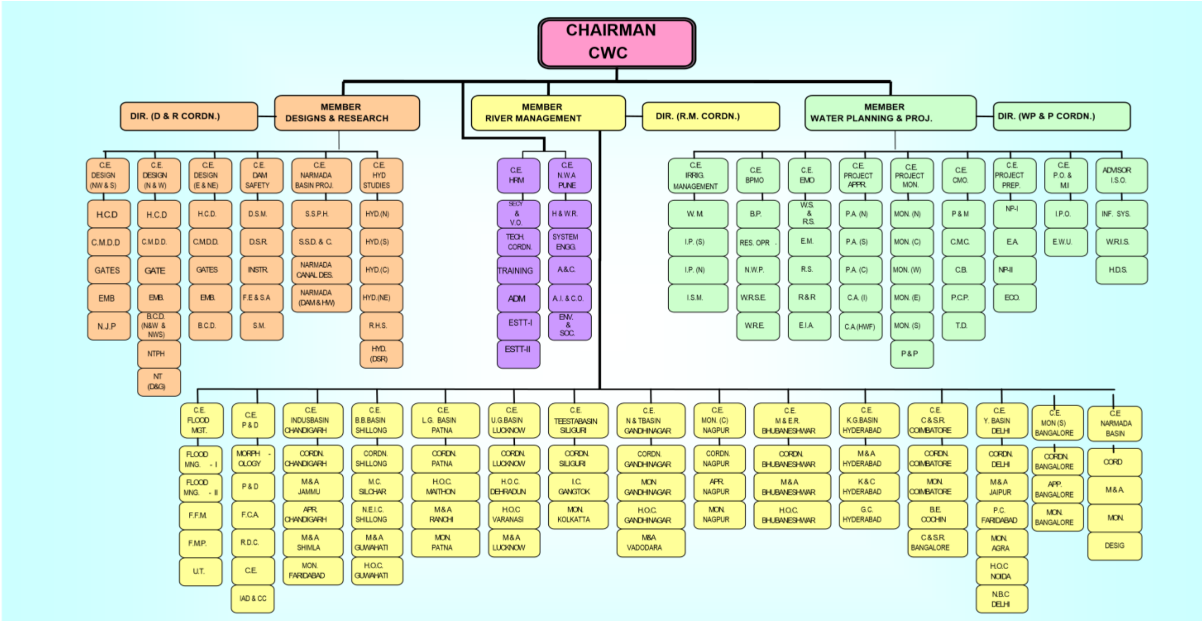


Figure 3.1

3.1.4 Regional Offices

In order to achieve better results in the Water Resources Sector and have better coordination with the State Government departments, CWC has established regional offices in the major river basins. It has 13 regional offices, each headed by a Chief Engineer. The offices are located at Bangalore, Bhopal, Bhubaneswar, Chandigarh, Coimbatore, Delhi, Gandhi Nagar, Hyderabad, Lucknow, Nagpur, Patna, Shillong, and Siliguri.

3.2 Inadequacy of Human Resources in CWC

An understanding of various hydrological processes (Figure 3.1) through the water cycle brings out their interlinkages and bearing on both terrestrial and aquatic ecosystems as well as on humans and their diverse interests.

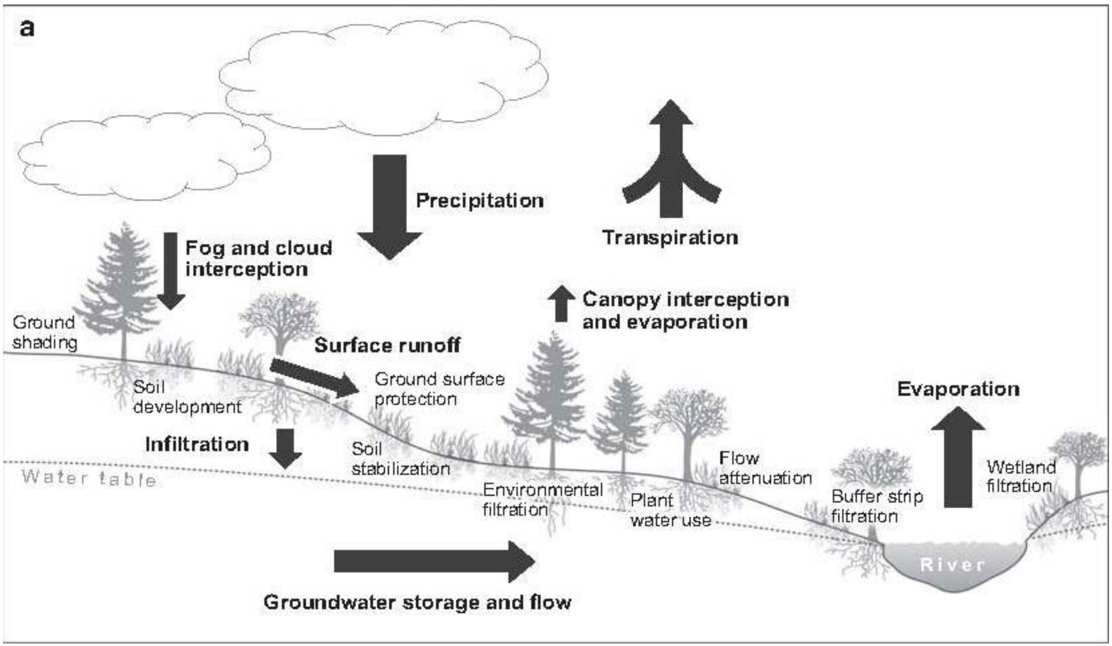


Figure 3.2

All global assessments of the water cycle (see Figure 3.2) show that far more amounts of water are stored (stocks) in soil, atmosphere and wetlands than in the rivers. Even in terms of flows (fluxes) water moving annually through lakes, wetlands and atmosphere is only next to that flowing in the rivers.

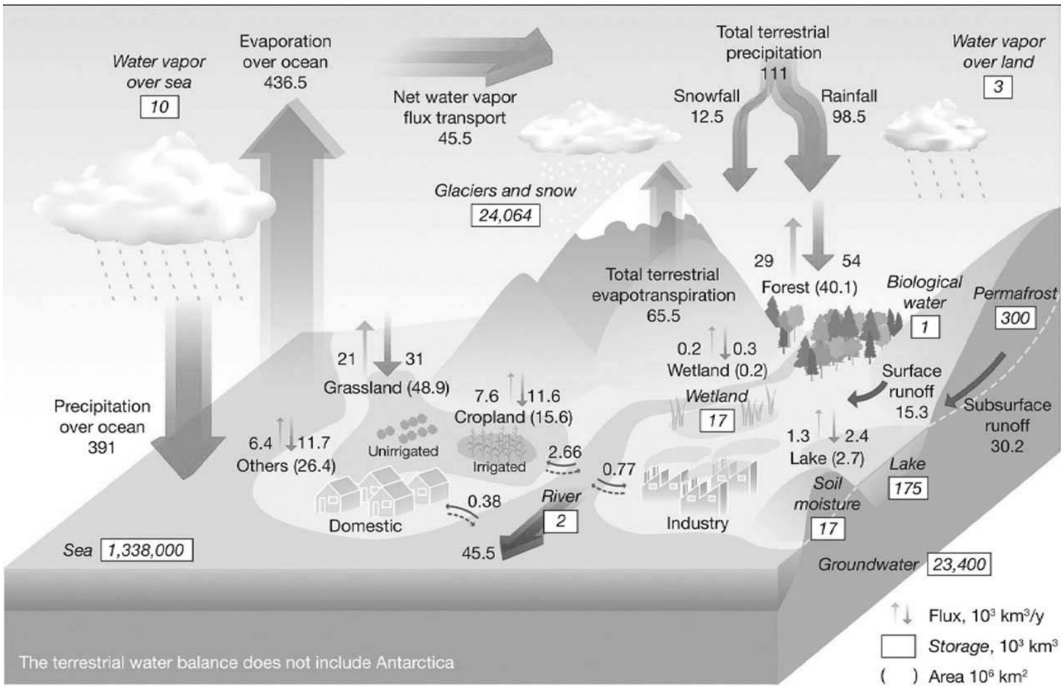


Figure 3.3

It is globally agreed that the total amount of water on the Earth has not changed over centuries and is unlikely to change. Yet, we know that lakes are drying out, rivers have ceased to flow and groundwater levels have declined. Where has all the water gone? Water has not disappeared; it has just changed form and location. Recent data show a change in the location and intensity of precipitation coupled with an increase in evapotranspiration – that also fuels climate change.

Management of water resources, therefore, requires an integrated approach that accounts together all water moving through the soil (soil water), lithosphere (groundwater), atmosphere (Evaporation), biota (ET) and human-made systems, and integrates the requirements of all stakeholders including humans, by considering both direct and indirect benefits. Such an integrated approach ensures that, for example, urban water bodies are valued for their microclimate regulatory function as much as the water used for cooling in residential areas, and the water flowing down the rivers to the sea is valued also for its influence on the water cycle (monsoon regulation by coastal salinity changes).

Rivers constitute the most important part of the hydrological cycle, and an indispensable link between the land and the oceans. However, rivers should not be judged by the amounts of water flowing through their channels that could be stored or diverted for human uses. The innumerable benefits generated by the water flowing on its way to the oceans, and also moving below ground, must also be considered before any upstream intervention.

The water moving belowground and stored above the hard substrata is also not for human exploitation alone as it supports biodiversity and sustains base flow in the streams. In general, infiltration through the ground helps improve the water quality – requiring no further treatment.

During the past few decades, researches at the interface of two or more water related disciplines have given birth to new disciplines such as eco-hydrology, hydro-sociology, hydro-politics, and hydro-informatics. At the same time, the hydrological science has evolved into an interdisciplinary domain heavily dependent upon wide range of natural and social sciences including ecology, environmental science, geomorphology, sociology, economics, politics, law, etc. and utilises a variety of tools and techniques for data collection and analysis.

The above stated perspective implies that a major change is required in the management and governance of the water resources in the country. It requires an integrated holistic multidisciplinary approach. In this context, a major change is needed in the institutional architecture as the sectoral interests of CWC and CGWB cannot meet the required goals. At the same time, water management can no longer be vested in a single institution or any one group of professionals because of the necessity for simultaneous multidisciplinary consideration of other related sectors and issues that lie in the domain on various natural and social sciences.

In effect, the CWC's sphere of responsibilities and activities is restricted to surface water resources in the rivers alone. The 'schemes for the control, conservation and utilization of water resources' are planned and implemented on the rivers only and in total disregard of other components of water resources in the hydrological cycle, and especially the groundwater, as well as the impacts of these schemes on the water budget of downstream areas.

In our analysis, the river water quality monitoring function overlaps and to some extent duplicates the work of the CPCB. The hydro-meteorological data collection overlaps with the function of IMD. Hydrological studies lie within the mandate of the NIH, Roorkee. As far as Environmental and Socio-economic Issues are concerned, currently there exists no expertise in the area within the CWC. Similarly, efficient irrigation management and water utilisation is an area where CWC lacks expertise.

The CWC is also expected to conduct studies on river morphology and socio-agro-economic and ecological aspects of irrigation projects. Another important function of CWC is to "impart training to in-service engineers from Central and State Organizations in various aspects of water resource development". The present expertise within the CWC is inadequate for these purposes.

Current functions of the CWC address only a fraction of issues of water management as several major components of the hydrological cycle and hydrological processes remain untouched. More importantly, the ecological and social impacts of engineering interventions as well as those on the hydrological cycle and water quality are not addressed. The CWC focuses entirely upon the supply side provision of water resources and even in this area, ensuring last mile connectivity (taking water to the end user) lies outside their domain. The new responsibility of the MoWRRD&GR for river rejuvenation and an integrated river basin level approach to water resource management also brings into focus lack of essential capacities within the CWC. Further, there is a clear absence of integrated functioning of the CWC with the CGWB to address issues of surface and groundwater interaction and their conjunctive use.

In keeping with the current focus of the CWC on 'development' of water resources for supply-side management alone which involves storage and diversion of river flows, the CWC is staffed exclusively with engineers drawn from the Central Water Engineering Group 'A' Service, and lacks almost totally a capacity in any other discipline that interfaces with water resource management.

3.3 CWC: Capacity Building

Currently, the CWC's function is restricted to "to impart training to in-service engineers" exclusively through the National Water Academy at Pune. The NWA is headed by a Chief Engineer who reports directly to the Chairman, CWC.

The objectives of the NWA are to train the in-service engineers from Central and State Organizations on various aspects of Water Resources Planning, Development & Management. It also strives "to develop institutional capability at the national level for imparting training in new emerging technologies in water resources sectors on continued basis". The training programmes of the NWA are targeted at CWES Officers, State Governments, and foreign nationals. Since 2010, the training programmes have been extended to various other Stakeholders (including PSUs, School Teachers, Media Personnel's, NGO, Panchayati Raj Institutions).

The training programmes cover many Technical Areas namely, Designs, Project Planning, Hydrological Sciences, Irrigation Management & Agriculture Hydropower Engineering, Information Technology, Water Supply, Sanitation & Waste Water Treatment, River Management and Basin Planning, and Non-Technical Areas such as Environmental Science, Social Science, Economic aspects, Management Development, Policy and Legal Issues related to Water. However, a perusal of the information provided by the NWA in response to our queries shows that the training programmes emphasise only technical and management development aspects.

The most important of all training programmes is the 26-week Induction Training Programme for newly recruited officers. An examination of the programme shows that Environmental, Economic and Social Aspects were allocated a mere 2% time. Even the technical topics are not covered satisfactorily and there seems to be no motivation to include recent advances in the areas. The time allotted to the different topics covered under the module on River Management is grossly inadequate. What is actually covered and how cannot be evaluated because the details of the lecture topics and field visits were not provided by the NWA.

Table 3.1 Structure and content of the Induction Training Programme

	Module Details and Duration	
A	**Module on Human Resources and Management**	
	• Orientation to perspectives in Water Resources Sector	1.0 Week
	• Office Administration and Procedures	1.0 Week
	• Financial Accounting in Government Sector	0.5 Weeks
	• Works Management	1.0 Week
	• Computer Application	1.0 Week
	• Management Development Program	1.5 Week
B	**Basic Sciences**	1.0 Week
C	**Module on River Management**	
	• Hydrometry including Water Quality	1 Week
	• Techniques of Hydrological Data Processing and Validation using soft tool	1 Week
	• Reservoir Operation and River Morphological Survey and Coastal Erosion	0.5 Week
	• Flood Forecasting & Flood Management	1.5 Week
	• Preparation of DPR, Project Investigation & Planning	1.0 Week
	• Modelling Tools for Water Resources Projects	1.0 Week
D	**Module on Water Planning and Projects**	
	• Irrigation Management	1.5 Week
	• Water Resources Planning and Project Monitoring	1.5 Week
	• Environmental, Economic and Social Aspects of Water Resources Projects	0.5 Week
	• Construction and Contract	0.5 Week

	Management	
	• Application of Remote Sensing and Geographical Information System in Water Resources Projects	1.5 Week
E	**Module on Design and Research**	
	• Hydrology and related software application	1 Week
	• Analysis and Design of Gravity Dams	1.5 Week
	• Analysis and Design of Embankment Dams	1 Week
	• Hydel Civil Designs	1 Week
	• Design of Weirs, Barrages & canals	1 Week
	• Design of Hydro-mechanical Equipment Gates	1 Week
	• Dam Safety and Instrumentation	1 Week
Total: 26 Weeks		

Among other programmes are a one-week management development programme for non-technical officials of CWC/MoWR, a 3-week Orientation /Induction Program for newly promoted Officers of CWC, a 2-week Orientation program for newly recruited Junior Engineers of CWC, and a range of short-term training programmes.

The topics covered by these programmes, and demand-driven trainings organised for state governments and various organisations (e.g. WAPCOS and HPPCL) cover only technical/engineering aspects.

The current expertise of the nine officers of NWA is as follows:

Table 3.2: Current Expertise of Officers of NWA

Sr No.	Designation	Broad Expert Areas
1	Chief Engineer & Head	Water Resources Management, Project Planning, Water Quality Management, Policy Issues etc.
2	Director – 1	Hydrology & Irrigation, River Management, Designs etc.
3	Director – 2	Designs, Legal Issues, Financial Management etc.
4.	Director – 3	Water Resources Management, Environmental Management, Investigations & DPR etc.
5.	Director -4	Basin Planning, Hydrological Modelling, Hydro-informaticsetc.
6.	Director -5	Information Technology, Construction Equipment Planning and Application of RS & GIS in Water Resources Sector etc.
7.	Deputy Director -1	Hydro-meteorological Observations; Contract Management, Procurements etc.
8.	Deputy Director -2	Hydropower, Flood Management, River linking etc.
9.	Deputy Director - 3	Information Technology, Design of Hydropower Structures, Software Development etc.

In response to a query from the Committee about the faculty involved in training, the NWA communicated that:

" NWA usually avoids calling faculty from the academic institutions since the training programs conducted by NWA are for in-service engineers, the programs conducted by the academy gives more emphasis on sharing the experience and skill development. Thus, the guest faculty invited from the various organizations is practicing engineer's professionals with vast field experience and expertiseon the subjects.The major chunk of the guest faculty in the NWA programs are from the CWC-HQ / Field Offices having vast practical and field experience; Officers fromthe State Govt organizations; Central organizations and other Organisations of Ministries."

The officers at the NWA are said to have developed expertise in several areas other than their own, and these faculty members cover also the six non-technical areas. Except for Management Development under the 'Human Resources and Management' module, the remaining 5 non-technical topics receive a miniscule attention even in the ITP despite a claim for a very comprehensive coverage.

3.3.1 The Missing Elements

The current training programmes of the NWA do not address the water resources and their management in a holistic or integrated manner and cater simply to the engineering side of water resource projects. The large number of current issues of ecological, environmental, social, economic and management concern remain unattended.

The lecture notes on Environmental Flows available on the NWA website reflect the personal views of the concerned faculty and do not present a correct, scientifically appropriate, comprehensive and up-to-date analysis of the subject, and do not reflect even the current policy of the Government.

Confining the faculty to people from within various directorates of the CWC absolutely defeats the purpose of training as the closed loop approach keeps the same old knowledge in re-circulation again and again. Young and middle level engineers are caught in their own web and cannot see anything beyond the narrow techno-centric and bureaucratic view of water resources. They are grossly deprived of the freshness of new ideas and approaches as well as the rapidly changing scope of water science. It is necessary that the young engineers be exposed to an integrated, interdisciplinary approach that transcends beyond the limited domains of hydrology and hydrogeology into the domains of biology, ecology, environment, terrestrial, aquatic and groundwater ecosystems, water quality, human health, geomorphology, social sciences, ecological economics and also the climate change.

Since 2014, the Ministry of Water Resources is entrusted with the additional task of River Development and Ganga Rejuvenation. The overall mission of the Ministry is to manage sustainably India's surface and ground water resources in an integrated manner to ensure human well being with equity along with protection of the ecological integrity of nation's rivers, lakes, wetlands and aquifers as well as coastal systems. The Ministry has recognised that "water resource planning, management and utilization including budgeting, have to be done in an integrated manner, by taking major river basin as a hydraulic unit and its tributaries as sub-basins, and that aquifers are integral elements of any river basin".

Surface and groundwater should be treated together to emphasise upon the linkages in the water cycle, and the amount of water in the soil, biota and air and its role in nature. We should not forget that "*All three phases of water play a fundamental role in the organization of the thermodynamic equilibrium, and hence of the climate dynamics of the planet*" (Lall 2014). In order to achieve the goal of using an integrated approach to water resources management (considering aquifers as 'integral' part of river basin) at a river basin scale (as the hydrological unit) for water and food security as well as for rejuvenating rivers, the training of water resource managers requires a total overhaul and a fresh comprehensive multidisciplinary dynamic curriculum and equally competent faculty drawn from several disciplines and institutions working with water related issues.

India, like most other countries, has the challenge of meeting multiple and conflicting demands on water to meet the ever-growing needs of food, water and energy for humans while protecting ecosystem integrity and biodiversity in the face of already happening climate change. The challenge can be met only by understanding the dynamic nature of the hydrological systems and their interactions with the social systems. Hydrological science cannot be separated from management (Nalbantis et al. 2011). Hydrology (water science) is no more confined to civil engineering for managing water supplies; it has rapidly emerged into a complex interdisciplinary science connecting with geosciences, environmental sciences and socio-economic sciences. However, "*Hydrology education in India is currently limited, in most part, to the* *traditional civil engineering branch. A typical undergraduate programme in civil engineering consists of one, or, at most, two courses (out of the nearly 40, that a student has to take) related to hydrology"* (Majumdar 2015).

The NWA must therefore be developed into an autonomous body with freedom to invite high quality trainers both from within the country and abroad. It is absolutely necessary that the young engineers are trained adequately and prepared to take up the challenges – current and future - of assessing, conserving and managing the country's water resources and at the same time protect and rejuvenate the rivers and associated aquatic ecosystems for their multiple environmental services. The NWA needs to develop a suitable programme with appropriate course structure that takes care of multidisciplinary nature of water resources management. The NWA needs to collaborate with the RGI to ensure that the SW-GW interactions are properly taken into consideration at all levels of capacity building.

It is not enough to train water professionals (engineers) within the CWC and in the States. Water resource management has to be a participatory process with all stakeholders (including NGOs) and local communities (particularly farmers at the Panchayat level) who should be made aware of the water resource issues and who need capacity building for management of the limited water resources (e.g., participatory irrigation management, appropriate crop selection, micro-irrigation, conjunctive use, wastewater reuse/recycling, etc.). The present training activities of the NWA in this respect are practically negligible.

3.3.2 Specific Suggestions

The graduates entering the CWES need not only an extensive training in the latest concepts, approaches, methods and techniques in hydrological sciences but also in other related disciplines in order to be able to contribute to the goals of water resources management. Keeping the newly recruited staff away from the academic world of other water related disciplines is particularly detrimental to the future of India's water resources.

As the science and management of water resources become increasingly complex and multidisciplinary, India's water resource managers at the middle and senior level need to be exposed to the breadth and depth of the latest developments, approaches, methods, tools and techniques in hydrological and related ecological and social sciences. At the same time, the fundamental base for hydrologic sciences needs to be refined and strengthened along with the development of its interdisciplinary character and especially the interface with the socio-economic sciences. This task can be performed only by institutions like the NIH and the traditional departments in the universities and IITs.

Recent developments have to be communicated to all levels of governance and management as well as to the local communities whose participation in the water management is critical in view of the strong two-way interaction between hydrological systems and the society. In order to reach out to the large number of water professionals, water managers, stakeholders from other disciplines and local user communities across the country, we may require additional institutions at national and/or state level – may be a network of Regional Centres - and adopt latest information technologies (such as developing web-based e-training programmes).A massive programme to revamp and expand the requirements of capacity building and knowledge transfer to the level of local communities (farmers and civil society) makes it imperative to involve various universities, institutions and NGOs as partners.

It is necessary that the training /capacity building programmes of the CWC and CGWB develop close linkages and the issues related to surface and groundwater availability and utilisation are discussed together on a sub-basin scale and wastewater is considered as a resource. The human and non-human needs of water should be considered in an integrated manner.

The current training programmes of the CWC and CGWB and the courses they offer need to be revised to emphasise multidisciplinary character of integrated management of water resources, and accordingly, the capabilities and capacities of the Institutions need to be upgraded and strengthened.

There is no doubt about the need for raising the strength of the faculty and bringing in new disciplines (as proposed by the NWA). However, this should be done after formulating the training programmes and re-structuring the courses. Whereas the engineering and technical expertise is abundantly available within the CWC, there is an urgent necessity to provide representation on the faculty to several major disciplines such as hydrology, aquatic ecology, river ecology/restoration, ecological economics. agronomy, social sciences, soil science, and climate change.

It is of crucial importance that the young and old officers of the CWC (as also the CGWB) are not insulated from the influence of other disciplines. The NWA must develop partnerships and collaborations with a large diversity of institutions, universities, established NGOs, and involve them actively in the training programmes at all levels. These institutions and NGOs will be particularly helpful in the capacity building and awareness programmes at the community level

It would be useful to consider the possibility of the NWA being upgraded and developed into an autonomous institution charged with research, education and training in the interdisciplinary area of water resources management – covering both surface and groundwater resources. This will require a much larger strength of faculty drawn from different disciplines of hydrological, social-economic and environmental sciences. The autonomous 'Academy' will have greater freedom to employ and invite faculty in a wide range of fields, organise discussions on technical and policy matters, and contribute effectively to the goals of the Ministry without getting bogged down with technical issues alone.

3.4 Present Structure and Functions of CGWB

The legacy of exploring and developing groundwater resources lies with the CGWB, since the 1950s, when the early development of groundwater resources was being planned as part of the pursuit of food security under the green revolution. While it was part of the larger agriculture division then, it carried the legacy further even when it became independent of its earlier function and became part of the 'water resources' ministry. Established in 1971, the CGWB grew out of a small organization with a narrow, specific purpose, viz., drill exploration wells to assess groundwater resources and then provide guidance / advice on where and how to harness the resource through drilling. Progressively, CGWB took on the function of monitoring the resource and it was only in the latter part of the 1980s that groundwater assessment began to take shape in CGWB's thinking as the realization of an apex national groundwater organization began to sink in. Today, Central Ground Water Board (CGWB) is the apex national organisation that deals with groundwater resources in India. CGWB is the arm of the Ministry of Water Resources that deals with groundwater resources in India, Central Water Commission (CWC) being the organization that is vested with the responsibility of dealing with surface water resources.

CGWB essentially deals with surveys, assessment and monitoring of groundwater to estimate (and in a limited way predict) the status of groundwater resource at the national scale. It does so with support from various state entities and brings out periodic assessments on the state of groundwater resources in all the blocks in India, except those across the steeper slopes of the Himalayan region. Given its genesis, it also has a strong portfolio in drilling and drilling technology for groundwater; it essentially drills exploratory wells with the purpose of providing insights to future groundwater resource development in a region. Through its training centre, established in Raipur in 1997, it runs training programmes, essentially for its own officers and for different line departments and for the States, but more recently for others including corporates and civil society. Apart from these, it has been called upon to discuss and interface with various other departments from across ministries such as MoRD, MoUD, MoDWS, MoEF, MoMines etc., from time to time. CGWB is also engaged in answering 'parliamentary questions' that are raised about issues pertaining to the depletion and contamination of groundwater resources in different parts of India. CGWB responds to such queries based on the data-on-hand while sometimes customizing studies and investigations to answer them.

CGWB is headed by its Chairperson, who reports to a Joint Secretary (Groundwater) at Ministry of Water Resources. CGWB operates through the following 4 wings, each headed by a Member:

1. Exploratory Drilling & Material Management: This wing of CGWB is responsible for the drilling and construction of exploratory and other type of boreholes required for ground water exploration including monitoring of stores, consumption and inventory for efficient and economic machine utilization, purchase action in respect of drilling equipment, vehicles, instruments and other associated aspects.
2. Sustainable Management & Liaison: The SAM wing, as it is often referred to, looks after sustainable management of ground water related policies, issues etc., augmentation of ground water resources including artificial recharge and monitoring of artificial recharge studies, urban ground water management, storage and retrieval of groundwater and related attributes.
3. Survey, Assessment & Monitoring: This wing is vested with the responsibilities for undertaking ground water management studies, work related to monitoring of ground water regime and development, conjunctive use of surface and ground water; aquifer mapping and assessment of aquifer characteristics based on exploration and surveys, hydrochemical analyses and studies, pollution studies, short term water supply investigations, drought management, data collection, special studies, preparation of various hydrogeological

maps, atlases, master plans, state reports, district reports and specific reporting as may be required from time to time.

4. Training and Technology Transfer: This wing is vested with the responsibility of imparting training at different levels to entrepreneurs, professionals and administrators concerned with ground water development and management. The wing is also responsible for formulation of overall training policy, assessment of training needs, conceptualization of the training modules and the programme implementation strategy for the organization.

'Members', each of whom heads the above wings, also constitute the Central Ground Water Authority (CGWA). The CGWA, in some ways, is an extension arm of CGWB, dealing with various portfolios such as the periodic assessments, training and procurement as specified through the 'wings' mentioned above. CGWA also gives permits and licenses to industry / corporate houses (non-farm sector), particularly in notified zones that are based on the periodic groundwater assessments by the CGWB. The administrative & financial matters of the Board are being dealt with by the Director (Administration) and Finance & Accounts Officer (FAO) respectively.

Central Ground Water Board has about 500 Scientists, 200 Engineers and about 3500 technical & administrative/ministerial supporting staff. CGWB has a fleet of 88 drilling rigs (34 Direct Rotary, 41 Down the Hole and 13 Percussion Combination types) for taking up drilling operations. Headquartered in the NCR (Delhi-Faridabad), CGWB operates through 18 regional offices, 17 divisional offices and 11 state unit offices as part of its own hierarchical structure. The regional offices (or directorates, as they are sometimes referred to) exercise overall administrative control on the divisional and state unit offices. The regional directorates are headed by a Regional Director and are important nodal elements in the structure because these directorates interface with CGWB's own state offices – established in those states with large geographical areas – as well as State

Departments dealing with groundwater – ranging from agencies in some states to departments to smaller groundwater cells housed in other ministries or departments of that State. The divisional offices, headed by an Executive Engineer, deal mainly with the exploratory drilling component undertaken by CGWB and work closely with the state-units on one side and the regional offices on the other. Moreover, it is also unclear how the CGWB interfaces with the CWC. For all practical purposes, they may be considered as two, almost independent arms of the Ministry with very little co-ordination, discussion and collaboration, working within the silos of groundwater and surface water respectively.

CGWB's relationship with the states includes the periodic assessment of groundwater resources that is undertaken through a collaborative effort between the regional directorates of CGWB and the respective states falling under a particular regional directorate. Hence, the quality and level of interface with States is crucial in the performance of CGWB's regional directorates. In some States, CGWB is compelled to play the dual role of a State agency and its designated role as the central agency dealing with groundwater because such states have no dedicated groundwater agency or have cells or departments that are either weak in human resources and/or in capacities to deal and engage with groundwater issues.

The relationship between CGWB and states is not as simple as may be implied by the structure summarized in the foregoing paragraph. It is complicated, to say the least, and the quality of the relationship varies depending upon many factors. As a matter of fact, improving the relationship between the State and the CGWB is crucial in improving the performance and status of the CGWB. *Hence it is imperative to establish a groundwater department in every state. Such a department or agency or division should have a team of trained hydrogeologists that work on the development and management of groundwater resources through an aquifer-based approach.*

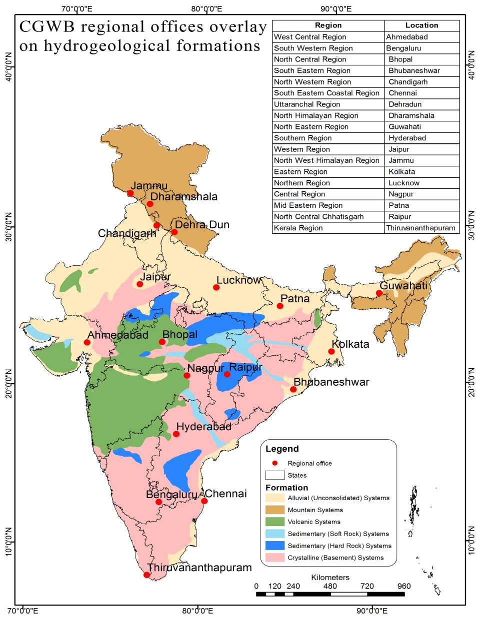
While this report is largely restricted to the structure of CGWB, the structure and functions of a reformed CGWB will also be influenced by its partnership with the CWS on one hand and how the states are structured when dealing with groundwater resources under their geographical jurisdictions, on the other. Currently, states are left to their own will to decide whether or not they need a groundwater department and to design the structure of the department or agency dealing with groundwater. Except for two states – Maharashtra and Andhra Pradesh – most other states have small groundwater departments that are either understaffed or are small, almost insignificant entities housed in a larger department or ministry. Some of these departments and divisions have already imploded beyond a point of redemption. In states like Karnataka, an otherwise progressive state, the groundwater department is part of the larger ministry of geology and mines, while Jharkhand has a department that is currently housing only engineers from the State Irrigation Division. Assam, on the other hand, does not even have a cell that is named as a groundwater cell. Hence, a common 'state-structure', with some degree of autonomy to work on issues that deal with groundwater, will enable CGWB regional offices to interface more efficiently with the States. Getting all the States to provide for a groundwater department will enable a better interface with CGWB at the river basin scale.

Given the current focus on river basins as the fundamental units for strategic planning and management of water resources, it may seem a straightforward move to relocate CGWB's regional offices to match with major river basins. Before doing so, however, it is important to study the current location of the CGWB regional offices and examine their locations with regard to two basic parameters. Firstly, it is important to understand how the offices are located with reference to the broad hydrogeological settings that determine the geometry and characteristics of aquifer systems in each of these settings. And secondly, whether the current location of the regional offices map onto some crude typology of the main river basins identified and recognized by MoWR.

We have attempted to analyse the current location of CGWB's Regional Offices, based on the above two criteria and present a short synopsis (Table 3.3) below. This analysis is based on the typology of aquifers (represented here through a broad classification of hydrogeological settings). We have attempted to locate the regional offices within 6 broad categories – *Himalayan setting, unconsolidated alluvial deposits, sedimentary (soft) formations, sedimentary (hard) formations, volcanic province, crystalline formations.* At the same time, CGWB, in its Aquifer Atlas of India has developed a classification based on *principal and major aquifer systems.* The atlas may also be used for further sub-classification and refinement of such an overlay. However, even at a broad-based level, based on the 6 broad categories, it is obvious that the decision regarding regional offices was developed with a clear vision of addressing multiple hydrogeological settings. On similar lines, one may also consider the location of the regional offices with respect to major river basins of India, and explore how the regional offices of CGWB as currently located within the thirteen main river basins / clusters of river basins provided by CWC on its website. These river basins / clusters of river basins are:

i. Indus
ii. Ganga
iii. Chambal-Yamuna
iv. Brahmaputra
v. Luni
vi. Mahanadi
vii. Narmada
viii. Tapi
ix. Godavari
x. Krishna
xi. Cauvery
xii. East-coastal rivers
xiii. West-coastal rivers

Table 3.3: **CGWB's regional offices – with respect to (a) broad typology of hydrogeological settings and (b) major river basins**



Most of CGWB's current regional directorate offices are located in cities that occupy strategic locations with regard to the broad hydrogeological settings of India, For instance, Jammu, Dharamshala, Chandigarh, Dehra Dun and Guwahati straddle the boundaries between Himalayan systems and the alluvial sediments of the Indo-Gangetic plains. Similarly, its offices at Jaipur, Ahmedabad, Bhopal, Nagpur, Raipur, Hyderabad and Bhubaneshwar are located in close proximity to at least two or more hydrogeological settings. Lucknow (alluvial), Bengaluru, Chennai and Thiruvananthapuram (crystalline) are located within somewhat similar geological environments.

Regional office	**River basin**
Ahmedabad	Sabarmati
Bengaluru	Boundary of Cauvery Basin and East Flowing Rivers between Pennar and Cauvery Basins
Bhopal	Close to Boundary of Ganga and Narmada Basins
Bhubaneshwar	Mahanadi Basin but also close to boundary with Brahmani – Baitarni Basin
Chandigarh	Indus Basin and close to boundaries with Ganga Basin and Inland Basins of Rajasthan
Chennai	East Flowing Rivers between Pennar and Cauvery Basins
Dehradun	Ganga Basin
Dharamshala	Indus Basin
Guwahati	Brahmaputra Basin but in close proximity to Barak and other Minor Basins
Hyderabad	Krishna Basin and in close proximity with its boundary with Godavari Basin
Jaipur	Ganga Basin
Jammu	Indus Basin
Kolkata	Ganga Basin
Lucknow	Ganga Basin
Nagpur	Godavari Basin
Patna	Ganga Basin
Raipur	Mahanadi Basin
Thiruvananthapuram	West flowing rivers of Kerala but in some proximity to East flowing rivers of TN

3.5 Inadequacy of Human Resources in CGWB

The CGWB's country-wide presence with Regional / Unit / Divisional offices in all States of the country forms the largest pool of groundwater professionals within a single institution in India and arguably anywhere in the world. This pool is supposed to form a multi-disciplinary work force with core competence in dealing with groundwater related issues. Availability of exhaustive data related to ground water, generated through decades of field studies, is a clear strength that the organisation has developed over the years. In addition, CGWB has a fleet of machinery and equipment in addition to a dedicated groundwater Training & Research Institute in Raipur.

The major concern, going forward, especially in terms of the reforms and restructuring suggested in the report, is that of decentralised human resources being limited by the increasing number of tasks that the organisation is likely to be tasked with. The other concern is the inability of CGWB to attract talented youngsters due to lack of career prospects comparable with other similar organizations. Moreover, the lack of institutional coordination among the Central and State level organisations is limiting the scope of work on groundwater. Current training and exposure in cutting edge technologies and the restriction imposed by deployment of outdated equipment in the field / laboratories are further stifling the potential of CGWB. However, the most major concern is the inadequacy within the organisation for hand holding with stakeholders in implementing the concept of aquifer-based participatory groundwater management. This is further limited by the allocation of the scientific workforce for non-scientific activities.

The benchmarking of CGWB by the World Bank has emphasised the transition of CGWB from a monitoring and resource-development organization to a monitoring and applied-research organization. Having said that, the benchmarking also stresses that applied research be done using a multi-disciplinary approach. For doing this, greater authority and responsibility for operation needs to be devolved at headquarters and Regional Offices. More than anything else, the CGWB is severely understaffed! Given the potentially expanding mandate and the ever-increasing attrition rate within the organisation, the number of vacant posts in the organisation need to be filled as soon as possible. Hence, a certain degree of autonomy to recruit and hire new employees must rest with the CGWB. One of the options that the organisation is considering is that of outsourcing. With proposed budget increases and limited staffing the organisation thinks it will be important to develop efficient outsourcing mechanisms. Public outreach programs that do not require a high level of technical expertise, according to the CGWB, should be outsourced. This is thought to help CGWB focus their skilled manpower for delivery of the outputs of NAQUIM.

Hence, if we consider 20 river basins to begin with, with a representation of about 650 districts, It is imperative that:

1. CGWB is represented by a regional office in each river basin, i.e. 20 regional basin offices with at least 4-5 officers on average being deployed in each river basin. Note: the larger river basins like Ganga, Brahmaputra, Godavari, Krishna and Cauvery may require 8-10 officers while the smaller ones might require 2-3 officers.
2. While ensuring representation of CGWB's groundwater portfolio in each of the river basins, it is imperative that each district of the country is represented by at least two officers of the CGWB.

Hence, the two reference parameters imply that CGWB's majority staff is deployed through this structure, implying that the CGWB must have at least 100 + 1300, i.e. 1400 officers, to reflect this structure. At the same time, the CGWB has already envisioned a projection of its structure presented to the committee in one of its meetings. This projection is summarised in the table below. While the table below shows the positions at different levels, it is still short of the structure that needs to be developed based on the recommendations that will be made in Chapter 4, in alignment with the structure and reflection of the National Water Commission. However, at least 1500 officers of the CGWB will need to be deployed for managing India's groundwater resources within the framework of a river basin approach.

Table 3.4 GRADES AND STRENGTH PROPOSED BY CGWB

Cadre Structure/Grade	**Pay band-Grade Pay**	**Present Post**	**Proposed Post/ years**	**Proposed Strength**		
				Scientific	*Engineering*	*Total*
Apex Scale	Rs 80,000 (Fix)	-	Chairman (25 year)			1
Higher Administrative Grade (HAG+)	HAG+ (Rs 75500-80000)	-	Member (24 year)			4
Higher Administrative Grade (HAG)	HAG (Rs 67000-79000)	Chairman	Additional Member - Scientific / Engineering (21 year)			24
Senior Administrative Grade (SAG)	PB-4 (GP 10,000)	Member	Regional Director - Scientific / Engineering (17 year)			33
Non Functional Selection Grade (NFSG)	PB-4 (GP 8700)	Regional Director	Superintending Hydrogeologist / Geophysics/Chemist/ Hydrology/Hydro meteorology /Engineer - *Selection Grade*(14 year)	33	5	38
Jr Administrative Grade (JAG)	PB-3 (GP 7600)	Superintending Hydrogeologist/Geophysics /Chemist/ Hydrology/Hydro meteorology / Engineer	Superintending Hydrogeologist / Geophysics/Chemist/ Hydrology/ Hydro meteorology/Engineer (9 year)	49	8	57
Sr Time Scale (STS)	PB-3 (GP 6600)	Senior Hydrogeologist/ Geophysics/Chemist/ Hydrology/Hydro meteorology / Executive Engineer	Senior Hydrogeologist/ Geophysics/Chemist/ Hydrology/Hydro meteorology/ Executive Engineer (5 year)	129 (49 +80)*	19 (8 + 11)*	118 (57+91*)
Jr Time Scale (JTS)	PB-3 (GP 5400)	Junior Hydrogeologist/ Geophysics/Chemist/ Hydrology/Hydro meteorology / Asistt. Executive Engineer	Junior Hydrogeologist/ Geophysics/Chemist/ Hydrology/Hydro meteorology/ Asistt. Executive Engineer	231	32	263
			Total	478(398+80)	71 (60 +11)	549* (458+91)

3.6. CGWB: Capacity Building

The Training and Technology Transfer Wing of CGWB is vested with the responsibility of imparting training at different levels to entrepreneurs, professionals and administrators concerned with ground water development and management. The wing is also responsible for formulation of overall training policy, assessment of training needs, conceptualization of the training modules and the programme implementation strategy for the organization. While regional and state offices also conduct training programmes, the training portfolio of CGWB is anchored at Rajiv Gandhi National Ground Water Training and Research Institute (RGNGWTRI), located in Raipur, Chhattisgarh. The institute was envisioned to create and build the training and research canvass for the country with a view to develop training inputs at various levels within the groundwater institutions, state agencies and also within the larger stakeholder base in the country. The objectives of RGNGWTRI are stated as follows:

- To be an international center of excellence in Training, Research and Development in the groundwater sector
- To provide training to ground water professionals and sub-professionals in various fields of ground water
- To train NGO, PRIs and other stakeholders of ground water
- To train various stakeholders for taking up ground water monitoring and data collection work for Aquifer Mapping under Participatory Ground Water Management Program of National Project on Aquifer Management (NAQUIM)
- To undertake research and development works in Ground Water Sector

The training calendar for 2015-16 (Table 3.5, below) was used to identify the focus of current trainings and synthesise gaps for developing a more open and meaningful training programme under the Training Institute, that is likely to move from Raipur (where it is currently located) to Pune (in the neighbourhood of National Water Academy, the key water training institute of the MoWR).

Table 3.5 Training Programmes of RGNGWTRI (2015-16)

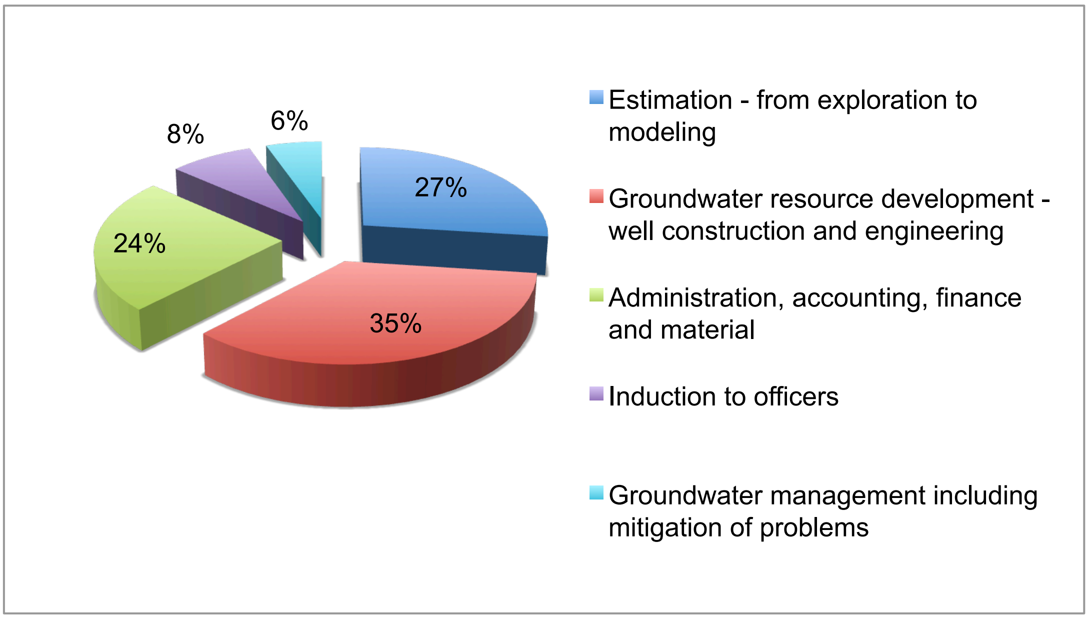
	Topic	Target Group
1	Ground Water Development	Students of Agriculture, Civil, Water Resources, Soil & Water Engineering
2	TOT for Engineers	Engineering Officers of CGWB
3	Application of Geophysical Techniques in Ground Water Studies	Officers of State & Central Government Organizations and Students/ Faculty from Academic Institutions.
4	Application of Remote Sensing & Geographic Information Systems in Ground Water Studies.	Officers of State & Central Government Organizations and Students/ Faculty from Academic Institutions.
5	Ground Water Resources Estimation	Officers of State & Central Government Organizations and Students/ Faculty from Academic Institutions.
6	Ground Water Quality, Contamination and Remediation	Officers of State & Central Government Organizations and Students/ Faculty from Academic Institutions.
7	Water Well Construction: Technology & Management	Board Employees
8	Project Management	Board Employees
9	Mathematical Modelling of Ground Water System	Board Employees
10	Safety on Road	Board Employees
11	Management Principles and Practices	Board Employees
12	Administration & Finance	Board Employees
13	Maintenance Management	Board Employees
14	Ground Water Data Analysis	Board Employees
15	Ground Water Development &Management Level I (Induction)	Board Employees
16	Ground Water Development & Management Level I & Level II (Induction)	Board Employees
17	Ground Water Development & Management Level I, Level II & Level III (Induction)	Board Employees
18	Ground Water Development & Management	Board Employees
19	Pumping Test Data Analysis	Officers of Himachal Pradesh State Government.
20	Water Well Construction: Technology & Equipment -Level 1	Board Employees
21	Water Well Construction: Technology & Equipment - Level 2	Board Employees
22	Maintenance of Drilling & Ancillary Equipment - Level 3	Board Employees
23	Water Well Construction: Technology & Equipment - Level 1	Board Employees
24	Water Well Construction: Technology & Equipment - Level 2	Board Employees
25	Maintenance of Drilling & Ancillary Equipment - Level 2	Board Employees
26	Water Well Construction: Technology & Equipment - Level 1	Board Employees
27	Water Well Construction: Technology & Equipment - Level 2	Board Employees
28	Water Well Construction: Technology & Equipment - Level 1	Board Employees

29	Water Well Construction: Technology & Equipment - Level 2	Board Employees
30	Maintenance of Drilling & Ancillary Equipment - Level 2	Board Employees
31	Water Well Construction: Technology & Equipment - Level 1	Board Employees
32	Material Handling, Storekeeping & Store Accounting - Level 1	Board Employees
33	Material Handling, Storekeeping & Store Accounting - Level 2	Board Employees
34	Material Handling, Storekeeping & Store Accounting - Level 3	Board Employees
35	Water Well Construction: Technology & Equipment - Level 2	Board Employees
36	Water Well Construction: Technology & Equipment - Level 3	Board Employees
37	Material Handling, Storekeeping & Store Accounting - Level 2	Board Employees

A quick analysis of the above calendar clearly reveals how skewed the training modules within a single (most recent) training calendar at RGNGWTRI is. While much of the topics dominate a ‘supply-side’ set of topics, only 6% of all the training topics can be grouped under some ‘demand-management, mitigation’ aspects. This clearly points to the gap between current training topics and the desired set of topics that will enable capacities on groundwater management.

More recently, one of the members of this committee had the opportunity to sit through a training session for various stakeholders He also had the opportunity to conduct a training session at the CGWB orientation training for incumbent officers at Raipur. The analysis below is derived out of a combination of the calendar of trainings (above) and feedback and experiences from the actual training sessions as stated earlier in this paragraph.

Figure 3.4: Distribution of training sessions across categories during the 2015-16 training calendar of RGNGWTRI



Groundwater science is becoming increasingly interdisciplinary as the challenges in managing groundwater change from those that can be addressed exclusively by the erstwhile 'exploratory, source-based' approach to a 'resource management and governance' approach. Moreover, the potential move into 'mission mode' on work pertaining to groundwater resource management requires significant perspective building and skill development at various levels. Hence, as elucidated in the 12thPlan, capacity building is a cascading process through which the science of hydrogeology is progressively demystified and brought closer to the community. Such a cascading process will empower communities to take informed decisions about the use of groundwater and also to possibly stimulate and initiate collective action regarding the conservation, augmentation, usage and overall management of groundwater. In other words, capacity building is visualised as a process of creating a knowledge-base accessible to the community as a crucial decision support tool, in order to foster various sustainable groundwater management initiatives. Hence, Civil Society Organisations (CSOs) who hold experience in natural resource management and sustainable development must play a significant role in such a capacity building exercise clearly calling for a two-tiered training of communities and CSOs.

Further, Central and State groundwater agencies themselves will benefit from inputs on developing sustainable groundwater management systems. Whether such inputs come from Civil Society at large (including NGOs, institutes of research and learning) or from the private sector is immaterial. A potential input-providing institution should be welcomed to partner CGWB on groundwater management projects. One such partnership could be through a long-term capacity building and training effort. The outcomes of such State-CSO partnerships will develop capacities especially for informed governance of groundwater ranging from mapping and assessment to monitoring and management of groundwater resources. *CGWB already possesses a directory of capable agencies working on various groundwater issues from across the country.* It will prove fruitful to use such a database (of directories) to pool in both resource persons as well as potential trainees in order to facilitate the process of participatory mapping and capacity building. Institutional partnerships in training could be forged on the basis of such a directory.

Capacity building also provides the platform for the development of human resources both within and outside government. The human resources available in the government (Central and State) are grossly inadequate to address the challenge of assessment of groundwater resources and sustainable groundwater management. The inadequacy is not just in terms of numbers, but also in terms of the width and depth of subject-matter understanding and experience. More specifically, while the pool of trained hydrogeologists will need to be increased at the district and block levels - the cutting edge of implementation – strengthening the work capabilities of existing human resources is equally important. In view of this, it becomes imperative for every State in the country to have a separate department or agency dealing with groundwater. Some States like Maharashtra and Andhra Pradesh have such structures in place but they are both inadequate and weak in their capacities to conduct work of relevance.

Cadres will be required to assist Panchayats and support development programmes in their management of groundwater resources. The same cadres can be brought forward to help map aquifers and continue as facilitators during the groundwater management phase. The example of Government of Sikkim, in mobilizing ‘field facilitators’ and building their capacities to efficiently implement the ‘Dhara Vikas Programme’, is a clear example in this direction. State level capacities will need to address the ability to collate information, analyze its implications to develop policies and inform development programs. Therefore groundwater geologists with qualifications in management and policy formulation should lead these efforts.

Towards this RGI will:

- Make a consortium of Capacity Building Institutions to train District and Block cadres of groundwater geologists for each State/Hydrological Setting drawn from State Groundwater Survey Office, State Water Resource Departments, Technical Institutions/Universities/IIT’s/IIM’s and Civil Society Organisations with the required expertise and experience.
- Develop strong partnerships for training State and Central organisations for the programme. These partner institutions will include NWA, Pune; NIRD, IIRS, NRSA, NGRI, IIT’s & IIM’s.
- Create a core group of faculty drawn from private and public institutions to develop curriculum and oversee delivery of training programmes.
- Identify inspired leadership that can provide sustainability to the training institute in order to oversee and ensure the core objective of the program is not diluted.
- Develop an Electronic Resource Centre at RGI on groundwater system policies and management.

- Bring relevant experiences and knowledge already developed on mapping, monitoring and management of aquifers and training methodologies from within and outside the country. Linkages will be developed with centers of excellence like Groundwater Division - British Geological Survey (BGS), USGS – Groundwater Division, ITC & TNO (Delft) – Netherlands; National River Water Authority (UK); Royal Institute of Technology (RIT) – Sweden; International Groundwater Modeling Centre – Denver; International Foundation for Sciences (IFS); USAID & USEAP; and International Groundwater Resources Assessment Centre (IGRAC), to name a few.
- Coordinate with University Geology Departments and other such organisations, to ensure training and specialization in groundwater geology. Curricula need to be brought up-to-date regarding perspectives of aquifers and groundwater management, appropriately tailored to the Indian context.
- Facilitate the training in around one thirds area of the country with critical groundwater situations on priority in the 12th five-year plan.

Capacity building will need to be undertaken at different levels. Three broad levels are envisioned for simplicity sake, sub-levels notwithstanding.

1. **Aquifer Level**: Grass-root facilitation to a cadre of geo-hydrology workers or *parahydrogeologists*, capable of providing information on the status of groundwater at the aquifer level to strengthen Panchayat Planning, thus improving deployment of development programmes inclusive of groundwater equitability and sustainability.

2. **State Level**: Training at State Government level to be in a position to assess the status of their aquifers and groundwater for developing policy and programmes.

3. **National Level**: National and regional organisations to provide standards for mapping, aquifer and groundwater assessment and capacity building.

The important role of collation, synthesis and management of data is the role best executed by the government, with support from various organisations. Hence, CGWB and State Agencies should be strengthened to take on the challenge of developing a far more disaggregated 'groundwater picture' in the country than what is available today through the periodic groundwater assessments. Therefore, the emphasis should focus on meticulously developing the capacities of institutions and human resources within the government. CGWB and State Groundwater Boards will need to strengthen their existing capacities and develop new ones by expanding out their training mandate. The central nodal agency to develop such capacities will continue to be RGI. An expert group should guide RGI to implement the capacity building programme. RGI's own infrastructure and capacities will need to be increased to deliver this programme a process that is being set in motion as far as reports go.

CGWB has embarked upon the path-breaking programme on the mapping of aquifers across the country. Aquifer mapping can only be successful if it is appropriately followed up with participatory groundwater management. The idea behind any capacity building exercise on groundwater management, therefore, should ensure that groundwater resources are documented, monitored and local stakeholders facilitated to manage this resource sustainably. RGI will be the Nodal Agency for this capacity building venture as well. A target of 2000 blocks (more than one thirds of the total in the country) with critical groundwater situations can be selected for work in this regard or locations that are being prioritized in programmes like PMKSY.

The current training structure that RGI has adopted – *tiers I, II and III trainings* – can still be used, with some modifications. However, the approach towards conducting the tiered training will need to change significantly. Strategies for each of the tiered trainings will need to be developed and their details worked out through a process that includes RGI identifying civil society organisations capable of conducting hydrogeological investigations including aquifer mapping and building capacities of potential barefoot hydrogeologists. They, in turn, will identify and train a team of trainers in different States, who will execute these trainings. RGI will identify a regional training institute to coordinate all trainings. The local State and District groundwater geologists, universities and others with legal/social/technical knowledge on groundwater will be brought into the trainings as resource persons so as to develop, strengthen and build a pool of hydrogeological capacities at different levels and within multiple institutions.

Table 3.6 below indicates the structure and broad content of the trainings under tiers I, II and III. Each tier of training must be defined through a purpose, the content related to the purpose, the trainee group (target) and the background of the trainers, along with the forward linkage for each of the trainings.

Table 3.6: Proposed Structure and Content of the Trainings under Tiers I, II and III

TIER	PURPOSE	CONTENT	TARGET	TRAINERS	FORWARD LINKAGE
TIER I	To develop and promote groundwater governance through a water policy and legislative process	Perspective building on groundwater at policy level; Groundwater governance; Resource assessments; Aquifer mapping; Research; Data & database	CGWB, State Departments linked to groundwater and Authorities; National and regional NGOs	CGWB (officers with the capacity to 'train'); External experts from organisations conducting research and training on groundwater; State-level experts drawn from the groundwater departments/agencies	Groundwater governance – especially regarding the linkage between Groundwater Model Bill and State Legislations; ToT for aquifer mapping trainings under Tier II
TIER II	To develop a process and institutions for participatory groundwater management in all States in India	Perspective building on the regional groundwater situation; Aquifer mapping; Groundwater management – *comprehensive & thematic topics*; Groundwater legislation; Interdisciplinary hydrogeology; Institutions	NGOs, District level officers from various departments linked to groundwater; Independent consultants; Municipal officers and authorities	Regional CGWB Centres; State groundwater departments/agencies; State-level research and training institutes dealing with groundwater; Local resource persons from NGOs who work on groundwater and are trained in Tier I trainings	Groundwater management & governance at State level – process of robust legislation development; ToT for groundwater management under Tier III training; Research capacity development
TIER III	To promote and develop and environment and pilots in aquifer-based, community-centric, participatory groundwater management	Perspective building on the local groundwater situation; Process of groundwater monitoring including data collection; Aquifers and groundwater management – r*esource, demand and supply aspects*; Groundwater legislation; Institutions	NGOs, Block-level officers; Panchayat members; Trained parahydrogeologists; Citizens and volunteers – *including NSS staff and students*	State groundwater departments/agencies; NGOs with capacity to conduct community-level training and who are trained in Tier II trainings;	Community based participatory aquifer monitoring and management at scales of aquifers; Institution building
NATIONAL & REGIONAL WORKSHOPS	To conduct multi-stakeholder discussion and dialogue on various issues related to groundwater be discussed at least once a year in each State and once at the National level on lines similar to *Bhoojal Manthan*	Perspective building on aquifers, community-level groundwater management and regulatory mechanisms; Reporting progress on programmes like aquifer mapping and its integration with agriculture, drinking water security and river basin planning and management	Multiple agencies and organisations across the country	Led by CGWB with inputs by other experts from educational institutes, NGOs and other such organisations	Consistent dialogue on groundwater with various stakeholders

Finally, RGI must also set up a training advisory council experts who have experience and expertise to develop:

1. Robust curricula for training
2. Generate new ideas for training and capacity stakeholders at different levels
3. Help RGI design training modules for different s groundwater scarcity, groundwater contamination, management – as well as for the diverse geographies of I
4. Help RGI forge partnerships and indicate the possibility upon experiences from the nooks and corners of the co potential groundwater management is being attempted
5. Provide periodic guidance in designing interna programmes for CGWB's own staff

Given the present inadequacies of both the CWC outlined in this chapter, we propose in Chapter institutional architecture to overcome these problems.

Chapter Four

National Water Commission

4.1 Why we need the National Water Commission

As Chapters1 and 2 have argued, 21st century India faces a completely new set of challenges that demand a paradigm shift in water management. Chapter 3 has shown how 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

We propose that the CWC and CGWB be restructured in a manner that brings unity of purpose to their functioning. We propose the creation of a National Water Commission that unifies these two apex bodies.

4.1.1 Strategy and Structure

The institutional architecture of the proposed National Water Commission needs to be informed by the discussion among organization theorists about the relationship between structure and strategy. Strategy, in this context, refers to the sum total of what an organization does to work towards its objectives[17]; and structure means, besides the organogram showing hierarchy and reporting relations, people, skills and capacities, groupings of people and relationship between groupings, culture and

[17]Chandler (1962), who led this debate, defined strategy is the determination of the basic long term goals of an enterprise and the adoption of courses of actions and the allocation of resources necessary to carry out these goals.
http://www.ukessays.com/essays/business/study-the-relationship-between-structure-and-strategy-business-essay.php#ixzz41dHGzNaF

internal task environment. Some argue that once a structure is created, the strategy follows. Others argue that successful organizations evolve the strategy first and design a structure appropriate to the strategy. In the ultimate analysis, a good 'fit' between strategy and structure is critical for an organization to deliver on its goals. In market driven businesses, misfit between organization strategy and structure results in loss of competitive advantage and the organization withers away. In bureaucracies, organisations with such a misfit may survive for long but remain out of sync with their operating environment and become insignificant. Unless they reinvent themselves, these may gradually be reduced to a skeleton by starving them of resources. Irrigation and groundwater bureaucracies in India are themselves a case in point.

The history of state irrigation departments (IDs) in many states illustrates this. These were created and staffed with civil engineers when the key objective was construction of irrigation projects, which is largely what IDs did. Once construction was over, IDs proved a misfit for management of irrigation systems, which required a different set of skills and operating culture. In many states, IDs still survive but only in name; most states have not recruited irrigation engineers in 20-25 years. In Gujarat, the last ID engineer will likely retire next year.

The same is the story with groundwater departments. These were created to construct public tubewells. But the current situation on ground water in India is different from that of 60 years ago. For that matter, it is quite different from the situation 30 years ago. India today is facing a severe groundwater crisis even as our dependency on groundwater has significantly grown. Some parts of India are underlain by aquifers that are stressed from the exploitation of groundwater. Others face serious challenges from groundwater contamination, of both geogenic and anthropogenic nature. There are a few areas in India that suffer from challenges of both exploitation and contamination. India therefore needs to manage groundwater resources at various scales, ranging from regional

– river basin scales to more macro and local scales, particularly in the context of groundwater exploitation and contamination.

CWC and CGWB have followed a somewhat similar trajectory; but GoI is less resource-constrained than state governments; therefore these have not only survived but even grown. However, they are already facing reduced budgets and today require urgent restructuring.

4.1.2 New Context, New Demands

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.

Several State Governments testified before the Committee that the huge delays in the techno-economic appraisal by the CWC had become a matter of concern for them. To quote the Government of Madhya Pradesh:

> "CWC in particular has been playing the role of a regulator for long. MOWR has made vetting of all medium and major irrigation projects by CWC mandatory. CWC has more than 15 directorates to examine a major project and examination takes years. State Governments have to deploy project engineers to chase their projects for months and do considerable liaison work with CWC engineers. Consequently, most state governments have ended up with posting of resident engineers and opening their offices in Delhi. The time taken for project examination is at times equal or more than the time taken to complete the project."

There is a need to address this concern and make appraisal a demand-based exercise, done through a partnership between the central and state governments. This is a common concern of many states. It is also true as stated by GoMP that:

“Most large states have developed expertise in project preparation, hydrology study, design of large dams and canal systems, and executing medium and major projects in the past 2 decades. Bureau of Designs and Hydrological Investigations (BODHI) of various states have acquired requisite competencies. In addition, institutions of national repute such as IIH, Roorkee, CWPRS, Pune, IIT Roorkee, IISc, IITs and various regional engineering colleges have expertise with knowledge of latest developments and software in the water sector. State Governments can avail their services on payment on need basis”

Thus, project appraisal can become a truly collaborative process, with expertise flowing on demand from the best institutions of the country.

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.

While the situation in India demands a shift in capacity from a well-construction organization to a resource management entity, CGWB has been unable to keep apace with such a change, creating a slack between what the organization needed to do and what it has been doing. At the same time, the two significant changes that CGWB adjusted to were:

- Periodic national-level groundwater assessment about the status of the degree of resource usage
- Establishment of the CGWA as a consequence of the Supreme Court directive to abolish the problem of groundwater overexploitation

However, these were probably only forced adjustments that were mandated by a rapidly changing groundwater scenario on one side and the directive by the judiciary on the other. In many ways, these two adjustments underscored the need for CGWB to transform itself from an organization pursuing pure groundwater development goals, to the country’s apex groundwater agency, with a mandate for the management and governance of groundwater resources in India.

India has embarked upon an ambitious plan of mapping aquifers with clear meaning, messages and direction to managing quantities and quality of groundwater resources across a diverse socio-ecological typology. However, even the early aquifer-mapping pilots have revealed that mapping and managing India's aquifers requires strategic skills that require going beyond merely map-producing skills. Such mapping and management of groundwater resources in India involves three important and sometimes competing objectives. These objectives include:

1. The social dimension of securing domestic – drinking water –from aquifers across both the rural and urban landscapes, even while the same aquifers are stressed to ensure water security to our farmers and to the industry in order to propel growth on both the fronts.
2. Hence, the second dimension involves ensuring food-security through various forms of irrigation – ranging from protective irrigation to secure the kharif crop from climate vagaries to ensuring good produce during the dry seasons of rabi and summer, when groundwater is the only means of water for farm lands in large parts of the country. The economic dimension also involves industrial water use, often in regions where agriculture and industry co-exist and source water from the same set of aquifers.
3. The usage of water for domestic, irrigation and industrial needs has a significant bearing on the ecologic dimension of groundwater, mainly on the base-flows that feed streams, rivers and keep our wetlands intact. Some groundwater must eventually flow to the sea or ocean, by way of base flows, for ecological integrity of coastal systems.

Doing justice to such a perspective requires interdisciplinary skills that will enable a transition from an organization that spent much of its time in the exploration and drilling for groundwater to an organization that has the capacity to lead and anchor a national programme on aquifer management from different parts of India. The aquifer mapping effort must also be increasingly backed by more frequent assessments in real-time – annual assessments must become available at least once every year – and based on aquifer information including groundwater levels and groundwater quality. At the same time, this information can become even more effective if data on the profiles of users and uses is also available along with information and data on economics, social indices, ecosystem and energy so that a much better understanding emerges on the nexus between groundwater, agriculture, industry and energy. This information can then be more fruitfully used in the planning and management of our river basins. Most significantly, the reform must include steps whereby data and information improve in terms of accuracy, representativeness and scale, at the same time being backed by simple data-analytics that have a high degree of applicability in developing and implementing groundwater management plans that emerge out of the aquifer mapping exercise. The crucial task is of managing aquifers through a participatory process involving various stakeholders across a diverse and variable socio-ecological landscape requiring an increasingly proactive role not just in the mapping of but also in the management and governance of India's aquifers.

India's water strategy has so far concentrated on public investment in infrastructure. This has undoubtedly played a significant role in meeting the goal of national food security. We have paid much lip service to, but in reality placed very little emphasis on, management improvements, governance reforms and institutional innovations. This is why returns to public investments in water infrastructure in India have been poor; and water projects have suffered from the build-neglect-rebuild syndrome. The country can make rapid strides in water security by emphasizing management improvements and institutional reforms rather than just public investment in water infrastructure. This shift of emphasis is the key challenge to be met by the National Water Commission.

A few States have, in fact, taken the lead in charting out a path of reform in some of their command areas, as described in Chapter 2. But overall, the discourse on policy reform in key infrastructure sectors in India has generally given water a go by. It could actually be argued that India's growth prospects in the medium- and long-term will depend critically on how fast we can reform our water sector by moving away from an engineering-centred, command-and-control approach towards a people-centred, sustainable and equitable demand management of water.

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, 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. [18] In a

[18] 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.

representation to this Committee, it has been powerfully argued with regard to the CGWB that:

"Ministerial staff like Administrative Officers (AOs) and Senior Administrative Officer (Sr AO) are merely supporting the clerical cadre and hardly play any role in decision making / policy issues. At CHQ level, other than Dir (Admin) and the Chairman at apex level, virtually no officer appointment is sanctioned to link up the Administrative Chain. Similarly, at regional and divisional levels, only Heads of Offices (HoOs) play the role of Administrators. The administrative chain needs to be strengthened by an appropriate administrative chain with sufficient powers that justify administrative functions at different levels. While a few options have been provided by different experts, it is best to integrate these functions at the river basin offices, where CWC and CGWB can share an administrative structure." (Submission of Col. Rajesh Gaur)

We are also persuaded of the view expressed in the same representation that:

"an Officer must be experienced and exposed to the socio-ecologic conditions in various parts of the country, as he climbs the ladder of career progression. However, the reality, at least in some cases, conveys that a number of senior officers have spent their last 20 to 30 years either in one location with a little or no movement to other regions. In some cases such officers have risen upto the Regional Director or higher. All Round Experience and wide-ranging Area/Terrain Exposure must be part of mandatory requirements for rise in career progression for officers. Unless we ensure this point, we may land up with officers at senior / very senior positions with lesser / no exposure to areas/ terrains in the country" (Submission of Col. Rajesh Gaur).

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.

4.1.3 Surface and Groundwater Together

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. In India today, we see repeated instances of what the 12th Plan document has called "hydro-schizophrenia", where the left hand of surface water does not seem to know what the right hand of groundwater is doing. 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.

4.1.4 Accessing the Necessary Capabilities

As was explained in Chapter 3, 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. In such a situation it is unfair for us to expect these bodies to fulfill the mandate devolved upon them by the new realities of the water sector. 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.

Our goal is, therefore, to make a manifold increase in the capacities of the apex bodies managing water in India. This can be done through both in-house enhancement of capacities (through capacity building of existing personnel as outlined in Chapter 3 and by inducting fresh personnel) and through building robust partnerships with institutions of excellence across the country.

4.1.5 National Water Commission

The Committee, therefore, recommends that:

f) a brand new National Water Commission (NWC) be established as the nation's apex facilitation organisation dealing with water policy, data and governance;
g) 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;
h) NWC should be headed by a Chief National Water Commissioner, a senior administrator with a stable tenure and with strong background in public and development 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.
i) NWC should have strong regional presence in all the major river basins of India;
j) 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

4.2 Mandate and Functions of the NWC

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

i. enable and incentivize state governments to implement all irrigation projects in reform mode, with an overarching goal of *har khet ko paani* and improved water resource management and water use efficiency, not just construction of large scale reservoirs, as the main objective;
ii. lead the national aquifer mapping and groundwater management programme;
iii. insulate the agrarian economy and livelihood system from pernicious impacts of drought, flood and climate change and move towards sustainable water security;
iv. 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;*
v. 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;
vi. promote cost effective programmes for appropriate treatment, recycling and reuse of urban and industrial waste water;
vii. develop and implement practical programmes for controlling point and non-point pollution of water bodies, the wetlands and aquifer systems;
viii. 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;
ix. 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;

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

4.3 NWC: Structure

Since the NWCs mandate is based on the concept of integrating various disciplines into a river basin framework, as also to guide participatory water resource planning and management at different scales, integrating upwards into a river basin framework, its structure must find a resonance between various disciplines represented by its 'commissioners' and the key functions of the Divisions described below. Each Division may be headed by a Deputy Director General (DDG: Additional Secretary rank; some may be drawn from the existing Members of CWC and senior positions of CGWB). Each such Division would include sub-divisions called 'directorates'.

As described in detail in Chapter 3, at present CWC has three technical wings, each headed by a Member, Designs and Research Wing, Water Planning and Projects Wing, River Management Wing. CGWB operates through four technical wings, each headed by a Member, Exploratory Drilling & Material Management Wing, Sustainable Management & Liaison Wing, Survey, Assessment & Monitoring Wing and Training and Technology Transfer Wing. There are also the NWA and RGI tasked with capacity building. We believe the work of all these remains very important but it needs to be restructured and strengthened as proposed below, in order for them to more effectively fulfil their new mandate.

4.3.1 Divisions

The common thread connecting the divisions must be that of participatory resource planning and management. Given this fundamental basis for constituting the divisions, the roles and responsibilities for each division can be detailed out as the first task that the NWC can take upon itself. However, the following divisions are proposed here, with some basic elements that indicate the roles that each will play in integrating towards a river basin plan and its implementation:

1. Irrigation Reform Division

This Division will take care of the NWC mandate to 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* and not just construction of large scale reservoirs and river development projects as the main goal. 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 *harkhetkopaani***.

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 utilised 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 supporting and advisory body for the 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 decentralised so that their presence is strong enough at the river basin scale but also so that they work closely with all the States present in every single river `basin in the country.

2. River Rejuvenation Division

This Division will answer to the mandate of the NWC to 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.* It will help catalyse 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 work in close association with the groundwater management Division in understanding the surface-groundwater interaction, especially in the floodplains and with regard to regions that depend upon springs

3. Aquifer Mapping and Participatory Groundwater Management Division

This Division will lead the National Aquifer Management Programme (NAQUIM). 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 programme. These will include other than state groundwater departments, other water-related government departments, academic and research institutions, civil society organisations, Panchayati Raj Institutions and others as per requirement so that NAQUIM, the largest aquifer mapping and management programme in human history, can be completed within a decade. It will have to work closely at the village and watershed levels, given the highly decentralised 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.

4. 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 meeting the NWC mandate of 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 programmes for tackling these challenges. The Division will provide flood-forecasting services to all major flood prone inter-state river basins of India. 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 all other NWC Divisions, as also the Ministries of Drinking Water and Sanitation, Rural Development, Agriculture and Environment, along with State Governments.

5. Urban and Industrial Water Division

Historically, urban and industrial water has not come under the purview of the CWC. However, given the enormous challenges of a rapidly urbanising and industrialising 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 industrialisation and urbanisation 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.

6. Water Quality Division

This Division will work to fulfill the NWC mandate to develop and implement practical programmes 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 CPCB to address these issues

7. Data Management and Transparency Division

This Division will take care of the mandate of the NWC to 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 organisations, both government and non-government (academic and civil society), collect data at local scales. Reaching out to such organisations for their data and bringing it into the main national data-base with due acknowledgement and standardisation to ensure no compromise with quality, can also be one clear role of this Division.

8. Knowledge Management and Capacity Building Division

This Division will be in-charge of creating world-class institutions for broad-based capacity building of water professionals in integrated water and land management.

The Division will 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 will be responsible for creating mass awareness regarding water resource programmes and policies and initiatives in which people have a central role.

The Division should 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 should be open to all water related disciplines, not only Engineering and Geology.

The Division will also be the one responsible for the research and knowledge management within 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 behaviour, 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

4.4 Management of Partnerships

For the NWC to be able to play its mandated role will require the organisation to build strong partnerships with a wide range of organisations across the country in the water sector. We are not advocating that all the capacities required should be housed within the NWC. A lot of the professionals needed by the NWC would become available through a carefully crafted architecture of partnerships with world-class academic and research institutions, of which there are many in India, as also civil society organisations with a strong presence in the field and a track record of excellence over many years. The key here is how these partnerships are managed. Historically, many knowledge institutions such as the IITs have had close working relationships with the Ministry of Water resources but the feedback we have from a large number of professionals who have had experience of working with the Ministry is that these partnerships have lacked stability and enduring value. What we need are formal partnerships embodied in a reasonably long-period MoU, closely tied to well-defined deliverables to ensure accountability that government rightly worries about. But the key change has to be that our academic partners feel an enduring part of the NWC team and not be subject to fluctuating whims and fancies, which could see them going in and out of the team.

We illustrate the significance of partnerships through the example of groundwater. In its own articulation of the tasks ahead, CGWB categorises various tasks into a list, which are included in column 1 of the table. For each task, we specify the necessary reform and the indicative partnerships that the new NWC may get into seeking such reforms. NWC partnerships would be with:

- national and international institutions, whether in the field of pure or action research, in taking the understanding of aquifers in India to another level in the next 10-15 years
- academia and civil society in developing a cadre of hydrogeologists and para-hydrogeologists who have the capacity to work with communities on the ground and take the findings from the aquifer mapping programme and convert these into decisions and actions so that challenges in groundwater management and governance can both be overcome
- other programmes or ministries, donor agencies for database development and to build a unique, India-specific integrated watershed-aquifer-river basin rejuvenation programme

This table is illustrative of the way the NWC can build partnerships to manage all aspects of the reform strategy for water management in India.

Table 4.1: NWC's Mandate on Groundwater: Potential Partnerships

Key tasks	Key elements of reforming current process / setting up a new process	Indicative institutions for partnership/collaboration
1. Aquifer mapping	Not just maps, but a plan leading to management of groundwater resources	State Agencies, Space Science Institutions, Academia and Research Organisations and Civil Society Organisations that work closely with communities
2. Periodic assessment of groundwater resources at the national scale – integrating groundwater quality with quantitative assessment	Driving down to scales of aquifers or smaller hydrological/administrative units	Various Government Agencies that collect water-related data – CWC, IMD etc. – apart from State Agencies as well as research and development efforts based on aquifer-based information at local scales
3. Exploration of deeper aquifers	Strategic public usage as a purpose, rather than opening up to business-as-usual groundwater development through individual deep drilling	GSI (which is envisioning collaboration with CGWB), ONGC and other private / public agencies who are likely to have drilling and geophysical data (including NGRI, GSI, ONGC etc.) whether for groundwater exploration or otherwise
4. Urban groundwater management	Mainstreaming groundwater into public urban water supply through aquifer mapping, characterisation and strategic groundwater recharge	Urban local bodies, research institutions, academic institutions, NGOs, industry associations like CII and FICCI
5. Managed Aquifer Recharge (MAR)	Systematic groundwater recharge linked to aquifer mapping and period assessments	Academia and research institutes, organisations engaged in water conservation efforts, especially watershed management
6. Mountain aquifer management with special emphasis on spring water	Expanding the scope of hydrogeology to mountain aquifers that feed to spring-water supplies	Institutes (academia, research, civil society) working on mountain ecology and livelihoods – many of these work across the Himalayan

management in the highlands		landscape, Western and Eastern ghats
7. Coastal aquifer management	Understanding sea-water ingress in diverse aquifer settings	Institutes working on coastal ecology and livelihoods and including a wide-ranging set of issues in their work
8. Participatory groundwater management	Planning strategic management of groundwater under the concept of 'aquifers as common pool resources' with the forward linkage to river basin approach	Institutions, mainly civil society, that have a community-reach and who understand the concept and practice of participatory groundwater management
9. Groundwater in the river basin framework	Weaving the various strings especially from 1 to 7 together and attempting to understand the dynamics between aquifers and river-channels, wetlands, springs – e.g. base flows, interflows and their relevance in the larger context of ecosystems	Wide-ranging partnerships with academia, research, donors and civil society, many of whom are already into participatory groundwater management pilots in different parts of India
10. Capacity building and knowledge-sharing	Various levels of training – from groundwater governance to groundwater management skill-sets through multidisciplinary approaches	Academia, research and organisations engaged in customized trainings on groundwater – especially that of building skill-sets on management of aquifers
11. Database management	Publicly accessible data platform with a wide variety of 'real-time' groundwater-related data-sets	Private sector partnership along with research organisations dealing with data and database management
12. Groundwater governance – helping develop legislative reform	Model bill reform and facilitation to States in groundwater legislation processes	Mainly with state agencies, policy – related entities and law schools

4.5 NWC: Strong Regional Presence in River Basins

River basins must form fundamental units for strategic planning and management of water resources. For this we need to correct the currently skewed and inadequate presence of CWC and CGWB in the river basins and hydrogeological settings of India.[19]

Figure 4.1 is a representation of CWC and CGWB offices on the CWC-classified river basin map of India as well as on the broad hydrogeological typology of India.

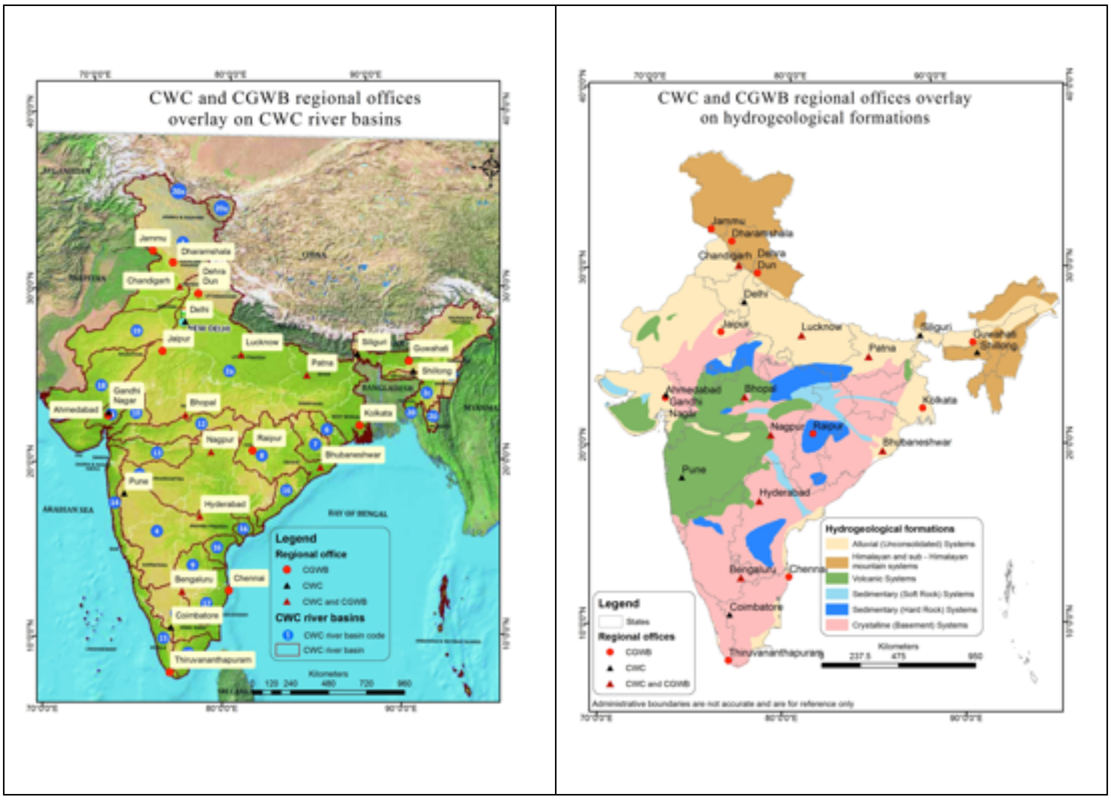


Figure 4.1

The map can be further simplified into Tables 4.2 and 4.3 below.

[19]It may be noted that the river basins specified by CWC and India-WRIS are slightly different (CWC-MoWR and India-WRIS, MoWR websites). This is primarily because of reclassification of the CWC basins under India-WRIS. While a few basins have been added under India-WRIS – those in Andaman-Nicobar and Lakshadweep Islands – some of the earlier basins have been regrouped – for instance, the inland rivers in Rajasthan from CWC's classification have been grouped under the Indus basin under WRIS.

Table 4.2: River basins of India and location of CWC and CGWB regional centres/ offices

Basin no.	Basin name	CWC offices	CGWB offices
1	Indus	Chandigarh	Jammu, Dharamshala, Chandigarh
2a	Ganga	Delhi, Lucknow, Patna, Bhopal	Dehradun, Delhi, Lucknow, Patna, Kolkata
2b	Brahmaputra	Shillong	Guwahati
2c	Barak and others	Shillong	
3	Godavari	Nagpur	Nagpur
4	Krishna	Pune, Hyderabad	Hyderabad
5	Cauvery	Bengaluru, Coimbatore	Bengaluru
6	Subarnarekha		
7	Brahmani and Baitarni		
8	Mahanadi	Bhubaneshwar	Bhubaneshwar
9	Pennar		
10	Mahi		
11	Sabarmati	Gandhinagar	Ahmedabad
12	Narmada		
13	Tapi		
14	West flowing rivers between Tapi and Tadri		
15	West flowing rivers between Tadri and Kanyakumari		Thiruvananthapuram
16	East flowing rivers between Mahanadi and Pennar		
17	East flowing rivers between Pennar and Kanyakumari		Chennai
18	West flowing rivers of Kutch and Saurashtra including Luni		
19	Area of inland drainage in Rajasthan		
20	Minor rivers draining into Myanmar and Bangladesh		

Table 4.3: Broad hydrogeological settings of India (after Kulkarni et al, 2014) and location of CWC and CGWB regional centres/offices

Basin no.	Basin name	CWC offices	CGWB offices
1	Himalaya	Shillong	Jammu, Dharamshala, Dehradun,
2	Unconsolidated sediments	Chandigarh, Delhi, Lucknow, Patna, Siliguri, Bhubaneshwar, Gandhinagar	Chandigarh, Delhi (& Faridabad), Lucknow, Patna, Kolkata, Gwahati, Bhubaneshwar, Kolkata, Ahmedabad
3	Soft sedimentary formations		
4	Hard sedimentary formations		Raipur
5	Volcanic rock formations	Pune, Bhopal, Nagpur	Bhopal, Nagpur
6	Crystalline rocks	Hyderabad, Bengaluru, Coimbatore,	Hyderabad, Bengaluru, Chennai, Thiruvananthapuram

The above figure and the two tables help us draw certain key inferences, crucial for developing a decentralised, river-basin structure for NWC. The inferences are listed below:

- Both the CWC and CGWB have regional centres in 7 of the 22 river basins.
- There are 4 river basins where there is either a CWC or CGWB regional centre.
- **There are 11 river basins where neither CWC nor CGWB has a regional centre (there may be local offices such as district or operational level offices).**
- Both CWC and CGWB have regional centres within 4 of the hydrogeological settings.
- There is one hydrogeological setting where CGWB alone has one regional office (Raipur).
- **There are no regional offices of CWC or CGWB in 1 of the 6 hydrogeological settings.**
- The distribution of such regional centres, currently, is skewed and needs an improved representation because:

- Larger river basins such as Ganga are significantly represented through many regional centres, although Brahmaputra does not seem well-represented despite its size.
- Smaller river basins are poorly represented and as many as 11 such river basins have no significant presence of these organisations.
- Hydrogeologically too, the unconsolidated sedimentary aquifers are well represented along with the Himalayan, volcanic and crystalline aquifer settings.
- There are fewer regional offices within consolidated sedimentary aquifer formations.

4.5.1 NWC – Proposed Locations of Regional Offices

The above tables help us recognise the need to ensure the presence of surface and groundwater related 'interdisciplinary' expertise in each of the river basins as the NWC will integrate interdisciplinary functions at a river basin scale. Therefore, the current regional centres – represented by the highest order of the offices of the CWC and CGWB - in various river basins and across different hydrogeological settings can be used as the first set of NWC-reflecting centres to be fully representative of river basin planning and management portfolios.

The highest order of offices of the CWC for various river basins is assumed to be the office of the Chief Engineer, while that of the CGWB is the office of the Regional Director. However, as explained above, they are inadequate even from a representational aspect. Hence, based on a rationale that integrates the size of the river basin and physiographic, hydrological and hydrogeological factors, the following centres are proposed for strengthening existing regional offices or setting up new ones in the different river basins of India: (Table 4.4)

In proposing a 'first cut' template, this report attempts to rationalise a set of sub-centres under the NWC that can be used to decentralise the operations pertaining to surface water and groundwater management. The headquarters of the NWC for each river basin have then been so chosen as to ensure that it is either a CWC Chief Engineer's headquarters and/or the Regional Directorate of CGWB. The mandate and structure of the NWC will be mirrored in the constitution of the regional river basin centres of the NWC, primarily in the interdisciplinary functions that such centres are expected to perform. While doing so, the current CE's offices of CWC and the Regional Directorates of the CGWB can be retained where they already exist while integrating their functions through the NWC centre present in the respective river basin.

Moreover, the table also indicates how the concept of the NWC can percolate further down to a more decentralised, sub-basin water management. The sub-centres are only a list of indicative locations for devolution of the NWC mandate, structure and operations and can be modified based on more work on the ground, especially on institutional devolution of the river basin concept for managing water resources.

Table 4.4: Proposed location of regional offices of NWC major river basins (*names in bold represent current offices of CWC and / or CGWB*

Basin no	Basin name	CWC offices (Chief Engineer's Officers)	CGWB offices (Regional Directorates)	Proposed basin headquarters of NWC	NWC – proposed sub-basin offices
1.	Indus – 1 (Indus, Jhelum and Chenab)	Chandigarh	Jammu, Dharamshala, Chandigarh	Chandigarh	Ludhiana
2.	Indus – 2 (Beas, Ravi and Sutlej)	Chandigarh	Jammu, Dharamshala, Chandigarh	Leh	Jammu, Dharamshala
3.	Ganga	Delhi, Lucknow, Patna, Bhopal	Dehradun, Delhi, Lucknow, Patna, Kolkata	Delhi	Dehradun, Lucknow Patna, Kolkata, Bhopal, Gwalior, Hazaribagh, Dhanbad
4.	Brahmaputra (including Teesta)	Shillong; Siliguri	Guwahati	Guwahati	Itanagar, Dibrugarh, Siliguri
5.	Barak and others	Shillong		Shillong	Silchar
6.	Godavari	Nagpur	Nagpur	Nagpur	Nashik, Karimnagar, Rajahmundry
7.	Krishna	Pune, Hyderabad	Hyderabad	Hyderabad	Pune, Raichur, Kurnool, Vijaywada
8.	Cauvery	Bengaluru, Coimbatore	Bengaluru	Mysuru	Coimbatore, Bengaluru, Tiruchirapalli
9.	Subarnarekha			Jamshedpur	Ranchi, Ghatsila, Balasore
10.	Brahmani and Baitarni			Rourkela	Keonjhar, Kendrapara
11.	Mahanadi	Bhubaneshwar	Raipur, Bhubaneshwar	Raipur	Bilaspur, Cuttack, Bhubaneshwar
12.	Pennar			Nellore	Ananthapur, Tadipattri
13.	Mahi			Anand	Ratlam, Jambusar
14.	Sabarmati	Gandhinagar	Ahmedabad	Gandhinagar	Khed Brahma, Ahmedabad, Kheda

15.	Narmada			Hoshangabad	Mandla, Jabalpur, Omkareshwar, Bharuch
16.	Tapi			Jalgaon/Bhusaval	Burhanpur, Akola, Surat
17.	West flowing rivers between Tapi and Tadri			Panaji (Goa)	Silvassa, Mumbai, Ankola
18.	West flowing rivers between Tadri and Kanyakumari		Thiruvananthapuram	Thiruvananthapuram	Mangaluru, Thrissur,
19.	East flowing rivers between Mahanadi and Pennar			Vishakhapatnam	Ganjam, Srikakulam, Ongole
20.	East flowing rivers between Pennar and Kanyakumari		Chennai	Chennai	Tirupati, Puducherry, Ramanathapuram, Kanyakumari
21.	West flowing rivers of Kutch and Saurashtra including Luni			Bhuj	Bhavnagar, Diu, Rajkot, Jamnagar, Kandla, Pali, Jalore
22.	Area of inland drainage in Rajasthan			Jodhpur	Bikaner, Barmer, Jaisalmer
23.	Minor rivers draining into Myanmar and Bangladesh			Imphal	Imphal and Keitum
24.	Rivers in Lakshadweep Islands			Kavaratti	Kavaratti
25.	Rivers in Andaman and Nicobar Islands			Port Blair	Car Nicobar

4.6 Ensuring a Smooth Transition to the NWC: Redeployment of Personnel

It should be definitely possible to reallocate the existing CWC-CGWB personnel into the various divisions of the NWC both at the Centre and at the river basin offices. This is because our proposal is essentially concerned with strengthening the existing capacities of both these institutions with additional personnel, both in-house (on contract) and available on call through institutional partnerships with eminent organisations across the country

Table: 4.5 Present Deployment of CWC Technical Officers (June 2016)

HQ/F/O	Member	Chief Engineer	Director/SE	Deputy Director	Assistant Director
CWC-HQ	Member (D&R)	6	32	63	92
	Member (WP&P)	9	35		
	Member, RM	2	11		
		CE, HRM	4		
CWC-Field	Bangalore	1	3	2	2
	Chandigarh	1	4	4	12
	Shillong	1	5	7	34
	Patna	1	4	4	17
	Lucknow	1	3	5	20
	Silliguri	1	3	1	6
	Gandhinagar	1	4	2	11
	Nagpur	1	3	2	6
	Bhubaneshwar	1	3	2	9
	Hyderabad	1	3	4	27
	Coimbatore	1	4	5	15
	Delhi, Yam. Basin	1	7	5	22
	Bhopal	1	4	5	6
Other-Offices	Member (GFCC)	4	4	1	1

Mechanical Engineering	70
Civil Engineering	493
CWES Cadre Officers	563

We can see that of the 563 technical officers in the CWC, 493 are civil engineers and 70 are mechanical engineers. They can all be easily absorbed within the NWC. What is more important to note is that, officers from a large number of disciplines as outlined in this chapter will be required, in addition to many more engineers who will be required at the regional offices at the river basin level. These offices can be gradually set up over the next 5 years and necessary recruitments be done accordingly.

A similar picture can be seen in the CGWB.

Table 4.6 Strength of Technical Officers (Scientific & Engineering) in CGWB (as on 01.06.2016)

SCIENTIFIC CADRE		Qualification	Sanctioned	Filled	Vacant
Posts	**Discipline**				
Group-A **Chairman, Member, Regional Director, Scientist 'D', Scientist 'C' and Scientist 'B'**	**Hydrogeology, Geophysics, Chemists, hydrologists, Hydro meteorologist/ Engineering/**	**Post Graduation in Science / Engineering**	**403**	**320**	**83**
Group-B (Gazetted) * **Asstt. Hydrogeologist/ Chemist/ Geophysicst/Hydrologist**			**219**	**120**	**99**
Sub Total			**622**	**440**	**182**
ENGINEERING CADRE					
Group-A **Suptd. Engineer, Executive Engr, AEE**	**Engineering**	**Bachelors in Engineering**	**56**	**41**	**15**
Group-B (Gazetted) **Asst Engr., Driller In Charge**		**Bachelors in Engineering / Diploma in Engineering**	**110**	**33**	**77**
Sub Total			**166**	**74**	**92**
Grand Total			**788**	**514**	**274**

Of the 788 posts, as many as 274 are lying vacant. And the posts are manned mainly by hydrogeologists and engineers, supplemented by a few hydro-metereologists and physics and chemistry post-graduates. There is an acute lack of the other disciplines whose importance has been outlined in this chapter. All these officers can easily be absorbed into the NWC and placed at both headquarters and river basin offices, along with the new recruits from several related disciplines needed to fulfil the fresh mandate of the NWC, who will be needed both at headquarters and at each river basin office of the NWC.

Annexure I: ToR of the Committee

Water Resource planning, augmenting and budgeting has to be done in an integrated manner. The best way to develop the same is taking major river basin as a hydraulic unit and its tributaries as sub-basins for water resource management and its utilization including budgeting. Aquifers are integral elements of any river basin, apart from watersheds and sub-basins. Hence, it is important to map and characterize aquifers in such river basin planning. River basin as a hydraulic unit for planning and development of water would be an ideal approach as it will help the planners to know the total rainfall, flows and stock on the surface, rate of ground water recharge, storage and flows in underlying aquifers, including the status of exploitation/utilization of water and the base flow contribution of aquifers to the streams and rivers in the basin, recharge zones, soil-moisture storage and the changes therein, given the increasing vagaries of the monsoons and the changing scenarios of other climate factors.

The Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD & GR) has two specialized organizations called Central Ground Water Board (CGWB) and Central Water Commission (CWC) which are respectively working for ground and surface water. CWC is generally confining its manpower resources to according Techno-economic Clearance (TEC) whereas CGWB conducts studies and runs periodic national – level assessments of ground water resources but has conducted its activities in an unsystematic manner. In order to develop integrated water resources, management and development, and adopting basin./sub-basin as a hydraulic unit, both the organizations namely CWC and CGWB, needed to be re-oriented and re-structured along the river basin basis.

Specifically, the CWC must be able to move forward the agenda of large irrigation reform pioneered in Gujarat and followed by several other states in the Country to ensure last-mile connectivity so that water actually reaches the farmers in all command areas of the Country. The CGWB must be able to build partnerships that enable it to complete the task of aquifer mapping and aquifer management that it has been tasked with.

In the above background it was decided to constitute a committee to undertake a detailed study and make suitable recommendations. The composition of the Committee is as under :

(1)	Dr. Mihir Shah, (Ex-Member - Planning Commission)	Chairman
(2)	Professor. Brij Gopal of IIT, Delhi	Expert
(3)	Professor. Vinod Tare of IIT, Kanpur	Expert
(4)	Dr. Kanika T. Bhal, IIT, Delhi	Member
(5)	Dr. Tushaar Shah, IWMI, Anand	Member
(6)	Dr. Himanshu Kulkarni, ACWADAM, Pune	Member
(7)	Shri B. Rajendra, Joint Secretary (PP)	Member Secretary

The Committee had following terms of Reference

i. To recommend suitable re-orientation and re-structuring of CWC and CGWB at the basin and sub-basin level.

ii. To assess the capacity requirement of CWC and CGWB to discharge all functions as envisaged for integrated water resource management.

iii. To prepare specific task, duties and responsibilities, to each of the two organisations so as to enable them to achieve the objectives of integrated water management, development, planning, water use efficiency and water budgeting.

iv. To assess the need for specific capacity building requirement among the staff of CWC and CGWB.

v. To recommend an ideal structure at basin/sub-basin level for CWC and CGWB to discharge their duties to accomplish the above objectives.

vi. To assess the financial implications to achieve the objectives.

Annexure II: Procedure Adopted by the Committee

Procedure adopted by the Committee was democratic and consultative. It was ensured that views of all relevant stakeholders were obtained on the issue of restructuring of CWC & CGWB. Extensive consultations were held with various stakeholders through meetings of the Committee as briefly outlined below. Views of State Governments were also sought. The State Governments were requested to share their views, experience and requirements in the management of composite use of water resources and the ToR of the Committee. We were extremely happy with the response we got from a large number of States. The staff/union representatives of CWC and CGWB were also given patient hearing and their views, perceptions, expectations and good practices for better management of water sector were invited Extensive deliberations were also held among members of the Committee on various issues, based on these consultations and an examination of all reports of former committees set up by the government concerned with the ToR of the Committee.

Subcommittees were also formed to assist the Committee for finalization the report.

A total of ten meetings of the Committee were held as described below:

Tenth Meeting	13.05.2016	Discussion and Finalization of Report
Ninth Meeting	31.03.2016	Presentation by JS(A & GW), Brief Address by Secretary (WR, RD & GR)
Eighth Meeting	2.03.2016	Interaction with CII and FICCI representatives over restructuring. Presentations by various sub-committees
Seventh Meeting	8.02.2016	Interaction with Staff associations of CWC and CGWB over restructuring.
Sixth Meeting	11.01.2016	Interaction with various eminent experts in water sector
Fifth Meeting	4.12.2015	Interaction with former Chairmen of CGWB
Fourth Meeting	2.11.2015	Interaction with representatives of State Govt. Ground Water Boards and CGWB
Third Meeting	16.10.2015	Interaction with CGWB staff
Second Meeting	7.10.2015	Interaction with CWC staff
First meeting	24.09.2015	Discussion on TOR of Committee

To enable in-depth exploration of issues involved, four sub-committees were constituted and were given freedom to explore and submit their views to the Chair.

Sub-Committee on CGWB

1.	Dr. Himanshu Kulkarni , Chairman
2.	Dr. Sekhar Muddu, IISc, Bengaluru, Member
3.	Dr. Rajiv Sinha, IIT Kanpur, Member
4.	Shri Sujit Sinha (CGWB), Member
5.	Shri Pratul Saxena (CGWB), Member

Terms of Reference

i. A Sub-Committee with above composition has been constituted to help the Committee under chairmanship of Dr Mihir Shah for restructuring of CWC & CGWB to fulfill its terms of reference.

ii. This Sub-Committee shall provide recommendations for restructuring of CGWB by 31st January 2016.

iii. These recommendations shall be as per terms of reference of Committee under chairmanship of Dr Mihir Shah for restructuring of CWC & CGWB

iv. Members of Sub-Committee from MoWR RD & GR, CWC and CGWB shall help finalize the report of Sub-Committee.

v. The preferred mode of communication for the sub-committee members shall be through email / skype / video-conferencing / Telephone.

vi. The sub-Committee may partially modify its scope of study or recommendation with approval from Chairman of the Committee for restructuring CWC and CGWB.

Sub-Committee on CWC

1.	Prof. Vinod Tare, Chairman
2.	Dr. Ravi Chopra, PSI, Dehradun, Member
3.	Shri K.J. Joy, SOPPECOM, Pune, Member
4.	Shri D.P. Mathuria (CWC), Member
5.	Shri Sanjay Gangwar, SJC (MoWR)- Member

Terms of Reference

vii. A Sub-Committee with above composition has been constituted to help the Committee under chairmanship of Dr Mihir Shah for restructuring of CWC & CGWB to fulfill its terms of reference.

viii. This Sub-Committee shall provide recommendations for restructuring of CWC by 31st January 2016.

ix. These recommendations shall be as per terms of reference of Committee under chairmanship of Dr Mihir Shah for restructuring of CWC & CGWB

x. Members of Sub-Committee from MoWR RD & GR, CWC and CGWB shall help finalize the report of Sub-Committee.

xi. The preferred mode of communication for the sub-committee members shall be through email / skype / video-conferencing / Telephone.

xii. The sub-Committee may partially modify its scope of study or recommendation with approval from Chairman of the Committee for restructuring CWC and CGWB.

Sub-Committee on Capacity Building

1.	Prof. Brij Gopal, Chairman Dr. Himanshu Kulkarni, Chairman
2.	Shri Biswadeep Ghose, ARGYAM, Bengaluru, Member
3.	Shri Sushil Gupta, Former Chair CGWB, Member
4.	Dr. Pradeep Majumdar, Member
5.	Dr. Rana Chatterji (CGWB), Member
6.	Representative from AFFRO, Member
7.	Sh. Asit Chaturvedi (MoWR), Member

Terms of Reference

xiii. A Sub-Committee with above composition has been constituted to help the Committee under chairmanship of Dr Mihir Shah for restructuring of CWC & CGWB to fulfill its terms of reference.

xiv. This Sub-Committee shall provide a report on capacity building programme for officers and staff of CWC and CGWB by 31st January 2016.

xv. The proposed capacity building programme shall be as per terms of reference of Committee under chairmanship of Dr Mihir Shah for restructuring of CWC & CGWB

xvi. Members of Sub-Committee from MoWR RD & GR, CWC and CGWB shall help finalize the report of Sub-Committee.

xvii. The preferred mode of communication for the sub-committee members shall be through email / skype / video-conferencing / Telephone.

xviii. The sub-Committee may partially modify its scope of study or recommendation with approval from Chairman of the Committee for restructuring CWC and CGWB.

Sub-Committee on Institutional Structure

Terms of Reference

Dr. Kanika T. Bhal , Chairman
Himanshu Thakkar, SANDRP, Member
Prof. Jayanta Bandoyapadhya, Member
Shri Shripad Dharmadhikary, Manthan, Member
Sh. Avnish Kant (CGWB), Member
Sh. S.K. Sharma (MoWR), Member

xix. A Sub-Committee with above composition has been constituted to help the Committee under chairmanship of Dr Mihir Shah for restructuring of CWC & CGWB to fulfill its terms of reference.

xx. This Sub-Committee shall provide a report on proposed institutional structure for CWC and CGWB by 31st January 2016.

xxi. The proposed institutional structure shall be as per terms of reference of Committee under chairmanship of Dr Mihir Shah for restructuring of CWC & CGWB

xxii. Members of Sub-Committee from MoWR RD & GR, CWC and CGWB shall help finalize the report of Sub-Committee.

xxiii. The preferred mode of communication for the sub-committee members shall be through email / skype / video-conferencing / Telephone.

xxiv. The sub-Committee may partially modify its scope of study or recommendation with approval from Chairman of the Committee for restructuring CWC and CGWB.