Chapter 1
Assessing Global Water Megatrends

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If you can look into the seeds of time,
and say which grains will grow and which will not, speak then unto me.

William Shakespeare in Macbeth.

Abstract Currently some 2.5–3.0 billion people do not have access to clean water. To ensure all these people and an additional 2.3 billion people expected by 2050 have access to adequate quantity and quality of water for all their needs will be a very challenging task. Future water-related problems and their solutions will be very different from the past. Identification and solutions of these problems will require new insights, knowledge, technology, management and administrative skills, and effective coordination of multisectoral and multidisciplinary skills, use of innovative approaches, adaptable mindsets and proactive functional institutions. Many of the existing and widely accepted paradigms have to be replaced in the future turbulent and complex era of widespread social, economic, cultural and political changes. The new paradigms must accommodate diversified and contradictory demands of different stakeholders and their changing economic, social and political agendas. Rapidly changing global conditions will make future water governance more complex than ever before in human history. Water management will change more during the next 20 years compared to the past 100 years. Policies and strategies that are future-oriented need to be formulated, which can reform public institutions, satisfy evolving social and economic aspirations and concurrently overturn decades of water misuse and overexploitation. During the coming uncertain era, water policies have to juggle regularly with competing, conflicting and changing needs of different users and stakeholders and simultaneously ensure water, food, energy and environmental securities. Water is one of the few common threads that will bind the development concerns of the future. In the wake of the revolution taking place in water management, many long-held concepts are likely to

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disappear completely. New paradigms and models need to be developed to successfully meet the water challenges of the next three decades.

Keywords Global water future · Water megatrends · Population Urbanisation · Water scarcity · Water infrastructure · Millennium Development Goals

1.1 Setting the Scene

Predicting future trends in any field is a difficult and complex process. Making predictions is also an imperfect science. During the past several decades, scientific knowledge to predict future trends has grown steadily. However, even in spite of such advances, the capacity to predict the future reliably has not advanced that much to make any significant difference in formulating long-term national policies. Whatever advances there have been, unfortunately, are much less that those needed and desirable for long-term policymaking purposes.

This lack of progress has been due to the complexities of different issues that appear to be growing at a much faster rate than our knowledge and capacity to predict, analyse and assess them. Every challenge facing the world and the myriads of interacting and interrelated issues that could affect that challenge directly, indirectly and tangentially are continuing to evolve rapidly in known and unknown ways. These issues continue to mesh, collide and/or interact with each other in different ways because of changing economic, social, cultural, political, environmental, scientific, technological, ethical and many other associated conditions. Such a state of affair means that whatever trends that can be discerned are being affected by rapidly evolving global and national landscapes of expected, unexpected and uncertain events. Many of these trends converge but others diverge and their interrelationships may often vary with time. These often contribute to the development of complex feedback loops that are difficult to predict and may again change significantly over time and space.

Further, uncertainties and ambiguities need to be superimposed on these complexities because of rapidly increasing disruptive technologies, which are becoming increasingly more frequent over time. These are then further complicated by the emergence of totally unexpected events such as the 2008 financial crisis, which affect every sector in different, appreciable and unpredictable ways. No one was able to predict this crisis in terms of magnitude, extent and duration before it occurred. Add to this plethora of complexities expected events such as climate change whose actual implications over space and time over the next several decades are mostly unknown and unpredictable at present. Accordingly, it is not easy to predict what kaleidoscopic patterns or trends may emerge in various water and water-related fields in the coming years and decades, globally, regionally, nationally and sub-nationally.

Over the past several decades, the main preoccupations of governments and society have been events of the recent past, current events and likely possible developments at most three to six years in the future that may define a country's electoral cycle. The issues considered are often primarily local or national that directly affect specific groups of communities. All these make it very difficult to discern what may be changing over longer time horizons, the magnitude, extent and distribution of these changes over space and time, and why and how they may impact different segments of society in positive, negative or neutral ways. Equally, it is difficult to predict whether these trends will be transient or last over longer periods. This will determine the interest and emphasis that should be placed on these trends.

Equally, it is essential to determine what are likely to be the new emerging issues and what may be their potential long-term implications. Thereafter, it is necessary to estimate who may benefit from these forthcoming developments and who may pay the costs. Such calculations are always at the very heart of any democratic or even non-democratic decision-making processes. Only after such studies are properly completed, it is possible to determine what policies should be formulated and implemented to maximise the benefits and minimise the costs, and then what policies may contribute to maximum net benefit to the society that may be socially, economically and politically desirable and acceptable.

Even these considerations of future trends may not be enough. It will be necessary that the forecasts of future trends be complemented with how societal attitudes, values and aspirations may change over time, and what could be their likely implications to the water and water-related sectors. The emerging societal value systems may affect how water should be planned, managed and used in the coming years so that the future aspirations of the society as a whole can be gauged and fulfilled.

A good example of changing societal attitudes and expectations can be seen by examining what happened during the second half of the last century. During the 1950s, 1960s and 1970s, main focus all over the world was on economic development. Unfettered and continued economic growth was one of the most important political and societal goals, to the extent that environmental conditions were compromised by such growth rates. They were taken in stride and considered to be the price of progress that society should consider worth paying. Even as late as 1970, there was not a single country in the world that had a dedicated Environment Ministry. Prior to 1970, even reasonable methodologies to conduct environmental or social impact analyses simply did not exist. Nor was it necessary to get environmental clearances for large water infrastructure development projects. Economic growth considerations reigned supreme.

The societal attitudes to environmental issues started to change very dramatically during the 1970s and 1980s. By the mid-1980s, an overwhelming majority of countries had made it mandatory that any reasonably sized development project must go through an environmental impact analysis. By 1992, there was *not* a single country in the world that did not have a dedicated Environment Ministry that was responsible for clearing projects on exclusively environmental grounds.

Thus, within a short period of only about two decades, societal expectations and importance of environmental considerations radically changed in dramatic ways.

It is thus absolutely essential to understand and appreciate the values and societal attitudes and perceptions that underpin the existing trends, as well as how they may evolve in the coming decades that will influence future policies. Concurrent considerations of evolving value systems and changing trends must thus be considered simultaneously so that the future water management practices or processes can meet the societal goals, expectations and aspirations successfully.

This means that the future-related analyses should not only consider what are likely to be the trends but also how societal perceptions and attitudes may change through which the implications and relevance of the expected trends can be systematically scrutinised and then appropriately assessed. Accordingly, it is essential to determine how societal beliefs, ideas and doctrines may evolve over time. It will be further necessary to envision what may be the next generation of paradigms that will provide the lens through which the water-related trends should be viewed, analysed and then incorporated in policymaking frameworks.

Accordingly, identification of potential worldviews is needed within which existing and emerging trends can be properly studied and then adequately incorporated into future policies. This may provide an understanding as to why certain trends emerged and continued to thrive but others, after a short period, petered-out. This will give a better understanding of how new global trends may be evolving and their lasting power. Furthermore, how, and to what extent, planning for desired outcomes may affect the dominant views, cultures and paradigms of the future at specific periods of time.

Unless such complex and comprehensive studies are conducted and the policymakers and analysts understand how the future global societal and development landscapes are likely to change, there is a strong possibility that seemingly good ideas may precipitate sub-optimal, or even socially unacceptable, and undesirable outcomes. The reverse may also equally likely to be true.

Unquestionably, predicting the future trends that may affect the water sector in a reasonably and reliable manner is a most challenging task under the best of circumstances. However, one fact is certain. Unless water management practices and processes are significantly improved within a decade or so, more and more countries and cities are likely to face serious and prolonged water security problems: types, magnitudes and extents of which no other earlier generations had witnessed or had to cope with. This is because there will be several major developments that are bound to occur during the next several decades that will affect water management practices and processes in significant ways. Only a few important ones will be discussed here.

First and foremost is the fact that the world population will continue to increase. Between 2015 and 2050, the global population is estimated to increase by 2.3 billion. This means that if future water management practices only improve incrementally, as has been the case in recent decades, significantly more parts of the world will witness serious problems due to increasing scarcities and steadily declining water quality conditions. Already, at least some 2.5–3.0 billion people do

not have access to clean water that can be safely drunk without significant treatment at household level (Biswas 2014). If it has not been possible to provide clean water even to current global population after nearly four decades of sustained efforts, how can safe water be provided reliably to an additional 2.3 billion people in only a little over three more decades? In other words, in little over three decades, the world must provide clean water to an additional 4.9–5.4 billion people, a truly Herculean task under the best of circumstances.

In addition to a higher population, there are other factors that could ensure total global water requirements will continue to increase for decades if water management persists to improve only incrementally in the future. Some of these factors will be briefly discussed herein.

Developing countries are witnessing sustained urbanisation. Already, for the first time in human history, more than half of the global population live in urban areas. This percentage will advance steadily in the coming decades. As the urban centres grow, greater quantity of water has to be imported from the hinterlands to meet their water needs. The marginal costs of bringing additional water over increasingly longer distances are rising rapidly, as are the environmental and social costs. In addition, the population of the hinterlands and their economic activities are also likely to increase further in the future. Accordingly, their water requirements are going to increase as well. People in the hinterlands are already becoming increasingly reluctant to export water to the cities for which not only they do not receive any perceived economic benefits but also lose control of their own water sources, which they would need themselves in the near future for the development of their regions.

In addition to physical scarcities, another equally important problem has been regular deterioration of quality of all water bodies within and around urban centres of the developing world, and in many cases even in the developed world. This is because management of wastewater in developing countries has been grossly neglected in the past. This neglect is likely to continue for much of the developing world in the foreseeable future. Thus, cities are running out of water due to continuing mismanagement of this resource and concurrent contamination of their water bodies with known and unknown pollutants, making such sources unsafe for consumption without sophisticated and expensive treatment. Since nearly all cities in developing countries provide free or highly subsidised water, water utilities do not have necessary funds and technical and management expertise for treating contaminated water sources properly, which are becoming progressively more and more polluted.

Furthermore, as the number of middle-class households in the developing world has exploded in recent years, and will continue to do so during the next several decades, the total water requirement is increasing significantly. These middle-class households are likely to demand reliable availability of water, electricity, consumer goods, protein-rich food and employment opportunities in good-paying manufacturing and service industries. None of these requirements can be fulfilled without either more water and/or significant improvements on how this resource is managed at present. Globally, nearly 70% of water is used for agriculture. As households become richer and more literate,

their diet changes from being cereal-based to more significantly protein-rich. Ensuring a protein-rich diet is available means use of significantly more water. This trend is likely to continue for the next several decades. Agriculture now accounts for 70% of all global usage. While in absolute terms the global agricultural water use is increasing, in percentage terms it has been steadily declining for well over a decade. In contrast, in percentage terms water use for industry and electricity generation has been steadily increasing. In future, there simply will not be sufficient extra water for producing significantly more protein-rich foods that the middle class will demand.

The world is now facing a perfect storm in terms of water availability and management. Demands for water are rising significantly for various reasons but new sources of water are becoming increasingly more expensive and difficult to produce. Water is not only an existential issue but also is an essential requirement for economic development and good quality of life. Even though the importance of water is widely recognised throughout the world, there is not a single country at present anywhere where water has been consistently high-up in the political agenda during the recent decades. It only becomes a political priority when droughts, floods or other natural disasters occur. As soon as these events are over, water simply disappears from the political agenda until the next catastrophe. This is despite the well-established fact that water problems cannot be resolved on a long-term basis with only short-term ad hoc political decisions. At present, there is no indication that the sector is likely to attract long-term consistent political support that is essential for ensuring global water security.

1.2 Changing Global Water Landscape

The future water-related problems are likely to be different from those of the past or that are being encountered at present. While historical knowledge and past experience are always useful to understand and appreciate the genesis of the problems, new lenses are necessary through which they should be viewed and analysed. Identification, analysis and solution of nearly all future water-related problems will invariably require new insights, coordinated multidisciplinary and multisectoral skills, innovative approaches, adaptable mindsets and proactive institutions. In addition, many of the currently held beliefs and widely accepted paradigms may have to be jettisoned and new functional and implementable approaches found that should have the potential to solve future global water problems.

Historical developments, as well as many of the existing analytical tools, are becoming increasingly irrelevant in the new and turbulent era of societal changes, economic and political developments and water availability and use patterns. Water management practices will have to accommodate diversified, even contradictory, demands from different stakeholders and their economic, social and political agendas, institutional requirements and a sceptical media with varied interests and agendas. The situation is likely to become even more complex due to rapid technological changes, relentless economic competition between countries and within

countries, concurrent and even conflicting demands from the forces of globalisation and antiglobalisation, and intensifying pressures from single-cause activist non-governmental organisations (NGOs). All these and many other associated factors will affect how water is managed, directly or indirectly, in the future.

Currently, major changes are taking place in many different aspects of water management. The majority of water professionals are not even aware of them, let alone what could be their medium- to long-term implications. In the wake of this future era of continuing significant changes, many long-held popular concepts and paradigms of water management will undergo rapid evolution. Some are likely to disappear altogether, replaced by new and more appropriate and applicable paradigms. Never before in the history of water management has such profound changes taken place that are likely to be witnessed during the next two to three decades. Water management practices during the next couple of decades will change more than they have during the past 100 years. Many of these changes will come from non-water related sectors such as food, agriculture, energy, environment, economy and societal changes in attitudes and perceptions on which the water profession will have limited or no say, or control. Such external pressures are likely to make water management during the post-2030 period exceedingly complex and a difficult task.

Let us consider how a few selected issues have changed or are changing, and how some of the popular paradigms are becoming no longer relevant for managing water sustainably.

1.2.1 Domestic Water Supply

A good example of how some of the global perceptions and attitudes are changing is from the domestic water supply sector. Surprisingly, even though water has always been essential for human survival, it was not on the global development agenda until the early 1970s. During the UN (United Nations) Conference on Human Settlements, held in Vancouver, Canada, in 1976, the issues of universal access to clean water and sanitation came up for the first time in a serious and sustained way. These issues were further discussed during the UN Water Conference, held at Mar del Plata, Argentina, in March 1977. This Conference proposed that the UN should declare the 1981–1990 period as the International Water Supply and Sanitation Decade (Biswas 1978). The recommendations of Mar del Plata were approved by the UN General Assembly, and thus the issue of clean water for all humanity was put firmly on the global agenda for the very first time as an important target to be met.

The objective of the Decade was ambitious. It aimed to provide everyone in the world with clean water by 1990. The Decade successfully increased the access to water for hundreds of millions of people throughout the developing world. During the Mar del Plata Conference, the consistent focus was access to ‘clean’ water (Biswas 2004). For example, its Secretary General, Yahia Abdel Mageed, categorically stated in his opening address that ‘clean’ water should be accessible to all

(Mageed 1977). The idea during the Mar del Plata Conference was that the Secretariat of the Decade should be independent.

Following the approval of the Decade by the UN General Assembly, the World Health Organisation (WHO) successfully lobbied so that the Secretariat of the Decade was located within the WHO. It was also decided that the WHO and the UN Children's Fund (UNICEF) should jointly monitor how the Decade objectives were being met.

The WHO and the UNICEF then changed the narrative completely by proposing the idea of 'improved sources' of water in contrast to 'clean' water. The definition of 'improved sources' of water was deliberately left vague. Individual governments basically decided what they considered to be 'improved sources', irrespective of whether water was clean or not.

Shortly after the Decade started, and for some 35 years thereafter, the UN Agencies and the World Bank and other development banks have consistently misrepresented and obfuscated the national and the global drinking water situations. The discussion at Mar del Plata had two main goals. First, people should have easy access to water, and second, water should be clean to drink without any perceived or real health hazards.

In terms of access, people all over the world always had access to water: otherwise they could not have survived. The Decade's focus was on easy access. Unquestionably, the Decade made access significantly better for hundreds of millions of people living in both urban and rural areas of the developing world. This, by any standard, must be considered a remarkable achievement.

Where the UN agencies and development banks have failed miserably is on the quality of water that people have access to. Unfortunately, the meaningless terminology that has been consistently used by the international organisations, 'improved sources' of water, never had any relation to, or consideration of, its quality. Since 'improved sources' is such a vague term, the quality of water may have had declined significantly and still could be accepted as an 'improved source'. It all depended on how each individual or institution interpreted this ambiguous and amorphous term.

The issue has been consistently obfuscated since these international organisations have used 'improved sources', 'clean' and 'safe' water interchangeably from the early 1980s onwards. This may have been deliberate since it would allow them to claim success and also show that the targets have been met within the stipulated time. Consider the 2016 report by the WHO and the UNICEF on the global progress on water supply and sanitation. In the very first paragraph, the report mentions 'safe drinking water' (UNICEF-WHO 2016). In the second paragraph, it switches to 'improved sources of water'. This has been the consistent pattern over the past three decades. The net result of this dubious practice has been that it is now accepted globally by almost everyone that 'improved sources' mean clean and safe water. This obfuscation has made various UN Agencies and development banks claim that the Millennium Development Goal for water was reached well in advance of the target date of 2015. Nothing, of course, is further than the truth.

The absurdity of this claim becomes obvious when the UNICEF and the WHO (2016) misleadingly and totally erroneously claimed that some 663 million people in the world lack safe water. The nature, extent and validity of this dubious claim can be realised by considering only the South Asian countries. Together they have some 1.7 billion people. Unfortunately, there is not even one city, town or village in any South Asian country where citizens have access to safe water that could be drunk from a tap, or source, without any health concerns. Globally, there are least 2.5–3.0 billion people who still do not have access to safe water. This estimate is around four times the currently accepted figure. Thus, the magnitude of the problem is significantly greater than what it is universally believed at present(Tortajada and Biswas 2017).

Another issue that has not received enough attention is how much water a person needs each day to lead a healthy and productive life. In the framework of the global discussions on human rights to water, and depending on the countries and institutions concerned, it has been generally considered to be between 50 and 150 L per person per day. These figures are not based on any scientific or medical study but are decided simply on an ad hoc basis by different countries.

The only study to estimate an amount of water a human being needs to maintain a healthy and productive life was carried out in Singapore between 1960 and 1970. It showed that beyond 75 L per capita per day, there did not appear to be any appreciable and additional health benefits (Biswas 1981). The additional water used beyond 75 L was primarily aesthetical, and not related to health reasons or concerns.

There is considerable merit to the results of the Singapore study. With a strong emphasis on water conservation and good management practices, several European cities have now reduced their per capita daily water consumption to between 90 and 100 L. These figures are still declining. It is likely that by 2030, many cities may be able to reduce their per capita daily consumption to 80–85 L, not so different from the results of the Singapore study.

The implications of this finding are important. It means that not only less water may be needed for each healthy person than considered necessary at present, but also less water and wastewater have to be properly treated. Less water used will result in less wastewater generation. In other words, with good management, availability of adequate quantity of drinking water even in the most arid countries should not be a problem, not only now but also by 2050 when the world is estimated to have over two billion extra people.

What will continue to be a problem is the continuing deterioration of water quality, especially in developing countries where domestic and industrial wastewaters are seldom adequately collected, taken to plants for proper treatment and then discharged to the environment in safe and acceptable ways. The pollution problems are further intensified by agricultural runoffs of fertilisers and pesticides. Even developed countries have not managed to control agricultural runoffs properly, as well as discharges from large scale feedlots. For most developing countries, control of agricultural runoff is still not on the political radar.

As population and industrial activities have steadily increased in the developing world, neglect of wastewater management has meant that all water bodies in and

around urban centres are now already severely contaminated with many harmful pollutants. Except for a few countries, there are still no signs that the politicians are taking water quality management seriously. Herein lies one of the major future water challenges for the developing world: how to provide clean water to a steadily increasingly population when water sources have already been seriously polluted and are highly likely to become even more contaminated in the future with hazardous chemicals. Thus, the total stock of water that can be cost-effectively used for drinking purposes is steadily decreasing in developing countries due to quality considerations.

While the global preoccupation in the past and the present has been primarily with the physical scarcities of water, a more serious problem for the future must certainly be the quality of water and the associated health and environmental impacts.

Neither the water profession nor the rest of the world has appreciated the complexities and difficulties of proper and efficient water quality management. The complexities of managing water quality have steadily increased over the past half century. For example, in the 1950s and 1960s, the best water utilities in the world used to monitor about 30–40 water quality parameters, and average utilities around 15–20 parameters. Quality of water sources were significantly better than what they are today. Environment and health considerations and awareness of the public to these issues were much less than at present. Equipment available for water quality monitoring in the past was not highly sophisticated and inexpensive and easy to operate. Only very few, if any, pollutants used to be measured in concentrations of parts per million. With the acceleration of industrial activities, numbers of chemicals, heavy metals and other hazardous chemicals in wastewaters have increased significantly. Equally, many pollutants need to be measured in ever-lower concentrations. Instrument technologies have advanced rapidly in recent decades. Thus, it has become possible to measure parts per billion, and even parts per trillion.

In addition, up to about 1970, most water utilities in the developed world used to monitor about 30–40 quality parameters. This number has steadily increased over the past 40 years. Figure 1.1 shows the number of water quality parameters that PUB Singapore's National Water Agency, has been monitoring from 1963–2016. The number has increased from about 36 in 1963 to about 340 in 2016, a 940% increase within a period of 53 years (Fig. 1.1). In the future, as many emerging contaminants are likely to become important, the total number of pollutants that must be monitored will increase further. Most of these pollutants require measurements for tiny concentrations of parts per trillion. This will be an expensive and difficult process.

Monitoring and analysing the ever-increasing number of parameters are beyond the capacities of all developing countries. Not only they do not have the funds to buy the instruments that are becoming increasingly more sophisticated and thus steadily expensive but also they simply do not have enough trained manpower to operate and maintain these instruments and subsequently analyse and assess regularly the implications of the monitored results, especially if they should indicate any problem.

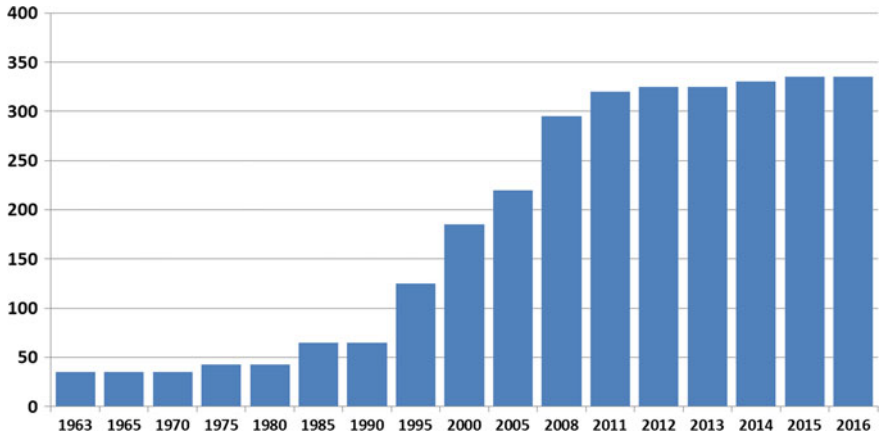

Fig. 1.1 Number of water quality test parameters monitored by the PUB, 1963–2016. *Source* Compiled by PUB at the request of the authors

These are only some of the issues facing the domestic water sector now and in the future. While their magnitudes, intensities and complexities are increasing, typology of the problems encountered has been around for decades.

In addition, there are new types of issues that are surfacing which water utilities have not encountered before in any sustained fashion.

Globally, people all over the world appear to be progressively losing trust in the quality of water supplied by the utilities, irrespective of the actual quality of water supplied. In developing countries, the trust was never present for decades. Consequently, each household has been forced to become a mini-utility to manage their own individual water supply. First, they had to build an underground storage tank where water could be stored when it is supplied for only a few hours each day. Water is then pumped to an overhead tank as and when needed. This ensured that households had 24 $\times$ 7 water supply even though utilities supply water for only 3–5 h each day. Water then had to be treated before it could be drunk without any health risk. Some 10–20 years ago, households mostly used simple carbon filters to purify water. Nowadays, with water sources becoming increasingly more contaminated and people becoming more aware of health implications, households are often using membrane technology for purifying water. Membrane technology, as used at present, is highly inefficient. Nearly 60–65% of water treated must be thrown out at present.

Changes are now also occurring in those cities in developed countries where utilities have provided clean water for decades. Residents in cities such as New York, London, Berlin, Singapore or Tokyo have increasingly stopped drinking water supplied by the utilities even though quality has not been an issue for decades. Use of bottled water for drinking has now become increasingly common. Households are now treating their own water before drinking. Point-of-use water treatment systems are becoming increasingly common, even though they are not

necessary and are becoming more sophisticated and expensive to buy, operate and maintain. In cities such as Singapore and Hong Kong, the majority of households continue to boil water before drinking, even though quality has not been an issue for decades.

The water profession has still not realised that people in both developed and developing countries are steadily not using water from the utilities even when their quality is good. Why this loss of confidence and trust is occurring globally is difficult to say. It is probably for a variety of social, cultural and aspirational reasons, and these may vary from city to city. Only a few important ones will be noted here.

First, there have been several well-publicised failures of water supply systems in the Western World. In 2010, seven people died in Walkerton, Canada, and 2300 people felt ill due to devastating outbreaks of waterborne diseases. Cryptosporidium infections in cities such as Milwaukee, Melbourne or Adelaide have not helped to instil trust in utilities. Equally, well-publicised events such as lead contamination in Flint and Hong Kong have raised questions on the quality of tap water people are receiving and drinking.

There are also perceptional and aspirational issues. Companies selling bottled water and point-of-use water treatment systems have successfully transformed water into a lifestyle issue by enticing advertisements. While they have never implied that water supplied by utilities in the cities of the developed world is not safe to drink, they have managed to convince consumers that the alternatives they offer are vastly superior, and thus desirable and preferable for their families. In contrast, not even a single utility in the developed world spends any funds in elevating tap water to be an aspirational lifestyle issue. Furthermore, utilities cannot afford to have an advertising budget that is even a small fraction of those selling bottled water and point-of-use treatment systems. They are always under pressure to keep the cost of water to a minimum. Thus, it is likely that utilities will steadily lose their share in the drinking water sector in the coming decades in most parts of the developed world.

1.2.2 Large Water Infrastructure

A major development of the post-1975 period was the emergence of a progressively stronger environmental and social movement. This movement, which developed over a short period of years radically changed societal attitudes and perceptions on all issues relating to the environment. The importance of this movement can be realised by the fact mentioned earlier. In 1970, there was not a single country in the world that had a dedicated environment ministry. Some two decades later, by 1990, one would have been hard pressed to find a single country that did *not* have a dedicated environment department.

Environment, now, has become rightfully a mainstream consideration. Environmental Impact Assessments have now become mandatory in nearly all

countries of the world. Proper consideration of environmental issues of all development projects was undoubtedly a most welcome development. Unfortunately, in the real world there are very few, if any, major developments that contribute only to positive outcomes and have no negative implications. This has also been true for the new environment movement.

For reasons that are still difficult to identify, and regrettably not properly researched, construction of large dams became the lightning rods for many environmental activist groups. This started to become evident in the 1980s, and picked up steam during the early 1990s. The environmental activists initially came primarily from the developed world where the era of construction of large dams was generally over by the 1970s. They provided financial, intellectual and media support to their counterparts in the developing world to oppose, steadfastly, construction of large dams irrespective of their net social and economic benefits.

These single-cause anti-dam activists from the developed world already had a decent standard of living, including access to clean water, proper sanitation, electricity and food, as well as good employment opportunities. In order to promote their single cause anti-dam agenda, they often eschewed scientific and technical facts, and frequently quoted data and statements that were erroneous or out of context. In an era that universally considered 'small' was always 'beautiful', large dams automatically became 'bad' or 'ugly', irrespective of their desirability and overall benefits to the society. These activists successfully managed to propagate the myth that water, energy and food problems of the developing world could be successfully resolved by small dams and water harvesting techniques that would have very minor social and environmental costs. They also successfully portrayed to the media how large dams have universally contributed to major social and environmental costs, but very limited, if any, benefits. This, of course, was mostly untrue. However, the media always look for critical stories. These stories served their purposes well and were given significant publicity.

There is no question that small dams can play important roles in rural and smaller urban areas to meet their water needs. Equally and undoubtedly, they will not be able to meet the water requirements of larger urban-industrial complexes, where demands are already high and increasing; population is growing due to natural causes, and urbanisation, economic activities are expanding; and rainfalls often may not be enough and are always erratic.

The opposition to large dams reached its peak around the mid-1990s. In 1993, facing certain defeat in the Executive Board, India withdrew its loan from the World Bank amidst a global controversy over the construction of the Sardar Sarovar project. In the same year, 1993, the World Bank established an Inspection Panel as an independent complaints mechanism for people and communities who believe they have been, or likely to be, adversely impacted by any World Bank project. Not surprisingly, nearly all the projects the Inspection Panel considered during the 1990s were related to dams.

In the cacophony of anti-dam rhetoric in the 1990s, the Sardar Sarovar project became the 'Vietnam' for the World Bank in terms of funding support to dam construction projects. The financial support for large water infrastructure projects

by the World Bank, Asian Development Bank, Inter-American Development Bank, and all other major bilateral donor agencies declined precipitously due to the success of the opposition from the anti-dam NGOs and lobby. The media became enamoured by the claims of the activist NGOs. Furthermore, dams are invariably constructed in inhospitable regions with poor transportation and communication facilities. Thus, very few media people actually verified the claims of these activist NGOs and simply published their unsubstantiated and often dubious assertions as facts.

A decade later, the World Bank and other development banks realised their folly, and reinstated funding of large dams. In fact, for nearly two decades it has been known how adverse environmental and social impacts of large dams can be minimised and positive benefits can be maximised so that their net benefits to the society can be greatest. During this period, it was consistently advocated that the people who have paid, or were likely to pay, the costs for earlier large water infrastructure projects should be made direct beneficiaries, and this should be seen as a development opportunity and not as a cost or constraint. This is especially true for people required to be resettled: they must have better lifestyles compared to what they used to have before the projects were constructed.

During the post-2000 period, the traditional development banks and bilateral aid agencies have been forced to re-examine their approaches and views because of the rapid emergence of Chinese institutions such as its Export-Impact Bank and China Development Bank. These two banks, by 2010, were providing more export funding compared to all the Group of Seven (G7) countries combined. Similarly, by 2010, the two Chinese banks were providing more loans on an annual basis than the World Bank. Not surprisingly, the World Bank and G7 export financing institutions have witnessed a steady decline in global influence since 2000 in terms of infrastructure construction because of their inconsistent policies.

The narrative further changed when a China-led multilateral development institution, the Asian Infrastructure Investment Bank (AIIB), was formally established on December 25, 2015. This happened despite the fact that both the USA and Japan lobbied strongly and consistently against its formation. The AIIB currently has 80 countries whose memberships have been approved. This is the first time a development bank is led by a developing country.

The emergence of the Chinese banks and the AIIB has changed the global narrative on infrastructure development, including of large dams. Further, the World Bank and all regional development banks realised, by 2000, that they had made the wrong decision by reducing funding significantly for the construction of large dams. Even after their increased funding, the rapid emergence of the Chinese banks has meant that the older financing institutions can no longer dictate the global narrative on construction of major infrastructure projects.

An important side benefit of this emergence of the Chinese support has been that the global discussions on dams have now become consistently more fact-based and nuanced since about 2000. This trend is likely to continue through the next couple of decades when other major countries such as India and Brazil become

increasingly involved in providing export credits for construction of large dams in other developing countries.

1.2.3 Integrated Water Resources Management

The concept of integrated water resources management (IWRM) has been around from the late 1930s. For much of the 1940s, 1950s and 1960s, it was known as comprehensive water resources development. The UN was promoting this concept as early as the mid-1950s. Unfortunately, for a variety of reasons, it was not possible to operationalise it. Thus, slowly it lost traction during the 1970s and 1980s (Biswas 2008).

IWRM received a new lease life in the 1990s. It was not because ways had been found to use it effectively in the real world to improve water management but because of several political and institutional developments and vested interest from some Western donor countries.

The main reason of its re-emergence was, in January 1992, the UN System organised an International Conference on Water and the Environment in Dublin. The World Meteorological Organisation (WMO) took the leading role for its organisation. This Conference was expected to formulate sustainable water policies and programmes for consideration by the UN Conference on the Human Environment (UNCHE) that was held in Rio de Janeiro, in June 1992. UNCHE was attended by most heads of states from countries all over the world. An objective of the Dublin Conference was that its deliberations and recommendations would help to place water high-up in the global political agenda during the Rio meeting.

The Dublin Conference failed spectacularly to achieve its objectives for two main reasons. First, and most surprisingly, its main proponents had no idea about the rules governing UN mega-conferences. It was organised as a meeting of experts and not as an intergovernmental meeting. The rules of such UN World Conferences stipulate that the Rio meeting could only consider recommendations from inter-governmental meetings and not Expert Group meetings such as Dublin. Thus, some governments objected at Rio to discuss the results of the Dublin Conference.

Second, intellectually Dublin was basically a 'SOS' (same old stuff) type of conference. It did not discuss any idea that could be new or innovative. Poorly planned, managed and executed, and devoid of any serious intellectual content, it was unanimously considered by the participants of the 1992 Stockholm Water Symposium to be an abject failure.

For about a decade, the prime movers of the Dublin Conference, a few UN agencies and bilateral donors, spoke glowingly of the four so-called Dublin principles, which were bland and politically correct statements of the obvious. These, even if the principles could be implemented by a miracle, could, at best, improve water management only marginally.

One important, but not meaningful, development happened following the Dublin Conference. The donors, notably the World Bank and the United Nations

Development Programme (UNDP) and some governments, especially Sweden, went on to establish a Global Water Partnership (GWP). The leading figures of Dublin Conference were also the dominant founding figures of the GWP. Not surprisingly, the GWP's initial programme focused on the four Dublin principles. After spending millions of dollars on the programme based on these four principles, the GWP found that it received no traction or global interest.

The GWP then began to promote IWRM as the primary focus of its programme. It was also included in the Dublin recommendations. Most unfortunately, the then leaders of the GWP were mostly unaware that IWRM concept was tried in the 1940s, 1950s and 1960s under a different name and, even after three decades of effort, it did not work.

Not being aware of IWRM's history, the GWP claimed that 'IWRM draws its inspiration from the Dublin principles'. Not only this was totally incorrect but the Dublin principles had very limited relation to IWRM.

With the GWP and its supporting donors pumping hundreds of millions of US dollars to promote IWRM, it became a powerful all-embracing paradigm during the 1995–2005 period. This is despite the fact that, operationally, it has not been possible to identify even one major water development project anywhere in the world that has been planned and managed in such a way that it could inherently become integrated, irrespective of how it is defined. On a scale from zero to 10, zero being no IWRM and 10 being full IWRM, it is not possible to identify even one significant water project anywhere in the world that could receive a grade of three. This is also valid for those donor countries who have been promoting IWRM vigorously and strenuously for over two decades in the developing world.

Even after two decades of relentless promotion by donors that IWRM is the *nirvana* of water management, there is still absolutely no agreement among its promoters as to what this concept exactly means (Giordano and Shah 2014), what are the issues that should be integrated, whether such integration is possible or even desirable, and if by a miracle such integration was possible, would it improve water management appreciably? Most surprisingly, these fundamental questions have never been asked by its proponents, let alone answered.

Extensive analysis of IWRM literature published during the past 20 years indicated at least three undesirable developments. First, there is no clear understanding what IWRM exactly means. Different institutions and water professionals define it very differently. The absence of any usable and implementable definition and measurable criteria has only compounded the vagueness of the concept and has reduced implementation potential to a minimum.

Second, because of the resurgent popularity of the concept and amount of serious money that was spent by the donors to promote the concept, many water professionals and institutions decided to do what they have been doing already, but under the guise of IWRM to attract additional funds and attention. Third, even after the donors have spent heavily to promote the concept, the results of IWRM have been very meagre and not discernible.

Accordingly, the GWP's IWRM toolbox contains cases that have, at best, only tangential reference to the concept. Equally, no serious objective and independent

studies were conducted as to whether the case studies actually produced true and lasting results.

In one aspect, IWRM has been highly beneficial to the donor countries. The tremendous amount of funds they have spent has ensured that their nationals received employments as IWRM experts, educational institutions are being supported with funds and students studying IWRM and equipment manufacturers in their countries are being bolstered by this funding. About 70–80% of the donor funding returns to the donor countries as salaries for their nationals as 'experts', sale of equipment manufactured in their countries, capacity building by using their institutions and experts and other activities that benefit the donor countries significantly. There is no question IWRM has served the donors quite well. Even in cases where the donor countries have provided funds to multilateral institutions such as the various UN agencies, the World Bank and regional development banks, as funds in trust, the implicit understanding has always been that most of these funds would be spent in the donor countries using their nationals and services.

Concepts and paradigms, if they are to have any validity and usefulness, must be implementable so that they contribute to better and more effective results. Not only this is not happening at present with IWRM but also there are no discernible signs that this is likely to happen any time in the foreseeable future.

In addition, the world is heterogeneous, with different cultures, political processes, social norms, physical attributes, availability of investment funds, planning and management capacities, institutional arrangements and a host of other factors. The systems of water governance, legal and regulatory frameworks, effectiveness of institutions and decision-making processes and people's expectations and aspirations mostly differ from one country to another, often in very significant ways. Thus, a fundamental question that needs to be asked and answered: can any paradigm such as IWRM be equally valid for all countries of the world and for all times despite widely varying conditions? Given the fact that for nearly three generations it has not been possible to implement IWRM, the probability of this paradigm being useful to improve water management is indeed very, very unlikely.

Developing countries on which IWRM was imposed by the donors are slowly realising that the 'emperor may not have any clothes'. A few countries have already reached this conclusion and more are likely to be disenchanted by the ineffectiveness of this paradigm within the foreseeable future. Based on past experiences, it is highly unlikely that the donors will admit that IWRM has not worked in the past, is not working at present and is unlikely to work in the future. The most likely scenario will be that donors will steadily reduce their strong IWRM rhetoric and start focusing on the 'ends' of water management rather than exclusive focusing on one of its many 'means', as has been the case for the past two decades for IWRM (Biswas 2008).

1.2.4 Integrated River Basin Management

Another popular paradigm whose usefulness must be seriously questioned at present is integrated river basin management (IRBM). The idea of using a river basin as a unit for management is not new. It has been around for at least over 200 years. River basins do not follow administrative or political boundaries. Some experts believe that water can be best managed within the framework of river basins but all other resources and economic activities can be managed within administrative and political boundaries.

Accordingly, over the past 200 years, there have been many attempts to manage water at a river basin scale but with limited success. For a select few small river basins that are exclusively within one country they have worked reasonably well, especially where the main management and political concerns have been in terms of water quality and environmental issues, and the central governments of the countries concerned are directly responsible for water management. IRBM has had rather limited success when the countries have federal structure, and constitutionally provinces or states are in charge of water management. Furthermore, the successful cases generally did not have water allocation as an important issue between upstream and downstream regions.

While managing water at a river basin scale has been attempted in nearly every continent, this has not worked well for a variety of reasons. First, is the issue of scale. If the river basins are large, such as Ganges, Brahmaputra, Mekong, Amazon, La Plata, Congo or Nile, and encompass two or more countries, it has not been possible to manage them at basin scale. The complexities of managing large scale river basins are so huge that the situations are unlikely to change any time in the future.

If a river basin like the Ganges is considered, managing it exclusively within the Indian border has not been possible due to its sheer scale, and political, institutional and legal complexities. Even if its main tributary, Yamuna, is considered, its basin area of 366,263 km^2 has also proved too large to manage. The Indian Government tried to split the Yamuna basin into two, Upper Yamuna and Lower Yamuna. Even after this split, it was not possible to manage them due to the complexities involved.

Second, another important issue that the water profession has basically ignored is the characteristics of river basins have changed significantly in recent decades. As major cities needed more water for various purposes, it was often possible only by inter-basin transfer. Accordingly, during the post-1960 period, an increased number of river basins have been interconnected because of increasing water demands.

At present, in several cases these interconnections have become massive. For example, China's south-to-north water transfer project has connected several major river and lake basins. Many examples now exist of similar inter-basin interconnections in countries as diverse as China, India, Brazil, Mexico and South Africa. Such interconnections mean that the areas of many river basins over which they should be planned and managed are increasing steadily. These developments are making them unmanageable due to rising complexities. In addition, lack of good

sites where large dams could be constructed and the long distances separating them from potential users of water are becoming serious constraints that may make good and implementable planning at the basin level very difficult to achieve.

As IWRM became popular in recent years, there has been a big push for integrated river basin management as well. Like IWRM, many fundamental questions must be asked about IRBM. Among these are what exactly should be integrated, who will do the integration, is such integration possible or even desirable at basin scales, and would such integration improve water management perceptibly?

In terms of what should be 'integrated', there has been very little serious discussion for IWRM and even less for IRBM. Biswas (2008) identified a consolidated set of 41 issues that different authors or institutions have suggested should be integrated within the context of IWRM. Since these issues are often closely interrelated, directly or indirectly, and are mostly not mutually exclusive, they simple cannot be integrated even at a conceptual level, let alone in the real world. Nor can this integration be possible in the future.

For IRBM, the issues are even more complex in developing countries of Asia, Africa and Latin America because many of the large rivers span several countries. For these trans-boundary rivers, there are mostly no clear and binding regimes for water allocation between the countries concerned that are fair, equitable and sustainable. Furthermore, even when such treaties do exist, as on the Indus River between India and Pakistan, or on the Colorado River between the USA and Mexico, the conditions when the treaties were signed several decades ago in all the concerned countries are very different from what they are at present. While in both the above mentioned two cases some changes have been made to the treaties, these modifications have not been significant. There is very little knowledge and experience available at present on how to negotiate living treaties or how they should be formulated. In fact, serious and sustained discussions as to whether such treaties are even possible, or desirable, have not yet been started.

Attempts at integrated river basin management in major to medium size transboundary rivers have often led to poor coordination and sometimes even conflicts. Institutions such as Lake Chad Basin Commission, Mekong River Commission and Nile Basin Initiative (including their predecessors) or Joint Rivers Commission of India and Bangladesh have spent years of efforts and millions of dollars for somewhat meagre results.

The situation in terms of IRBM in countries where the responsibilities of water management lies with the states or provinces and not with the central government, such as in Brazil, India or Pakistan, even managing exclusively national rivers, has not been encouraging. There are many reasons why IRBM has not worked and is not working.

A major reason has been that central and state water institutions continue to have inconsistent, inefficient, substandard and overlapping policies (Tortajada et al. 2018). Even though river basin institutions have existed for decades, data on water availability, use and quality leave much to be desired. Different water institutions use data that are often not reliable or even consistent. Without reliable data over a

reasonable time period, it is not possible to efficiently plan and manage any river basin.

Furthermore, what was supposed to be the main conceptual attraction of IRBM has now become its Achilles' heel. Their encyclopaedic responsibilities to integrate various factors and issues has proved to be too complex, onerous and demanding to achieve. These constraints are ensuring that there is fundamental discrepancy between promise and actual performance of IRBM. The proponents of IRBM are facing formidable limitations as to how such a paradigm may contribute to better water management in the real world.

Thus, in the coming decades, many existing popular and even once promising paradigms such as IWRM or IRBM, will undergo very significant modifications, or even disappear altogether completely.

1.3 Changes in Other Areas Affecting Water

Water is one of the very few resources that are essential for activities in other areas of human endeavour. Water is linked with all human activities. Equally, all human activities have direct and indirect impacts on water, both in terms of quantity and quality. In the coming decades, developments in other areas, sectors and changing perceptions and attitudes of human beings to water will have significant bearing on water management, certainly much more than ever witnessed in human history. Thus, activities in other areas will increasingly affect water management practices and processes through many known and unknown pathways.

While developments in all other areas will affect the water sector, only two aspects will be discussed here due to space limitations: implications of future developments in population and urbanisation. These developments will have significant impacts on water, many of which are being basically ignored at present in all existing policies in nearly all countries of the world.

1.3.1 Population

While increases in population have received much attention globally, what is basically being ignored is the implications of structure of population changes that are likely to affect the water sector significantly in the future. An important issue that the water sector is basically ignoring at present is the likely impacts of an increasingly ageing population.

Ageing of the global population is one of the important trends of the twenty-first century. Driven by reductions in fertility levels and increases in lifespans, the number of elderly persons of 60 years or older will steadily increase in both numbers and as a percentage of the population. In 2015, one in eight people globally was elderly. This ratio is estimated to increase to one in six by 2030, and to

one in five by 2050 (UN 2015). Globally, the number of older persons is increasing at a much faster rate than any other age group. Furthermore, the number of older persons is growing faster in urban areas compared to rural areas. During the 2000–2015 period, the growth of numbers of older persons in urban areas increased by 68%, compared to 25% in rural areas.

Increase in the elderly population will affect social progress, economic development and resource consumption in a variety of complex and interacting ways. It will affect rates of economic growth, national savings and consumption rates, government revenues and expenditures, housing, infrastructure, health care, pension commitments and intergenerational wealth transfers. In addition, compared to earlier experiences from the developed world, developing countries will be ageing at a much faster rate and more extensively. This will mean that developing countries will have to adjust to the changing conditions more rapidly than the western world, even though the former will have less financial capabilities, limited management and administrative capacities, weaker institutions and less efficient governance policies compared to those developed countries had faced when their populations aged.

Possible implications of an increasing elderly population in the developing world have mostly been neglected thus far. Yet, this is very likely be an important public concern in developing countries within the next 2–4 decades. Thus, appropriate and implementable policies must be formulated in this area. Unfortunately, most of the world does not appear to have much experience in this area.

The interrelationships between water management and an increasingly elderly population is now an unexplored territory. They are likely to influence each other in a variety of ways over time and space. Only a few of these will be discussed here.

First, for rural, peri- and semi-urban areas of many developing world countries, in the absence of water connections and wastewater disposal facilities at household levels, people are forced to use communal land and water bodies for their daily personal hygiene. For a steadily increasing number of elderly people carrying out such routine daily chores, especially when their physical movements become weaker and when their health starts to deteriorate or when they become sick, becomes difficult. With improvements in health care, education, food and nutrition, the lifespan of the people is likely to become longer. Inadequate access to water supply and proper sanitation at home will pose particularly heavy burdens on a rapidly increasing number of the elderly population as well as on their families.

Second, as people get older, their immune systems become progressively weaker. In the developing world, there are some 2.5–3.0 billion people who still do not have access to clean water. People may manage with a poor quality of water when they are younger and healthier. However, as they become older, their immune systems will start to deteriorate. Accordingly, the quality of water will become an increasingly important health concern. The problem may become increasingly serious because quality of ground and surface waters are steadily declining in the developing world due to neglect of water quality management.

Third, as the older generation of people retire from work, considerable knowledge, experience and collective memory will be increasingly lost. In countries such as Japan and South Korea, a significant percentage of knowledgeable and experienced people will retire from the water and wastewater management sectors within a very brief period of years. Accordingly, the overall institutional knowledge, experience and memory will start to decline steadily which will not be possible to replace immediately by younger and newer recruits. This loss has already been identified as a serious issue for the water sector by the concerned ministry in Japan. Such concerns are likely to become more widespread all over the world in the coming decades.

Fourth, throughout history, cities have had to expand water supply and wastewater treatment continuously because of increasing populations and economic activities. However, in countries such as Japan and South Korea, where populations are declining, the water supply and sewerage systems are becoming progressively much larger than necessary. At present, there is no idea as to how to downsize water supply and sewage collection and treatment systems progressively. Furthermore, as the city populations decrease, ways must be found to ensure viable and sustainable financial models for water utilities that can serve a progressively lower size of population. No serious research is now being conducted on how to downsize successfully urban water supply systems.

Fifth, it is generally the younger people who migrate to urban areas in search of better standard of living. Thus, the percentage of young people in rural areas and smaller towns is likely to decline, with attendant deterioration in economic, social and cultural activities. This could accelerate the breakdown of centuries-old extended family systems where younger generations took care of the elderly relatives. Consequently, the family support system that had existed for generations may start to decline steadily. This may contribute to additional social and economic problems, especially in terms of a deteriorating quality of life of the elderly.

1.3.2 Urbanisation

The water profession has been giving considerable attention to urbanisation-related issues. However, like population, this focus has been almost exclusively on concerns and issues of the past and present and not on the likely problems that different countries are likely to face in the future. Like the issues noted on ageing, the future problems are likely to be of very different nature.

Much of the global attention in the water area has been on megacities, that is urban agglomerations that house more than 10 million people. It is a fact that the highest percentages of the global population do not live in megacities. Rather they will live in medium to small-sized cities where provision of all types of services, including water and wastewater management, construction and maintenance of infrastructure and appropriate levels of investments will be some of the major challenges of the post-2020 world. The population growth rates in these smaller

urban centres during 1975–2015 have been about four times higher than in the megacities.

Unfortunately, these smaller urban centres have not been on the radar of most national and international institutions and policymakers. This is despite the fact that their growth rates have been significantly higher than the megacities. These smaller urban centres will find it significantly more difficult to solve their water and wastewater problems compared to megacities.

This is because all megacities have significant political and economic power. Important politicians and business people live in megacities. The bases of major media companies are in megacities. They have access to the lion's share of available national investments, as well as to significant technical, management and administrative expertise. The legislatures of countries or states are located mostly in major urban centres. Thus, the megacities may have problems in the future but somehow, they will manage to bumble along. Smaller urban centres, without adequate political power, financial wherewithal and lower levels of technical and management expertise, will find it very difficult to manage their water and wastewater problems, magnitudes and complexities, which are likely to be significantly higher that their much larger counterparts. Thus, unless these smaller urban centres receive notably higher levels of attention from the policymakers compared to what has been witnessed in recent years, they are likely to become black holes for water and wastewater management.

An important issue that is often raised is how developed countries managed to handle their urbanisation process much better than the third-world countries. There are several reasons for this seeming anomaly. First, the magnitudes and rates of

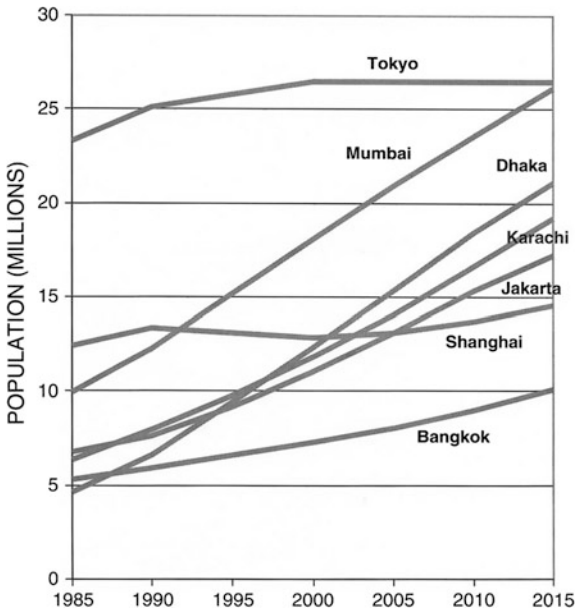

Fig. 1.2 Population increase in selected Asian megacities. *Source* Biswas and Tortajada (2009)

urbanisation that the developed world faced in the past were much less than their counterparts in developing countries are facing at present. Cities such as London and New York urbanised progressively over nearly a century (Fig. 1.2). Their gradual growth rates, economic conditions and management and technical expertise available enabled them to develop and manage their water and wastewater services effectively over a longer period of time. In contrast, the growth rates of Dhaka, Jakarta or Mumbai in recent decades have been explosive (Fig. 1.2). These later urbanising cities have been simply unable to cope with this explosive growth rates in terms of providing satisfactory drinking water and wastewater management services (Biswas and Tortajada 2009). They are finding it very difficult to run faster just to stay in the same place.

1.4 Concluding Remarks

There is no question that rapidly changing global conditions will make future water and wastewater management exceedingly more complex than it has ever been in human history. Interrelated and changing drivers such as population (number and structure), urbanisation, industrialisation, economic development, growth of the global middle class and their increasing aspirations for a better standard and quality of life, and changing societal attitudes and perceptions will make good water and wastewater management progressively more complex and difficult to achieve. Issues such as climate change will add extra levels of uncertainties and complexities.

Continued mismanagement and poor governance practices throughout the world, spanning several decades, have meant that future water security for humankind is now at a crossroads. Extensive policy and market failures in the water sector have received limited corrective actions from the concerned institutions in the past. The net result has been misuse and overexploitation of water all over the world, though in some places less but in others more.

There is now an urgent need to formulate and implement future-oriented, business-unusual water policies and strategies that can reform and strengthen public institutions, manage properly urban and rural environments, increase public and private sector investments, encourage prompt adoption of available and forthcoming new technologies, consider good management practices irrespective of where they originate, and develop a new generation of capable managers and experts from different disciplines and sectors with good communication skills.

Historically, water management policies and plans have been mostly framed narrowly on a sectoral basis with very limited consideration of future drivers from other sectors that are likely to affect water. Very seldom have water managers considered changing societal attitudes and perceptions to water-related issues as has been noted in the earlier part of the present chapter. There continues to be emphasis on short-term fashionable solutions such as IWRM and IRBM, which are extremely unlikely to provide the acceptable long-term sustainable policies and solutions for

the new generation of water challenges. Future water problems cannot be solved by using past paradigms and experiences that are becoming progressively infective.

All the major challenges facing the world are becoming increasingly complex and interconnected. The dynamics of human future will not be determined by any single issue but by the constant interactions among a multitude of issues. Increasing population, urbanisation, industrialisation, globalisation and human aspirations will require more economic and equitable development and improved management of natural resources. Ensuring food, energy and environmental securities will require better and continually improving water governance over the long term. The common requirements for all the realistic solutions must include greater and efficient investments, use of more knowledge, technology and expertise from all disciplines, functional institutions and legal systems, and intensified cooperation between countries.

The interrelationships among these issues are global in character. Accordingly, they are likely to be best understood and appreciated within a global framework. While the interrelationships may be global in character, within this there must be a wide variety of efficient and coordinated national and local responses. Water-related problems of the future need to be viewed, analysed and resolved within global, regional and national frameworks. This will be a radical departure from the current practice and will not be an easy task.

During the coming uncertain and turbulent decades, policymakers will have to juggle continuously with competing, conflicting and changing water needs for different purposes by disparate users and stakeholders, as well as concurrently assuring water, energy, food and environmental securities to maximise human welfare. Water will be one of the important threads that will bind all the major development concerns of the future.

There is already a revolution taking place in water management, even though most institutions and professionals are not aware of it. In the wake of this accelerating revolution, long-held and popular concepts and models are likely to evolve further or even disappear completely. Never before in human history has the water profession faced so many profound changes within such a short period of time, as are likely during the next 2–3 decades. The water profession will do well to heed the advice of the eighteenth century British statesman and philosopher Edmund Burke, ‘Never plan the future by the past’.

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