Chapter 24
Implications of Water Insecurity and Future Prospects in Asian Cities

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Abstract The world has witnessed unprecedented urban growth since the beginning of the twenty-first century, concentrated mostly in the less developed countries of Asia. Cities are particularly vulnerable to water scarcity and water stress, being the centres of economic growth and population concentration. There is also an increased demand for water in order to maintain the intense pace of activities in urban areas. This chapter intends to focus on the problems of water insecurity in the cities of Asia and to highlight some of the best practices adopted in urban water governance. As cities grow in terms of population and diversity of urban functions, demands on the urban water systems rise and hence the existing water systems and available water resources are faced with daunting and multifarious challenges as they are often exploited beyond their sustainable limit. Communities in urban areas are hence seeking resilience in the existing urban water systems and to future uncertainties in water supply because of climate change and population growth. An attempt is hence made for integrated water management approaches involving different stakeholders instead of compartmentalized management of urban water systems. It is already evident and documented that the existing water management approaches are inadequate to address water insecurity and water stress. Transforming urban water systems into more resilient and hence more sustainable systems would require innovative approaches. These approaches have also been discussed under two broad categories—the infrastructure-based approaches and the system-based approaches.

Keywords Resilience · Innovative · Infrastructure based · System based
Water management

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24.1 Introduction to Water Insecurity in Asian Cities

The world has witnessed unprecedented urban growth since the beginning of the twenty-first century. This growth is concentrated mostly in the less developed countries of Asia. Despite its low level of urbanization, 54% of the world's urban population is found in Asia and the percentage share is expected to reach 66% by 2050. Nearly 93% of the growth is expected to be concentrated in the less developed countries with more than 60% in the cities of Asia. It is also the million-plus cities that are witnessing the most phenomenal urban growth under the impact of forced or voluntary migration from rural areas to urban areas in search of better employment opportunities, better living conditions and better access to education and health services. Along with climate change impacts, the rapid pace of mass urbanization or pseudo urbanization is putting cities under increasing water insecurity and water stress. The megacities have also grown in numbers from 10 in 1990 to 28 in 2014, accounting for nearly 12% of the world's urban dwellers. Sixteen of these megacities are located in the countries of Asia.

Cities are particularly vulnerable to water shortages under the twin impact of rapid urban growth and reduced availability of fresh water. There is also an increased demand for water in order to maintain the intense pace of activities in urban areas. With the subsequent growth of cities, the demands for water also increase, driven on the one hand by the rapid increase in urban population and on the other hand by the increased percentage of urban dwellers using municipal water services. Urbanization and changing lifestyles because of a higher standard of living further increases per capita water use, as the use of modern amenities in the form of showers, washing machines and dishwashers leads to a substantial increase the residential use of water. Cities also concentrate the sources of greenhouse gases caused by anthropogenic carbon emissions that accelerate global warming and impact the hydrological cycle thereby further increasing the water stress in cities. Increase in impervious surface and consequent depletion of groundwater reserves, increased water pollution from city waste and industrial affluent decrease the availability of finite water resources. Choked water bodies and urban drainage systems increase the vulnerability of cities to floods. Cities thus spatially concentrate the water demand of millions within a limited area and also contribute to increased frequency and intensity of water stress, urban flood, global warming and droughts. Urban areas also account for huge water footprint because of the consumption of water-intensive food and high-energy nexus. Climate change impacts are further expected to increase water insecurity by altering rainfall patterns while making cities increasingly vulnerable to major disasters including frequent floods, severe droughts, hurricane, storm surges and landslides that interfere with sustainable development, poverty alleviation, water security and other prominent goals in the region.

The book deals with the various aspects of urban water insecurity, concepts and relevance with special reference to urban water insecurity in Asian cities. The first section discusses the concepts of urban water insecurity and the implications of climate change on urban drought. This section would also explore the parameters for developing urban water security index. The second section deals with various case studies from Asia covering varied dimensions of urban water insecurity and the good practices and adaptive policy responses to manage urban water crisis.

24.2 Urban Drought and Implications of Climate Change

Urban areas concentrate population, economic activities and built environment over a relatively small area and use a disproportionate share of resources making the cities key drivers of global environmental degradation. Urban areas contribute to global warming and heat island effect with anthropogenic carbon dioxide emissions when fossil fuels are burnt for heating and cooling, in industries and for transportation. Clearing of land for the growth and expansion of cities, for the development of transport network and increased intensity of urban activities since historic times are responsible for regional land use change, deforestation and the reduction of natural sinks like wetlands. Urban areas also alter the hydrological cycle because of increased surface run-off and reduced infiltration. It results in groundwater depletion and increased water stress, aggravated by a higher frequency of extreme climatic events, greater variability of monsoon rains, floods and endemic drought due to erratic precipitation pattern and the increased chances of water contamination during such events, sea-level rise and saltwater intrusions. More frequent and high-intensity rainfall caused by global warming is already apparent in streamflow records over many decades. Behavioural and lifestyle changes imposed upon by climate change in urban areas including the increased demand for artificial heating and cooling and increased mechanization that result in increasing water use and overexploitation of groundwater also impact urban water use along with unplanned urban growth in vulnerable areas, impaired ecosystem services and altered hydrological cycle.

Hence urban drought or urban water scarcity is caused by climate change impacts resulting in physical water scarcity or a decline in water resource availability and socio-economic scarcity brought about by inadequate access to water resources and inequitable power distribution (Table 24.1). While policy experts often focus on the issue of physical scarcity and estimates of water availability to explain water insecurity, it is often more than a technocratic response. Both geographical limitations like location in dry climates or far from water sources as well as financial limitations, with the poor cities unable to construct robust urban water infrastructure increases their vulnerability to urban water insecurity, at a time when the rationale for delivery of water services in a non-discriminatory manner is well documented. Institutional, operational and financial causes of water insecurity shape the response patterns that differ in the rural and urban context.

Urban areas are seen to battle urban water insecurity through controlled urbanization, using alternate water sources like rainwater harvesting, desalinization, groundwater recharge, introduction of sewage treatment plants, improving water infrastructure by replacing old worn-out pipelines and extending the water supply network up to the fringe areas, improved water governance and cost recovery through water

Table 24.1 Urban water insecurity: issues and challenges

Urban water insecurity	Issues and challenges	Implications
Physical scarcity	• Low rainfall and arid climate • Water pollution • Reduction in water bodies • Altered hydrological cycle • Saline intrusions	Physical water scarcity or water stress
Climate induced	• Climatic variability • Extreme events • Altered precipitation pattern • Climatic events like El Nino • Heat waves and droughts	Physical water scarcity or water stress
Water governance	• Outdated infrastructure • Leakage loss • Competing water use • Inequitable distribution of water • Inadequate accessibility and affordability	Socio-economic water scarcity or water insecurity
Urbanization	• Rapid population growth • Increased per capita water use • Land-use changes • Choked water bodies • Soil sealing	Physical and socio-economic water scarcity
Disaster risk	• Increased frequency of floods and droughts • Contamination of groundwater • Groundwater depletion • Sea-level rise and coastal flooding • Water footprint	Physical and socio-economic water scarcity

Source By authors

metering, reduced greenhouse gas emissions, green infrastructure like rooftop gardens, permeable pavements, underground water detention systems and improved disaster preparedness. Examples are plenty even in Asian cities.

24.3 Assessing Urban Water Insecurity: Defining the Urban Water Security Index

Water scarcity is the inability to meet the demand for water in an area due to the unavailability of sufficient amount of water. Water insecurity, on the other hand, refers to the denial to use adequate quantities of safe pollution-free water to meet the basic human functions and local ecosystem services as well as an increased risk of water-linked disasters. The two main challenges facing urban areas are the inadequate access to water supply and sanitation facilities and increased frequency and intensity of extreme weather events with adverse consequences on economic growth, health and well-being. Water insecurity implies the denial of access by the marginalised sections of the population and is often the result of poor water governance not necessarily linked to severe scarcity or lack of availability. Ensuring water security is thus a defining global challenge in the twenty-first century, and involves, in addition to having enough water, the mitigation of environmental risks like floods and droughts caused by excess or lack of water, addressing conflicts over shared water systems, reducing stress amongst the different stakeholders and competing uses of water. It is thus embedded in various development issues including food security, social equity and environmental sustainability.

Various attempts have been made to measure and define urban water insecurity. The Falkenmark indicator developed in 1989 is one of the most accepted methods of water scarcity and water stress. It is defined as the fraction of the total annual run-off available for human use (Charkhestani 2015), using a per capita estimate of water requirement. No stress conditions prevail when the annual per capita availability of water is more than 1700 m^3 (Water Strategy Man 2004). Water stress occurs when the amount of water available per head is between 1000 and 1700 m^3 per annum. Water scarcity implies an annual per capita availability between 500 and 1000 m^3. When the available amount of water is less than 500 m^3 per person per year water conditions are one of absolute scarcity. The indicator, however, does not take into account the socio-economic and institutional dimensions that aggravate the water scarcity caused by climate variability and physical water scarcity. An integrated approach to water scarcity parameters was suggested by Vorosmarty et al. (2010) bringing together the physical and socio-economic dimensions. The International Water Management Institute (IWMI) has also assessed both physical water scarcity and economic water scarcity. The Water Poverty Index (WPI) (Sullivan 2002, Lawrence et al. 2002) developed by the Centre for Ecology and Hydrology (CEH), Wallingford further tries to assess the connection between water scarcity issues and socio-economic conditions (Water Strategy Man 2004). It ranks countries according to the provision of water, combining five components (Water Strategy Man 2004). The components include resource availability, access, use, capacity and environment. Each of these components is derived from two to five indicators which are normalized to a scale from 0 to 1 (Water Strategy Man 2004). Vörösmarty et al. (2010) and the Asian Development Bank (2003) assessed global threats to human water security and biodiversity based on twenty-three indicators. The SIPE approach to water scarcity was developed by Abedin and Shaw (2014) covering the socio-economical, institutional, physicochemical and environmental dimensions of water scarcity. Each dimension consisted of five primary indicators (Abedin and Shaw 2014). Each primary indicator was made up of 5 secondary indicators amounting to a total of 20 primary and 100 secondary indicators. Authors have demonstrated that the inclusion of five dimensions (physical, social, economic, institutional and natural) (Abedin and Shaw 2014) is essential to measure resilience including urban water resilience (Joerin and Shaw 2011). The Arcadis Sustainable Cities Water Index assessed 50 global cities on issues impacting the resiliency, efficiency and quality of the urban water sector and their impact on long-term sustainability. Indicators were chosen for the three categories encompassing physical availability, socio-economic parameters and water governance and included among others fresh water withdrawn as percentage of total available water, number of water-related disasters like flood, droughts, percentage of city area covered by green spaces, water charges, proportion of water lost in transit, households having access to safe drinking water, households with metered supply, hours of supply, wastewater reuse and the incidence of water-related diseases. The water security dimensions proposed by the Asian Development Bank 2016 to determine water security status cover five dimensions of water security index (WSI): WSI1or basic water (renewable, supply, sanitation), WSI2 or sufficient water (water supply, consumption, agricultural water), WSI3 or development water (irrigation area, industrial water use, water for energy, water for aquaculture), WSI4: water disaster (loss from floods and drought) and WSI5 or water for future (population growth, urban population growth, water footprint) (Asian Development Bank 2016).

Based on the concepts and indicators that define and measure water insecurity, an attempt has been made in this book to identify the parameters and indicators that may be used to assess water security in urban areas and resilience in the urban water system (Ray and Shaw 2016). Apart from the physical scarcity of water, cities in Asia also suffer from water insecurity, often magnified by improper water management. Hence in the listing of indicators, emphasis has been given to institutional dimensions of urban water security. Fifty indicators have been chosen under the physical, socio-economic and institutional dimensions of urban water security. These indicators are to be normalized on a scale from 1 to 5, ranging from very poor or not available score of 1 to a best score of 5. In addition, all five variables within a parameter would have to be ranked (W_1, W_2, W_3, W_4, W_5) between each other in the range of not important (1) to very important (5) in order to give a particular variable a higher or lower weightage in the calculation of the aggregate scores (Joerin and Shaw 2011). The constant use of five choices, ranks and weights allows the adoption of a formula based on weighted mean (Joerin and Shaw 2011) (Eq. 24.1, Formula for weighted) to calculate the urban water security for each indicator, parameter and dimension (Abedin and Shaw 2014). Cities may then be ranked according to the aggregate-weighted mean index combining all the components. The dimensions and indicators used may be modified to suit local conditions to ensure global applicability of the dimensions and parameter/indicators.

$$\frac{\sum_{i}^{n=1} W_i X_i}{\sum_{i}^{n=1} W_i X_i} = \frac{W_1 X_1 + W_2 X_2 + W_3 X_3 + W_4 X_4 + W_5 X_5}{W_1 + W_2 + W_3 + W_4 + W_5} \quad (24.1)$$

24.4 Learning from Asian Cases

Already identified as the world's driest continent in terms of per capita water availability, severe droughts are common over vast regions of Asia, extending from southern Vietnam to central India. With the annual per capita availability at 3920 m^3, the availability of freshwater is less than half the global annual average of 6380 m^3 per inhabitant. Asian cities are the worst hit under the impact of rapid and mass urbanization. Increased demand because of a growing urban population and lifestyle transformations along with climate change-induced water shortage is already putting pressure on the water management systems in the water-scarce urban areas. The region is also vulnerable to disasters, often water linked disasters like endemic floods and droughts, hurricane, storm surges and landslides but continues to be inadequately prepared. Hence the Asian cities are embracing new approaches to urban planning for a water-secure future. This chapter intends to focus on the problems of water insecurity in the cities of Asia and to highlight some of the best practices adopted in urban water governance. The Asia-Pacific Water Forum anticipates that climate change impacts will impose additional threat on the already vulnerable countries in the Asia and the Pacific region, challenging the very concepts of sustainable development, poverty alleviation and improved water security. Water-related natural disasters are also common in the Asia-Pacific region.

The case studies have been selected to cover all aspects of urban water insecurity and thus highlight key-learning experiences (Table 24.2). The selected cities range from megacities with a population above 10 million that include Delhi and Kolkata in India, Dhaka in Bangladesh and Metro Manila in the Philippines. There are million-plus cities with a population exceeding 1 million. Such cities include Tehran in Iran, Darjeeling, Nagpur and Thane in India, Kathmandu in Nepal, Peshawar in Pakistan and Ulaanbatar in Mongolia. The medium-sized towns include those towns that have a population 1 lakh and above. Colombo, Kandy, Galle in Sri Lanka, Banda Aceh city, Indonesia, Iloilo and Cebu in the Philippines, Udon Thani in Thailand fall in this category. Small towns with a population of less than a lakh include Yanagawa in Japan and Galle in Sri Lanka.

Many of the chapters highlight the various aspects of urban water insecurity and water stress. Water stress and urban drought resulting from physical scarcity of water and climate-induced uncertainties and water stress have been dealt with in the context of the megacity of Delhi as well as the million city of Tehran. Darjeeling and Kathmandu valley focus on the urban water challenges in mountain environment. Climate change and its impact have been discussed with reference to the city of Delhi while impact of El Nino occurrences on water availability and consequent urban drought has been dealt within the context of Metro Manila, Iloilo and Cebu in the Philippines. The socio-economic conditions of water insecurity in urban areas have been considered for the cities of Kolkata, Delhi and Dhaka, the three important and densely populated megacities in the Indian subcontinent. Old worn-out infrastructure, inadequate and inequitable distribution of water result in acute water insecurity amongst the urban poor and in the fringe areas of these cities. These issues thus further highlight poor urban water governance and inefficient water management. The key issues of urban water governance have also been dealt with separately for Colombo city of Sri Lanka. Health risks associated with poor drinking water availability is evident from the case study of Hong Kong. Rapid urban growth is also responsible for soil sealing that aggravates the already evident water scarcity by reducing infiltration and groundwater recharge when most Asian cities are seen to supplement municipal

Table 24.2 Key learning from different Asian cities

Key learning from urban experience	Case studies from Asia
Physical scarcity of water, climate-induced uncertainties and water stress	Delhi, India Tehran, Iran
Urban water scarcity in mountain environment	Darjeeling, India Kathmandu, Nepal
Soil sealing and urban drought	Peshawar, Pakistan
Water insecurity in the formal water supply and management system and community resilience in parallel water supply systems	Kolkata, India
Socio-economic water insecurity	Kolkata and Delhi, India Dhaka, Bangladesh
Water insecurity in urban slums	Dhaka, Bangladesh
Urban water governance issues	Colombo, Sri Lanka
Health risks associated with water resources management	Hong Kong, China
Risks and vulnerabilities to water-related disasters	Dhaka, Bangladesh
Institutional obstacles to climate resilience and vulnerability to floods and droughts	Udon Thani, Thailand
Flash floods and water scarcity	Ulaanbatar, Mongolia
El Nino, urban drought and risk governance	Metro Manila, IIoilo and Cebu, Philippines
Impacts of tsunami on the availability of clean drinking water	Banda Aceh city, Indonesia
Traditional water management through canal restoration	Yanagawa, Japan
Role of urban infrastructure in building resilience	Nagpur, India Dhaka, Bangladesh
Studies of policy initiatives for mitigation and management of urban drought	Colombo, Gale and Kandy, Sri Lanka
Water conservation measures	Thane, India

Source By authors

supply with groundwater. Impacts of soil sealing on urban drought have been dealt with for Peshawar in Pakistan. On mitigation and management of urban drought, studies of policy initiatives have also been done with case studies of Colombo, Gale and Kandy. The twin problem of flash floods and water scarcity of Ulaanbatar city and the impacts of tsunami on the availability of clean drinking water in Banda Aceh city, Indonesia cover the disaster aspect of urban water insecurity. Apart from the analysis of urban drought and its causes, water conservation measures that may be adopted for tackling urban drought have also been studied. Analysis of existing water conservation throws light on the issues and challenges in the existing measures while evaluating traditional water management schemes in Yanagawa city of

Japan. The chapter describes the process of the canal restoration to revitalize the water environment in urban areas by bridging the distances between far water and near water. Resilience in the existing urban water system has been evaluated through urban infrastructure in Nagpur and Dhaka.

Urban water insecurity issues discussed in the previous chapters thus focus on some of the targets specified in the Sustainable Development Goals (SDGs), including goals 6, 9, 11, 13 and 15. Goal 6 is devoted to universal access to safe water and improved sanitation, sustainable management of water resources and capacity building through innovations. Goal 9 highlights on innovations for improved infrastructure while Goal 11 emphasizes upon making cities inclusive, safe, resilient and sustainable. Goal 13 focuses on climate change and hence on urban drought while Goal 15 promises to combat desertification, reverse land degradation and loss of biodiversity.

24.5 Future Prospects in Asian Cities

It is quite evident that urban water systems develop and function as complex socio-ecological system. Water management strategies need to adopt a multidisciplinary-integrated approach including all the different stakeholders and must address issues evolving from changes in regional climate as well as other socio-economic factors like population increase, economic development and urbanization. Water is one of the most vital resources for the functioning of urban water systems with competing water use across commercial, residential and industrial sectors. With industrial and domestic water consumption levels expected to increase by twice the present level by 2050 (UNDESA 2007), competition for water use is expected to increase significantly between urban, peri-urban and rural areas. To make matters worse, impact of climate variability including the increased frequency of extreme weather events has altered the quality, quantity and the seasonal availability of water for most urban centres (Global Water Partnership 2000). In the context of changing expectations, urban water systems are confronted with increasingly complex and multi-faceted challenges, in particular, when the existing and available resources reach the limits of sustainable exploitation (Brown et al. 2009; Pubmed). As cities grow in terms of population and diversity of urban functions, demands on the urban water systems rise and hence the existing water systems are often exploited beyond their sustainable limit. It is already evident that existing water management approaches are inadequate to address water insecurity and water stress. An attempt is hence made for integrated water management approaches involving different stakeholders instead of compartmentalized and isolated management of urban water systems. Integrated urban water management encompasses all forms of water sources including blue water (surface water, groundwater, desalinated water), green water (rainwater), black and grey water (Global Water Partnership 2000). The targets for urban water management include assured access to water and sanitation facilities and services, proper management of rainwater, wastewater treatment, stormwater drainage, reduced levels of pollution of water resources, control over waterborne diseases, reduced risk of water-linked hazards of floods, droughts and saline intrusions as well the preservation and proper functioning of wetlands. Integrated urban water management (IUWM) offers a set of principles that ensure better coordinated, responsive and sustainable water management practices (Global Water Partnership 2000). It recognizes alternate water sources for enhanced water security, differentiates and recognizes water quality parameters and the use potential of different sources of water, manages water storage, distribution, treatment, recycling and disposal as part of the same resource management cycle (Global Water Partnership 2000) rather than as discrete activities. Urban water must align formal institutions (organizations, legislation and policies) with informal practices (norms and conventions) (Global Water Partnership 2000), simultaneously pursue economic efficiency, social equity, and environmental sustainability and encourage participation by all stakeholders (Furlong et al. 2017). It must also plan for the protection, conservation and exploitation of water resources (Global Water Partnership 2000). The existing urban water systems must be more efficient, reduce leakage loss to the tune of 32 billion cubic metres per year (Kingdom et al. 2006; Global Water Partnership 2000) and reduce the volume of non-revenue water. Apart from technological solutions to improve water security, urban water management also includes behavioural changes, institutional capacity building and water resource assessment or water audits. The aim of urban water management is to create cities and towns that are resilient, liveable, productive and sustainable (Government of Western Australia). Urban water management thus takes into consideration the total water cycle, facilitates the integration of water factors in the planning process, and encourages all levels of government and industry to adopt water management and urban-planning practices that benefit the community, the economy and the environment (Government of Western Australia).

Urban areas in the less developed countries of Asia, crippled by severe financial and institutional constraints, and poor water governance, need to better understand and manage water security issues including adaptation options. Global urban communities are striving for increased resilience within the existing urban water systems and to future uncertainties in water supply because of climate change and population growth. It is already well documented that the conventional water systems are often inadequate to address water insecurity and water stress in urban areas. Transforming urban water systems into more resilient and hence more sustainable systems would require innovative approaches. These approaches may be categorized into infrastructure-based approaches and system-based approaches (Fig. 24.1).

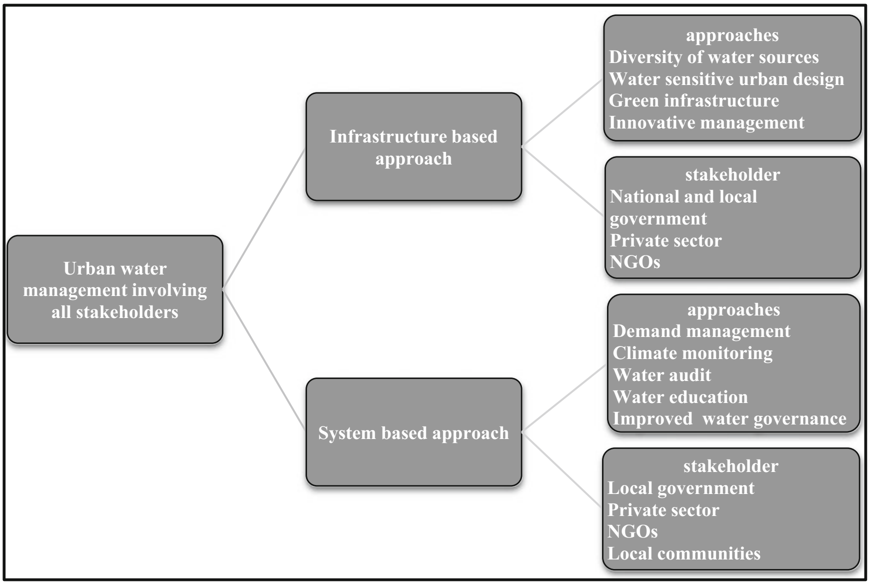

Fig. 24.1 Innovations in urban water management

24.5.1 Infrastructure-Based Approaches

- Diversity of water sources

It is pertinent to note that there are a wide range of water sources that the cities can access to supplement the existing ones including rainwater harvesting, construction of new storage facilities, appropriate and sustainable extraction of groundwater, groundwater recharge, urban stormwater use, treated wastewater and desalination options. Appropriate policy initiatives would enable cities greater flexibility in identifying the alternate sources for improved supply and delivery options.

- Water-sensitive urban design

Water-sensitive urban designs allow cities the option to utilize grey water for non-potable uses in toilets, laundry, gardens and car-washing stations. Such use of water may be made compulsory for residential areas and the building bylaws amended accordingly. Provisioning of green infrastructure in new buildings and urban areas like rooftop gardens, permeable pavements, underground water detention systems may also be explored. Green retrofitting of existing buildings like the introduction of rainwater harvesting at institutional level needs to be promoted through legal binding if necessary.

Strategies to mitigate urban warming by changing the materials used for individual buildings and improved building design and layout would help to reduce energy demand. Increased number of open spaces may also be adopted as a strategy to reduce urban heat island effect while the introduction of detention areas and ponds would reduce urban run-off to increase infiltration for groundwater recharge.

Drainage pumping stations can significantly reduce the chances and intensity of urban flooding. The old worn-out water supply system in many cities needs to be replaced to reduce leakage loss and increase the availability of water.

- Innovations in water management and water usage control devices

The private sector may be engaged in innovative water management strategies like water usage control devices to reduce the flow of water from taps to reduce wastage. The saved water may be reallocated to vulnerable areas of the city and also to the vulnerable sections of the population. Such devices could include the installation of an isolating ball valve or a flow restrictor to monitor the flow of water. With a tap aerator, the design of the tap nozzle allows air to mix with water giving the appearance of increase in water flow. These devices are easy to retrofit to existing taps (Nibusinessinfo). An ‘eco-tap’ or ‘eco-brake’ cartridge stops an user from using the full flow that the tap can provide by stopping the tap lever from moving more than halfway (Nibusinessinfo). It offers substantial savings as the potential water flow is halved (Nibusinessinfo). The other option could be the use of a spray tap. In a spray tap, the nozzle found in normal taps gets replaced with a snout that gives out water in the form of mist or spray. Spray taps can save up to ten litres of water per minute and are hence highly effective at saving water.

- Mobile-based water flow monitoring system

An online or mobile-based application may be introduced that monitors and controls the flow of water through taps (Kumar and Mahmoud 2017). The water flow monitoring system is an interactive android-based mobile application (Kumar and Mahmoud 2017), fitted with external hardware, where registered users can view their water usage and flow on the screen. The rate of flow of water gets updated every second to a database available online. An user’s on/off instruction is set within the database; the hardware synchronizes this instruction and performs the desired action (Kumar and Mahmoud 2017). Set Timer and Set Schedule are two additional functions provided to users (Kumar and Mahmoud 2017). The Set Timer function enables the users to set a timer to turn on/off a water supply tap while the Set Schedule function enables the users to set a timer to turn on/off a water supply tap on a desired date (Kumar and Mahmoud 2017). This can be made available for the centralized potable water schemes at the city level as well as for localized water supply schemes like simple rainwater harvesting systems at household or community levels.

24.5.2 System-Based Approaches

- Increased urban water resilience

Urban water systems are also facing an increasing need to improve water resources management and build efficient infrastructural facilities to meet the requirements of an escalating demand and diminished water availability. Climate monitoring, assessment of water stress, demand management, land-use planning and resource mobilization, urban landscaping will ensure better urban water systems and reduce climate-change-related disaster risks. Institutional capacity building, promoting scientific research and awareness, new and innovative approaches to urban water governance and community involvement aimed at reducing water insecurity and removing water stress is expected to increase urban water resilience.

- Stakeholder participation

The role of urban communities needs to be recognized in identifying urban water stress and their participation should be encouraged in developing water-sensitive strategies. Brown et al. (2008) argue that unless new technologies are socially embedded into the local institutional context, their development in isolation is insufficient to ensure their successful implementation in practice (Wong and Brown 2009; Brown et al. 2008). Participation of the key stakeholders is warranted for understanding and balancing the interests and needs of different stakeholders and for strengthening mutual cooperation.

- Demand management

Managing water demand is considered as an effective tool to ensure urban water security. It promotes water conservation through changes in the attitude of the end-users and through the use of conventional practices for the conservation of water resources. Demand management for urban water security could employ communication tools, public awareness campaigns for behavioural change and to conserve scarce water resources, social media campaigns on water conservation practices and public workshops on water-use efficiency.

- Water education

Water-focused school education and innovative practices like the maintenance of water diaries of domestic water usage per week or month and presentation of water certificates for reduction in water usage may be considered as a system-based approach to save water.

- Water pricing and water audit

Country-specific water pricing based on institutional and cultural framework may be thought of. Water audit may be carried out at institutional or subcity/ward level for effective demand-supply system. Automated water systems are best avoided as they result in inefficient and excessive water use leading to stress in the water supply systems. On occasions when automated water systems cannot be avoided, they need to be fitted with timers to ensure controlled use.

- Water conservation measures

Regulatory tools may also be adopted for forced water conservation and may include such measures as setting water-use limits, slab-based pricing of water use based on local culture and water-use requirements, special concessions for the use of water-efficient technology by the city corporations and legal bindings for water conservation. Coordination between the formal and informal water sectors, improvements in water storage and management, community participation would also lower water insecurity. Rainwater harvesting techniques may be used to divert rainwater captured in rooftops and gutters for groundwater recharge or for gardening. Aiming for water security through diversity and optimum use of all water sources, matching water quality with the purpose of use are some of the other interventions suggested.

24.6 Conclusion

The cities in Asia are faced with multifarious problems and include inadequate availability of fresh water, leakage loss from distribution networks, intermittent supply, poor water quality in municipal taps and poor cost recovery. Excessive use of groundwater has caused rapid depletion of groundwater reserves and severe environmental damages. Inadequately developed sewerage systems and the absence of sewage treatment plants also often result in water contamination, making it exceedingly difficult for cities to supply clean water. In addition, heavy seasonal monsoon rain and frequent floods are common in Asian cities.

Preparing the urban water systems in cities of Asia for climate change impacts requires innovations in the traditional approaches practiced by the local communities. Technological improvements and institutional capacity building are needed to develop resilient and sustainable urban water systems. Many urban centres and countries of Asia have already adopted innovative measures in managing water stress and drought in urban areas. The densely populated city of Singapore, for example, with no source of fresh water supply, is amongst the most highly water-stressed countries with its demand exceeding the naturally occurring supply. Yet the city is able to provide enough water for its industrial, agricultural, commercial and domestic use through investment in technology, international agreements and effective water management. Advanced rainwater detention systems account for 20% of the water supplied in Singapore. 40% is given by Malaysia. Use of grey contributes another 30% while desalination process provides the remaining 10% of the supply. However, in order to make any water management system resilient and sustainable, an integrated water management strategy must be formulated and implemented. Interventions are required at planning and policy level that would have some legal binding on the citizens. Such bindings would ensure the proper implementation of innovations in the urban water system.

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