

# Ground Water Development - Issues and Sustainable Solutions

S. P. Sinha Ray  
Editor

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*The Members of Centre for Ground Water  
Studies, Kolkata*

# Foreword

India is facing a perfect storm in terms of managing water, both surface and underground. Decades of continued mismanagement by central, state and municipal authorities, private sector and general public as well as political apathy and interference, institutional incompetence, rapid industrialization and urbanization, a steadily increasing population aspiring and demanding a better quality of life, poor implementation of existing environmental laws, pervasive corruption, poor adoption of currently available cost-effective technologies and absence of good policies at all levels of government are only some factors which have contributed to the development of this perfect storm. All the indications are that unless the current water management practices all over the country are significantly improved, the situations will get progressively worse.

In spite of this sad current state of affairs, there are no real signs that politicians are waking up to address effectively the rapidly deteriorating water situations all over the country and are willing to take hard decisions to improve the existing conditions. Policies have been mostly ad hoc, incoherent, short term, often incorrect and at best incremental. Even these policies are rarely implemented properly. It really has not mattered which political parties have been in power at central and state levels; net results have been steadily deteriorating water conditions all over the country both in terms of quantity and quality.

At the central level, the last competent water minister who stayed in the position for a reasonable period of time was Dr. K. L. Rao. It was more than half a century ago. During the past 20 years, India has had ten water ministers. One even lasted all of one day! During the same period, the Ministry has had 14 secretaries. Not surprisingly, this revolving door has ensured that not one minister nor one secretary has had any lasting impact on water management of the country.

Surface water conditions in the country are bad, but groundwater situation is even worse.

Groundwater abstractions in the country are increasing steadily and significantly. It has become progressively more and more unsustainable over the past six decades. Consequently, in many parts of the country, groundwater levels have been declining by more than 1 metre per year. Lack of proper wastewater management from

domestic, industrial, agricultural and mining sources has ensured progressive deterioration of groundwater quality by known and unknown contaminants. This is already endangering the health of both humans and ecosystems.

Monitoring of surface water quality is poor. However, monitoring of groundwater quality is truly dismal!

During the past three decades, there has been an explosive growth of private tube-wells in agricultural farms because of the absence of reliable surface water supply for irrigation. This is compounded by Indian laws which guarantee exclusive rights to landowners over groundwater. These factors, plus free electricity to farmers for pumping, have ensured groundwater use in the country has been unsustainable for decades.

Consider monitoring of groundwater quantity and quality uses. Despite having four separate central bodies regulating groundwater, there is no single groundwater database for the country. In 2016, the Standing Committee of Water Resources of the Indian Parliament finally recommended the need for having a central groundwater database. However, when this will happen is anybody's guess.

Data on groundwater availability, use and quality are patchy and often unreliable. The best estimate now is India is using 230–250 km<sup>3</sup> of groundwater each year. More than 60% of irrigated agriculture and 85% of domestic water use now depend on groundwater. Because of prolonged and poor groundwater governance, India alone now accounts for one-quarter of the global groundwater use. The country currently uses more groundwater than China and the USA combined.

In 2009, NASA reported that the Indus Basin is the second most overstressed aquifer in the world. The Basin includes Punjab and Haryana, the two main granaries of the country. NASA also noted that groundwater depletion rate in North India is about 1 metre every 3 years. This is 20% higher than an earlier assessment of the Indian Water Ministry.

The extent and gravity of the Indian groundwater situation is not in doubt. With increasing population, urbanization and industrialization, the situation will get progressively worse. Nearly half of India's employments are now in the agricultural sector. This means groundwater management in India needs urgent attention from all the levels of government, private sector, academia, research institutions and general public.

I am thus heartened to see Dr. Syama Prasad Sinha Ray, one of the India's leading groundwater experts, writing an authoritative and objective book on the groundwater problems of the country and their sustainable solutions. There is absolutely no question that this book was long needed. I not only wish the book much success but earnestly hope that India's policymakers and academics will make a determined attempt to implement many of the solutions recommended in this book. The country has simply no other choice.

Distinguished Professor, Lee Kuan Yew School  
of Public Policy

Asit K. Biswas

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# Preface

Major groundwater development problems in India and adjoining South Asian countries are over-exploitation, chemical contamination, seawater intrusion and uneven distribution in time and space. A precise understanding of the complex groundwater regimes in different hydrogeological settings and under different socio-economic conditions in this part of the world is a primary necessity for planning sustainable and equitable management of these precious resources. Deterioration of groundwater quality consequent to large-scale groundwater development to support agricultural and industrial activities has already emerged as a threat to sustainability of groundwater development schemes already in progress. The problem of drinking water supply, especially in rural areas which rely 90% on groundwater sources, has been aggravated, and in some places, availability of safe and adequate drinking water supply to the communities has become a matter of great concern. It was therefore felt necessary to review such groundwater development issues which are so similar in nature in India and other South Asian countries.

The majority of the scientific papers included in this book were submitted in the International Seminar on “Challenges to Ground Water Management: Vision 2050” organized by the Centre for Ground Water Studies at ITC Sonar Hotel, Kolkata, on 13–14 November, 2015. Prof. P. K. Sikdar, member, Centre for Ground Water Studies, made painstaking efforts to review the papers as per the format prescribed. Mrs. Pampa Bhattacharya, member, Centre for Ground Water Studies, assisted Prof. Sikdar in his effort. Their valuable contributions made at the initial stage are gratefully acknowledged. Subsequently, when it was contemplated by Springer IN to publish the book on our request, the selected papers were sent to the authors for revision and updating. The individual authors whose contribution in this field of hydrogeology is well known took considerable pains in revising the manuscripts. It is needless to emphasize, only due to their sincere and timely efforts that it has been possible to bring out the publication.

It is my proud privilege that Prof. Asit Kumar Biswas, distinguished visiting professor of Lee Kuan Yew School of Public Policy and co-founder of Third World Centre for Water Management, Mexico, who is well recognized universally because

of his highly illustrious work in the field of Water Development and Management, has kindly written the “Foreword” of the book. I have no words to acknowledge such kindness.

I am deeply obliged by the active cooperation of my colleagues in CGWS, especially Shri. Abhijit Ray, president, and Dr. Sandhya Bhadhury, assistant secretary, whose encouragement at every stage made it possible to go ahead with the publication in spite of my ailing conditions. Shri. Saheb Das, technical assistant, CGWS, offered most useful secretarial assistances in making correspondences with the authors and Springer IN which is deeply acknowledged.

My special thanks are due to the editorial groups of Springer IN, specially Dr. Mamta Kapila, Mr. Daniel Ignatius Jagadisan and Ms. Raman Shukla who have continuously provided guidance in making out the publication.

Kolkata, India

S. P. Sinha Ray

## **Thoughts from Abroad: Communication Received from Prof. Asit Kumar Biswas**

Regrettably groundwater management has not received adequate attention in India for decades. How much groundwater the country has, how much of it is being withdrawn every day and how much is being replenished annually are not reliably known. In the absence of reliable estimates and public apathy and lack of sustained political and bureaucratic will to manage groundwater efficiency and equitably on long-term basis, serious mismanagement is continuing to take place.

The problem was compounded by poor advice the country received from the development banks in the 1970s and 1980s, which equally, unfortunately, the Indian Government accepted without any serious scrutiny. Thus, for the World Bank/IFAD Project on UP Groundwater Irrigation of the 1980s had to have dedicated electrical transmission lines so that the farmers would have 24-h free electricity for pumping. This was in spite of the fact that the inhabitants of major cities like Lucknow did not even have continuous electricity supply. This was a necessary condition for the World Bank/IFAD loan for the project.

Not surprisingly, food production did increase for several years, but no one, neither the World Bank nor the Indian Government, anticipated the long-term economic and social costs to the country of such ill-conceived policies. It created many vicious circles. As farmers pumped water indiscriminately, groundwater levels started to decline. Consequently, the farmers had to install higher horsepower pumps for pumping water from greater depths. Thus, groundwater levels have continued to decline precipitously in many parts of the country for decades. Free, or highly subsidized, electricity for pumping has ensured that nearly all Indian utilities are nearly bankrupt. It has thus been a lose-lose situation for the country as a whole, both in terms of water and electricity.

In drought years, pumping by the farmers intensifies further because of surface water shortages. A major problem is likely to be that continuation of such unsustainable practices may soon reach tipping points during future drought years. This could deplete groundwater to such levels in the coming years that pumping becomes impossible or seriously uneconomic. In addition, this would contribute to serious environmental problems, including land subsidence.

This is *only* one of the numerous groundwater management problems the country is facing at present.

I sincerely hope that the seminar will discuss these types of complex and real issues and come out with a roadmap for sustainable development and management of groundwater in India for the coming years.

Dated: June 16, 2017

## India's Wells Are Running Dry, Fast



*Ratanpura Lake, on the outskirts of Ahmedabad, Gujarat, has almost completely dried up. Amit Dave/Reuters*

Over the past 3 years, the monsoon – the rainy season that runs from June through September, depending on the region – has been weak or delayed across much of India, causing widespread water shortages.

With the onset of summer this year, southern India, particularly Karnataka, Kerala and Tamil Nadu states, are already wilting under a blistering sun and repeated heatwaves. Drought is expected to affect at least 8 states in 2017, which is a devastating possibility in a country where agriculture accounted for 17.5% of GDP in 2015 and provides the livelihood for nearly half the population.

Across rural India, water bodies, including man-made lakes and reservoirs, are fast disappearing after decades of neglect and pollution.

“They have drained out the water and converted the land into a plot for schools, dispensaries, and other construction activities”, Manoj Misra of NGO Yamuna Jiye Abhiyan warned in *The Hindu* newspaper as far back as 2012.



*Residents wait for the government-run water tanker in Masurdi village, Maharashtra. Danish Siddiqui/Reuters*

## **Not a Drop to Drink**

It was not always this way. For the past 2500 years, India has managed its water needs by increasing supply.

Prior to industrialization and the accompanying global “Green Revolution” in the 1960s, which saw the development of high-yield variety crops using new technologies, India’s water availability was plentiful. Households, industries and farmers freely extracted groundwater and dumped untreated waste into waterways without a second thought.

But such practices are now increasingly untenable in this rapidly growing country. Per capita availability of water has been steadily falling for over a decade, dropping from 1816 cubic metres per person in 2001 to 1545 cubic metres in 2011.

The decline is projected to deepen in the coming years as the population grows. India, which currently has 1.3 billion people, is set to overtake China by 2022 and reach 1.7 billion in 2050.

Water scarcity is also exacerbated by a growth in water-intensive industries, such as thermal power production, extraction and mining, as India seeks to feed and power its growing population. In addition to affecting biodiversity, these activities also alter natural water systems.

Still, successive governments have pursued the same old supply-centric policies, paying little heed to the country’s waning clean water supplies.

For nearly 50 years, a misguided groundwater policy has sucked India dry; water tables have declined by an average of 1 metre every 3 years in some parts of the Indus basin, turning it into the second most overstressed aquifer in the world, according to NASA.

Across nearly the whole country, basic sewage management is also lacking. According to the Third World Centre for Water Management, only about 10% of wastewater in the country is collected and properly treated. As a result, all water bodies in and around urban centres are seriously polluted.

Today, the country is struggling to provide safe drinking water to every citizen.



*Sugarcane production is highly water-consuming and should be managed more efficiently. Kolkata, 2015. Rupak De Chowdhuri/Reuters*

## What Conservation?

Even so, residents of New Delhi or Kolkata today use more than twice as much water, on average, than people in Singapore, Leipzig, Barcelona or Zaragoza, according to data compiled by the Third World Research Centre.

The water use in Delhi is 220 litres per capita per day (lpcd), while some European cities boast figures of 95 to 120 lpcd.

Excess consumption is attributable in part to citizen indifference about conserving water after so many years of plentiful supply. Since large swaths of many Indian megacities lack piped supply of clean water, leaks and theft are common. Cities in India lose 40% to 50% due to leakages and non-authorized connections.

At this point, the only viable option for India would seem to be managing demand and using water more efficiently.

The country is making tentative steps in that direction. The 2016 new National Water Framework, passed, emphasizes the need for conservation and more efficient water use.

But under India's Constitution, states are responsible for managing water, so central policies have little resonance. Neither the 1987 nor 2012 National Water Policy documents, which contained similar recommendations to the 2016 policy, had any real impact on water use.

And after millennia of exclusive focus on expanding the water supply, the idea of curbing water consumption and increase reuse remains a mostly alien concept in India.

## **Water Wars**

Consistent supply-centric thinking has also resulted in competition for water as states negotiate the allocation of river water based on local needs.

The century-long conflict over the Cauvery River, for example, involves Andhra Pradesh, Tamil Nadu and Karnataka – three major south Indian states. With each state demanding ever more water, the river simply cannot keep up.

In Karnataka, where agricultural policies are heavily skewed towards water-guzzling commercial crops, such as sugarcane, mismanaged ground and surface water are dying a slow death. Still the state continues to petition the Cauvery Water Dispute Tribunal for an increase in its share.

Water scarcity in Karnataka is aggravated by non-existent water quality management. Its rivers are choked with toxic pollutants, and oil-suffused lakes in Bengaluru, the capital, are reportedly catching fire.

Meanwhile, in the northern part of the country, the Ravi-Beas River is causing conflict between Punjab and Haryana states.

In India's water wars, rivers are a resource to be harnessed and extracted for each riparian party's maximum benefit. Very little emphasis has been placed on conserving and protecting existing water sources. And not one interstate negotiation has prioritized pollution abatement or demand management.

Even policies from the national government, which claims to target water conservation and demand management, remain reliant on supply-side solutions. Big infrastructure programmes, such as the Indian river-linking plan, envision large-scale water transfer from one river basin to another, again seeking to augment supply rather than conserve water and reduce consumption.



*Sand mining on the Cauvery river in 2017. [Prashanth NS/Flickr](#), [CC BY-SA](#)*

For inspiration on managing demand, India could look to Berlin in Germany, Singapore and California, all of which have designed and implemented such policies in recent years. Successful measures include raising public awareness, recycling water, fixing leaks, preventing theft and implementing conservation measures such as water harvesting and storm water management.

Between rapidly disappearing freshwater, unchecked pollution and so many thirsty citizens, India is facing an impending water crisis unlike anything prior generations have seen. If the nation does not begin aggressively conserving water, the faucets will run soon dry. There is simply no more supply to misuse.

Asit K. Biswas, distinguished visiting professor, Lee Kuan Yew School of Public Policy, National University of Singapore; Cecilia Tortajada, senior research fellow, Lee Kuan Yew School of Public Policy, National University of Singapore; and Udisha Saklani, independent policy researcher

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October 6, 2015

Asit K. Biswas

# Communication Received from John M. Mc Arthur

A good understanding of groundwater resources – their amount and quality – is essential for the planning and development of any nation that wishes to avoid the mistakes of the past. Those mistakes have left a global legacy of both polluted water on the surface and underground and over-abstraction that impedes sustainable development and reduces the quality of life for many peoples.

Through 30 years of working in India and with Indian colleagues, I know that Indian scientists and engineers currently have much of the knowledge necessary to formulate an excellent management plan for groundwater in India and could rapidly complete their understanding were they given the right conditions in which to do so. Principal amongst those conditions is an increased willingness to share data and understanding between the numerous institutions that are involved in groundwater management and to do so especially at the level of junior staff. In a federated country, that means that states and the centre should work together better. Let me list the organizations involved at present:

1. Central Ground Water Board, Ministry of Water Resources, River Development and Ganga Rejuvenation
2. Ministry of Drinking Water and Sanitation
3. State Ground Water Boards (in West Bengal the State Water Investigation Department)
4. Public Health Engineering Departments
5. The Departments of Science and Technology
6. IITs, IISWBM and universities and research organizations such as NGRI, CWRDM, BARC
7. Municipal corporations in urban areas and Panchayats in rural areas

An enduring management plan for groundwater in India, and I emphasize the word *enduring*, can only be achieved if all relevant organizations buy in to the plan, and that means working together and sharing data and information. Junior staff, in

particular, should be freed to exchange and discuss information with less restraint than now from bureaucratic impediment. I hope the seminar succeeds in bringing together relevant people to help achieve those aims.

Earth Sciences  
University College London  
London, UK  
20th October, 2015

John M. McArthur [j.mcarthur@ucl.ac.uk](mailto:j.mcarthur@ucl.ac.uk)

# **Communication Received from Prof. K. M. Ahmed**

## **Challenges of Groundwater Management in Bangladesh in 2050: Mission Impossible Vis-a-Vis Visions for Sustainable Development**

### *Groundwater in the Context of Bangladesh*

Groundwater has been the backbone of Bangladesh's remarkable achievements in the fields of access to safe water and food security. Despite being a delta country crisscrossed by numerous rivers including the Ganges-Brahmaputra-Meghna, dependence of groundwater is increasing every day to meet the demands of various sectors.

### *Current Challenges of Groundwater Management: Mission Impossible?*

The ever-increasing demands along with natural stressors result into major challenges for management of the vital natural resource in the country. Increasing population is the major challenge where groundwater is the main source of safe water for drinking and domestic purposes in rural and urban areas. Meeting the demand for increasing food production is another major challenge for the world's most densely populated country. Significant increase in dry season rice production through groundwater irrigation has made the country self-sufficient in rice, and production of all major crops has also increased. Demand for water is also increasing due to faster rate of urbanization and industrializations; groundwater is the major source of supply of municipal and industrial waters. The scenario of too much and too little surface water compels to use more and more groundwater all over the country, and large groundwater is fresh and free from pathogenic contaminants over most of the

country, and switching to this source for drinking saved millions of lives over the year. Occurrences of natural arsenic and salinity are the two most severe water quality issues of the current time. Millions of people are still drinking arsenic above national and international standards, whereas people living in the coastal areas are exposed to high salinity. Also, pollution of groundwater due to municipal, agricultural and industrial sources is becoming widespread. People living in the slums in the big cities and adjacent to industrial towns suffer from safe water scarcity.

Groundwater abstraction is increasing every day without a proper management and monitoring plan. Conventional water pumps are becoming inoperative in many areas due to declining water levels and need to be replaced by alternative expensive pumping technologies. Groundwater governance is almost nonexistence in the country due to mainly lack of proper institutional arrangements. There are rules, regulations and policies to ensure proper management, but enforcement is lacking.

### ***Bangladesh in 2050: Water Challenges for the Emerging Tiger***

Bangladesh economy is growing fast and will become the 23rd largest economy in 2050. Water for agricultural and industrial sectors will be much needed to sustain this growth. Bangladesh population will reach 202 million in 2050, and about half of the people would live in urban areas. Dhaka is the fastest growing megacity and will be joined by other megacities in 2050, resulting in a very high demand of municipal water supply. Intensification of agriculture would continue, and production has to be increased by 97.4% to ensure food security. Groundwater irrigation would play the major role here, but at the same time, agricultural pollution will become a major issue. Industrial development would surpass many western economies which would lead to more abstraction and more contamination. Emerging contaminants like pharmaceutical by-products and personal care products can be a major source of groundwater pollution. Intra-sectoral conflict would increase particularly between domestic water supply and irrigation sectors. Transboundary groundwater issues will emerge, and sharing both surface and groundwater resources with neighbouring countries will pose a major challenge. Climate change may have significant impacts on the hydrologic cycle, and hydro-disasters may become more frequent, resulting in quality- and quantity-related issues for the groundwater resources.

### ***Visions for Sustainable Groundwater Management***

Better governance has to be the main agenda for meeting the challenges of groundwater management in 2050. A national institute empowered with necessary technical, financial and legal resources is crucial for ensuring sustainable use of the vital natural resource. Full commitment towards adaptation to integrated water resource

management has to be ensured at all levels. Decentralized water management at planning area or basin scales has to be introduced. Managed aquifer recharge has to be adopted at all levels to augment the declining water levels. Water-sensitive urban designs have to be adopted and implemented for major urban areas and urban conglomerates for reducing impacts of urbanization on groundwater. Recycle and reuse of wastewater has to be promoted by combining technical options and awareness of stakeholders. Regional cooperation on water has to be increased for basin-wide management by conjunctive management. Bangladesh will have to adapt various water purifying technologies including reverse osmosis for salinity removal. Paradigm shift in people's perception about groundwater, which is now undervalued by users, is necessary for proper evaluation of the resource. Groundwater management has to be placed high in the political agenda in order to make it everybody's business. Courses on groundwater sciences have to be introduced at tertiary levels to produce more water experts. The research institutes have to be equipped with state-of-the-art laboratory facilities. Predictive groundwater modelling can aid better in decision-making. National monitoring system has to be updated along with open access to data for all users and interested parties. Groundwater has to be protected from overexploitation and degradation by introducing abstraction controls and licensing.

### ***Groundwater: Vital Resource for a Better Bangladesh in 2050***

Like today, groundwater shall remain one of the main sources of water for various uses in 2050 as well. However, ensuring sustainability of groundwater development shall become a mammoth challenge. Various natural and anthropogenic stressors will make the sustainable management extremely difficult.

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S. P. Sinha Ray

## About the Editor



**S. P. Sinha Ray** has been a member of Central Ground Water Board and Central Ground Water Authority, Ministry of Water Resources, Government of India. He has more than 40 years of experience in groundwater exploration, development and management. By virtue of his long association with the country's apex organization dealing with groundwater resources, he has acquired substantial expertise in the field. Besides having a vast knowledge of the subject within the country, he has also gained insights and know-how in other countries like Algeria, Bangladesh, the USA, Korea, Zimbabwe and Japan. He is a Fellow of West Bengal Academy of Science, a Member, International Association of Hydrogeologists and Emeritus President, Centre for Ground Water Studies, Kolkata.