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Niasse, Madiodio; Varis, Olli

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Quenching the thirst of rapidly growing and water-insecure cities in sub-Saharan Africa

Madiodio Niasse^a and Olli Varis^b

^a Land, Water and Environmental Governance Expert, B.P. 197, Ngaparou, Senegal madiodio.niasse@gmail.com

^b Water and Development Group, Aalto University, Espoo, Finland. olli.varis@aalto.fi

ORCID: Olli Varis <https://orcid.org/0000-0001-9231-4549>

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ABSTRACT

It is in the water sector that Africa faces some of its more pressing challenges, which are exacerbated with the sprawl of megacities. The gap between water requirements and available water resources is widening. While the urbanization process is still accelerating, acute seasonal and chronic water shortages are already encountered in almost all major cities. Unless the direction is radically changed, sub-Saharan Africa is headed towards an urban water crisis of alarming proportions. Based on city experiences from Africa and their comparison to those from India, we draw lessons and suggest response options for tackling urban water crisis risks in Africa.

Keywords: Africa, urban water, India, development, slums, megacities, water scarcity

INTRODUCTION

Severe water crises are becoming increasingly frequent on all continents. In Australia's east coast cities, in the west and southwest of the US, in Mediterranean countries, in many parts of Asia, particularly in India's megacities (Delhi, Chennai, Bangalore, etc.), and perhaps most strikingly in Africa. Situations such as Cape Town's unprecedented water shortage in 2017—a crisis also referred to as “Day Zero”—was a dire warning to the world.

Experiencing the world fastest population growth and highest pace of urbanization (AfDB, 2018; 2019)—with sprawling metropolises—Africa seems particularly vulnerable to water shortages, especially with regard to the continent's largest cities. Many of them are already facing either seasonal or chronic water shortages. These include Bamako, Niamey and Harare and also cities located in the wettest regions of the continent such as Luanda and many others.

If the current trends persist and contemporary projections (cf. Hoornweg & Pope, 2014) are not totally wrong—in terms of demographic change, urban growth and climate change impacts on water—one could expect an urban water crisis of alarming proportions in sub-Saharan Africa in the decades to come.

Since urban water and development issues are highly complicated and context-specific, and a myriad of inconsistent views and argumentation prevail (Kumar, 2018), Tortajada and Biswas (2019) called for objective case studies of urban water management in order to understand more broadly what has worked and what has not in various contexts of urban development. We examine the urbanization process in sub-Saharan Africa, starting from the root causes of the water crises threatening the continent's largest cities and conurbations. We analyse the key risks (climate change, intensified competition, struggles for water, and possible knock-on effects related to peace and political stability) associated with severe and unresolved urban water crises. In order to improve our understanding of the urban water crisis risk in sub-Saharan Africa, we analyse the experiences of selected cities (from Africa and India) that are among the most vulnerable or are evolving toward widening water supply gaps. Building on the key findings and lessons from the investigated city experiences, we propose an array of response options that could be considered to avoid, delay or minimize the water crisis risks in megacities of sub-Saharan Africa.

MAGNITUDE OF THE WATER CRISIS IN AFRICAN MEGACITIES

Africa's urban water challenges are primarily related to the fast-growing population, and especially the pace at which urban areas inflate. While the world's population is growing by around 83 million people each year, Africa contributes to one-third of this growth, even though the continent represents only 13% of the global population (UN, 2017). The population growth in African urban areas is even more spectacular.

Africa's demographic growth and rapid urbanization: a time-bomb?

Sub-Saharan Africa's population is now growing by 28 million people per year (UN, 2017). The population is projected to double by 2053, triple by 2086 and grow four-fold by the end of the century. It will soon have a larger population than India (in 2028) and China (in 2026) (Figure 1). Whereas India's and China's population is projected to peak during this century (China in 2030 and India in 2070) and begin to decline thereafter, sub-Saharan Africa's population growth will keep accelerating for several decades.

An increasing share of this massive growth will be urban. Although Africa is today the least urbanized of all continents, it has the fastest pace of urbanization (Muggah & Kilcullen, 2016). With an annual growth of almost 4%, Africa's urban population doubles every twenty years (Jacobsen et al., 2012).

Along with Africa, China and South Asia dominate the urban growth, each contributing to around 16 to 17 million urban residents per year (UN, 2017). Africa's outlook is different from the two other regions in the sense that its growth is projected to continue very rapidly for the rest of the century (UN, 2017), whereas in Asia (even in South Asia), the growth rate—despite being speedy now—will start to slow down in the next three decades. Hutton and Varughese (2016) project that the urban population growth in sub-Saharan Africa will increase by 72% between 2015 (372 million people) to 2030 (642 million people), compared to 40% growth for South Asia.

Hoornweg and Pope (2014) analysed the growth and development pathways of the world's 101 largest cities of this century. By using the shared socio-economic pathway scenarios (Arnell & Kram, 2010) and United Nations World Population Projections of 2011, they produced a matrix of scenarios for the development of population, urbanization, resource availability and scarcity, as well as economic growth. All scenarios manifest a massive growth of these urban centres.

By 2050, the largest megacities are projected to be in South Asia and Africa. In other continents, the size of cities and their growth rate are more modest. After 2050, Africa stands out having the most massive growth.

India and Africa are almost the same size in terms of demography and economy (Table 1), although Africa is nine times larger in surface area. Similarly, they are more or less equally represented in the list of the world's top 101 largest cities (9 for Africa and 7 for India). By 2050, Africa is projected to have almost tripled its count on the list (to 25 cities), while India's count is 11 (Table 1).

The urban water crisis in Africa—contemporary threats and warning signs for the future

Urban water insecurity is a threat not only for the future but also for the present, which is shown by the soaring number of severe water shortages hitting several major African cities each year. In the last five years alone, a countless number of cities from all sub-regions of the continent—both arid and humid—faced water deficits. We will mention a few cases, starting with Southern Africa. Harare and Bulawayo (Zimbabwe's two largest cities) faced severe water shortages in the first half of 2019, leading to drastic water-rationing measures. During the same period, in neighbouring Mozambique, Maputo residents had access to tap water on alternating days (Dontoh & Cohen, 2019).

In West Africa, we use two illustrative examples: Dakar (the coastal capital of Senegal) and Bouake (the 2nd largest city in Côte d'Ivoire, more than 200km from the coast). With its satellite towns and villages, Dakar largely depends on Lake de Guiers, a tributary of the Senegal River, 250 km away (Cogels et al., 2001). The city experiences severe water deficits almost every year, including April–July 2019, when tankers were used to compensate the failing utility-managed water distribution system. In 2018, Bouake faced a severe water shortage due to rainfall deficits and the shrinking Loka reservoir, which covers 70% of the city's water supply (Larcher, 2018). The government responded with massive water supplies from tankers and a decision to dig 44 boreholes, which can only be effective if the current trends in the dropping of groundwater tables is reversed.

In Eastern Africa, Nairobi (Kenya) illustrates the challenge of dealing with an ever-expanding water demand. Nairobi's population swelled threefold from 1985 to 2010, leading to a 200% increase in urban water demand. It is no surprise that the city finds itself in frequent water crises, such as in 2009, when water had to be rationed as a result the city's main reservoir shrinking (Jacobsen et al., 2012). As the city continues to grow rapidly, the water demand has increased by 30% since 2012. As a result of the widening gap between water demand and supply, water crisis management has become a permanent challenge for Nairobi, as for the whole of Kenya (Goswami, 2018).

Each of Africa's sub-regions is affected by urban water shortages, increasingly threatening the future of cities as diverse and dissimilar as Marrakech, Ouagadougou, Dar es Salaam and even cities like

Kampala and Kinshasa, which are at the shores of large water bodies—Lake Victoria and the Congo River, respectively. Throughout the continent, the gap between water demand and supply widens, leading to crises each time a pronounced rainfall deficit occurs, which, in the current context of climate change, is more the rule than the exception.

To sum up, it is in the water sector that Africa faces one of its more pressing contemporary challenges, which grows more difficult with the sprawl of large cities as we move to the future. Van der Bruggen et al. (2009) estimate that for every urban citizen in sub-Saharan Africa in 1950, 53 more will have to be accommodated by 2050 and supplied with water. In a century, there will be more than a fifty-fold increase in the urban population of sub-Saharan Africa. Along the same lines, Jacobsen et al. (2012) project that over the next 25 years the demand for water in Africa will almost quadruple, largely due to the anticipated dramatic growth in the urban population but also due to economic development translating into industrial expansion, prosperity and a larger middle class. The challenge is not limited to Africa. Globally, it is anticipated that urban dwellers living with seasonable water shortages will grow from about 500 million people in 2000 to 1.9 billion by 2050 (World Bank, 2018). Large conurbations present additional water challenges of their own. They put enormous pressure and rapidly exhaust local sources, and hence require extensive, complex and onerous infrastructure such as dams and water transfer canals to transfer water over long distances.

THE ROOT CAUSES OF URBAN WATER CRISES

In order to improve the continent's preparedness for preventing and managing urban water crises, it is important to understand the causes of these crises. In this section, we analyse the causes of the currently observed urban water crises in sub-Saharan Africa from various angles: the pace, patterns and modalities of urbanization; the structure and spatial distribution of settlements; and the extent and soundness of investments made in the urban water infrastructure.

Soaring Sub-Saharan Africa's urban population and sprawling cities

From a water-planning perspective, as well as for mobilisation of finances and for physical construction and operation, the pace of urban sprawl is a serious challenge. While only two cities (Kinshasa and Lagos) exceeded 5 million in 2000, two more exist today (Dar es Salaam and Luanda). By 2030, the following 15 sub-Saharan African cities are projected to host more than 5 million inhabitants: Addis Ababa, Nairobi, Antananarivo, Kampala, Dar es Salaam, Luanda, Douala, Yaounde, Kinshasa, Cape Town, Johannesburg, Abidjan, Abuja, Kano and Lagos. Four of these cities are expected to exceed 10 million: Dar es Salaam, Luanda, Kinshasa and Lagos (the latter two having each more than 20 million people) (UNDESA, 2018). Fast-growing cities tend to rapidly exhaust locally available natural resources, sucking the aquifers underneath and drying out lakes and reservoirs in their neighbourhood.

When patterns of urbanization influence the water stress risks of cities

The very process of urbanization and the pathways followed in city creation and urban growth play a major role in the water crisis we are witnessing today in many large African cities and conurbations. They explain why and how the location of the city was decided and the modalities and pace of urban growth. The location of a city—at the shore of a freshwater body, in a region with abundant aquifer reserves or instead in a hard rocky environment far from surface waters—is a determining factor for a city's water stress and the available options to gain and preserve water security as the urban population expands.

Most of Africa's largest cities are former colonial capitals that maintained their status after independence. As colonial cities, they were created to serve as military barracks and economic entrepôts for trade (imports and exports). Often located along a coast and/or major rivers, many colonial capitals flourished as trading centres when they were administrative headquarters and hosted

harbours linked to the countryside by railways (Horvath, 1969; Thomas, 1970; Coquery-Vodrovitch, 1991). As they became capitals of newly independent states, they consolidated their political, administrative, intellectual and economic roles. They received a large share of investments as symbols of the aspirations for modernity and affirmation of the national pride of newly independent states. As a result, they attracted more and more people to become the vast agglomerations they are today. Colonial centres were created with limited or no consideration to the natural resource potentials and limitations of their locations. At present, we see a widening gap between the requirements of the cities they have become today and the natural endowment of their local environments, including physically available water resources.

Resulting from urbanization processes that fail to adopt an ecological approach (defined by Filani & Okafor (2006) whereby the location of cities is decided upon in relation to their immediate physical environment), many African cities are today located in areas at high water stress risk, as is the case for cities such as Bamako, Lagos, Niamey, Ouagadougou and Dakar.

From the collapse of Africa's farming sector to the rural push to urban slums

Typically, cities grow either through natural population growth, immigration, and/or the absorption of neighbouring cities and villages (Kasarda & Crenshaw, 1991). The natural or “organic” growth of the population is and will remain very high, reflecting the high birth rate in sub-Saharan Africa, which applies to both urban and rural areas. In-migration (voluntary and involuntary) is what makes the difference for urban areas (Muggah & Kilcullen, 2016). Cities that experience high population growth from natural growth and in-migration, essentially from rural areas and smaller cities, will inexorably encroach upon and convert neighbouring agricultural land and absorb surrounding settlements.

In order to understand the magnitude and nature of migration to African cities, it is important to place it in the context of Africa's particular development path. In the classic economic development path, growing agricultural production leads to wealth accumulation, which serves as the basis for industrial development (a secondary sector), which in turn boosts agricultural production through mechanisation, both sectors feeding into the tertiary sector. Industrial development creates jobs and contributes to agricultural modernisation, which frees labour from the agricultural sector that becomes available for generally urban-based secondary and tertiary activities. In such a development path, rural–urban migration takes place in a context where rural push coincides with urban pull (cf. Niva et al., 2019).

Africa's trajectory is different. Despite the continent's considerable potential for agricultural expansion (including irrigation), the farming sector is ailing, which means low productivity, degrading soils and high vulnerability to fluctuating agricultural commodity prices and the vagaries of climate change (Evans, 2010; Bernstein, 1990). Impoverished and desperate farmers flee from rural areas in a massive rural exodus—and settle in the rapidly swelling slums of big cities (Moseley et al., 2010). At the same time, the underdeveloped agriculture is unable to feed the expanding cities that have to rely on food imports for their food supply. This means that an important transfer of wealth outside of the country (since the trade balance usually becomes strongly negative) and insufficient finance inhibit agricultural development. Comparing factors behind rural out-migration to cities in China and Africa, Collier (2017) points out that in the former, rural migration was more a response to urban growth than to rural desperation, as is the case in Africa. This pattern of urban development has far-reaching impacts on urban water management and on the ability of African metropolitan areas to respond to water crisis risks.

The above-described pattern of rural-to-urban migration results in what Filani & Okafor (2006) call the “peasantization” of African cities, as new in-migrants tend to maintain their 'peasant-type' strategy to survive in their new urban environment.

This phenomenon contributes to the spectacular expansion of slums which accompanies the growth of major cities in sub-Saharan Africa. The United Nations define slum household as ‘a group of individuals living under the same roof in an urban area who lack *one or more* of the following five conditions: durable housing, sufficient living area, access to improved water, access to sanitation, and secure land tenure titles (UN Habitat, 2006)’. It has been estimated that more than 70% of sub-Saharan Africa’s urban population lives in slums (UN-Habitat, 2006; Dagdeviren & Robertson, 2011; Jacobsen et al., 2012; Bahri et al., 2016). Thereby, the urbanization process in sub-Saharan Africa has become virtually synonymous with slum growth (UN-Habitat, 2006).

This large proportion of informal settlements is highly relevant to urban water security in Africa. Access to tap water is very limited in slums. Slum dwellers find alternative solutions to their water needs by digging wells and using surface water ponds, which are often polluted because of the lack of sanitation and domestic waste treatment, resulting in high exposure to water-related diseases. The anarchy that often prevails in slums means a weak government presence without the ability to enforce the law or coordinate a response such as administering quotas for water allocation when it becomes necessary to apply drastic measures to limit urban water consumption.

Booming cities, flourishing water-intensive activities and lifestyles

Urbanization is accompanied by a boost in many water-intensive sectors and activities. As the population grows and becomes more urban, the need for food, energy, minerals, consumer goods, construction materials and other materials becomes manifold compared to the current situation. Within their supply chains and life cycles (Hellweg & Milà i Canals, 2014; O’Rourke, 2014), they all have specific links to water. Urban areas also attract water-intensive industrial installations, increasingly located in special economic zones in the suburbs of megacities.

In addition, urban metropolises typically host most of society’s wealthiest segments and the middle class whose water demand per capita often far exceeds the national average. In Asia’s developing countries, per capita water use increases dramatically in households experiencing improvements in their living standards when introducing access to tap water facilities (ADB, 2010). The same phenomenon is also seen in Africa (Dos Santos et al., 2017).

All of the above factors, together with a swelling urban population, amplify the ever-expanding thirst of megacities in developing countries in general and in sub-Saharan Africa in particular.

The challenge of the water infrastructure gap

The importance of infrastructure in the development of societies is essential (Muller et al., 2015). Investment gaps in water storage and an ageing water infrastructure contribute significantly to Africa’s water crisis, especially in the largest urban areas. However, the water infrastructure investment gap is a global concern. Estimates of the investment needs vary significantly (cf. Barenjee & Morella, 2011; Foster & Briceño-Garmendia, 2010; Hutton & Varughese, 2016). According to Woetzel et al. (2016), all infrastructure investment needs at the global level amounted to an annual level of 2.5 trillion USD in 2013. This means that the needed annual spend by 2030 to meet the United Nations Sustainable Development Goals would be in the order of 3.3 trillion USD. According to other estimates, the annual water infrastructure investment should be twice as much as the 2015 level of 236 billion USD (Hutton & Varughese, 2016). Substantial finances are necessary to close the water infrastructure gap. Nevertheless, when divided among the world’s population of 7.7 billion in 2019, the sum becomes more comprehensible: from 30 to 60 USD per person annually.

In the African context, the water infrastructure (water storage, water transfer schemes, wells and boreholes, water and wastewater treatment plants, sewer systems, etc.) typically covers only parts of urban areas—generally ignoring slums, which as we have seen now take up the most area in most of the large African cities. Where water infrastructure exists (for example in the centres of former colonial

cities), it tends to be ageing, obsolete and a source of important water losses (Bahri et al., 2016). Africa's water infrastructure gap is more striking when examined using existing dams and water storage facilities. Of the world's registered 58,000 largest dams, only 2,150 (or 4%) are in Africa, and the majority of African large dams are in North Africa (20%) and between South Africa and Zimbabwe (63%). The level of water control is hence quasi-nonexistent in most of sub-Saharan Africa.

Water transfers from a water-abundant to a water-poor region—including cities facing water deficits—may be increasingly used in the future as discrepancies in water allocation widen due to climate change and evolving water demand. The highest water demand is concentrated in urban agglomerations and agricultural growth poles. In Africa, inter-basin water transfer schemes are more developed in Southern Africa (South Africa, Namibia and Botswana). However, there are notable water transfer schemes in other sub-regions of the continent. Among these, we can mention Libya's Great Man-Made River Project, which is a 3000-km long network of underground pipes transferring water from the deep aquifers of the southern regions to the northern and coastal regions of the country for irrigation and water supply for Tripoli and other coastal cities. On the Atlantic coast, the cities of Dakar and Nouakchott receive the largest share of their water consumption from the Senegal River, through water transfer schemes of 250 and 170 km. respectively. In the future, the most ambitious water inter-basin transfer project is the Lake Chad Replenishment Project. It is a mega-water transfer scheme 2,400 km long, transferring about 50 billion cubic metres annually from the Ubangi River (in the Congo basin) to replenish Lake Chad (LCBC, 2016). The project has very ambitious targets in hydropower production and irrigation, but it will also benefit the cities of N'Djamena and Maiduguri and potentially the Komadugu-Yobe River basin, where Kano, Nigeria's second largest city, is located.

IMPLICATIONS OF PROTRACTED, UNRESOLVED URBAN WATER CRISES

The many impacts of the exponentially growing urban water demand in sub-Saharan Africa cannot all be covered here. We focus on two of these—the competition for water between rural and urban areas, and the intensification of water riots—and their possible implications in terms of social unrest, conflicts and political instability.

Competition within cities and between cities, the countryside and other sectors

Agriculture accounts for about 70% of global freshwater consumption. The high levels of water withdrawals in the agricultural sector are closely linked to irrigation activities. Despite the very low level of irrigation development in sub-Saharan Africa (less than 7% of cultivated land), agriculture still accounts for 80% of the region's water consumption due to the fact that the industrial sector is embryonic and household water use remains very low. Per capita freshwater availability (rainwater, surface water and groundwater) is estimated at 3,967 m³ per year for sub-Saharan Africa, which is far above the water scarcity level of 1,000 and even the water stress level of 1,700m³/year/person (WDI, 2019). The region is therefore rather water-rich. One would therefore expect limited competition for water between sectors, between regions within a country, between river basin reaches and between urban and rural areas. In fact, there are marked differences in water availability between sub-regions and between countries. In addition to North Africa, Southern Africa (Burundi, Ethiopia, Kenya, Rwanda, Tanzania, Uganda) is below the 1,000m³ threshold, and so are many countries in Southern Africa and in the Sudano-Sahelian region (such as Cape Verde and Burkina Faso). Evidently, the threshold values do not have much to do with water availability on the ground; essential is how well water—a renewable resource—is managed (cf. Biswas & Tortajada, 2019).

Competition for water between urban and rural areas and between sectors is thus intense and soaring, especially in locations that are water-stressed or experiencing a fast-growing population and economy. In fact, we are already observing that in some regions, substantial amounts of water are being drained from rural regions. A review by Garrick et al. (2019) covering 69 urban agglomerations served by 103

water reallocation projects—mostly in Asia and North America—found that approximately 16 billion cubic metres of water were transferred in 2015 to urban recipient regions through water transfer schemes of about 13,000 km in total length.

The already heavy reliance of urban areas on water transfers from rural areas is expected to continue to increase dramatically (Garrick et al., 2019). This is not only because of the expanding urban population but also because the largest share of the predicted growth of the industry and energy sector will take place in urban and peri-urban areas.

If current urban development trends persist, along with the expansion of irrigated agriculture—which is unavoidable if the continent has to minimize the vulnerability of its food system to climate change—the competition between cities and the farming sector can be expected to intensify, especially if Africa experiences sustained economic growth.

Urban water demonstrations and riots intensify as the unmet water demand grows

Urban water demand is increasing rapidly in sub-Saharan Africa, especially in large cities. As government, municipalities and water utilities fail to make the necessary investment to meet the growing water demand, citizens take to the streets against water shortages and sometimes water tariffs, especially when the water supply is unreliable.

Using the Pacific Institute (2019) database on water conflicts—while focusing on the types of water conflicts, and especially water riots and water-related demonstrations in sub-Saharan Africa in the last 10 years—we observed the following features:

- The majority of citizen protests for improving water service quality occurs in urban areas, often in major cities and/or the capital cities. Water riots and demonstrations have taken place in all sub-regions of sub-Saharan Africa: in West Africa (Dakar, Bamako, Conakry, Abidjan, Lagos), in Central Africa (Kinshasa), in Eastern Africa (Nairobi, Dar es Salaam) and Southern Africa (multiple cities in South Africa, Bulawayo in Zimbabwe, Antananarivo).
- Demonstrations have so far generally been in the form of peaceful marches; but some involved burning tyres, throwing stones at security forces, and blocking main roads and highways, hence affecting urban mobility.
- Demonstrators complain about chronic water scarcity, untimely water cuts in water supply (sometimes with electricity blackouts), ineffective draining of excess rainwater, etc.
- Urban residents taking to the streets to organise marches and riots to complain about water service failures are from all types of neighbourhoods, although they tend to be predominantly from poor and populous neighbourhoods, especially slums.
- Complaints are typically directed at the government in general; but in some cases, municipal authorities or water utilities are specifically targeted.

The question is how concerned should we be when seeing more and more urban residents expressing anger and organizing marches, which sometimes escalate into riots. For Almer et al. (2015), these riots are not always mere “short-lived and local events”. Based on an analysis of a series of water-related conflicts, they observe that high frequency and intensifying rioting can be warning signs of a build-up to “major events like rebellions, political unrest and even revolutions”. This view is shared by a US Intelligence report: “The lack of adequate water will be a destabilizing factor in some countries because they do not have the financial resources or technical ability to solve their internal water problems.” (US Intelligence Community, 2012). This report predicts that in the next decade, water shortages and inadequate government response to the challenge will likely ‘lead to social disruptions, pressure on national and local leaders, and potentially political instability’.

WHAT CAN WE LEARN FROM CURRENT EXPERIENCES IN AFRICA?

Africa is diverse, with marked contextual differences between sub-regions to and between countries. FAO (2003) distinguishes between seven agro-ecological regions in the continent (Table 2). Based on their natural and per capita freshwater endowments, three of these regions (Central Africa, the Gulf of Guinea and the Indian Ocean) can be considered “wet regions”. Together they have 84% of the continent’s total freshwater (combined rainwater, surface and groundwater resources), with a per capita annual water availability ranging from 3,400 m³ to more than 12,000 m³, which is far above the water scarcity and stress levels discussed above. The other four agro-ecological regions (North, Eastern and Southern Africa, as well as the Sudano-Sahelian region) can be considered “arid and semi-arid regions”. Together they account for 16% of the continent’s total freshwater resources, with North and Southern Africa falling below the water scarcity limit.

We examine the experience of a large city in each of the semi-arid regions of sub-Saharan Africa—Dar es Salaam for East Africa, Dakar for the Sudano-Sahelian region, and Cape Town for Southern Africa. For the three wet regions, we review the case of Kinshasa.

A common feature to these four cities is their rapid population growth over the last 70 years. During this period (1950 to 2020), their combined population has increased 26-fold, ranging from the case of Cape Town (which “only” increased 7-fold) to Dakar (15-fold, not including the conurbation), and to the staggering cases of Kinshasa and Dar Salaam, which increased 71-fold and 90-fold, respectively. By 2030, their total population is projected to increase by 30%. Rapidly swelling population size is the primary driver of water demand and the widening urban water supply gap.

Experiences from wetter regions: Kinshasa (DR Congo)

Kinshasa’s population grew from 200,000 inhabitants in 1950 to 443,000 in 1960 when DRC became independent. Thereafter, the population has grown almost 30-fold and is projected to be over 22 million in 2030 (UN, 2018). Kinshasa depends on the Congo River for its water supply. The Congo is Africa’s second longest river (after the Nile); and with its mean annual discharge of 1,320 km³, it ranks as the world’s second biggest river (after the Amazon) (van der Bruggen et al., 2009). This discharge represents about 20% of the projected 2030 global water demand of 6,900 billion m³. Thus, Kinshasa can be considered as having access to an unlimited amount of renewable freshwater. This is in addition to the annual rainfall of more than 1,300 mm.

The paradox is that one-third of Kinshasa’s residents are not connected to the city’s drinking water network (Bahri et al., 2016), and the households with access to tap water suffer from water quality problems and face frequent service disruptions, partly due to the ageing water infrastructure. Only 60% of the city’s estimated water demand of 900,000 m³/day is covered (Ilemba & Nzitattira, 2019). Kinshasa is an archetype of a technical and governance-related water scarcity in the context of physical water abundance.

Experience from a semi-arid/sub-humid region: Dar es Salaam (Tanzania)

At the time of Tanzanian independence in the early 1960s, the city of Dar es Salaam had slightly more than 160,000 residents. The number went up to 850,000 by 1980 to 2.2 million by 2000, and today is over 6 or 7 million and projected to pass 10 million by 2030. Dar es Salaam is one of the fastest growing cities in the world (5% annual growth).

The city has a sub-humid climate, with an average annual rainfall of 1,000 to 1,300 mm. Four main rivers (Mpiji, Msimbazi, Kizinga and Mzinga) run across the city. While Dar es Salaam is well-endowed with abundant and diverse water resources, the city faces serious water challenges. The city’s demand for drinking water is estimated at 533,000 m³/day, while only 245,000 m³ is made available daily in the city’s water distribution network, of which 20% is lost due to the ageing water infrastructure and illegal water abstractions (Nganyanyuka et al., 2014). While no clear long-term, forward-looking strategy exists to address the widening water deficits (today 45% of the city water demand is not covered),

most city residents (especially slum dwellers) are left on their own and have to fend for themselves to cover their drinking water needs. The various water survival strategies include unregulated drilling of deep wells, installing water pumps and reserve tanks, buying water from private vendors, neighbours and even mosques, connecting illegally, and stealing water from the water utility network (Nganyanyuka et al., 2014).

Experience from the arid and semi-arid Sahelian region: Dakar (Senegal)

Dakar is among the fastest-growing cities in West Africa and the Sahel region. From 400,000 people when Senegal gained independence in 1960, today Dakar (the greater Dakar, including its eponymous administrative region) hosts more than 3 million inhabitants and is projected to grow to over 4.3 million by 2030 (UN, 2018). Dakar is located in the southern margin of the Sahel region, and it used to receive about 600 mm in a normal rainfall year. Groundwater is dwindling at a rapid pace due to the combined effects of increased aquifer abstraction, reduced recharge volumes (due to rainfall deficits), and excessive groundwater abstraction. Further groundwater withdrawals are constrained not only by dropping water tables but also by risks of salt intrusion (Dasylyva & Cosandey, 2005). An increasing proportion of freshwater supplies to Dakar (20% in the early 1990s, more than 50% today) is transferred from Lac de Guiers (a tributary of the Senegal River), 250 km away. Water losses (about 20%) are significant along the water pipe from Lac de Guiers and in the water distribution network in the city, which is largely a consequence of the ageing water infrastructure: 1,565 km (25% of the existing water conveyance network of 6145 km) is more than 30 years old (JICA, 2014).

The 2011 Urban Water Master Plan projects water demand for greater Dakar to increase to 500,000 m³/day by 2030. In anticipation of this growing demand, important measures are being taken, including an additional water treatment plan and water pipe from Lake de Guiers and two water desalinization plants (JICA, 2014).

It remains to be seen if these measures are enough. The demographic projections, and hence the forecasted water demand, seem to be too conservative. Moreover, the demographic effects of the creation of the Diamniadio urban centre (a quasi-new capital, less than 30 km from the Dakar city centre) are clearly not factored in. If the population of the conurbation of Dakar grows faster than predicted, which is highly probable, the objectives set for covering the medium-term water demand and measures conceived to attain these objectives will be overtaken by the actual water demand even before the completion of these interventions.

Experience from semi-arid Southern Africa: Cape Town (South Africa)

Cape Town is South Africa's second largest city. It had 600,000 inhabitants in 1950, passed 1 million by 1970, doubled in the following two decades, and doubled again in the three subsequent decades. From the current 4 million people, the city is expected to reach 5.5 million by 2030. Since 1950, the city has increased 7-fold, which is a very fast growth pace, but much lower than Dakar (15-fold), Kinshasa (70-fold) and Dar es Salaam (90-fold).

While the thirty-year average annual rainfall is over 800 mm, the city is experiencing a long-term decline, both in the number of rainy days and in the volume of recorded rainfall. Due to three consecutive years of severe rainfall deficits in 2015–2017, the water level in the six dam reservoirs of the city shrank dramatically, especially in the first half of 2017 (Table 3). Water levels in the dams dropped below 30% of the reservoirs' capacity, triggering fears of a "Day Zero", i.e., the day when water stored in reservoirs falls below 13.5%. At this level, water supplies are depleted, and the water taps are turned off (City of Cape Town, 2019; Burls et al., 2019). In the Day Zero scenario, each city resident is entitled to 25 litres/day to be distributed from water collection sites (Burls et al., 2019).

The city developed and implemented a comprehensive response to the challenge. First it activated its disaster risk management plan (dated 2015), involving close monitoring of available water resources

and water allocations. Second, drastic measures were taken to prevent (or at least delay) Day Zero. In addition to imposing 50 litres of safe drinking water per person per day, the response included a drastic reduction in water allocation for agriculture (a sector that ordinarily uses 60% of the water) and a ban on the use of potable water for non-essential purposes (such as watering lawns, filling swimming pools and washing cars).

With the successful enforcement of these measures, Day Zero (which was initially predicted to occur on April 12) was subsequently moved to July 9 and later postponed again.

The experience of Cape Town—which was feared to be the “first city to run out of water in modern times” (Mulligan, 2018)—is a dire warning about the magnitude of the water challenges facing megacities as a result of growing urban populations, changing lifestyles and climate change (Biswas & Tortajada, 2018). The way Cape Town responded to the challenges—despite imperfections noted here and there—is exemplary, from the resource-monitoring side, for the development of a clear disaster management response, the enactment of stringent restrictions, and the actual enforcement of measures taken.

INDIA’S URBAN WATER CHALLENGES—KEY FEATURES OF RELEVANCE FOR SUB-SAHARAN AFRICA

India is facing acute and frequent water shortages in its urban areas, especially in the country’s major cities (Biswas & Tortajada, 2017). The urban population is growing rapidly, with megacities continuing to sprawl. With a rapidly growing economy, the often water-thirsty industrial and energy sectors are developing, especially in urban and peri-urban areas. These factors, along with an expanding middle class, boost urban water demand. At the same time, the country is experiencing a drastic decline in groundwater resources, a shrinking of surface waters and deficits in rainfall in the context of record high temperatures. Hence the gap between urban water demand and supply is widening. NITI Aayog, a renowned government think tank, predicts that 21 major cities—including New Delhi (the capital), Chennai, Bangalore and Hyderabad—may run out of water by 2020, affecting no less than 100 million people (NITI Aayog, 2018). Alarming voices warn of a growing “national crisis” (NITI Aayog, 2018; Nagpal, 2019).

The urban water crisis in sub-Saharan Africa has clearly not yet reached the acute level we are seeing in India today. The current pace of population growth, the rapid urbanization, and the rise of megacities and expansion of slum populations in sub-Saharan Africa are all signs that the continent may be heading toward a major urban water crisis, at least on the scale of the current urban water nightmare in India.

What can we learn from India’s experience that can serve sub-Saharan Africa to prevent, delay, mitigate and manage a major urban water crisis in the coming three to four decades? We use here the example of three cities to understand the magnitude and key features of India’s water crises, which can serve as a basis for discussing the potential lessons for Africa: India’s capital city, Delhi; Bangalore, a major economic growth pole; and Chennai, a fast-growing megalopolis.

New Delhi. The population of the New Delhi city and conurbation (the Delhi region) increased from 1.5 million in 1951 to more than 20 million today. Along the Yamuna River, the city was surrounded by hundreds of small lakes and ponds, through which underlying aquifers were seasonally recharged. Today, many lakes have dried out and been absorbed by the expanding city. The Yamuna waters are highly polluted, while groundwater levels are dropping dramatically. To make things worse, from mid-2018 to mid-2019, the city experienced its driest year in 27 years while recording its highest ever monthly temperature in June 2019 (Bhardwaj, 2019). As can be predicted in such a context, the fight for water is intensifying, exposing inequalities between wealthy neighbourhoods and slums. Competition at all levels, using legal as well as illegal means, gives rise to corruption with a more present “water mafia” and proliferating “water gangs” (Bhardwaj, 2019; Saikia, 2018). Despite water

scarcity and the extent of water pollution, little consideration and negligible investments are made in water reuse and water recycling.

Bangalore has grown even faster than Delhi. Known as “India’s Silicon Valley”, the city’s expansion is closely related to its attractiveness as India’s information technology hub. Bangalore’s population grew from 750,000 in 1950 to 1.6 million in 1970, reaching 4 million in 1990 and 6 million in 2001. Today’s population of 12 million is expected to nearly double by 2030. Its freshwater sources are from the Cauvery River (100 km away), from groundwater and from local monsoon rain. A network of more than 160 small lakes in and around the city used to play the role of natural storage for Bangalore, also facilitating groundwater recharge. Most of the small lakes have been swallowed up by the expanding territory of the city, and the remaining ones have almost all dried out. The declining water table resulted from intensive groundwater abstraction (Banerji & Accheri, 2019). In response to increased water demand and declining water resource availability, numerous coping tactics have been taken. Private operators dig wells deeper and deeper to reach the falling water table. It is estimated that in some locations, wells can be 10-times deeper than a decade ago (Banerji & Accheri, 2019). Thousands of tank trucks distribute water in the city. Water prices tripled in 15 years; and in some areas, water can be “auctioned to the highest bidders” (Dilip et al., 2019).

Chennai’s population grew from 1.4 million in 1951 to 2.4 million in 1971 and reached 3.8 million twenty years later (Sujatha & Janardhanam, 2014). Today the 10-million mark has been passed. Because of poor monsoon rainfall in 2018 and heat waves in the second quarter of 2019, Chennai faces a severe water crisis. The four reservoirs that supply water to the city have almost entirely dried up. Groundwater levels have declined dramatically. In response to the water shortage, city residents had to resort to water distributed by public trucks and private water providers. Radical responses included trains loaded with water tanks bringing water to the city from wetter remote regions. In parallel, medium-term solutions are expected from interventions such as the clearing and deepening of reservoirs, wells and canals (Karthikeyan & Gupta, 2019; Palanichamy, 2019).

LESSONS LEARNED AND OPTIONS FOR THE FUTURE

The lessons presented here are essentially drawn from the experiences of large urban agglomerations in sub-Saharan Africa and India discussed in the previous sections. The emphasis on India’s experiences is justified by many similarities in the contexts in Africa and India.

The key points from the Indian cities of New Delhi, Bangalore and Chennai that are potentially relevant for Africa can be highlighted as follows:

- Those three cities are all fast-growing urban agglomerations, swelling demographically and expanding in area to swallow neighbouring small towns and cities. This is a pattern we see in many big cities in India as well as in sub-Saharan Africa.
- Many concurrent trends contribute to the acute water scarcity facing all three megacities. Water needs increase dramatically due to population growth, higher per capacity water use as the middle class expands, and higher water demands from the rapidly growing industry and energy sectors. These sectors are predominantly located in or near cities.
- On the supply side, the amount of water made available to urban dwellers is declining or at best growing, but at a slower pace than the demand, as has been pointed out by Biswas (2016). Many factors hinder the urban water supply: ageing water infrastructure resulting in the loss of massive quantities of water, surface water sources (like neighbouring lakes, rivers and man-made reservoirs) drying out, and water tables in aquifers falling deeper. All of these factors are linked to excessive and unsustainable water withdrawals.
- Spatially expanding cities disorganise and destroy natural aquatic ecosystems (a network of small rivers, lakes and ponds), with negative consequences on hydrodynamics that enable regular groundwater recharge—let alone the fact that growing cities massively pollute both surface water and groundwater.

- Climate change makes things worse: in addition to monsoon rainfall deficits, average temperatures are reaching historic highs in many locations in the country.
- As the water supply gap widens, diverse and rapid-response alternatives (sometimes radical) are put into motion. These include digging deeper and deeper in the aquifers and importing water, even by train for remote locations.
- Typically, an informal and messy water trade system is emerging to compensate for deficient government responses. Water vendors multiply, including water truck tankers collecting water by all means, in local deep aquifers and from remote locations. Water prices skyrocket in a water market marred by corruption involving unregulated operators, local politicians, and organised crime gangs and mafia.
- Strikingly, limited attention is being paid to the treatment, recycling and reuse of the masses of wastewater generated by megacities.
- In reaction to the acute water crisis facing the country, especially many of the largest cities, the government of India launched a comprehensive water security and water conservation campaign known as “*al Shakti Abhiyan*”, targeting the country’s most water-stressed districts (ETI, 2019). Key lines of action are: (a) water conservation and rainwater harvesting; (b) renovation of traditional and other water bodies; (c) water reuse for industrial and agricultural purposes and water recharge of wells and aquifers; (d) watershed development; and (e) intensive afforestation (ETI, 2019). The programme is ambitious, but it is too early to assess its effectiveness.

More general messages and recommendations based on the present analysis are collected in Table 4.

CONCLUSIONS

Africa today records the world’s fastest population growth and pace of urbanization. This comes with many challenges, one of which is related to water supply and management for the continent’s largest urban agglomerations. Africa’s urban water problem is one of the continent’s major challenges today and will be more so in the decades to come. As experience shows, per capita freshwater use, especially in urban areas, surges dramatically as societies develop, industrialise, and become more affluent with an expanding middle class. All of these factors are currently at play in sub-Saharan Africa, especially in the many burgeoning metropolitan areas of the continent. At the same time, growing affluence often leads to increased awareness and political will to treat wastewater and take care of the environment, as well as to stabilize water consumption to a certain level. Nevertheless, these positive sides of development are conditional on improvements in education level, from primary to vocational and the highest university education. With regard to these, Africa stands today at the lowest level globally. Africa’s upcoming economic structure and employment creation will depend largely on the education level of the population; and harnessing the opportunities of green growth, circular economy and the modern service sector would vastly benefit the capability to enter the fourth industrial revolution in a timely manner.

Africa’s current water problems cannot be fully grasped without taking into account some distinctive features and patterns of the urban trajectory of the continent. First, many African megacities are former colonial capital cities and centres created by colonial rulers to serve primarily as economic entrepôts, trade platforms and administrative centres and military barracks. Local freshwater availability in the medium and long term was given little consideration in the choice of these cities, most of which are located along the coast. Second, the rapid urbanization of the continent is largely the result of the crisis in the agricultural sector. Impoverished and destitute farmers are fleeing to urban areas and in particular to informal urban settlements in slums, whose spectacular growth is part of the “*ruralisation*” of African cities. Third, investment in water infrastructure is lagging far behind the needs, while the existing infrastructure (sometimes dating back to the colonial era) is ageing and contributing to the high proportion of water leakages.

While the urbanization process is still accelerating, we already see acute seasonal and chronic water shortages and other water challenges being experienced in almost all of the continent's major cities, regardless of the ecological conditions and natural water endowments of the regions where they are located. These include cities as diverse as Dakar, Abidjan and Niamey in West Africa; Kinshasa and Luanda in Central Africa; Nairobi and Dar es Salaam in East Africa; and Harare, Maputo and Cape Town in Southern Africa. In these cities, water shortages amplify competition between urban and rural areas and within cities. Unresolved water shortages create room for emerging informal water markets and often trigger water riots, violent demonstrations, etc. Where they occur in capital cities, these riots can easily develop into major social disturbances that can risk political stability. The Day Zero in Cape Town in 2017 is a dire warning of how far an urban crisis can go and its potentially devastating effects on all urban and peri-urban life and activities.

In order to prevent, delay or mitigate major urban water crisis risks, Africa and especially sub-Saharan Africa must learn from the Cape Town experience and from other city experiences in the continent as well as experiences from abroad, such as from India. There, chronic and seasonal water shortages affecting most megacities have reached alarming levels, a phenomenon now considered a "national crisis". Sub-Saharan Africa will be headed toward a worse scenario unless the necessary bifurcations are made in the continent's current urbanization trajectory.

Building on current experiences in Africa and India, we suggest the following measures be considered, depending on the country and city contexts:

- Plan early to anticipate and guide urban development, taking into account water resource availability and conservation; and plan for the long term, without underestimating the real magnitude and growth rate of the urban water demand.
- Close the urban water infrastructure gap, and improve disaster risk preparedness of megacities, paying due attention to water-related risks such as floods and droughts in the context of changing climate conditions. Diversify sources of water supply for cities through conventional and non-conventional water supply solutions. In addition to increasing surface water storage and groundwater abstraction capacities, cities should consider options such as groundwater recharge, rainwater harvesting, seawater treatment, etc.
- Invest in urban waste reclamation and reuse to increase urban water supply and serve the industrial and agriculture sectors, while exploring the possibility of applying "water banking" principles in the management of saved excess water.
- Invest in communication and outreach targeting urban dwellers to raise awareness about water challenges and to create conditions for raising water-consciousness among urban residents. Go boldly toward water demand management.
- Invest in societal development and capacity in the broadest sense. Everything possible should be done to make the current population projections overestimated. Education and economic development, together with governance progress, should turn the ruralized, slum-dominated urban areas into more affluent societies with balanced environmental and social development. In parallel, rural areas need a development boost along the same lines. Africa clearly lags behind other continents, including most of Asia in terms of human development, economic progress and governance quality (Varis et al., 2019).

Today is the time to act. While the African urban population is projected to triple by 2050, it is anticipated that "two-thirds of the urban space that Africa will have in 2050 does not yet exist and so must be built during the next 35 years" (Collier, 2017). This is indeed a challenge, but it is also an opportunity to correct past mistakes that have piled up as a result of the expansion of informal settlements hindering efforts to improve the urban water infrastructure in Africa's rapidly growing cities.

Urban areas are poles of economic growth. The urban labour market is growing rapidly. The future of sub-Saharan Africa will be decided to a large extent in its urban areas. It is therefore critical to create the conditions for developing a healthy and economically attractive urban environment. Designing and implementing sustainable water solutions will contribute to creating friendly, socially and economically attractive, dynamic cities.

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FIGURES

Figure 1. Population size of the main age groups in sub-Saharan Africa, India and China in 1950–2100 (UN, 2017).

TABLES

Table 1. Comparing Africa, India and China (population size, economy, present and future megacities)

	Africa	Sub-Saharan Africa	India	China
Population (x 1000) (2018)	1,273,000	1,078,000	1,353,000	1,393,000
Total GDP (Billion USD) (2018)	2,321	1,697	2,726	13,608
GDP per capita (USD)	1,823	1,574	2,014	9,769
Number of cities in the top largest 101 cities – 2010 (more than 3.4 million residents)	9	6	7	15
Number of cities in the top largest 101 cities – 2050 (more than 5.7 million residents)	25	22	11	11

Source: For population and GDP: World Bank Data - <https://data.worldbank.org/> (accessed on 15/08/19); for cities: Hoornweg & Pope (2017).

Table 2. Marked differences in freshwater endowments among Africa's ecological sub-regions

(*) Water availability data: FAO (2003).

(**) Source population data: <https://population.un.org/wpp/Download/Standard/Population/>

	Wetter regions			Arid and semi-arid regions				
	Central Africa	Gulf of Guinea	Indian Ocean	Eastern Africa	Southern Africa	Sudano-Sahel	Northern Africa	Africa
Freshwater avail km ³ /year (**)	1,950	1,025	345	262	309	374	135	3,950
Share of Africa freshwater	49%	26%	9%	7%	8%	9%	3%	100%
Total population (x 1,000)	153,644	296,843	28,459	283,137	145,169	172,029	195,492	1,274,772
% of Africa's population (*)	12%	23%	2%	22%	11%	13%	15%	100%
Freshwater per capita (m ³)	12,692	3,452	12,123	925	2,126	2,174	688	3,099
Representative city	Kinshasa			Dar es Salaam	Cape Town	Dakar		

Table 3. City of Cape Town – Variations in water volumes stored in Cape Town dams 2015–2019
(Source: City of Cape Town, 2019)

	Total capacity of six main dams	2015	2016	2017	2018	2019
Total water stored (in millions of m ³)	898.22	566.51	465.33	250.78	509.88	847.90
%	100%	63%	52%	28%	57%	72%

Table 4. Lessons learned from India and sub-Saharan Africa, and ways forward for preventing water crises in large urban agglomerations.

EARLY PLANNING Anticipate and guide urban development, taking into account water resource availability and conservation	By not having acted earlier, many options that could have helped address India’s current urban water crises are no longer available. They include the lack of territorial and urban planning that could have prevented the formation of monster cities. Proper planning in anticipation can prevent cities to expand in ways that profoundly disorganize the natural hydrodynamics in and around the city. Examples include Chennai and Bangalore, which have converted surface waters, such as lakes, ponds and other wetlands, into urban settlements (also Dakar to a large extent).
LONG-TERM PLANNING A long-term planning horizon with realistic estimates for magnitude and growth rate of urban water demand	Planning efforts—where they exist (e.g., Dakar)—tend to adopt short- to medium-term planning horizons and to use overly conservative projections for the growth of water demand. Hence, by the time medium-term solutions are designed and implemented, the actual demand appears to be much higher than what the “solutions” consider.
RISK PREPAREDNESS Improve disaster risk preparedness, and pay due attention to water-related risks such as floods and droughts	Given the current and predicted magnitude and frequency of extreme events (droughts, floods, storms), each city needs a disaster management plan entirely or partially focused on water. Without such a plan, with regularly updated information on the city’s water resources, Cape Town’s 2017 water crisis could have been worse. It is on the basis of this plan and the close monitoring of reservoir water levels that the city was able to identify the nature of the threats (including Day Zero, when the taps would be turned off) and deploy measures to delay and finally avoid the doomsday scenario.
INFRASTRUCTURE Close the urban water infrastructure gap	Investment in new water infrastructure and the renovation and refurbishing of existing structures need enhancement at unprecedented scales to match the exceptional nature of the urban water challenge (AfDB, 2018). This applies to cities both in water-scarce and water-rich environments. Paradoxically, arid and semi-arid cities (Dakar and Cape Town) have invested more in water infrastructure (although more could have been done) than have water-abundant cities (Dar es Salaam and Kinshasa). Consequently, safe water is more available in water-scarce cities than in water-abundant cities. In both cases, massive infrastructure investment will be needed in the coming years. Given the widening gap between water supply and demand—in addition to the vulnerabilities associated with climate change—large-scale water infrastructure (such as large storage as well as large inter-basin transfer schemes) cannot be ruled out, although these should be planned with the highest standards, given their complexity and the significance of the social and environmental impacts they generate (cf. Chan et al., 2019).
CLIMATE CHANGE Pay due consideration to climate change impacts on water resources	Climate change and variability need to be factored into water investment strategies, including the choice and design of water infrastructure. Strategies need to cope not only with inter-season water availability but also with spatial variations in water availability (which are likely to grow as a result of climate change). Storage infrastructure needs to be designed not only to cover water needs for the year, but also to cater to multi-year fluctuations in rainfall, surface water discharge and groundwater levels.
WATER STORAGE AND BANKING Explore the possibility of applying “water banking” principles in the management of saved excess water	Investment in storage infrastructure and groundwater recharging schemes could be envisaged to store excess water from wet years and very rainy seasons in order to help offset water deficits in severely dry seasons and years. The saved excess water could be managed on the basis of the “water banking principles”, whereby stored water is withdrawn by the “banker”—the owner or manager of the saved water—whenever needed in subsequent years and transferred to supplement the water resources of the “client” (the buyer) or for use by the banker in years of water shortages (World Bank, 2018).

WASTEWATER TREATMENT AND REUSE Invest in urban waste reclamation and reuse to increase urban water supply and serve industrial and agricultural sectors	In the examples from both Africa and India, investment in urban water collection, water treatment and reuse has been minimal. This is a lost opportunity for contribution to the urban water crises and to water challenges in general. Cities account for about 30% of global water use, a large part of which is disposed as wastewater (Dahan & Grijzen, 2017). Reclaiming more of this huge amount of water can contribute substantially to offsetting some of the non-drinking water uses. In Windhoek (Namibia), water reclamation supplies over 30% of the city's water use (World Bank, 2018). One of the major beneficiaries could be urban and peri-urban agriculture. The World Bank (2016) estimates that agriculture within a 20-km radius of urban centres covers more than 450 million hectares. Representing one-third of the world's agricultural land, urban and peri-urban agriculture contributes to the livelihood of 800 million urban residents (UNESCO, 2012). As it tends to be the primary victim of increased urban water demand, it is amply justified to transfer the treated wastewater back to peri-urban agriculture.
DIVERSIFICATION Diversify sources of water supply for cities	Reliance from one dominant source of water supply (either surface water or aquifers) is a major source of vulnerability for cities, especially in the context of climate change. Rainfall deficits have direct impacts on local surface water and largely on groundwater resources. Vulnerability resulting from limited sources of water supply is illustrated by the water crises in Cape Town. The city almost entirely depends on its six reservoirs. Similarly, the Indian cities of Delhi, Bangalore and Chennai have too little diversity in their water sources. Options for increasing and diversifying water supplies to cities include surface water storage, wells to draw water from aquifers, wastewater treatment and reuse, rainwater harvesting, and artificial recharging of groundwater and desalination of sea water (Dahan & Grijzen, 2017). The latter is highly relevant, given that the majority of Africa's largest conurbations are in coastal areas. In its current Urban Water Masterplan, Dakar seems to be heading toward more diversified sources of water supply by investing massively in seawater treatment in addition to surface and groundwater.
WATER DEMAND MANAGEMENT Enhance water demand management and raise water-consciousness among urban residents	Along with government and municipal authorities who are expected to show great leadership qualities, ordinary citizens have a key role in preventing urban water crises and mitigating their impacts (Biswas & Hartley, 2019). Central and local governments are expected to set in place an enabling governance environment (the right legal and institutional framework and water institutions), upgrade and maintain the water infrastructure, closely monitor the resources and invest substantially in information-sharing and awareness-raising. As shown in the case of the Cape Town water crisis, citizen's engagement, mobilization and cooperation with dedicated authorities is what really makes the difference. Citizens' commitment and water consciousness are paramount if efforts to promote water savings through water conservation and demand management (addressing leakages, promoting water demand management) will succeed.
EXTERNALITIES Enhance economic and social development	Considerable enhancement in societal development and capacity in the broadest sense is needed. Everything possible should be done to make the current population projections overestimated. Education and economic development, accompanied by governance progress, should turn the ruralized, slum-dominated urban areas into more affluent societies with balanced environmental and social development. In parallel, rural areas need a development boost along the same lines.