

Water Resources Development and Management

Asit K. Biswas
Cecilia Tortajada *Editors*

Water Security, Climate Change and Sustainable Development

 Springer

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Water Security, Climate Change and Sustainable Development

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Foreword

The Vibrant Gujarat series of biennial summits was the brainchild of my predecessor and the current Prime Minister of India, Hon. Narendra Modi. Started in 2003, it was conceived as an event to bring investments to Gujarat and to make the state the premier investment destination in the country by showcasing its business-friendly environment, transparent regulatory and administrative regimes and excellent infrastructure.

Gujarat accounts for about 6 % of the land mass of India and approximately 5 % of its population. However, the state now accounts for 7.6 % of the country's GDP, about 10 % of national employment and a whopping 22 % of Indian exports. Between 2001 and 2012, the state had an averaged annual GDP growth rate of 10 %, which was consistently well above the country growth rates. In 1991, it was an electricity deficient state. Through good planning and astute management, it now has a power surplus, with all its villages electrified. Viewed from any direction, Gujarat has made commendable progress over the past 15 years.

Geographically Gujarat is located in a very arid climate, with very few perennial rivers. Not surprisingly and historically, water scarcity has been a very serious issue in the state. Prior to 2001, during years of droughts, severe water crises often led to social tensions and even some years to riots in areas which severely suffered from lack of water. Migrations in search of water, and thus for survival of both humans and animals, were a common phenomenon during the dry summers.

With the construction of major water development projects like the Sardar Sarovar and completion of a Statewide Water Grid, water scarcities have become events of the past.

Because of the importance of water to social and economic development of Gujarat, and standard of living and quality of life of its people, the Government decided to hold one of the seven thematic seminars for the 2015 Vibrant Gujarat on water, climate change and sustainable development.

Gujarat has managed to ensure reliable water supply available for its people, both now and over the foreseeable future. However, with population steadily increasing because of natural causes and migration to the state due to steady and

progressive economic development and employment generation as well as rapid increase in human and economic activities, we have to run faster to stand in the same place in terms of ensuring water security. By 2050, per capita freshwater availability in the state will be significantly less than what it is at present. Thus, we have to significantly improve water use efficiencies for all our water-related activities. Accordingly, we are constantly searching for the latest scientific, technological and management advances and then adopt them to improve our water management processes and practices. The main reason for our success has been the formulation of state-of-the-art future-oriented plans and their timely execution.

Our planning and their execution have been consistently underpinned by responsible and proactive political leadership, clear, unambiguous and transparent administrative measures, relentless pursuit of economic growth, and perpetual quest for excellence to ensure better quality of life of our people. All these have contributed to steady improvements in the standard of living of our citizens. The net result, I am pleased to note, has been a true success story of self-reliance and resilience in all water-related areas, creation of consistent growth opportunities and continuing good governance.

While I am pleased with the situations of the past, present and the near future, the water issue has been made more and more complex and complicated due to the uncertainties posed by the expected climate change which is likely to affect nearly all our social and economic activities in somewhat unpredictable ways and rates. This is one of the main reasons why we chose to convene a special seminar during the last Vibrant Gujarat on the interlinkages between water, climate change and sustainable development.

Climate change has the potential to change perceptibly how we plan and manage rural and urban settlements, agricultural production, food availability and distribution, energy generation and use practices, manufacturing and transportation patterns and a host of other development activities. In the area of water, it could alter precipitation patterns and their spatial distribution over time, river flow regimes, groundwater availability and recharge patterns, and variations in water quality.

Aware of the potential impacts of climate change, we established the first Climate Change Department on human development and ecosystem conservation, in the year 2009, in any Indian states.

For our seminar we invited Prof. Asit K. Biswas, who is the Co-founder of the Third World Centre for Water Management in Mexico, to plan a truly world class seminar. He carefully selected and then specially invited the world's leading academics, heads of international organizations and captains of major industries to share their views on how best water, climate change and sustainable development be most successfully managed in Gujarat and the rest of the world. The result was a truly outstanding seminar which brought many new and innovative ideas to the fore. We are analysing them seriously for policy planning and possible implementation.

Because of the outstanding nature and results of this seminar, we decided to put together the best papers that were presented in Gandhinagar. This is the first time

during the entire history of Vibrant Gujarat, the results of one of its thematic seminars are being published as a definitive and authoritative book by a major international publisher so that not only Indians but also interested people from all over the world will benefit from the knowledge and ideas that were generated in Gandhinagar.

Finally, let me take this opportunity to express my personal appreciation to Dr. Rajiv K. Gupta and Prof. Biswas for arranging this authoritative and absorbing seminar, and Prof. Biswas and Dr. Tortajada for editing the resulting text. I am confident that the people of Gujarat as well as others from outside the state will benefit significantly from the contents of this book.

Anandiben Patel

Preface

Individually, each of the three issues of this book, water security, climate change and sustainable development, is a difficult, complex and somewhat challenging subject. Academics and policy-makers may often differ with each other as to even the definitions of each of the topics, let alone their implications and ramifications. Thus, and not surprisingly, when these three topics are combined together, their complexities, uncertainties and intricacies multiply by several orders of magnitude.

The fact is, in the real world, irrespective of how each of these three issues are defined, or how they interrelate and interact with each other with numerous known and unknown feedback loops, from a development-related policy perspective they have to be viewed, considered and analysed together. The danger is if each of these three topics is considered independently for formulation of appropriate policy responses, they may have negative implications on the other two issues. This could, for the most part, ensure that the impacts of the pursued policies on the society and the environment as a whole would most likely be sub-optimal, and in many cases even negative over the medium to long terms.

Water security, climate change and sustainable development are closely inter-related and, though difficult and challenging it may be to consider them together, we really have no other choice. Thus, this is a concerted attempt to consider them together from multi-sectoral, multidisciplinary, and multi-issues perspectives.

The book is based on the papers that were presented during an international seminar on the topic during the Vibrant Gujarat Investors' Summit, in Gandhinagar, in January 2015. All the authors were specifically invited to outline their views and thinking on these related issues. Following intensive peer reviews, only the best papers presented were selected. These were then modified by the authors in line with the reviewers' comments. The Government of Gujarat, through its Water Supply and Sewerage Board and Gujarat and Narmada Valley Fertilizers and Chemicals Limited was the main host and organizer of the Seminar with the Third World Centre for Water Management as the main knowledge partner.

Gujarat accounts for 6 % of India's land mass and around 5 % of its population. The state now contributes to 7.6 % of India's GDP, and about 10 % national

employment, but a stunning 22 % of the country's total exports. Between 2001 and 2012, Gujarat had an average annual growth rate of 10 %, almost consistently well above India's GDP growth rates. Furthermore, in 1991, Gujarat was a seriously electricity deficient state. However, it is now a power surplus state. All its 18,000 villages have been electrified.

In terms of water security, Gujarat has not been so fortunate. It is situated in a very arid climate within the Asian monsoon belt. Historically, people of the state have suffered serious water scarcity in non-monsoon months. During drought periods, which have been quite frequent, the people have suffered from serious water shortages for drinking, as well as for agricultural and livestock uses. Migrations in search of water have been a recurrent phenomenon during dry summer periods, when social tensions have been quite prevalent, including even water-related riots.

Fortunately, with good water governance practices, and accelerated construction of a state-wide drinking water grid, most of the ravages of water shortages and social tensions of the past have now been basically eliminated.

The socio-economic and water-related developments of the recent past, laudable though they have been, do not guarantee similar levels of continued progress in the future. This is partly because the water regimes of the past appear to be changing, rapidly changing urbanization and development patterns in the state, and equally rapid evolution of global Indian conditions.

Consider climate. Globally, driven by continued economic and population growth rates, anthropogenic emissions are now higher than ever. Annual emission growth rates up to the year 2000 were 1.3 %. Since then, this has increased to 2.2 %. Such developments are changing climate patterns all over the world, including changes in inter-annual and intra-annual precipitations in different parts of the world. This, in turn, is impacting on river flows and groundwater recharge potentials, and thus water availability and use patterns which will undoubtedly impact upon the future water security conditions of the world.

Gujarat has not been immune to these changes. Current data indicate that the frequency of hot days is showing a gradually increasing trend. Furthermore, frequency of cold days seems to be decreasing. Ahmedabad, the largest city in Gujarat, with already over 6 million people, has had serious heat waves in the recent past. In May 2010, temperatures soared to 46.8 °C, which led to heat stress resulting in serious health problems, including deaths, of its citizens. Many have predicted that the temperature may increase by an additional 2 °C which would have serious health, economic and social implications. It is the first Indian city which formulated a heat action plan in 2013.

Climate change may also bring a rise in seawater levels. The average annual rise in mean sea level in Gujarat is estimated to be around 1.3 mm. This is important for the state since it has 1,600 km of coastline, the longest in any Indian state. Rising sea level is likely to increase salinity of groundwater which would affect both humans and ecosystems. A one-metre sea level rise is estimated to affect 14,149 km² of area, about 6 % of its coastal population. Higher sea surges in the future may further exacerbate water security problems.

There is no question that water security has to be an integral and essential component of Gujarat's future sustainable development plans. Climate change and subsequent erratic and unpredictable rainfall patterns will affect river flow regimes of the past and groundwater recharge rates. Since a reliable and assured water supply of appropriate quantities and qualities is an essential prerequisite for sustainable development, the interplay and interactions between water, climate change and sustainable development will dictate the future of Gujarat's socio-economic development, as it will in all other Indian states and other countries.

The situation will be especially difficult and complicated in Gujarat since people during the post-2000 period have got used to steadily improving water availability as well as standard of living. They expect the future to be a continuation of the same. It will be a challenging task to meet the people's expectations and aspirations with all the uncertainties imposed on by climate change and rapidly evolving Indian and global conditions.

Fortunately, water is a renewable resource, and with good and efficient management, it can be used and reused numerous times. In addition, in the coming years, there will most certainly be tremendous advances in science and technology as well as management practices to store, use and reuse water. The starting point for solutions to ensure global water security will have to come from strong and effective institutions, political will, appropriate pricing for all types of water uses, good education for all water uses and continuous scientific, technological and management innovations.

We are convinced that the world's water problems are solvable, even after considering the uncertain implications of climate change over space and time.

The contributors to this book come from different disciplines. They represent different sectors like academia, government, business, international organizations and media. All the contributors are leading figures in their fields. We are convinced that this book will make significant contributions to the ongoing global debates and discussions on how we can best link water security, climate change and sustainable development to ensure a bright global future.

And finally we would like to pay compliments to Honourable Chief Minister of Gujarat Smt. Anandiben Patel who not only graced the occasion but also found time from her extraordinarily busy schedule to meet the experts who attended this international Seminar. Due to dedication and support of her team of officers headed by Dr. Rajiv K. Gupta IAS we could organize such a high quality event. We would also like to express our appreciation to Ms. Thania Gomez of the Third World Centre for Water Management, Mexico, for all her work to finalize this book.

Asit K. Biswas
Cecilia Tortajada

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Water Security, Climate Change and Sustainable Development: An Introduction

Asit K. Biswas and Cecilia Tortajada

Abstract The global population is estimated to increase from 7.3 billion at present to about 11.2 billion by 2100. Providing good quality of life for the existing hundreds of millions of people living in poverty and for the additional 3.9 billion people will be a challenging task under the best of circumstances. Many parts of the world are already facing serious water problems, both in terms of quality and quantity. Adding climate change scenarios further intensifies the uncertainties and complexities of the global situation by several orders of magnitude. The realities and politics of water security, climate change and sustainable development are likely to be one of the greatest challenges of the twenty-first century. Each country must rise to and meet these challenges successfully since there are no other alternatives. Status quo or incremental progress will not be an effective option.

A major global concern for all the countries and all the people of the world is how to ensure a high rate of economic growth that is both sustainable and equitable so that hundreds of millions of people who are now living in poverty can have a significantly improved standard of living and quality of life. Equally, the middle class can at the very least maintain their current lifestyles but preferably improve them progressively over time. This has to be achieved with full recognition of the fact that the world population is estimated to increase to 9.7 billion in 2050 and 11.2 billion by 2100, compared to around 7.3 billion at present.

Achieving this goal will not be an easy task because the world will have to eradicate poverty of the existing population and concurrently will have to cater to some 3.9 billion additional people during the next 85 years. Virtually all of these extra people will be in developing countries where lifestyles and standard of living

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of a majority of the people need to be significantly improved. It is currently estimated that more than 800 million people (14 % of the global population) live in extreme poverty which is defined as having an income of less than \$1.25 per day. It should be noted that these global figures by the international organizations, though extensively quoted and mostly taken at face value all over the world, are highly unreliable. In all probability, the numbers are significantly higher than what is now commonly believed.

Unfortunately the growth rates of industrialized countries have been somewhat anaemic in recent years. In addition, China's growth rates, which have been the envy of the world over the past three decades and have been responsible for moving hundreds of millions of the Chinese out of poverty, are now showing signs of trouble and declining from the earlier heady rates. This could be a serious development concern since the country has been an important engine for driving global economic growth in recent decades.

Water is an important component of sustainable development. Not only drinking water is essential for human survival but also it is needed for all types of human activities and endeavours, inter alia, food production, energy generation, resources extraction, industrial development, commercial activities, ecosystem preservation and host of other uses.

Water and energy are two resources which are needed for conducting literally all types of human activities. In addition, they are closely interrelated. Water cannot be produced and used without significant amount of energy, and energy cannot be generated without substantial quantities of water. Thus, however sustainable development is defined or assessed, it cannot be achieved without water and energy securities. Thus, ensuring sustainable development for the world means adequate quantities of water of appropriate qualities are available on a reliable basis over short-, medium or long terms. With the current unsatisfactory levels of water management nearly all over the world, this is unlikely to be possible.

During the Second World Water Forum, held in The Hague, in March 2000, the Ministerial Declaration noted the importance of water security in terms of "ensuring that freshwater, coastal and related ecosystems are protected and improved, that sustainable development and political stability are promoted, that every person has access to enough safe water at an affordable cost to lead a healthy and productive life, and that the vulnerable are protected from the risks of water-related hazards."

Water security of course includes all these issues but it also incorporates many others which the Ministers did not even consider. For example, one important issue that was ignored has been becoming an increasingly serious business risk over the past decades. In fact, the World Economic Forum perception survey of business leaders indicated that water currently is accepted to be the number one business risk in terms of impacts. Lack of adequate quantities of appropriate qualities of water on a reliable basis because of consistent poor governance over the decades has made it a serious risk for many types of business.

If the issue of climate change is added to water security and sustainable development, the problems become infinitely more complex and degrees of risks and uncertainties consequently increase by several orders of magnitudes. The

world's water supply is dependent on the rainfall of the past and present which is stored in the ground, lakes and rivers and also retained by man-made structures like dams and barrages. If the rainfall and distribution patterns change in the future, both over space and time, it will make ensuring water security a more complex, formidable and uncertain task. If water security cannot be assured, sustainable development will remain a mirage.

Water management and sustainable development will be affected very significantly because of future climate changes through a variety of pathways, only some of which are known at present and can be predicted with some degree of certainty. There are also likely to be other impacts which are currently unexpected and uncertain and thus are not being considered for any planning or policy-making purposes in any serious and consistent manner.

Climate change will have impacts on various aspects of water management and sustainable development in many different ways. The extent of the impacts on the people, economy and ecosystems will depend on a multitude of factors, and how each of these factors are managed, as well as the interactions between them. Among these factors will be the rates, magnitudes and distribution of the changes, institutional capacities to anticipate and manage the anticipated changes; preparedness of the governments, individuals and the civil society organizations to ameliorate them, advances in science and technology, and rates of adoptions of the new scientific, technological and managerial breakthroughs, as well as social, economic and political perceptions and societal and political willingness to manage the changes.

There are a few countries which are already trying regularly to formulate, update and implement good future-oriented plans which are underpinned by responsible and proactive political and administrative support. These countries will do significantly better than those which are not making comprehensive plans and depending upon ad hoc measures to counteract the potential impacts of climate change as and when they do occur.

Effective future-oriented plans to ameliorate the adverse impacts of climate change should include formulation of good long-term plans which are implementable. It should consider efficient and equitable water management that should take into account the future water needs of the country, both in terms of quantity and quality, and how they could be affected by climate change. Only planning will not be enough: it must be implemented in a timely and cost-effective manner.

This planning has to be conducted within a framework of relentless pursuit of sustainable development that would steadily contribute to steady improvements in economic and social conditions of the people and also meet their future expectations. This will be an exceedingly complex and difficult task which only a select few countries will be able to do properly in cost-effective and socially acceptable ways.

A good example is Singapore, a low-lying island where much of its land lies within 15 m above the mean sea level. Some 30 % of its land area is within 5 m of the mean sea level. Thus, for a country like Singapore, the most immediate threat due to climate change is sea level rise.

In order to reduce its vulnerability from coastal erosion, nearly 80 % of the island state's coasts now have hard walls or stone embankments. The rest are natural areas like beaches or mangroves.

In 1991, Singapore made a policy decision that all newly reclaimed land must be built at least 1.25 m above the highest ever recorded tidal level. As the threat of climate change increased and the scientific evidence indicated that sea level rise may be higher than what was expected earlier, in 2011, the country decided to raise the minimum level of the newly reclaimed land at least by an additional metre. This could ensure that the country could be safeguarded from the long-term impacts of higher anticipated sea level rise. Because of such continuous long term planning and its execution, the country is likely to fare much better in adapting to the new conditions due to climate change compared to all its neighbours.

The social, economic, environmental and political impacts of climate change, both over space and time, are complex interacting issues with numerous known and unknown feedbacks loops which are still not fully understood at present. Lack of proper scientific understanding of how various physical, social, economic and environmental forces may interact with each other, as well as absence of reliable data and information, are only two factors which currently prevent most countries to make reasonably reliable and actionable predictions of future multidimensional, multi-sectoral and steadily evolving impacts. These uncertainties further contribute to taking timely planning and investment decisions in a cost-effective and socially-acceptable manner. These are truly most challenging tasks under the best of circumstances.

At our present state of knowledge there are a number of important uncertainties in predicting the impacts of climate change on the water sector. These include, but are not necessarily limited to, future global emission scenarios, analysing them for various greenhouse gas emissions, predicting how these are likely to affect future global, regional and local rainfall patterns over time and space, interpreting their overall impacts on the hydrologic cycle at different scales including river flow regimes, assessing the types of scientific and technological breakthroughs expected that would allow us to better understand, predict and ameliorate the various issues associated with climate change and evaluating their impacts. These are likely to be mammoth tasks.

At our present state of knowledge, it is not possible to predict even how the annual average temperatures in various regions of the world may change over time, let alone the rainfall distribution patterns. In addition, even if such average global and regional changes in precipitation patterns could be predicted with some acceptable degree of reliability, they will be of very limited use for water sector planning and management. It would be essential to obtain information at river basin and sub-basin levels, which are often units of planning: country-level information will be of very limited value. The reliabilities of the current generation of hydrologic models have to improve by several orders of magnitudes before they can be used for planning and decision-making purposes with any degree of confidence.

The problem becomes even more complex for the water sector where it is essential to have not only reasonably reliable information on the distribution of

rainfall at the river basin and sub-basin levels, but also, more importantly reliable information on extreme rainfall events which would contribute to heavy floods and prolonged droughts. It is a fact of life that water structures are not designed on the basis of average rainfalls but primarily on extremes of rainfalls.

The magnitudes of uncertainties increase several fold when attempts are made to forecast extreme rainfall events on the basis of increases in average annual temperatures, and even more when rainfalls have to be translated into river flows. The peak river flows not only depend on high rainfalls, though it is a major factor, but also on many other factors, including land use changes and efficiencies and capacities of institutions responsible for water planning and management.

For successful and intelligent planning of the water sector within the framework of sustainable development, knowledge needs to advance much more than what is available at present. Meeting these challenges does not depend exclusively on advances in climatological-hydrologic modelling. Policies for adaptation and strategies for cost-effective mitigation measures have to be formulated on the basis of what are likely to be potential impacts. The forecasts of these impacts have to be periodically fine-tuned and considered for implementation according to changing societal and political expectations and also availability of additional knowledge, data and information.

Even more challenging will be the politics of policy-making and implementing which will require a quantum jump in existing planning and decision-making practices and processes. The politics of water security, climate change and sustainable development is likely to be one of the greatest challenges of the twenty-first century. How the individual societies will navigate these challenges in the coming decades will most likely determine the levels of their relative successes.

These will be immensely difficult, complicated and challenging tasks. However, countries must rise to meet these challenges successfully since there are no other real alternatives. Status quo or incremental progress will not be an effective long-term option.