A RAPID RESPONSE ASSESSMENT

GREEN HILLS, BLUE CITIES

AN ECOSYSTEMS APPROACH TO WATER RESOURCES MANAGEMENT FOR AFRICAN CITIES

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AN ECOSYSTEMS APPROACH TO WATER RESOURCES MANAGEMENT FOR AFRICAN CITIES

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JOINT STATEMENT

The challenge of providing safe water and adequate sanitation will be aggravated by unchecked climate change and rising urban populations.

Africa's urban population is projected to triple to over 1.2 billion by 2050 in cities already challenged in many places and in many ways by shortages of safe drinking water and inadequate sanitation services.

Access to clean drinking water and sanitation is perhaps one of the most important Millennium Development Goals because of its links to human health and the ability of people to carry out productive employment. It is also linked to gender and the nutrition of women and as well as their role in collecting water for families and communities.

Child mortality is also inextricably linked to water. Globally, at least 1.8 million children under the age of five years, or one every 20 seconds, die every year from water-related diseases. On the overall more people die from water-related diseases than are killed by all forms of violence including wars. Thus access to clean water is in many ways a pre-requisite for sustainable development.

The challenge of providing safe water and adequate sanitation will be aggravated by unchecked climate change and rising urban populations. As the world prepares for the UN Conference on Sustainable Development in 2012, 20 years after the Rio Earth Summit of 1992, water and urbanisation need to be key issues on the sustainability radar.

There is strong and growing evidence that a Green Economy, within the context of poverty eradication and sustainable development, can accelerate and scale-up delivery of these services if countries and communities commit themselves to managing the use and the sources of water such as forests, wetlands and other ecosystems central to this sustainability equation.

Creative and forward-looking policies, alongside partnerships across all sectors including agriculture, will also be key to sustainability.

This report, jointly produced by UNEP and UN-HABITAT in collaboration with the Africa Ministers' Council on Water (AMCOW) and funded by Tongji University, the Ministry of Science and Technology of China and Bayer Foundation, shows that there is a way forward for a more sustainable future where restoration of ecosystems, often in the green hills and watersheds surrounding cities, can provide cheaper, efficient and resilient water supply systems in a changing world.

Launched in Cape Town, a South African city surrounded by green hills that support water supplies to that city, it is our hope that World Water Day 2011 can provide a fresh vision for cities across Africa and beyond.

Achim Steiner
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SUMMARY

Africa is currently the least urbanised region in the world, but this is changing fast. Of the billion people living on the African continent, about 40 per cent lives in urban areas. The urban population in Africa doubled from 205 million in 1990 to 400 million in 2010, and by 2050, it is expected that this would have tripled to 1.23 billion. Of this urban population, 60 per cent is living in slum conditions. In a time of such urban growth, Africa is likely to experience some of the most severe impacts of climate change, particularly when it comes to water and food security. This places huge pressures on the growing urban populations.

Over the last 50 years, many African cities have grown from villages to large agglomerations. To date there are 48 cities with over a million inhabitants in the region. Lagos and Cairo have population figures exceeding 10 million.

The primary driver of the continent's urbanisation is economic activity, for example, oil in countries such as Angola, Gabon, Libya, Cameroon, Algeria and Nigeria; minerals in Botswana, Democratic Republic of Congo and Zambia; or small industries and agro-business in countries such as Côte d'Ivoire, Kenya, Tunisia and Zimbabwe. In Mauritania drought conditions provided the driver of urban growth, while it was civil war in the 1980s in Mozambique that resulted in the country's rural people seeking safety in the urban areas.

The high rate of urbanisation in Africa has not been matched with improvement in service delivery, resulting in inadequate access to safe drinking water and sanitation. The urban population without sanitation services in Africa doubled from 88 million in 1990 to 175 million in 2008. This trend is repeated for the provision of safe drinking water, with the number of people without access doubling from 29 million in 1990 to 57 million in 2008. Access to safe drinking water and sanitation is even more restricted in the densely populated slums and peri-urban areas of Africa.

The delivery of water and sanitation in Africa's urban centres is characterised by deficient, aging and overloaded networks. This, combined with the degradation of the quantity and quality of water sources through poor management of wastewater and solid waste, as well as low capacity to reuse and recycle wastewater, has resulted in inadequate water supply to serve a growing population.

As towns and cities rapidly increase in size, impoverished people tend to settle along drainages, where they can grow home gardens, while at the same time become exposed to flood risks. Moreover, with rising urbanisation and slums, particularly in towns and smaller cities with limited access to electricity, local forested watersheds are cut for firewood and housing materials, and vegetation is cleared for home gardens and crops. Hence, the water supply and cleaning function of the forested areas is lost, further aggravating the urban water gap.

The loss of ecosystem services, such as the natural filtering of rainwater in forests and riparian zones, brings with it a critical reduction in water quality and increases health risks as available water resources become polluted. The impervious un-vegetated ground of slum areas has little or no retention during heavy rains meaning human and animal wastes are flushed into the river systems polluting urban water supplies, rivers and productive coastal waters.

The lack of green urban, peri-urban and rural watershed management and consequent loss of critical ecosystem services threatens people's food security, health, livelihoods and subsequently development opportunities. Attempts to manufacture substitute ecosystem services through engineering solutions are extremely expensive and often unrealistic. Existing financing and planning for water and sanitation is not even able to cope with current population levels.

Until recently, cities have sought to meet increasing demand in water and sanitation services through engineering solutions. Some cities have built large water storage and treatment facilities, while others have embarked on river basin transfer schemes as a way of augmenting supplies. Besides being expensive and supply-focused, these engineering solutions do not address the depletion and degradation of available resources and ecosystem services, forcing cities in Africa to embark on water management reforms. The reforms seek to manage water demand, and to focus more on water resources management rather than supply. The reforms are a result of the need to balance water supply and sanitation services for urban areas with the ecosystem health of urban environments.

Water resources management reforms are based on consultation. Urban areas provide an ideal institutional structure for community engagement, representing an organised infrastructure to supply water and sanitation services, provide incentives for water use efficiency, as well as consider the environment in urban water solutions.

Ecosystems degradation can potentially derail the pace of urbanisation. This can happen if urban water solutions fail to take into account environmental impacts. The case studies provided in this report emphasize the pivotal role of ecosystems in sustainable urban water supply and sanitation, noting:

- There is a widening disparity between demand and availability of safe drinking water and sanitation services.
- There is a growing demand for alternative sources of water such as rainwater, groundwater and desalinised water as a way of addressing the shortfall between demand and supply.
- Urban water quality and supply will continue to deteriorate if urban planning does not fully integrate watershed management.
- City water supply is dependent upon watersheds outside city borders.
- Cities are vulnerable to waterborne diseases both from surrounding settlements and from the city itself.
- Consider environmental impacts, destroying ecosystems and spreading waterborne diseases to communities downstream as well as to the cities themselves.
- There are unique water supply and sanitation challenges to the various cities in Africa, and these include:
  - dependence on ecosystem services that are outside city boundaries;
  - growing reliance on groundwater supplies, the quality of which is at times compromised by the poor management of wastewater;
  - growing participation of the private sector in complementing government and local authority efforts in water supply and sanitation services; and
  - little use of alternative water sources, particularly rainwater harvesting and wastewater recycling.
- In light of the projected rise in urban populations, including those living in slums, access to water and sanitation is crucial for health, development and poverty reduction.
- Public and private management of water resources ensures access to clean water, but this requires concerted efforts including protection and restoration of ecosystem services, as well as engineering solutions.

RECOMMENDATIONS:

Cities must protect and restore ecosystems that are important as key water sources. This will provide cheaper, more efficient and flood resilient water supply systems for the fast urbanising region of Africa. Cities must reduce water consumption and recycle wastewater inside cities, restore adjacent watersheds and improve engineering solutions to supply water from well-managed ecosystems.

Tackle Immediate Consequences

1 Countries must adopt a multi-sectoral approach to water and wastewater management as a matter of urgency, by incorporating principles of ecosystem-based management from the watersheds into the sea, and connecting sectors that will reap immediate benefits from better water and wastewater management.

2 Ecosystem protection, management and restoration provide a central, effective, sustainable and economically viable solution to enhancing water supply and quality while mitigating effects of extreme weather events of too much and too little water.

3 Successful and sustainable management of wastewater to help support peri-urban agriculture is crucial for reducing water consumption, and requires a mix of innovative approaches that engage the public and private sector at local, national and transboundary scales. Planning processes should provide an enabling multi-scale environment for innovation, including at the community level with government oversight and public management.

4 Innovative financing of appropriate water and wastewater infrastructure should incorporate design, construction, operation, maintenance, upgrading and/or decommissioning. Financing should take account the important livelihood opportunities in improving wastewater treatment processes, while the private sector can have an important role in operational efficiency under appropriate public guidance, including ecosystem restoration projects.

Towards the Future

5 In light of rapid global climatic changes, communities should plan water management against future scenarios, including extreme events of too much and too little water combined with rapidly growing urban populations.

6 Solutions for smart water and waste management must be socially and culturally appropriate and acceptable, as well as economically and environmentally viable. Ecosystem protection, management and restoration are the cheapest, easiest and most effective ways of improving and securing water supply, filtration and quality including re-use of wastewater for irrigation.

7 Education must play a central role in water management and in reducing overall volumes and harmful content of wastewater so that solutions are sustainable.

CONTENTS

URBANISATION – WATER – ECOSYSTEMS NEXUS

There are 1 billion people in Africa of whom 400 million live in urban areas. With 40 per cent of the population living in urban areas, Africa is the least urbanised region in the world (UN-HABITAT 2010).

As centres of economic activity, innovation and development, Africa's urban areas are expanding rapidly, growing at a world annual fastest rate of 3.5 per cent (UNEP 2006). At this growth rate the urban population doubled from 205 million in 1990 to 400 million in 2010, and is projected to triple to 1.23 billion by 2050 (UN Population revision 2009). It is expected that by 2030 the proportion of people living in Africa's urban areas will be 50 per cent and reach 60 per cent by 2050 (UN-HABITAT 2010).

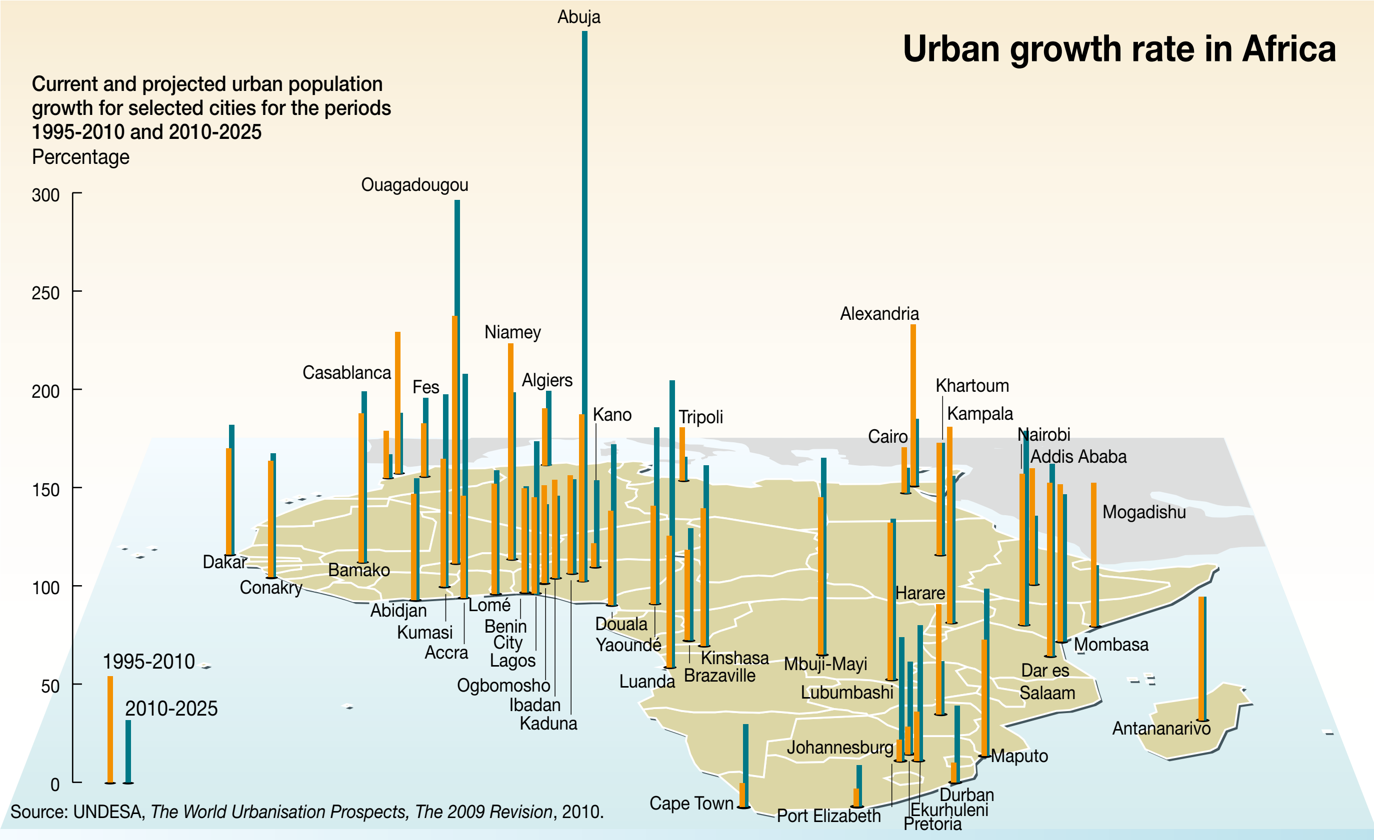
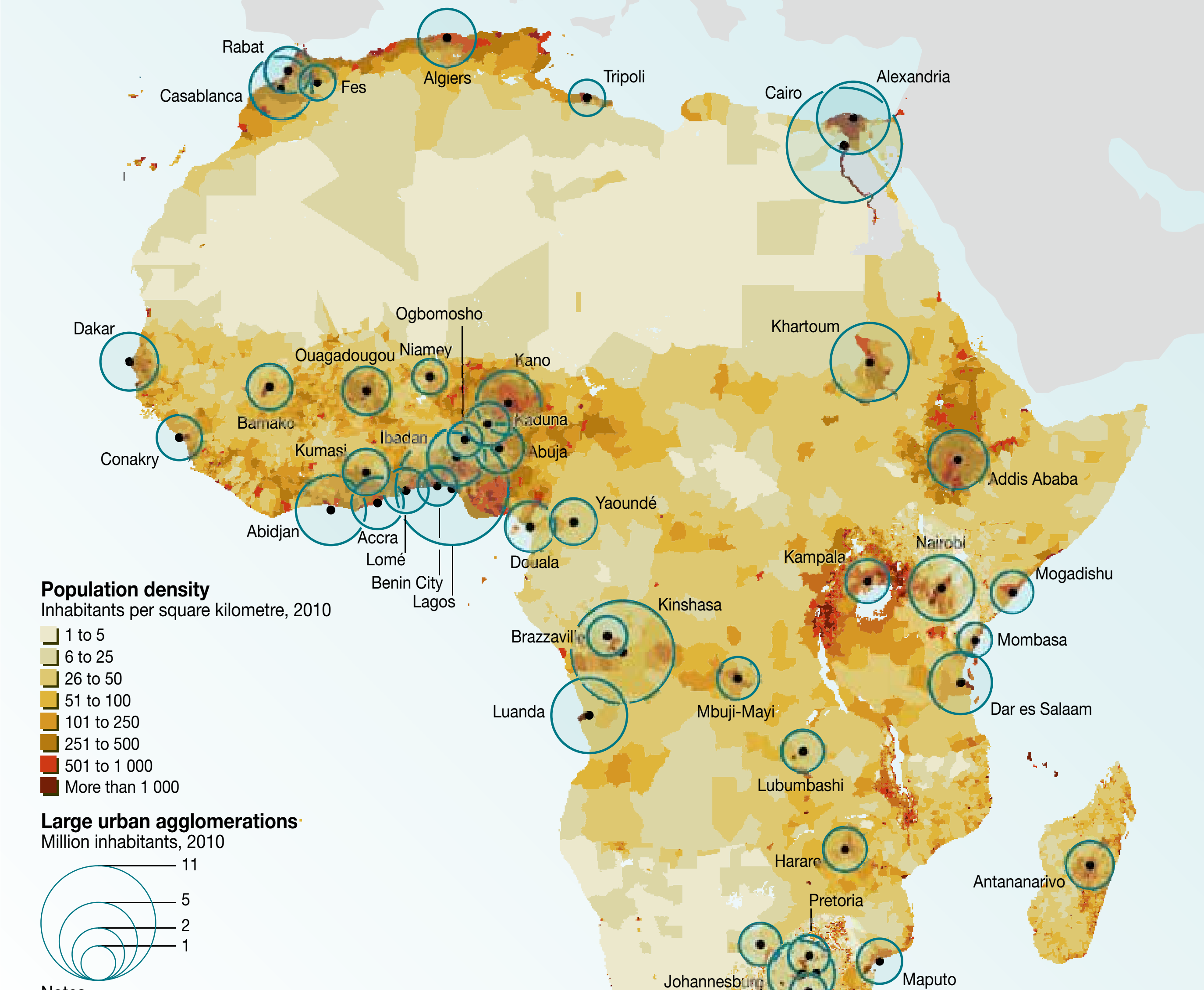


Figure 1: Africa's urban centres are currently growing at an annual rate that is the fastest compared to other regions. The urban expansion is expected to continue, with cities like Abuja and Ouagadougou expecting very high growth in the next decade, while Cairo, Africa's largest city, is projected to see a comparatively lower growth rate.

Population distribution in Africa



Notes
1. Only agglomerations bigger than 1 million inhabitants are shown.
2. Data projections based on 2009 estimates

Sources: UNDESA, *World Urbanisation Prospects, The 2009 Revision*, 2010; CIESIN, Socioeconomic Data and Applications Center, online database, accessed on January 2011.

Urbanisation in the region varies by country. With over 60 per cent of their population living in urban areas, Algeria, Botswana, Cape Verde, Congo, Djibouti, Gabon, Libya, Reunion, Sao Tomè and Principe, South Africa and Tunisia are some of the countries in Africa with large urban populations (UN-HABITAT 2010).

The rapid urbanisation in Africa has resulted in environmental degradation. The majority of Africa's urban centres face difficulties in accessing ecosystem services such as food, energy and water. The urban areas are also failing to fully benefit from regulating ecosystem services such as climate control, soil erosion prevention and water purification. This publication discusses the relationship between urbanisation and ecosystems, and focuses primarily on water.

AFRICA'S MILLION+ CITIES

Over the years, many cities in Africa have grown with some becoming home to more than one million people each. These million+ cities, as they are known, numbered 24 in 1990, and none of them had as many as 10 million people then. To date there are 48 million+ urban areas of which two, Cairo and Lagos, have become mega-cities with more than 10 million residents each (UN-HABITAT 2010).

URBANISATION OUTSTRIPS PROVISION OF WATER AND SANITATION

The high urbanisation rate in Africa has not been matched with service delivery. Many African cities are experiencing difficulties in supplying a growing number of inhabitants with adequate water and sanitation services. Demand for clean water supply and adequate sanitation is growing due to the increasing population, and in response to the international commitment to meet the Millennium Development Goals.[1] Between 1990 and 2008 Africa's urban population without an improved drinking water source increased from 29 million to 57 million (WHO/UNICEF 2010).

Access to improved water[2] ranges from as low as 17 per cent in Equator town in the Democratic Republic of Congo to 28 per cent in Ibadan. In some cities in Chad and Burundi, access is around 30 per cent. In the majority of African cities access to improved water is above 80 per cent (UN-HABITAT 2010). Access to adequate sanitation is generally above 50 per cent, but in some countries it is extremely low. For example, in Burundi access to adequate sanitation averages 10 per cent (UN-HABITAT 2010).

The provision of infrastructure for basic services such as water supply and sewer reticulation is hampered by the large population living in slums. According to UN-HABITAT (2010), 60 per cent of urban dwellers in Africa lives in slums, but this ratio is declining, and is not the same in all countries. In 2005, the proportion of urban population living in slums ranged from 13 per cent in Morocco to 94 per cent in the Central African Republic and Sudan, and 97 per cent in Sierra Leone (UN-HABITAT 2010).

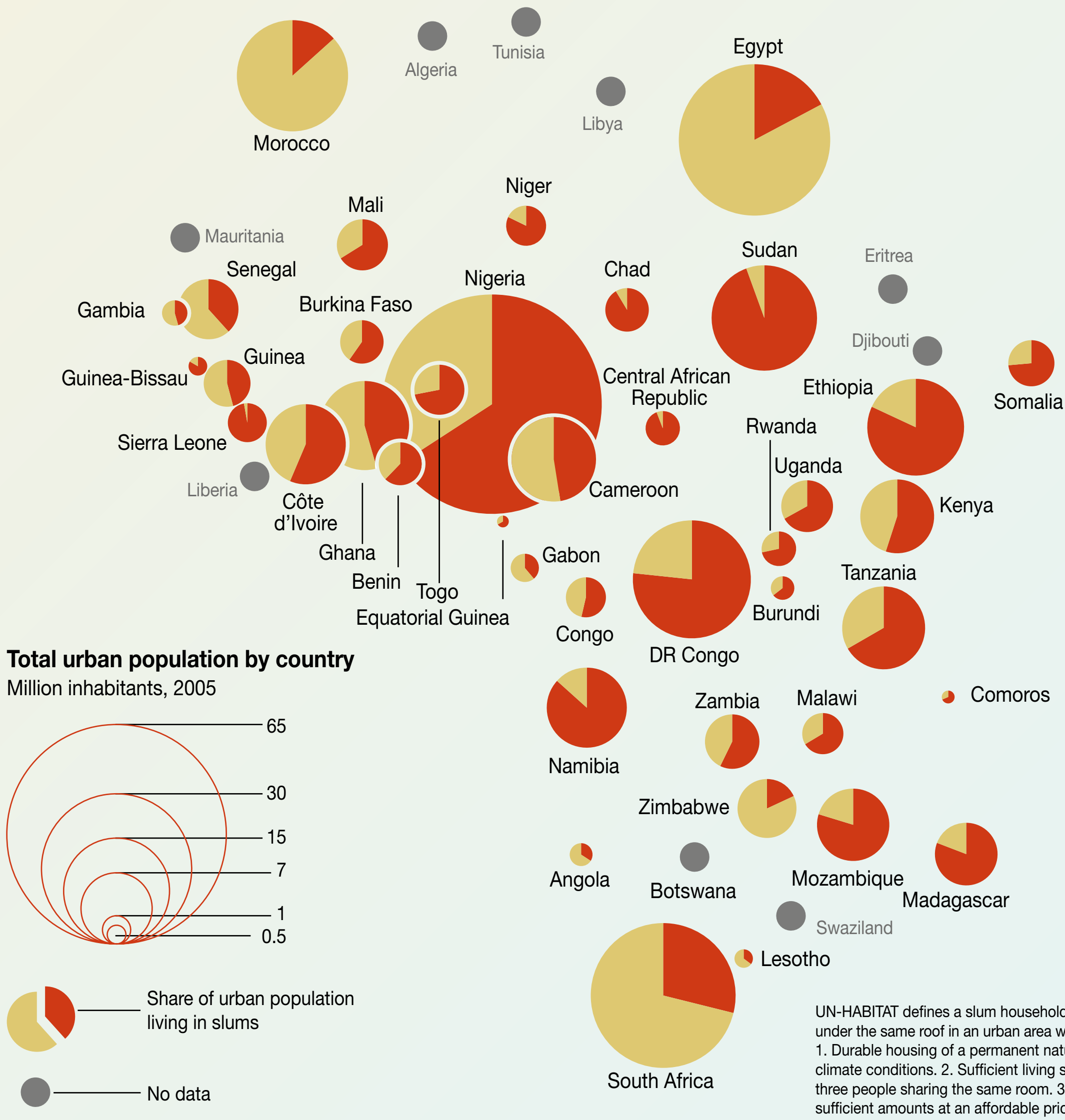
As informal settlements, slums are not planned and not adequately serviced. Ownership of land is unclear in slums. These areas are rarely mapped and most dwellings do not have official addresses. In order to improve information and better communicate the services and facilities that exist, some cities have begun initiatives to map slum areas, and these include Kibera slum in Nairobi (IRIN 2011).

Peri-urban areas also present challenges regarding access to safe drinking water and adequate sanitation. Characterised by strong urban influences such as easy access to markets, services and labour (Norström 2007), peri-urban areas are found around most urban areas in Africa. They lack proper infrastructure for safe water and adequate sanitation and tend to encroach on wetlands and river catchments. This impairs some cities' ability to deal with shocks such as floods and heavy rainfall, and this does not enable river catchments to serve as

← **Figure 2:** In 1990 there were only 24 cities in Africa with more than one million inhabitants. Today this number has increased to 48 cities, of which Cairo and Lagos are the largest with more than ten million inhabitants each.

1. The goal that is linked to water is Goal 7: Ensure Environmental Sustainability, particularly goal 7c: Reduce by half the proportion of people without access to safe drinking water and basic sanitation.
2. Improved drinking water sources are defined in terms of the types of technology and levels of services that are more likely to provide safe water than unimproved technologies. Improved water sources include household connections, public standpipes, boreholes, protected dug wells, protected springs, and rainwater collections. Unimproved water sources are unprotected wells, unprotected springs, vendor-provided water, bottled water (unless water for other uses is available from an improved source) and tanker truck-provided water.

Slum population in urban Africa



Source: UNDESA, *The World Urbanisation Prospects, The 2009 Revision*, 2010.

UN-HABITAT defines a slum household as a group of individuals living under the same roof in an urban area who lacks one or more of the following: 1. Durable housing of a permanent nature that protects against extreme climate conditions. 2. Sufficient living spaces, which means not more than three people sharing the same room. 3. Easy access to safe water in sufficient amounts at an affordable price. 4. Access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people. 5. Security of tenure that prevents forced evictions.

sources of freshwater supply for the urban areas. Peri-urban areas often have large open space that are used as dumping grounds for urban waste, affecting water quality for some cities (Norström 2007).

HYDROLOGICAL FEATURES OF URBAN AREAS

Africa's urban centres are located in areas of different topography, climate, physical features and precipitation. These ecological differences are essential in understanding how urban areas access freshwater, and how they have become victims of their own waste.

Some major urban areas such as Johannesburg, Lusaka, Harare and Nairobi are located on plateaus at over 900 m above sea level. These cities are located on watersheds with low stream flows. As these urban areas grew, the need for more reliable and secure water supply led to their drawing water from reservoirs downstream, but the flow of waste into the water supply sources became a problem. As a result some rivers such as the Crocodile River in South Africa had an increase in mean annual flow due to wastewater from Johannesburg (Magadza 2003). Some water bodies supplying these cities have become eutrophic, including Lake Chivero near Harare and Lake Victoria (Magadza 2003).

← **Figure 3:** A major challenge with urbanisation in Africa is the growing population of slum dwellers, who account for 60 percent of Africa's total urban population. These informal areas typically lack infrastructure for improved water and sanitation as well as capacity for garbage collection and disposal.

Hydrological conditions have also had a bearing on the supply of adequate water and sanitation in African cities. While some cities are favoured with plentiful rainfall and surface water, others are located in drought-prone areas. One example is Port Harcourt, which receives so much rainfall for nine months in a year that the water table, a major source of drinking water, is high but vulnerable to contamination. This city has potential for augmenting water supply through rainwater harvesting.

Other cities are located on peninsulas where the water is saline. These include Conakry and Dakar whose sources of safe drinking water are now located further inland due to saltwater intrusion. Cities such as Abidjan, Cotonou, Lomé, Freetown, and Accra have neighbourhoods that are located in flood-prone areas, exposed to periodic high tides and storm surges. Proper disposal of sewage and supply of clean drinking water in such areas are a challenge. Still other cities such as Ouagadougou, Bamako, and Niamey are located in geological zones where yield from underground water sources is low (Collignon and Vèzina 2000). In these areas investments in dam construction and large water treatment plants are necessary.

Cities have failed to protect local ecosystems as they have become masses of concrete, resulting in little groundwater recharge. At the same time demand has outstripped available water resources in some cities such as Johannesburg and Nouakchott (Collignon and Vèzina 2000). As such it is becoming more expensive to draw water for cities from both surface and underground sources, with some cities now accessing their water through intra-basin water transfers. For example, one of Johannesburg's key water sources is the Lesotho Highlands Water project, which transfers water from the catchment area of the Senqu/Orange River in Lesotho through an 82 km stretch of artificial water tunnels (International Rivers 2005). In Mauritania's city of Nouakchott water is drilled from boreholes 50 km away, and the nearest freshwater stream is 300 km away (Collignon and Vèzina 2000).

URBANISATION AND ECOSYSTEM DEGRADATION

Residents of urban areas depend on various ecosystem services for their livelihoods. For example, forested watersheds and wetlands are important for urban water supplies, among other services. Sedimentation caused by poor land uses and the general failure to protect and manage watersheds can result in reduced capacity to generate hydropower. For example, the generation of electricity from two of Rwanda's hydropower stations, Ntaruka and Mukungwa, fell by 68 per cent in the last two decades due to sedimentation (Safari 2010). The degradation of the ecosystem also saw the cost of energy per kWh increased from USD 0.075 in 1997 to USD 0.20 cents in 2005 (Andrew and Masozera 2010).

While ecosystem services such as provisioning of clean water are a necessary basis for city growth, urbanisation can also strain the same water ecosystems. In addition to siltation, water bodies around some cities are polluted with high nutrient levels mainly from peri-urban farming activities as well as from domestic and industrial effluent discharges.

Untreated sewage effluent is one of the most common types of pollution found around urban rivers and in groundwater sources. Dar es Salaam, Accra, Khartoum, Harare, Maputo and Kampala discharge treated and untreated sewage into their water bodies (Mangizvo 2009), causing eutrophication and the proliferation of water weeds such as the water hyacinth and water lettuce. The discharge of sewage into city water bodies is often compounded by spillages of raw sewage due to power failures, pump or pipe failures.

Industrial and mining wastes are also dumped into water bodies around urban areas. Industrial waste is found in ocean waters near major centres dotted along Africa's coastline, including Dar es Salaam, Maputo, Durban, Cape Town, Walvis Bay, Baia do Cacuaco and Luanda (Moyo and Mtetwa 2002). Mining activities lead to the discharge of heavy metals such as cadmium, lead and mercury into river systems and oceans. For example, the Kafue River in Zambia deteriorates in quality as it passes through the Copperbelt town of Kabwe due to mine waste discharges (Moyo and Mtetwa 2002)

The high demand for space for infrastructural development in urban areas has witnessed the disregard for the functions and services offered by the environment. Wetlands in and around cities, which function as a buffer against floods and heavy rainfall, as well as play a role in purifying water, have often been taken up for either construction of settlements or waste disposal. An example of this is the Bwaise wetlands of Kampala, which have been encroached by expanding slums, but experience severe flooding as a result (NEMA 2009).

In order to curb urban pollution several approaches have been attempted, including penalties through the Polluter Pays Principle (PPP). The PPP calls for corporate responsibility that requires the polluter to take economic and environmental responsibility for wastes. Examples of PPP application in the water sector in Africa are few, but include the payment for disposal of waste from tanneries in South Africa (McClean and others 2007).

MANAGING URBAN WATER

Most current urban water management strategies are targeted at supplying water, with priority given to quantity and quality. This requires water supply infrastructure such as piped systems for water and sewer reticulation, and the construction of storage reservoirs such as dams. Administrative units for the collection of revenues from the provision of water services also have to be set up.

Management of the water resources in Africa falls under various jurisdictions, including under the state, local authorities, catchment councils or the private sector. Management emphasis, ranges from making a profit to providing a social service. One example of water management is in South Africa, where the aim is to generate income out of water provision as well as to provide a social service. This is accomplished through a combination of tariffs, cost recovery and free basic water under which every household receives the first six cubic metres per month for free, and the tariffs are gradually increased with greater usage (Government of South Africa 2005).

Not all urban dwellers have access to improved water and sanitation, hence there is an increase in informal entrepreneurs in the water and sanitation business to fill the gap in service provision by public sector water and sanitation systems. Many African governments are opposed to their activities due to their informal nature (Cudjoe and Okonski 2006).

Urban authorities use a mix of incentives and penalties to promote water use efficiency through recycling and reuse, as well as access to alternative sources of water such as rainwater harvesting.

URBAN WATER SECTOR REFORMS

In view of economic reforms, the urban water sector as managed by local authorities and central governments has seen unsustainable pricing, inequitable subsidies, inadequate public

investment and costly engineering solutions. As a result reforms are being introduced to address the following (Batley 2004):

- Alter pricing structures so that they reflect real costs;
- Increase the focus on water management over water supply;
- Reduce the role of government to that of policy-maker and regulator;
- Place bulk water supply in a public corporation free of civil service controls;
- Encourage private financing of investment; and
- Further decentralise water delivery.

The water sector reforms seek to deal with the mismatch between resource abundance and human settlements (Gumbo and others 2005); to address historical inequalities (Robinson 2002), to manage water resource stock depletion and degradation (Mbaiwa 2004); and, to acknowledge water as a human right.[3] The reforms are also a result of better understanding of the connection between water, ecosystems and urbanisation. They include approaches to improve water resources management; to draw water from alternative sources; and to manage watersheds for better water quality and greater yields.

IMPROVING WATER RESOURCES MANAGEMENT

In shifting focus from water supply to water management, two approaches are emerging across some cities in Africa, and these are Integrated Water Resources Management (IWRM) and Water Demand Management (WDM).

INTEGRATED WATER RESOURCES MANAGEMENT

Defined as a process that promotes the co-ordinated development and management of water, land and related resources in order to maximise the economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP 2000), Integrated Water Resources Management (IWRM) has seen new institutional arrangements and legislation for the water sector. Through institutional reforms governments have devolved power to local stakeholders, creating structures such as catchment management authorities. Burkina Faso, Ghana, Zimbabwe, South Africa, Zambia, Swaziland, Malawi, Uganda, Kenya and the United Republic of Tanzania are some of the countries,where governments have devolved water management authority to local structures, including urban areas (Manzungu 2002). In Zimbabwe the Water Act of 1976, which largely provided for the interests of large-scale commercial farming, was replaced by a new water act in 1998, and management authority decentralized to catchment councils (Manzungu 2002). Through IWRM, the focus of water resources management is broadened for water use, planning and watershed management, to include all related practices such as agriculture, forestry and urban planning.

Despite its positive intents of equity, efficiency and sustainability, the IWRM concept also has challenges. Not all governments are willing to devolve power, and rural dwellers are at times suspicious of the motives behind reforms. In the urban areas efforts to fully recover costs have been met with civil society resistance. For example, in 2007 Egypt witnessed 40 civil society protests, which were partly driven by high costs of water (National Council for Services and Social Development 2007). Swatuk (2007) argues that some countries have not been able to speedily reform their water sectors because the new water architecture proposes a profound realignment of decision-making power in already fragile states.

WATER DEMAND MANAGEMENT

Water sector reforms have also seen the successful application of Water Demand Management initiatives in some urban areas (Gumbo and others 2005). Water Demand Management includes the estimation of potential savings, which can be made by reducing the amount of water that is wasted. This can be controlled by pricing mechanisms, and technical regulatory measures such as better management of catchments, recycling and investment in infrastructure to reduce leakages. Water Demand Management has been accepted in Abidjan, Accra, Addis Ababa, Dakar, Johannesburg, Lusaka and Nairobi as the cheapest form of augmenting supply at both utility and national policy-making levels (UN-HABITAT undated). At the national policy level, the willingness to invest in Water Demand Management measures has led to the incorporation of water demand principles and practices into the regulatory frameworks of countries such as Zambia. National regulators used the Lusaka Water Demand Management strategy as a model for developing a national Water

3. UN Resolution on water as a human right: Everyone has the right to clean and accessible water, adequate for the health and well-being of the individual and family, and no one shall be deprived of such access or quality of water due to individual economic circumstance.

Demand Management strategy. In Ghana, the water restructuring secretariat introduced Water Demand Management in the regulatory framework and in the national water policy. In Johannesburg Water Demand Management generated sufficient savings in water demand to justify the cancellation of a project to build an additional water reservoir, while in Addis Ababa, despite a growing population and drought, demand management resulted in a USD 1.6 million savings to the government per year (UN-HABITAT undated).

IMPROVING WATER QUALITY AND YIELDS

Payment for Ecosystem Services (PES) seeks to improve water quality and yields through better management of watersheds. PES is a management strategy, which focuses on maintaining the flow of an ecosystem service such as clean water, biodiversity habitat or carbon sequestration capabilities in exchange for something of economic value. In Africa PES activities are still at conceptual stages, with few exceptions such as the Lesotho Highlands Water Project in which communities in Lesotho are reimbursed by the downstream water users in the industrial Gauteng region of South Africa for the provision of watershed protection services. While South Africa pays about USD 2 million per year for water from Lesotho, the greatest benefit to the communities is the improved livelihoods of the Lesotho Highlands communities through better agricultural output from irrigated farming as well as access to alternative energy to firewood through the 110 MW of hydro-electricity (Santho and Gemmil undated).

Dar es Salaam, which faces water shortages as a result of decreasing flows and poor water quality in the Ruvu River, is mulling a payments for watershed services initiative. Under this initiative communities living in the river's upstream catchments in the Uluguru Mountains will receive incentives from the major industries in Dar es Salaam in return for better farming methods and reduced deforestation, which threaten vital hydrological functions performed by healthy forest ecosystems. The initiative envisions developing a market for watershed services in which beneficiaries of better river health, mainly industry, will 'buy' services produced by land managers in the water catchment. Besides illustrating the PES approach, the initiative also provides an opportunity to explore how public-private partnerships could work in Tanzania (Riddington and Scholler 2006).

ALTERNATIVE SOURCES OF WATER

Through rainwater harvesting, groundwater access and desalinisation, some cities are making efforts to ensure adequate water supplies.

Rainwater harvesting is promoted and implemented in urban areas for a variety of reasons. In Port Harcourt, water supplies have been diminishing due to limited capacity by the central government. This has spurred house-owners to invest in rainwater harvesting for household consumption. The increased use of rainwater harvesting provides additional water supply and reduces pressures of demand on surrounding surface and groundwater resources.

Access to groundwater through boreholes is widespread but largely unmonitored in Africa. In Nairobi, there is a growing demand for groundwater, which is tapped through boreholes.

Desalinisation is not widely used as an alternative source of water. Algeria, through the Hamma Seawater Desalination Plant, is one country that uses desalinised water (Ondrey 2008).

CASE STUDIES

Africa's cities are highly diverse, and as such they face unique challenges in as far as access to improved drinking water and sanitation are concerned. As the case studies in this publication demonstrate, the following are some common water and sanitation issues in African cities:

- Cities are depending more on external ecosystems for their water supplies;
- Alternative sources of water such as rainwater harvesting and groundwater are growing in use and importance;
- There is a growing role by the private sector in complementing government efforts in the delivery of urban water supply and sanitation;
- Management of urban water is being reformed in view of changes in economic development and growing environmental awareness; and
- The plight of the urban poor is known, but there are few pro-poor initiatives to improve their access to water and sanitation service.

The case studies present urban water challenges in African cities, and highlight approaches adopted to reduce the impacts of urbanisation on water and ecosystems. The case studies discuss urbanisation characteristics of their respective cities, state and trends of water withdrawals and demand, environmental impacts of bulk water supply and wastewater discharge, and lessons for policy.

URBANIZATION, WATER AND ECOSYSTEMS: THE CASE OF NAIROBI

David N. Mungai and Samuel O. Owuor[4]

Founded as a railway station in 1899, Nairobi is the largest city in Kenya covering an area of 696 km² (UN-HABITAT 2010). The city accounts for 60 per cent of Kenya's Gross Domestic Product (Ndorongo undated, Mungai and others 2011).

As Kenya rapidly urbanises, Nairobi's share of the country's urban population increased from 5.2 per cent in 1948 to 32.4 per cent in 2009 (GOK 1966, 1971, 1981, 1994, 2002, 2010). The annual urban growth rate for Kenya increased to a high of 7.7 per cent in 1979 but fell to 3.4 per cent in 1999 (GOK 1999). Nairobi continues to have the largest share of the urban population in the country. The city's population increased from 119 000 in 1948 to 3.1 million people in 2009 (GOK 1966, 1971, 1981, 1994, 2002, 2010). Despite its large population, Nairobi recently witnessed a decline in its growth rate. This indicates the emergence and importance of small and medium-size urban centres in the country.

It is estimated that half of Kenya's population will be living in urban areas by 2015. Urban growth, combined with urban sprawl, has overwhelmed the capacity of local authorities to provide the increasing urban population with adequate facilities and services, including water and sanitation.

4. The authors would like to thank Philip Gichuki, Mbutu Mwaura, Msafiri Wambua and Paul Kinyua for providing the information used in preparing this case study and for providing useful comments on the first draft of the text.

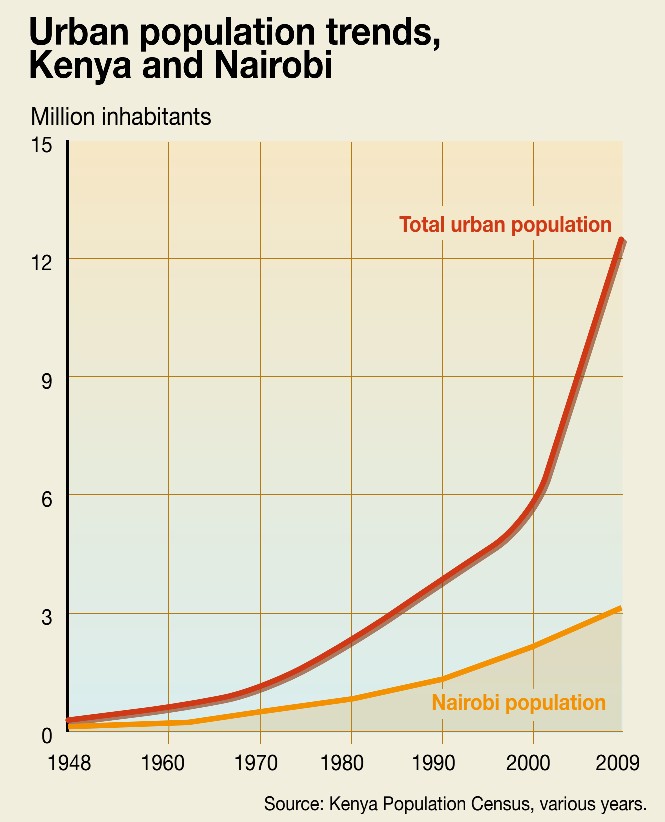


Figure 4: As the total urban population of Kenya continues to grow, the capital of Nairobi still harbours the largest share of the country's urban population.

The majority of the urban population in Nairobi live in poverty and in slums. A 2004 report estimated that 44 per cent of Nairobi's population lived below the poverty line (SID 2004) while about 30 per cent is living in slums.[5] Nairobi has over 200 slum settlements with inadequate access to safe water and sanitation. The four largest slum settlements in the city are Kibera, Mukuru Kwa Njenga , Mathare (GOK 2010) and Korogocho.

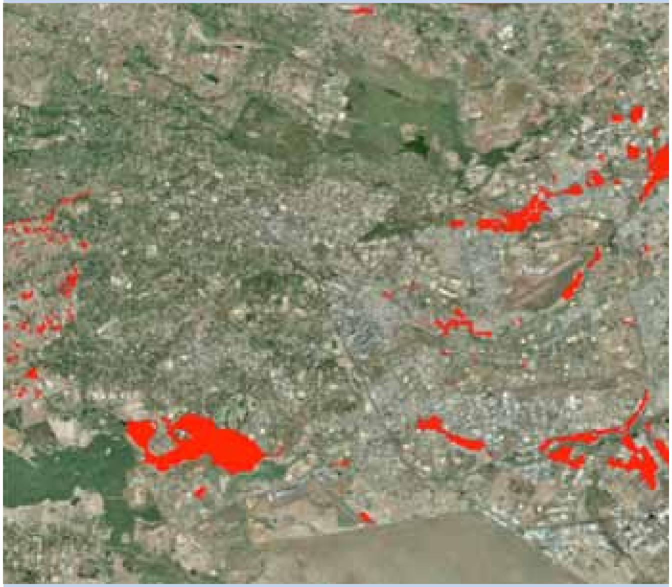


Figure 5: Satellite overview of Nairobi indicating locations of slums in red (Tibaijuka 2009).

WATER SUPPLY

LEGISLATIVE AND INSTITUTIONAL ARRANGEMENTS

The Water Act (2002) provides an improved legislative framework for effective management, conservation, use and control of water resources. It regulates and manages water supply and sewerage services. For both services and management, national and regional boards have been established and are responsible for regulation and supervision.

This institutional set-up as provided for under the Water Act examines issues related to water abstraction, treatment and distribution, wastewater treatment and disposal, and impacts of the water supply chain on ecosystem health. In line with the 2002 Water Act, the provision of water in Nairobi is undertaken by the Nairobi City Water and Sewerage Company (NCWSC) under contract from the Athi Water Services Board. The company has divided Nairobi into six regions and the water network into four corridors to facilitate water better distribution.

SOURCES OF WATER

The major sources of water for Nairobi are rivers whose sources are in the Aberdare range. The Aberdare ecosystem is

5. There is no official figure on Nairobi's total slum population.

Box 1: Key institutions created as a result of the Water Act

- Water Resources Management Authority (WRMA), responsible for the sustainable management of water resources.
- Catchment Area Advisory Committees, advises WRMA on conservation, use and allocation of water resources in their catchments.
- Water Resources Users Association, provides a forum for conflict resolution and cooperative management of water resources in designated catchment areas.
- Water Services Regulatory Board, responsible for the regulation of water and sewerage services.
- Water Service Boards, responsible for the efficient and economic provision of water and sewerage services in their areas of jurisdiction.
- Water Service Providers, contracted by Water Service Boards to provide quality water and sewerage services.
- Water Services Trust Fund, assists in financing the provision of water services to areas without capacity to develop adequate water services.
- Water Appeal Board, provides a mechanism for dispute resolution.

important for the regulation of river flows, as well as reducing soil erosion and sedimentation which, if not checked, would affect the water quality and increase the cost of water treatment.

The conservation of the Aberdare range ecosystem is crucial if Nairobi is to continue making significant contributions to the national economy. A recent study by Mungai and others (2011) found that there has been a significant reduction of environmental degradation in the Aberdare Conservation Area. This is evidenced by the increase in indigenous forest cover from 62 000 ha in 2000 to 131 000 ha in 2010 following the fencing off of this water catchment area through a private-public partnership initiative. To ensure continued supply of water, electricity and other goods and services to Nairobi from the Aberdare range, a policy framework and clear management system that incorporate the key stakeholders need to be put in place. At the same time, poverty reduction interventions are required in the forest margin landscapes to reduce pressure on the ecosystem from communities living adjacent to the forests (Mungai and others 2011).

WATER SUPPLY FROM THE DAMS AND SPRINGS

The bulk of water supply for Nairobi comes from Thika, Sasumua and Ruiru Dams, as well as the Kikuyu Springs. Over time water supply for the city has failed to meet demand. The current estimated water demand for Nairobi is 650 000 m^3/day compared to the production of 482 940 m^3/day (WRMA 2010). The difference between production and demand has been widening over time due to population growth, inadequacy of the carrying capacity of the distribution network and climate shocks.

GROUNDWATER SUPPLY

Nairobi also depends on groundwater drawn from the Nairobi Aquifer Suite, which covers an area of approximately 3 000 km^2. The most important natural recharge area for the acquifer is the southern Aberdare and eastern Rift escarpment, including the Ngong Forest. Of the total recharge area of 986.27 km^2, 450 km^2 is either under forest cover or swamp, while the rest is under intensive cultivation. Further loss of the forest will have direct impact on deep aquifer recharge. In addition, increased use of pesticides in the agro-zone of the recharge area will increase the levels of contaminants in the recharge water (WRMA 2010).

Groundwater abstractions in the Greater Nairobi Area started in the early 1950s. In 2002 the city had 1 350 boreholes withdrawing about 70 000 m^3/day (Mogaka and others 2006), and representing 21 per cent of the water supply to the Nairobi area (Mogaka and others 2006). A recent study (WRMA 2010) established that there are about 4 800 boreholes in Nairobi with a total annual abstraction of 58 million m^3. Estimates show that groundwater accounts for 65 000 m^3/day of domestic water needs, 60 000 m^3/day for industrial purposes, 3 000 m^3/day for livestock uses and 28 000 m^3/day for irrigation in the whole of the Nairobi Aquifer Suite catchment area (WRMA 2010).

There is evidence that the rate of groundwater abstraction is imbalanced, with over-abstraction in some areas while extraction in other areas is within "sustainable limits" (Mogaka and others 2006, WRMA 2010). The Water Resources Management Authority has identified several groundwater hotspots[6] in the Nairobi environs, the most notable being (WRMA 2010):

- Westlands, with 118 boreholes and a concentration of 20 boreholes per sq km;
- Kikuyu, with 90 boreholes and a concentration of 16 boreholes per sq km;
- Karen, with 61 boreholes and a concentration of 9 boreholes per sq km;
- Ongata-Rongat, with 45 boreholes and a concentration of 8 boreholes per sq km; and
- Thika, with 33 boreholes and a concentration of 6 boreholes per sq km.

PRO-POOR WATER SUPPLY MEASURES

The 200 slum settlements in Nairobi have inadequate safe drinking water and sanitation facilities. Kibera settlement, for example, receives about 20 000 m^3 of water per day, 40 per

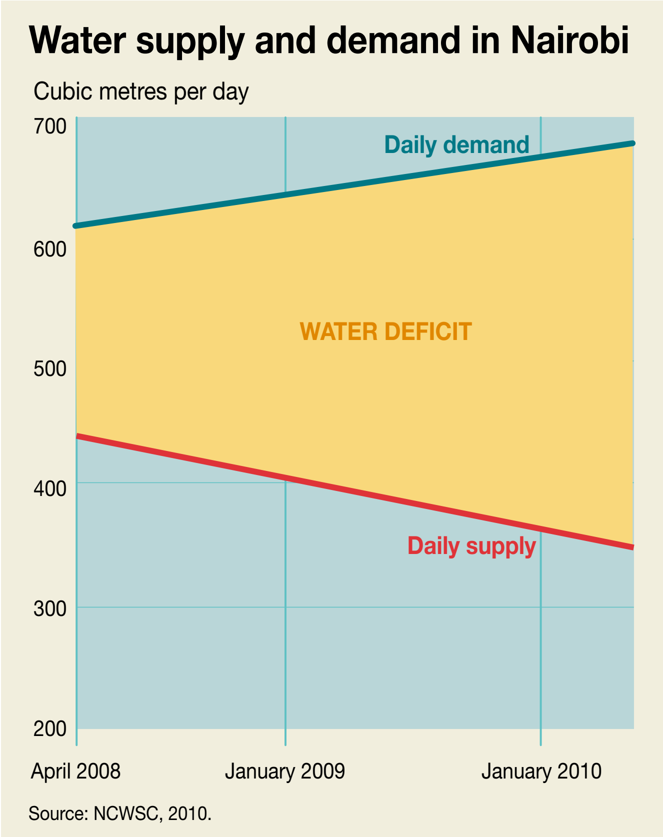


Figure 6: As the population of Nairobi expands, the pressure on water supply increases and the gap between supply and demand grows.

6. The term hotspot is used to refer to areas where there is an existing or emerging high demand for groundwater.

cent of which is unaccounted for as it is lost through leakage. About four per cent of Kibera's residents have in-house water connections, 15 per cent relies on yard taps and 68 per cent relies on water kiosks managed by private individuals, Non-Governmental Organisations or Community-Based Organisations. Although approximately 25 km of pipe network exists in Kibera, much of this network receives little or no water due to limited pump capacity, and the diversion of available water to neighbouring high income areas (COHRE 2007).

The NCWSC and Athi Water Services Board recognize the plight of the underserved residents of Kibera, and have developed the informal settlements' strategic guidelines. The objectives of the guidelines are to provide a framework for operations in informal settlements; promote and facilitate partnerships with key stakeholders; and increase the predictability and transparency of water and sanitation services interventions in informal settlements. It is within this framework that the NCSWC has established the Department of Informal Settlements, whose overall objective is to increase coverage, affordability and sustainable access to safe water and basic sanitation facilities aimed at raising the wellbeing of the poor living in unplanned areas within Nairobi.

The NCWSC has made some interventions in different informal settlements of Nairobi in a bid to improve access to water and sanitation services. Some of these interventions include (Muiruri and Kaseve 2008):

- The Mukuru Chamber Project, which houses metres for individual connections. So far, 67 chambers have been constructed with a total of 1 300 connections, and serving about 100 000 people in the 12 villages of Mukuru. The chamber project, funded by the World Bank and completed in 2006, has reduced the price of water from USD 0.24 to USD 0.05 per litre, besides providing access to safe water; and
- The Mathare Water Project, which is a joint collaboration between the NCWSC and Pamoja Trust, and is expected to construct 45 communal water kiosks in the settlements.

The NCWSC has met with various challenges in providing water services to the urban poor in Nairobi, including illegal connections, leakages due to poor quality pipes, unplanned construction above water and sewerage pipes, community conflicts, insecurity due to criminal gangs, uncoordinated interventions by different players, land tenure issues, and the unplanned nature of the slums (Muiruri and Kaseve 2008).

WATER DEMAND MANAGEMENT

Nairobi has a water deficiency of about 200 000 m^3 per day and the distribution network is inadequate and outdated. The NCWSC manages the supply deficit by rationing of the available water to the city residents. This means that some areas do not receive water at certain times of the day. Other efforts being made include:

- Bulk water transfers to areas that do not receive water on a regular basis;
- Modification of water distribution network to facilitate more equitable water distribution in the city;
- Development of new water sources; and
- Recharge enhancement.

Although rainwater harvesting and water use efficiency measures could substantially augment current and projected water demands for the city, these measures are not widely used in Nairobi.

WATER RE-USE, WASTEWATER TREATMENT AND DISCHARGE

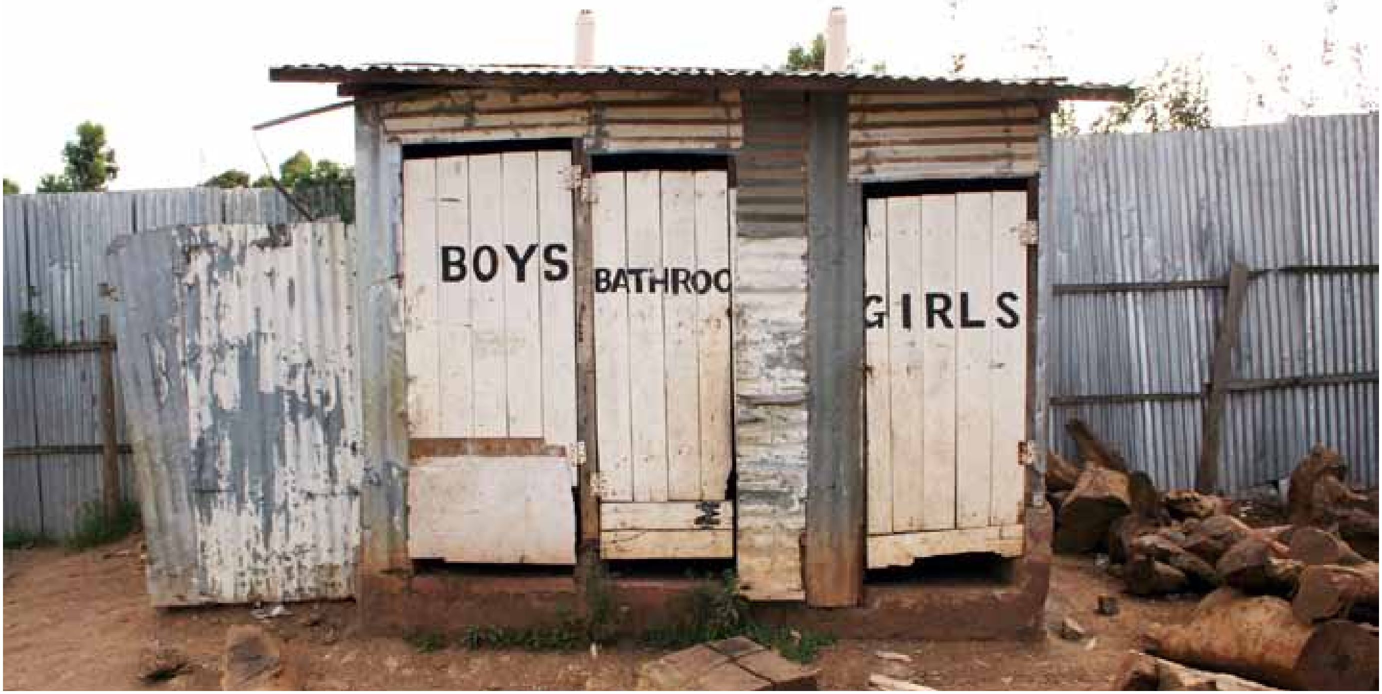
The enactment of the Environmental Management and Coordination Act (1999), with its requirement for environmental audits and fairly deterrent legal and financial sanctions, has forced a number of businesses and industrial plants to embrace cleaner production concepts and principles. It is estimated that over 10 000 establishments have carried out the initial environmental audit to determine the impacts of their production processes and outputs. The capacity of the National Environmental Management Authority (NEMA) to cope with compliance and enforcement of the statutory provisions, and to follow up on the implementation of the environmental management plans, has been a weakness in the improvement in water use efficiency and ecosystem degradation. Consequently, loss of water and discharge of wastewater, which does not conform to the set standards into the sewer or natural environment, are common.

Whereas water re-use and wastewater treatment may be minimal, Nairobi has two sewerage treatment plants at Ruai and Kariobangi. The utilization of the Ruai plant is about 74 per cent of the design capacity due to its dilapidated infrastructure. Plant utilization at Kariobangi treatment works is lower at 39 per cent. Despite improvements in treatment efficiency and reduction in the pollution load, the facilities do not meet prescribed effluent discharge standards. In both plants, the sewerage treatment efficiency is low and the final effluent discharged into Nairobi River does not meet the prescribed standards for Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS). For example, the BOD, COD and TSS levels of final discharges from the Ruai plant are 70 mg/l, 291 mg/l and 131 mg/l while the standard quality for such discharges are 30 mg/l, 50 mg/l and 30 mg/l, respectively (NCWSC 2010).

ENVIRONMENTALLY SUSTAINABLE APPROACHES

It is essential that water, which is a scarce but vital natural resource, is abstracted and used sustainably. To enhance sustainability and equitable water and sewerage services in Nairobi, the NCWSC has adopted the following approaches:

- Creating awareness and encouraging adoption of Cleaner Production practices among water users so as to minimize waste and increase water use efficiency;
- Reduction of non-revenue water from 45 per cent (2004/5) to 39 per cent (2008/9) through upgrade of infrastructure, improved billing systems, and reduction of illegal connections, leaks and bursts; and
- Developing an interest in Payment for Ecosystem Services (PES) as an attractive tool for sustainable conservation of watersheds (Pagiola 2006, World Bank 2006, Yatich and others 2008). Msafiri (2008) assessing Sasumua Dam and its catchment, argues that physical and chemical water purification are more expensive compared to natural systems. Opportunities for adoption and implementation of PES exist due to:
  - The water sector reforms following the enactment of the Water Act (2002)' which separated water services from water resources management;
  - The Environmental Management and Coordination Act (1999), which makes provisions for conservation of hilltops and other environmentally sensitive areas;
  - The NCWSC spends about USD 170 000 monthly on chemicals and USD 110 000 annually for de-sludging Sasumua Dam, funds which could be saved by adopting PES; and
  - The successful private-public-partnership involving the Rhino Ark (a charitable trust), the Kenya Wildlife Service and the Kenya Forest Service, which completed the fencing of the Aberdare Conservation Area in 2009, demonstrates the benefits to be derived from PES.



Given the trends in and impacts on groundwater abstraction in the Nairobi Acquifer Suite, the Water Resources Management Authority has developed a long term water resources management strategy in the Nairobi region based on water demand management actions, which entail awareness creation among users; irrigation demand management actions, which seek to limit commercial irrigation permits in certain areas and to make it a requirement to institute efficiency measures; catchment management; and, land use zoning to improve recharge and water quality.

WRMA (2010) has also prepared guidelines for assessment of applications for groundwater permits. Authorization to sink a borehole/replacement of abandoned well for domestic purposes in the city and environs will be granted to government departments/agencies entrusted with water supply, schools/ institutions/universities, hospitals, embassies, and authorized water service providers subject to some conditions, including (WRMA 2010):

- The final installation shall be subject to recommended maximum pump motor size ratings;
- Concurrent with the construction of the borehole, the owner of the borehole shall undertake installation of rain water harvesting structures in the premises within 60 days of issuance of the authorization to drill and must confirm to WRMA for verification;
- Only one borehole is allowed for construction in the premises for domestic purposes. No authorization will be issued where a working borehole already exists;
- Construction of new boreholes to be authorized only where the potential for deeper aquifers exists and in such cases, all preceding aquifers to be sealed off;
- The person(s) intending to construct the borehole will inform WRMA/Catchment Area Committee 14 days in advance before construction commences, and furnish the name and address of the drilling company that will undertake the work; and
- No authorization shall be granted for construction of boreholes for agriculture, industrial, commercial, commercial irrigation, subsistence irrigation and construction purposes in notified areas.

INVESTMENT IN WATER RESOURCES MANAGEMENT

Capital investment under the Water Act 2002 is vested in the Athi Water Services Board. The Board has plans to build two dams at Maragua and Ruiru to cater for water demand to the year 2035. In its current Strategic Plan (2010/11–2014/15), the NCWSC has earmarked USD 4.5 million for activities geared towards increasing production and access to water through upgrading and expansion of water infrastructure. In addition, the company continuously carries out trial tests on new chemicals and technologies to achieve more cost effective production of water for the city.

LESSONS LEARNED AND MESSAGES TO GUIDE POLICY

- According to the 2009 population census, Nairobi accounts for 25 per cent of the total urban population in Kenya. This proportion is higher if the Nairobi Metropolitan Region's population is taken into account. Due to the widening gap between water supply and demand, a comprehensive plan has to be developed to meet the water-needs of the city.
- The water sector reforms and interventions have improved water services in Nairobi, but these benefits are yet to trickle down to the urban poor households especially those living in the slums. The urban poor not only have access to less water, but they also pay more for the water. The NCWSC and other actors are making deliberate efforts to develop and implement a pro-poor strategy to provide better water and sanitation services to the urban poor.
- On the whole, the NCWSC has made notable achievements in providing water and sewerage services to Nairobi city even though the company is experiencing challenges such as managing old and dilapidated infrastructure; illegal connections; vandalism; inadequate capacity to manage the increasing demand for water; limited resources and high costs of operation and maintenance; local political interference; high debts and liabilities; lack of autonomy to do major investments; inequitable distribution of water; abuse of sewerage for farming with public health implications; discharge of industrial waste into the sewer network by industries and other consumers; and financial demands from riparian communities.
- The implementation of the long-term groundwater allocation strategy developed by WRMA will ensure continued availability and equitable supply of water to Nairobi and environs.
- The future of water services provision depends on reliable and updated data, as well as improved technology.

WATER SUPPLY AND SANITATION IN GRAHAMSTOWN: A HISTORICAL PERSPECTIVE

Jay O'Keeffe[7]

Grahamstown was established in 1812 as a military outpost. In the 1820s, large numbers of farming settlers migrated into the area, and within 40 years Grahamstown had grown to be what was then the second largest city in South Africa, after Cape Town.

The city gradually became a centre of learning and education with the establishment of both private and public schools and later the Rhodes University was founded.

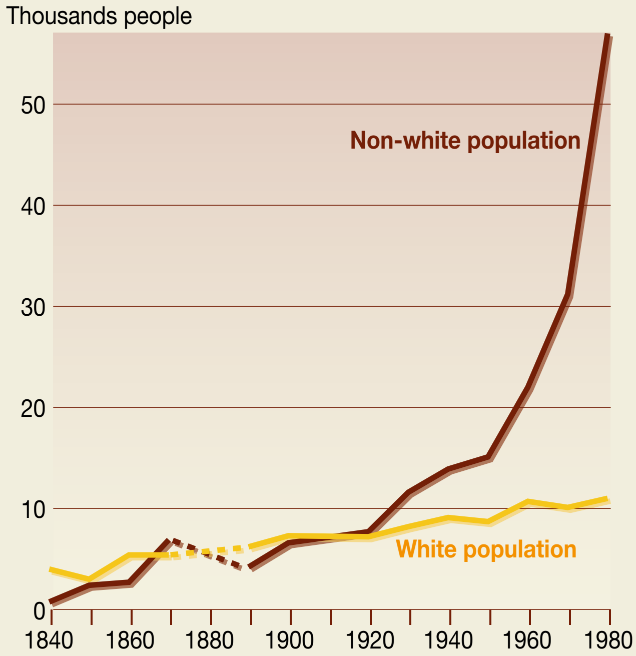
Grahamstown and some surrounding smaller urban areas are served by Makana Municipality, which is responsible, among other things, for the provision of water and sanitation services in the area.

POPULATION GROWTH

The 2001 national census estimated Grahamstown's population at about 76 000 (Makana 2004), while the municipality reported a higher figure of more than 132 000 (Makana 2007).

7. This article is based on documents, advice, suggestions and help from the following, to whom I am deeply grateful: Lorraine Mullins, Helen Barber, Nikki Kohly, Nelson Mabece, Michael Whisson, and Roger Rosewell.

Historical population trend, Grahamstown 1840-1980



Source: Maki, H., Mullins, L., Water in Grahamstown, *Then and Now – a history of Grahamstown's water supply from the beginning*, 2007, unpublished document.

Figure 7: While the white population were the majority in the early period of Grahamstown, they were outnumbered around 1920. Historically, the non-white population did not pay for water and sanitation services, and this became a problem when this demographic group became the clear majority.

The higher figure matches projections by Maki and Mullins (2007), who estimated the city's population to reach 125 000 in the ''2000s". The city is estimated to use 3693.2 megalitres of water per year (Makana 2007).

GENERAL WATER SUPPLY CHARACTERISTICS

Grahamstown is located in a dry area, with a mean annual rainfall of 680 mm, and is subject to frequent droughts. The wettest months are February and November, with a dry season lasting from April to September.

The main water source for Grahamstown is the Gariep Dam via the Glen Melville Reservoir, which receives water via an inter-basin transfer from the Orange River. The other water sources are Settler's Dam, Howison's Poort Dam, and the smaller Jamieson and Milner dams. Other than Glen Melville, all the dams capture runoff from local streams, all of which cease to flow during most dry seasons.

HISTORICAL DEVELOPMENT OF GRAHAMSTOWN'S WATER SUPPLY

The water sources for Grahamstown in the early 1800s were the courses that run into the town from the hills to the south. Small dams diverted the water into furrows and from these each household drew its share according to a timetable (from Maki and Mullins 2007, Hunt 1976). By 1837 the water supply was already inadequate and Maki and Mullins (2007) quote from Hunt (1976) that "Citizens constructed wells in likely places, but the less fortunate had either to beg for a kettle or draw off at the dead of night." By the 1850s there was an obvious need for water storage to supply the growing population, and following a severe drought in 1858, the council voted funds to build the first municipal reservoir – Grey Dam. Throughout subsequent decades, further and larger dams were built to increase the city's water supply.

Until the 1990s all the dams were designed to exploit the limited and unreliable supplies from local rivers in the Bloukrans, New Year's and Kariega catchments. In the 1970s a major inter-basin transfer was constructed from the Gariep Dam on the Orange River, via an 83-km pipeline and canal system into Grassridge Dam on the Great Brak tributary of the Great Fish River. The Great Fish River is naturally seasonal, with flow ceasing in July and August of most years (O'Keeffe and de Moor 1988). The Fish River scheme was originally designed to provide a constant flow of water for year round irrigation in the middle Fish River catchment. With the increasing water shortages of the 1980s, culminating in the worst drought on record in 1991, the Grahamstown Council took advantage of the transferred water by constructing a diversion and storage dam for urban supply. Some of the Orange River water is diverted from the Great Fish via a weir upstream of Fort Brown (Hermanuskraal) through a tunnel into the Glen Melville Dam on the Ecca River, close to the bottom of the Ecca Pass. Two-thirds of Grahamstown's water demands are met from Glen Melville.

Not all parts of Grahamstown had equal supply of water. The eastern part of the city, a settlement mainly for the black population, had inadequate water supplies and sanitation services. In 1938 a new water supply line was laid for Grahamstown East, and 53 standpipes brought water closer to people's homes.

The first water treatment plant for Grahamstown was installed in 1914. The water came in from Jameson and Milner dams.

In 1936 the first water borne Sewage Treatment works was opened. Neglect of the sewage system caused by lack of an engineer's assistant to oversee the treatment plant, eventually resulted in a total blockage in 1943.

PRESENT WATER SUPPLY AND WASTEWATER TREATMENT

There are currently two water treatment works in Grahamstown: at Glen Melville and at Waainek. Treated water from the Glen Melville works, with a capacity to produce 10 megalitres per day, is fed to the Botha's Hill, Mayfield and Tantyi reservoirs. Treated water from the Waainek works with a capacity to produce 9 megalitres per day is fed into the Waainek reservoir and the remaining three reservoirs situated in the vicinity of the town's filters (Makana 2008).

Due to the local topography, Grahamstown is divided into a northern drainage area and a southern drainage area served by the Mayfield wastewater treatment works and the Belmont Valley wastewater treatment works, respectively. The Municipality upgraded the Mayfield wastewater treatment works from an aerated lagoon and oxidation pond system to an activated sludge system. The Belmont Valley wastewater treatment works uses biological filtration to purify wastewater.

According to Makana Municipality (2004), 96 per cent of the households in Grahamstown has access to water from an improved source, and about 36 per cent of the households has access to adequate sanitation.

Makana Municipality has developed a water master plan to be put in place at a cost of USD 22 million. The plan outlines proposed water and wastewater projects such as the construction of a 4-megalitre reservoir at Botha's Hill; the upgrade of the Alicedale Water Treatment Plant; conversion from ventilation improved pit toilets to waterborne sanitation at Extension 6 and lower Makana; upgrade of the Belmont Valley wastewater works; and, the construction of bulk water supply at James Kleynhans water treatment works.

PROBLEMS WITH GRAHAMSTOWN'S WATER SUPPLY AND SANITATION

The goal of ensuring sustainable and reliable water supply and adequate sanitation in Grahamstown is faced with several challenges, including:

- The possibility of substantial reductions in rainfall by the end of this century like most of Southern Africa (IPCC 2007).
- Historical inequities in service delivery between Grahamstown East and West, with the previously white West receiving comprehensive services, and paying for them, while much delayed and often sub-standard services in the East are combined with a historical reluctance and inability to pay. A local councillor wrote in December 2006 "...the sum of unpaid accounts has steadily increased such that it is now in excess of one year's operating budget, which has virtually eliminated the capacity of the municipality to purchase new equipment and squeezes the maintenance budget to about 6 per cent of the operating budget" (quoted in Maki and Mullins 2007).
- Outdated and unreliable infrastructure, which has not been maintained adequately. The pumps and pipelines from Howison's Poort to Waainek were installed in 1931 and could provide 2 050 litres per minute up the 454 m lift to Waainek, which was then the highest lift in the country. In 2010 Howison's Poort was empty, and when it refilled in December, the pumps, unused for several months, failed to operate and had to be repaired.
- Inadequate technical capacity among municipal employees.

ENVIRONMENTAL IMPACTS AND SUSTAINABILITY APPROACHES

The provision of bulk water, and the treatment and disposal of wastewater from a community of more than one hundred thousand will necessarily have environmental impacts. The regulation, storage and abstraction of water from local rivers disrupt their flow and geographical continuity, with severe consequences to the riverine biodiversity. The disposal of even treated water has consequences for the downstream water quality, in terms of increased salinity and nutrients. In addition to these consequences of urban development, Grahamstown's water footprint is partly responsible for environmental problems in a wider geographical area. The Orange/Great Fish water transfer, on which Grahamstown relies for much

of its water, has had significant environmental consequences for the ecology of the recipient Great Fish River. These have been extensively documented (e.g. O'Keeffe and de Moor 1988, Rivers-Moore and others 2007), and include the introduction of a variety of alien fish species. An example is the emergence of a biting black-fly, Simulium chutteri, whose aquatic larval and pupal stages have come to dominate the invertebrate fauna of the middle reaches of the river since the inter-basin transfer.

An interesting success story in South Africa's environmental management is the "Working for Water" programme, which was initiated by the Department of Water and Forestry in the 1990s. It aims to combat alien plant species, which not only have a highly negative effect on indigenous species, but also tend to consume a very high amount of water. By the mid 20th century, exotic trees dominated the hillsides around Grahamstown, significantly reducing the runoff to local streams. In the 1990s, the Working for Water initiative began to clear some of the local catchments, the agreement being that the programme would fund the initial and second clearances, and that the landowner (usually the Makana Municipality) had the responsibility for further clearances until the native vegetation was re-established. The programme has had its successes, notably in the Featherstone Kloof catchment and on Mountain Drive, and where the runoff to dams such as Grey Dam, which receives runoff from Mountain Drive, has increased demonstrably.

INSPIRING WATER INITIATIVES IN GRAHAMSTOWN

In Makana Municipality a Blue Drop System is being implemented with the help of the Amatola Water Board, which is one of 20 water boards mandated by the South African Government to operate as a water services provider to municipal authorities. The Blue Drop System is a regulatory tool and certification system used by the Department of Water Affairs to monitor the quality of drinking water in South Africa.

Rainwater harvesting is being promoted by the project Galela Amanzi meaning "pour the water" in Xhosa, and was initiated by students in 2007. Galela Amanzi installs rainwater tanks in key locations in the disadvantaged regions of Grahamstown, providing water for irrigating community vegetable gardens, cooking and drinking purposes.

A demonstration of integrated algal ponding process to treat effluent at the Belmont Valley wastewater treatment works has been in operation for 17 years. The plant treats about 10 per cent of the effluent received at the wastewater treatment works, and produces treated effluent which meets the national standards.

LESSONS LEARNED AND MESSAGES TO GUIDE POLICY AND PRACTICE

Since its establishment, Grahamstown has struggled to provide adequate water services to its growing population, and the city is predicted to face future crises in terms of demand for environmental resources in the face of climate change. One solution is the Integrated Water Resources Management (IWRM) approach. A recent paper by Haigh and others (2010) discusses the requirements and impediments to IWRM at local government level in South Africa. They point out that many South African municipalities fail to comply with the Water Services Development Plan, and cite ignorance and lack of staff capacity; failure to manage infrastructure adequately; poorly run and inadequate wastewater treatment works; failure to clear alien vegetation from rivers; and failure to monitor water resources as the reasons for such failure. Many of these shortcomings echo the problems of Makana Municipality.

Haigh and others (2010) make several recommendations for the gradual achievement of IWRM objectives at local government level:

- Create an integration forum with an integration champion;
- Realign operational areas, so that all water-related activities are dealt with by one office;
- Maintain a healthy environment, by drafting and implementing an environmental management plan;
- Review the Integrated Development Plan procedures and place water requirements at the centre of each sectoral plan;
- Ensure rigorous and effective monitoring and reporting; and
- Develop management strategies that include community engagement, effective communication, rehabilitation and mitigation measures, and risk assessment.

Haigh and others (2010) also recommend a number of skills and training initiatives, including electronic data management, water resource management training, technical training including water chemistry, biochemistry and microbiology, legal knowledge, and financial management. They acknowledge that such capacity building will be a long-term process.

WATER AND SANITATION IN PORT HARCOURT

I. I. Kakulu[8]

While Abuja serves as the political capital of Nigeria, Port Harcourt, the capital city of Rivers State, serves as the centre of Nigeria's oil and gas industry (Obinna and others 2010). With two seaports, Port Harcourt has experienced a major growth in industry and population during the last decades.

Nigeria, the most populous country in Africa, has a total population of 158 million and approximately 50 per cent of all Nigerians live in urban areas (UN-HABITAT 2010). Since its establishment in 1913 (Anyanwu 1979) Port Harcourt has experienced a continuous population growth, with much of this expansion occurring on the fringes of the city as the surrounding rural communities gradually urbanise (Obinna and others 2010). Over the last 50 years, the population of Port Harcourt has increased from 56 000 inhabitants in 1950 to more than 1.1 million in 2010, and is projected to reach 1.68 million in 2025 (UN-HABITAT 2009).

The population growth in Port Harcourt has not matched the provision of infrastructure, utility, industrialisation and employment opportunities. The population growth in the city has resulted in expansion of slum settlements characterised by poor water distribution and poor waste disposal, resulting in negative impacts on urban ecosystems such as pollution.

WATER SUPPLY

The main source of water for domestic use in Port Harcourt is private boreholes. It is estimated that more than 50 per cent of the water supply sources in the city is independent boreholes (FRN 2006). Other sources are commercial boreholes that have much higher storage capacity. Water from these commercial boreholes is transported over long distances using tankers. In some of the large residential estates in the city, commercial water providers pipe their supplies directly to the consumers' homes. Approximately 20 per cent of the population in Port Harcourt has access to pipe borne water, which is either piped into their homes directly or within their premises (FRN 2006). In addition, water from wells (7 per cent), rivers, streams, or springs (3 per cent), are other important sources of freshwater (FRN 2006). Only a small percentage (less than 2 per cent) is dependent on rainfall harvesting (FRN 2006), Due to its geographical location, Port Harcourt has a high potential in terms of rainfall harvesting with its humid equatorial climate and heavy rainfall for more than 9 months a year.

SANITATION AND WASTEWATER DISCHARGE

Sanitation and wastewater discharge are a major concern in Port Harcourt. Sewage from septic tanks is dumped into

8. The contributions of the Commissioner of the Rivers State Ministry of Water Resources and Rural Development, Patricia Simon Hart, is gratefully acknowledged. Special thanks also to Ogonna Nsirim and Amatemeso O. Emmanuel both staff of the Ministry of Water Resources and Rural Development, for their invaluable assistance in obtaining the necessary statistics and records.

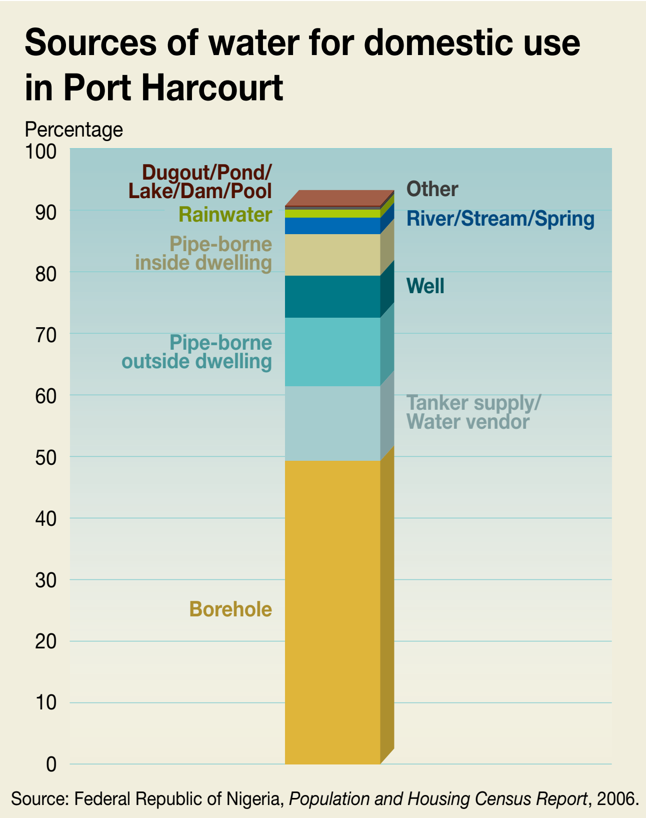


Figure 8: The main source of water in Port Harcourt is boreholes, which account to about 50 per cent of the water sources for domestic use. Many of these boreholes are shallow, making them prone to pollution, and increasing the risk of water-borne diseases.

streams or creeks, often in the vicinity of wetlands, in the hope that ecological services in these areas will purify the waste. This practice poses immense environmental and human threats (Kakulu 2008, 2009). The unregulated discharge of untreated wastewater from slaughterhouses into the city's rivers and waterways, and the practice of building pier latrines are also a major source of pollution in the city. Despite these challenges, steps towards improving management of wastewater are being taken. The Ministry of Environment has taken action to stop the dumping of sewage onto open spaces and wetlands. In addition, two new wastewater treatment plants are under construction to serve the city.

IMPROVING THE WASTE AND WATER MANAGEMENT IN PORT HARCOURT

The combination of inadequate wastewater facilities and the city's dependency on boreholes for freshwater, increases the chances of water contamination and the risk this poses to the city's population. Despite the current situation, projects and initiatives are in the pipeline, and one good example is the construction of two modern wastewater treatment plants, for Port Harcourt Township. The treatment plants are expected to receive and treat the sewage and dispose/re-use the end products, and construction work has already been commenced. It is imperative that management and restoration of ecosystems is done alongside improved wastewater management, as ecosystems in no way can currently buffer the direct spilling of waste undiluted. Wastewater management, water management and ecosystem restoration must be closely coordinated to improve water management in Port Harcourt, as well as all other African cities, thus providing a holistic approach to water scarcity and quality in the long term.

URBAN WATER RESOURCES MANAGEMENT CHALLENGES: THE CASE OF YAOUNDÈ

Ayonghe N. Samuel, Fantong Y. Wilson and Fouépé T. Alain

Yaoundé is located 250 km from the Atlantic coast and lies at the edge of the Congo Forest. Covering an area of about 300 km² (Nguegang 2008) Yaoundé has been the political capital of Cameroon since 1921 and also serves as the headquarters of the Centre Region.

Yaoundé and its surrounding area comprise mainly of secondary forest although much has been deforested for crop farming. In the swampy depressions semi-aquatic plants such as raphia and palm trees are found (Boeglin and others 2003).

The relief in Yaoundé is undulating with seven outstanding hills that rise to a maximum of 1 060 m above sea level. The city's average altitude is 700–800 m above sea level and the climate is characterised by annual precipitation of 1 600 mm, average temperature of 24°C and evaporation of 800 mm per year (Sighomnou 2004). Yaoundé experiences four climatic regimes – a long dry season (from mid-November to mid-March), a short rainy season (from mid-March to mid-June), a short dry season (from mid-June to mid-September), and a long raining season (from mid-September to mid-November).

The geology of the city is made up of crystalline rocks composed of granite, gneiss and schist rocks, which are highly weathered, producing predominantly ferric and lateritic soils. These chemically weathered soils serve as aquifers for shallow groundwater, while fractured rocks and more extensive faulted areas are locations for deep groundwater. Spring lines are located at the base of slopes and in wetlands, serving as sources of water for domestic use and subsistence agriculture during the dry periods (Fouépé and others 2010).

The city and its environs are drained by a dense river network, which can broadly be divided into two major drainage basins, namely the Sanaga River to the north-west and Nyong River to the south-east. Pipe-borne water in the city is supplied from the Nyong River from which it is withdrawn at Mbalmayo, 45 km south-east of Yaoundé, and conveyed by a 1 400 mm diameter pipe to the city.

URBANISATION CHARACTERISTICS AND WATER SUPPLY

In 2001 the population of Yaoundé was estimated at 1.5 million, and growing at an annual rate of 6.8 per cent (Wéthé and others 2003). In 2005 the population had increased to about 2.2 million inhabitants, averaging 5 691 inhabitants per km² (Nguegang 2008). Migration from rural areas to the city in search for jobs and for more suitable land for farming is partly responsible for the rapid population growth, which is also causing a rapid expansion of the city. It is estimated that Yaoundé's urban area expanded by a factor of 4 in 20 years; from 38 km² in 1980 to 159 km² in 2001, before growing to the current 300 km² (Nguegang 2008).

Tanawa and others (2002) and Wéthé and others (2003) describe Yaoundé as made up of:

- Traditional settlements characterised by less accessible housing, inadequate electrification, potable water supplies, and some basic urban services;
- Mixed or unplanned settlements, which covers 30–50 per cent of the city, and is characterised by limited accessible roads, has some optimal urban basic services such as pipe-borne water supplies, and adequate electrification and health-care services; and
- Modern settlements – constituting about 20 per cent of the city, and endowed with essential road networks, adequate pipe-borne water supply, and good electrification.

One of the most fundamental social facilities required for an expanding city is adequate supply of good quality water and in right quantities. Less than 50 per cent of households in Yaoundé have direct access to pipe-borne water. This falls to 30 per cent in suburban areas, where supply is erratic, forcing residents to use springs and wells (Leseau 1998, Nola and others 1998, Tanawa and others 2002, Kuitcha and others 2008). Irrespective of the type of settlement and financial status, the urban expansion of Yaoundé is not matched with adequate and potable pipe-borne water supply, and this has health implications on the residents. Studies by Wèthè and others (2003) indicated that 11 per cent of households suffer from diarrhoea and dysentery, while 10 per cent suffer from typhoid fever. Stagnant pools of water are favourable for breeding of the vectors that transmit malaria. Studies by Wèthè and others (2003) indicated that the disease affects an average of 35 per cent of the households in this city. These results reflect the consequences of not only lack of access to potable water in Yaoundé, but also the results of poor management of the resource.

In comparison to the World Health Organization's recommended minimum water consumption of 50 litres/person/day, Yaoundé requires about 100 000 m³ per day. This is far more than the 67 250 m³ city's water supply capacity. The shortfall in the water supply is met by water drawn from springs, public drinking fountains and hand-dug wells (Ewodo 2009). As the gap between supply and demand continues to widen with time, springs and hand-dug wells are increasingly becoming major sources of water supply for many inhabitants in the city.

Pipe-borne water is supplied to the city's residents by Cameroon Water Utility Corporation (CAMWATER) after undergoing a purification treatment process that includes coarse filtration, flocculation and decantation, fine filtration and chemical treatment to kill bacteria. The water supply company expects to meet demand in the future by capturing and supplying water to the city from Sanaga River that is located 100 km west of the city. Potential problems that are associated with this option are:

- The long distance of supply will render pipe-borne water more expensive to a low-income society that is presently unable to afford USD 10 per month in bills; and
- The quality of the water from this river, which drains over 30 per cent of Cameroon's surface area, is uncertain.

POLICIES AND REGULATIONS

The management of water in Cameroon is fragmented, involving many institutions. The role of these various institutions is provided for in the many laws and decrees governing water in the country. Among other things, the institutions are involved in project planning, policy formulation, pollution control, financing, and execution of water and sanitation projects. They also receive tenders, award contracts and supervise construction works.

In 1996, Cameroon enacted Law No. 96/12 to provide for environmental management. A separate law on water quality was enacted in 1998 to complement the environmental law. The law calls for the establishment of national quality standards, five yearly reviews of the National Environmental Action Plan, and the creation of an Inter-Ministerial Committee on the Environment (Fonteh 2004). In 2005, Decree No. 2005/493 laid the procedures for the management of public drinking water and liquid sanitation in urban and suburban areas.

The supply of potable water and drainage management in Cameroon has two approaches based on urban or rural uses of the water. In urban areas such as Yaoundé, the production and distribution of potable water is ensured by the National Water Company "Camerounaise Des Eaux" (C.D.E) within the framework of a contract of concession with the Republic of Cameroon. The production, storage and transportation of the water are under the CAMWATER. In the rural areas, these tasks are carried out by non-governmental organizations, churches, and traditional village/local councils (Fouépé 2011).

WATER QUALITY

In recent years, Yaoundé has witnessed widespread and unplanned settlements on slopes above springs as a result of the increase in population. This led to the destruction of watershed areas, which in turn resulted to the depletion of water yields from the springs. The unplanned settlements also led to the deterioration of water quality from the springs as a result of poor waste management, including construction of hand dug wells close to pit latrines.

Results on bacterial content in the water sources reveal total coliform counts of as high as 2 966 340 per 100 ml of water drawn from wells, springs, and rivers (Kuitcha and others 2010). This value grossly exceeds the WHO (2004) standard of 0 (zero) coliform count per 100 ml of water. The high coliform counts indicate the presence of the intestinal pathogens that cause cholera, dysentery, diarrhoea and typhoid fever (Benson 2002).

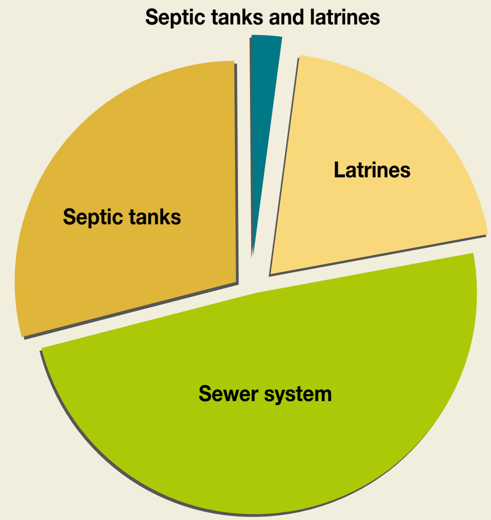
WASTEWATER TREATMENT AND REUSE

The treatment of wastewater, excreta, and sewage in Yaoundé can be classified into two categories – individual wastewater systems (septic tanks and latrines) and collective wastewater (sewer and treatment plants). Macrophytes are also used for household scale water treatment in some quarters such as Biyem-Assi. Close to 50 per cent of the residents of Yaoundè is connected to the sewer system, while 20 per cent uses latrines (Wèthè and others 2003).

CONCLUSIONS AND RECOMMENDATIONS

- Yaoundé City is expanding at a rate that is faster than the capacity of the city to provide pipe-borne water supply and sanitation services to its inhabitants, and as such the majority of the population do not have access to these services.
- All water points in the city are vulnerable to microbial pollution mainly due to anthropogenic activities.
- The quality of the water can be improved if the population is involved in development plans, the water points are rehabilitated, awareness on appropriate sanitation approaches is created, and groundwater recharge areas are identified and protected.
- Comprehensive data on water resources need to be generated. This data must not only account for anthropogenic influence, but also integrate and project future water resources. Such a database could also be used for planning the distribution of potable water to the residents.
- Existing wastewater treatment facilities are not adequately structured and will require further planning also in the future.
- Appropriate steps should be taken to continuously sensitise the population on approaches for conserving watersheds/ catchments of rivers, streams and even the small springs within the city that are utilised by many as their source of potable water.

Access to sanitation in Yaoundé



Source: Wéthé J., *et al., Assainissement des eaux usées et risques socio-sanitaires et environnementaux en zones d'habitat planifié de Yaoundé-Cameroun*, Vertigo, 2003.

Figure 9: Proper disposal of sewage is essential for urban water quality, and in Yaoundè about half of the residents are connected to the sewer system. The rest depend on either septic tanks, latrines, or a combination of the two.


LIFEGUARD
LIFEGUARD

PRO-POOR SOLUTIONS TO URBAN WATER SUPPLY AND SANITATION: THE CASE OF KAMPALA

Mushabe, S., Tibanyendera, B., Aharikundira, M. And Namukasa, L.

Kampala, the capital city of Uganda, has a population of 1.8 million people (UN-HABITAT 2010). About 85 per cent of the city's population lives in slums (UN-HABITAT 2010). These informal settlements cover 25 per cent of the total area of the city, and are underserved with improved drinking water and sanitation services.

The largely poor residents of Kampala's slums depend on water from unhygienic sources such as rivers, ponds shallow wells and springs. About 92 per cent of the city's population has access to improved water (UN-HABITAT 2010).

Access to adequate sanitation is very low in Kampala. It is estimated that 8.4 per cent of the city's households and commercial buildings is connected to the sewer network (ATPS undated). The majority of the city residents depend on latrines, septic tanks and open systems for sanitation. These disposal means are a major cause of pollution of groundwater, the main freshwater source for the poor.

The city is rapidly expanding, bringing with it loss of arable land to settlements, and degradation of essential ecosystems, including wetlands and forests. Industrial activities such as food processing and textiles are often blamed for pollution, although this is not regularly monitored.

Kampala is located on hilly terrain at an altitude of about 1300 m above sea level. The city is on the north shore of Lake Victoria, and has a tropical wet and dry climate. Many parts of the city are vulnerable to frequent and severe flooding (World Bank 2007, Businge and others 2010).

WATER SERVICE DELIVERY TO THE POOR

The National Water and Sewerage Corporation (NWSC) of Uganda characterizes the urban poor as households with incomes of less than USD 40 per month, clustered settlements with water consumption of less than 20 litres per person per day, and residents who are not connected to the city's water supply network (Environment and Social Management Framework 2007).

While the NWSC has improved the water service coverage to 62 per cent, increased revenue, reduced unaccounted-for water and increased the number of customers with metred accounts (Baieti and others 2006), the corporation faces difficulties in service delivery as 20 per cent of its customers has unreliable incomes and is not well informed. Lack of clear land tenure arrangements, water logging in most of the slum areas, and political interference hamper water and sanitation service delivery. The delivery of improved drinking water and sanitation services to the poor in Kampala is also linked to the city's physical planning, drainage system, ecosystem health and pollution.

PHYSICAL PLANNING

The Local Governments Act (2007) empowers local governments in Uganda to plan and manage the physical

planning of towns in consultation with the Town and Country Planning Board. As this legislation is largely ignored, many of the city's housing projects do not adhere to the guidelines for the building of new residential and commercial buildings.

As a result of inadequate city planning, the poor construct their homes in underserviced areas with no road network, water extension and sewage reticulation services. The inadequate planning is worsened by lack of coordination between Kampala City Council and infrastructure service providers such as NWSC and Uganda Electricity Distribution Company on matters of planning.

CLOGGED DRAINAGE

Kampala is facing increasing water drainage problems caused by the destruction of flood buffer zones such as wetlands, most of which have become slum settlements or croplands. A study by Byandala (2004) attributed Kampala's drainage problems to:

- The destruction of the upstream buffer zones that has reduced the runoff concentration time and increased the risk of flooding downstream; and
- The clogging of artificial drainage systems with debris and garbage, causing flooding in the lower areas of Kampala where the poor are settled in informal settlements on the low-lying wetlands. The African Development Bank (2006) estimated that as much as 70 per cent of Kampala's urban poor live in informal settlements.

ECOSYSTEM HEALTH

In order to eke out a living, the poor residents of Kampala depend on firewood and charcoal for energy, while at the same time engage in urban agriculture. In addition to the conversion of wetlands into barren patches for monoculture agricultural crops, deforestation is rampant in the city. In response to this encroachment of the urban environment, the Kampala City Council has embarked on a drainage improvement programme in which they have cleared and widened drainage channels. Policy responses include the National Wetlands Policy (1995), which promotes the conservation of Uganda's wetlands. Regulations are equally in place for the protection of river banks and lake shores. Despite the establishment of the Wetlands Inspection Division to enforce the above policies and regulations and to oversee the sustainable management of wetlands in the country, there has been little compliance with these measures.

Human Health Hazard

Due to their exposure to a polluted environment, as well as their reliance on water from unsafe sources, the poor residents of Kampala are vulnerable to many diseases. Cholera and other water-borne diseases are a common occurrence in the slum dwellings of Kampala. Dysentery has been on the increase, not only in Kampala but the rest of the country, registering a fourfold increase in the number of reported cases between 1999 and 2002. The number of patients suffering from persistent diarrhoea reported at Mulago Hospital alone increased by 32 per cent in a three-year period up to 2003, with most of the reported cases coming from Banda, Makerere-Kivulu, Kamwokya and other slums of Kampala (NEMA 2003).

ENVIRONMENTAL POLLUTION

The raw water supply on which the poor residents of Kampala rely, are polluted from many sources, including industry and households. One such polluted source is Lake Victoria, a key water source for Kampala. According to MacDonald and others (2001), urban municipal loads account for 77 per cent of the pollution into the lake, while fishing villages account for 15 per cent and industries for 8 per cent. Further research (Hutton and others 2007) attributed the rising levels of pollution in Kampala to:

- Poor sewerage infrastructure, including leaking old sewer pipes, and poorly constructed and managed septic tanks and sewage treatment works contaminating ground and surface water; and
- Wide use of pit latrines, especially in the slums, contributing to pollution of surface and groundwater in the high water table areas of Kampala.

IMPROVING KAMPALA'S WATER AND SANITATION SERVICES

Established in 1972, the National Water and Sewerage Corporation (NWSC) sought to address the need for improved water and sanitation service delivery in the major urban centres of Uganda. Over the years the NWSC faced operational and financial challenges, including high volumes of unaccounted-for water, caused mainly by leakages and illegal connections, and accounting for 60 per cent of all treated water. The utility was also overstaffed, with the salaries and wages bill accounting for 64 per cent of the total operating costs (Baieti and others 2006).

Through reforms that started in 1998, the utility managed to rehabilitate the water and sewerage infrastructure, and to increase water production capacity. To further consolidate and improve performance, the NWSC headquarters later entered into Area Performance Contracts with its subsidiary utilities to increase managerial autonomy, introduce performance incentives and hold the subsidiary operators more accountable. In addition to improving safe water access and sanitation services by the poor, the reforms were also designed to encourage (Baieti and others 2006):

- Simplification by reducing bureaucracy;
- Motivation in order to improve the speed of work with clarity of expectations;
- Participation so as to increase worker involvement and self confidence;
- Transformation by removing organizational boundaries; and
- Prioritization by setting appropriate performance targets and rewarding progress.

According to Mugisha and others (2004), NWSC reforms resulted in improved staff productivity with the ratio of staff costs to

operating costs falling from 64 to 26 per cent; the number of staff per 1 000 service connections falling from 36 to 11; unaccounted-for water reducing from 60 to 39 per cent; and revenue collection efficiency improving from 60 to 95 per cent. The number of customers connected to the city's water network grew from 50 000 to 93 000 connections, and annual operating profit rose from USD 1.5 million to USD 4 million. The significance of the reforms is that more water became available for residents, and at the same time more revenue was collected for further investment into water and sanitation provision, including the delivery of services to the poor. Also due to the improvement in service delivery, the poor are increasingly showing willingness to pay for improved drinking water and sanitation services. For example, a recent survey by Mushabe (2011) showed that the willingness to pay for improved water services by the poor communities of Ndeeba-Kisenyi increased dramatically, and 80 per cent of the residents indicated that they can afford to pay for the services.

In view of the importance of groundwater, especially as the only source of water by the poor, the Wetlands Monitoring Unit is gazetting important wetlands as protected areas. It is expected that the gazetted wetlands would be revitalised so as to play the role of water purification, among other ecological functions.

LESSONS LEARNED

- National water and sewerage cooperation should change their focus from development of infrastructure to better utilization and management of existing water infrastructure, than to improving regulation of water use.
- Changing patterns of the informal settlements through improved living standards, and increased awareness for better water and sanitation services, require adaptive institutions for sustainable, equitable, and productive management of services delivery.
- There is need for pro-poor approaches to urban water and sanitation delivery.
- Operation and maintenance should be decentralized, and the private sector involved as a way of improving efficiency, reducing costs, and ensuring service delivery even to the poor sectors of society.
- Involvement of community members from the beginning, in awareness raising, planning, implementation and monitoring, is a key supporting factor in the success and sustainability of the project.

PRO-POOR SANITATION SOLUTIONS: THE CASE OF DAKAR

Kane A. Alioune, Samba Ba, Awa N.Fall and Ndeye F. Toure

The capital city of Senegal, Dakar, is home to nearly 2.86 million inhabitants (UN 2009) that constitute about 30 per cent of the country's total population. In 1960 the city's population was 359 000 (UN 2009), but has grown eightfold since then.

Economic activities in Dakar contribute 55 per cent of Senegal's GDP, and account for 66 per cent of employees in the country's formal sector (ANSD 2011).

The city of Dakar, located on the peninsula of Cape Vert, covers an area of 550 km² (Ngagne 2007). The population of the city is growing at an annual rate of 2.4 per cent (ANSD 2011), causing a disparity between demand and supply of basic services such as improved drinking water and sanitation. In addition, huge volumes of solid waste amounting to 1 200 tonnes per day are generated in the city (ANSD 2011), and this is neither adequately collected nor appropriately disposed of.

WATER DEMAND AND SUPPLY

In 2004, Dakar's daily water supply was estimated at 240 000 m^3/day, 78 per cent of which came from fossil aquifers and the remainder from Lake de Guiers, a reservoir on the Senegal River (Hoang-Gia and others 2004). At that time, about 76 per cent of Dakar's households had within-plot piped supply, 19 per cent got water from community standpipes, and about 5 per cent depended on other sources such as wells and water vendors (Brocklehurst and Janssens 2004).

Water consumption in the city was estimated at 286 000 m^3/day in 2008, and projected to reach 346 000 m^3/day by 2020 (ANSD 2011). Due to fears of saltwater intrusion, the city gradually reduced water withdrawals from groundwater sources, and in 2009, about 75 per cent of the city's water was taken from Lake Guiers, while the remainder came from boreholes (Sow 2009). There is evidence of groundwater pollution in some of these boreholes and concentrations of nitrates up to as much as 50 mg/l have been registered from these sources (Sow 2009).

WASTE WATER TREATMENT AND DISCHARGE

In 2003, only 25 per cent of Dakar's households was connected to the sewerage system. Much of the city's sewer network was built in the 1950s and 1970s, and comprises about 742 km of pipes and 43 pumping stations (Hoang-Gia and others 2004).

This system discharges to a large activated sludge treatment plant at Cambérène. There is also a smaller sewerage network in Rufisque, discharging 2 860 m^3/day of wastewater into a local lagoon-based plant. In 2004, it was estimated that only about 14 per cent of sewage was collected and treated (Hoang-Gia and others 2004), and the rest was discharged into the sea without treatment.

A report by the Senegalese sanitation authority (ONAS 2009) states that during the period 2005–2008, about 28 000 connections were made to the sewerage network in Dakar, and that a further 64 000 connections will be made before 2015. The cost for connection estimated at USD 215 is not affordable to many residents, and a subsidy programme enabled 10 000 new connections at a cost of USD 30 per household

PRO-POOR SEWER SOLUTIONS

Given the high cost of sewer connections, a pro-poor sewerage programme was piloted in Dakar. The World Bank-funded Programme d'amélioration de l'assainissement des quartiers périurbains de Dakar (PAQPUD) serving peri-urban districts of Dakar introduced low-cost sewerage technologies on a large scale (Norman 2009). The technologies apply various technical strategies such as smaller diameter pipes, local materials, shallower gradients, and less frequent inspection points. The project involved socio-organisational strategies, including community financing, community construction and community maintenance, with the overall goal to reduce investment costs (Mara 1996).

The low cost sewer system initially targeted 127 000 people. Unfortunately, the project suffered diverse problems including poor design and poor construction (Hoang-Gia and others 2004), and failed. In hindsight, the project clearly served as a very useful model for scaling up affordable technologies (Norman 2009).

LESSONS LEARNED

- Pro-poor sanitation solutions must not only be affordable but also sustainable.
- Community engagement is central to pro-poor sanitation solutions.


UNITED

URBANISATION AND WATER POLLUTION IN ADDIS ABABA

Ayenew, T. and Belliethathan, S.

Addis Ababa, the capital of Ethiopia and one of the largest cities of Africa, is located at the edge of the East Africa Rift Valley. Since its establishment 130 years ago, the city has grown from a sparse and scattered settlement to 530 km² (Alemayehu 2005).

In the last 50 years, the population of Addis Ababa has grown from 100 000 to 2.7 million in 2007 (Central Statistics Authority 2007), and to 3.5 million inhabitants in 2010 (UN-HABITAT 2010). Due to the growing population, the city is facing challenges in providing its residents with enough freshwater and sanitation services.

WATER SUPPLY AND SANITATION

Addis Ababa is located within the Akaki River Basin, which covers an area of 11 454 km² (Ebba 2006). There are four artificial water reservoirs in the basin, namely Legedadi, Gefersa, Dire and Aba Samuel. With the exception of Aba Samuel, all reservoirs supply domestic and industrial water. The Aba Samuel Reservoir was constructed in the late 1930s for electricity generation, and today some of the municipal and industrial effluents are discharged into this reservoir (EPA 2005).

The city is also dependent on groundwater, supplied through springs, and shallow and deep wells. Most of the springs are found at the foot of the northern Intoto mountain range. The Akaki well located close to Aba Samuel Dam is a major water supplier for the city.

During its first fifty years, Addis Ababa was supplied by the Intoto springs. Due to increasing water demand a water treatment plant was built in 1938 at the foot of Intoto Ridge, and in 1944 the Gefersa Dam was built (Semie 1998). In 1970, the Legedadi Dam and treatment plant were commissioned. This was followed by the development of groundwater sources, as well as the construction of the Dire Dam.

The demand for potable water was estimated at 204 000 m³/d in 1994, and this was projected to increase to 431 000 m³/d and 1.1 million m³/d in 2006 and 2020, respectively (Semie 1998). Currently the demand for water in the city exceeds supply. And the current water supply coverage is 70 per cent (AAWSA 2011 personal communication).

Addis Ababa's sanitation coverage is low, with 13 per cent of the city's population using flash toilets, 57 per cent using pit latrines and 30 per cent having no sanitation facilities at all (AAEPA 1999).

The first centralized sewage collection system in Addis Ababa was established in the 1960s and was designed for the collection and conveyance of wastewater to a treatment plant located in Kaliti. With a capacity of 7 500 m^3/day, the Kaliti system was designed to serve only 200 000 inhabitants. When operating at full capacity, the wastewater treatment plant serves less than 10 per cent of the residential areas connected to the system (EPA 2005). The second wastewater treatment plant was established at Kotebe, and has a capacity of 30 000 m^3/day (EPA 2005), enough to serve 800 000 residents. The homes that are not connected to the wastewater treatment plant dispose waste into the city's storm-water drainage system (van Rooijen and Taddesse 2009).

WATER POLLUTION

The seasonal and perennial rivers and groundwater reserves of Addis Ababa are polluted by industrial and municipal solid and liquid wastes. The polluted river water is used by downstream residents to grow vegetables, which are sold and consumed by inhabitants of the city.

The city's rivers are contaminated with different organic and inorganic pollutants. The shallow groundwater and springs are also contaminated (Tale 2000, Alemayehu and others 2005, EPA 2005).

Solid waste that is generated is often disposed of in open spaces, where it is washed by runoff during rains, and flows into rivers and seeps into shallow groundwater.

INDUSTRIAL WASTE

There are more than 2 500 industries in Addis Ababa, 90 per cent of which lack onsite treatment facilities (AAEPA 2007, unpublished report in Gebre and van Rooijen, 2009). These industries discharge waste into nearby stream courses and open ditches and the Akaki River is heavily polluted. A 1999 report estimated the volume of wastewater discharged from industries into the rivers at 4.8 million m^3 (Central Statistics Authority 1999).

MUNICIPAL WASTE

Despite generating large amounts of solid waste from domestic activities, Addis Ababa does not have adequate waste management facilities. As a result solid waste is often piled on available open grounds, stream banks, and near bridges, where it is washed off into rivers. According to SBPDA (2003), 65 per

cent of the solid waste generated in Addis Ababa is collected and treated at the city's two treatment plants at Kaliti and Kotebe. Only five per cent of the collected solid waste is recycled.

The final effluent out of the treatment plants at Kaliti and Kotebe is high in coliforms, Total Dissolved Solids (TDS) and phosphorus, causing algal bloom in the receiving water body (Belachew 2010).

MEDICAL WASTE

A study by EPA (2009) found that 430.7 tons of contagious waste is generated by the 29 hospitals located in Addis Ababa.

Examples of the contagious clinical waste include laboratory cultures, wound dressings, blood and other body fluids, and needles. Although most of the hospitals have waste treatment facilities, some of the clinical waste finds its way into the nearby streams that are tributaries (EPA 2005).

INDICATIONS OF POLLUTION

While the quality of the water being distributed by the Addis Ababa Water and Sewerage Authority is monitored and generally safe for drinking, Alemayehu and others (2005) noted high concentrations of trace elements such as chromium in surface water. Chromium levels were observed to increase downstream of rivers. In the northern elevated non-industrialized area of Intoto Ridge, the chromium and manganese levels were found to be low, but increased to 14 µg/l and 6 531 µg/l, respectively, as the streams reached the southern part of the city. Manganese concentration higher than 0.1 mg/l is considered unsafe for industrial and domestic use (WHO 1984). The chemical pollution is blamed on industrial activity, including tanneries. Nitrate concentrations of as high as 728 mg/l were also found in some spring water (Alemayehu and others 2005). This is probably attributed to leaking septic tanks and the pit latrine system used in highly populated areas. According to the World Health Organization (1984), safe drinking water should not have nitrates exceeding 10 mg/l.

IMPACTS OF POLLUTION

The high levels of pollution in the water sources of Addis Ababa have impacts on human and animal health, as well as on the urban ecosystem.

HUMAN HEALTH

Pathogens transmitted through polluted water cause intestinal infections, and common water-borne diseases in Addis Ababa include typhoid, dysentery and cholera. According to EPA (2005) all of the people using the Akaki River water are affected by these pathogens. In addition, the people are also exposed to heavy metal toxicity in the vegetables that are grown using the Akaki wastewater (Itanna 2002). Although most levels of metals have been found to be tolerable, it is feared that metals such as arsenic will build up in Swiss chard, and chromium will build up in lettuce. Fears of food poisoning from wastewater are worsened by the fact that 60 per cent of the city's food consumption is supplied by urban farmers, who irrigate their crops using wastewater (Weldesilassie 2008).

ECOSYSTEM HEALTH

One of the environmental effects of the pollution of the water sources of Addis Ababa is eutrophication. Caused by excessive use of phosphorous and nitrogen in agriculture, and effluents from sewerage and pit latrines and municipal wastes, eutrophication causes growth of algae and weeds, which deplete the oxygen level of the water bodies, and in turn affect aquatic fauna and flora.

According to the Addis Ababa Environmental Protection Authority (AAEPA 2002), the pollution of the Akaki River is blamed for the emergence of water hyacinth weed in the Aba Samuel Lake. By the year 2000, the weed had covered almost 50 per cent of the lake.

RESPONSES

The City of Addis Ababa has stepped up its efforts to address water pollution by implementing a range of activities. These include the decentralization of Solid Waste Management services to the lower administration levels for more effective administration; the establishment of efficient and equitable service charge collection systems; community participation in sanitation activities; and planning the establishment of new sanitary landfills. Through its environmental arm, the Addis Ababa Environmental Protection Authority also initiated plans to green parts of the city. One example of such greening efforts is the allocation of 1 300 hectares of land for productive forest plantation to the Ethiopian Heritage Trust for the restoration of native flora and fauna (Gullele Botanic Garden 2011). In addition, the Addis Ababa Sewerage and Sanitation Authority initiated a plan to rehabilitate the Akaki River (Gullele Botanic Garden 2011).

LESSONS LEARNED

- It is imperative to improve municipal waste management, and for Addis Ababa, this can be done by constructing more on-site sanitation facilities; increasing the capacity of wastewater treatment plants; increasing the number of connections to the sewers systems; extending reticulated sewerage system to planned settlement areas; and discouraging the use of pit latrines.
- Industry and domestic users of water need to exercise responsible behavior, and ensure that their activities do not pollute water and the environment. Where such pollution takes place, punitive measures must be meted on the responsible.
- As some of Addis Ababa's water bodies are already polluted, it is important that they are reclaimed.

WATER RESOURCES MANAGEMENT OPTIONS FOR SUSTAINABLE CITIES

GLOBAL INITIATIVES SUPPORTING URBANISATION, WATER AND ECOSYSTEMS

The demand for clean water and sanitation services is increasing for Africa's urban areas in response to population growth, changes in lifestyles and economic growth. Countries continue to urbanise, and the search for cost effective and sustainable water solutions is becoming more important. Good infrastructure may facilitate accessibility to clean water and sanitation services, but inadequate planning and ecosystems degradation often result in a mismatch between service delivery and demand.

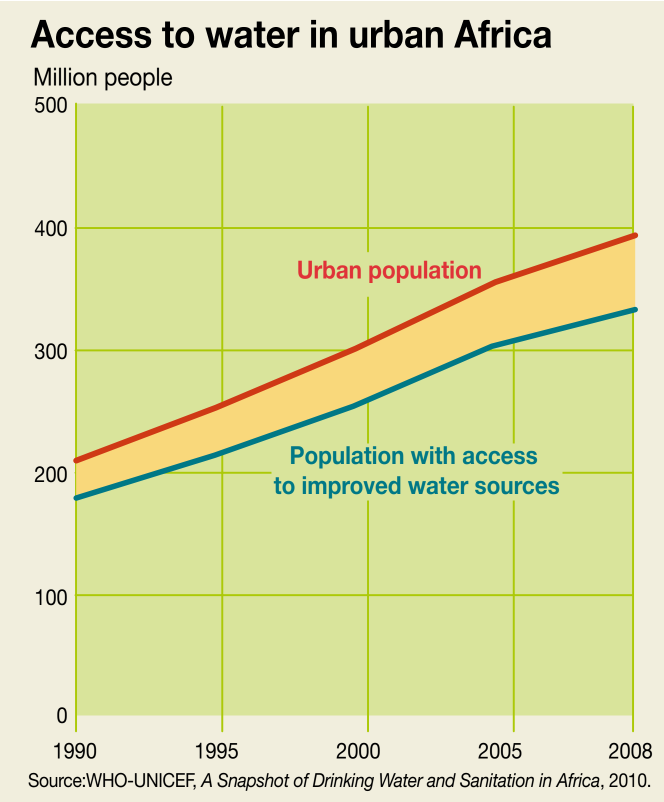


Figure 10: Improved water sources, defined as "one that is protected from outside contamination" (WHO/UNICEF 2010), is essential for ensuring the health of Africa's urban dwellers. Although an increasing number of people have access to improved water, rapid urban population growth in the region has equally increased the number of people without proper access.

Provision of safe drinking water is hampered by increasing levels of pollution, resulting in water delivered by some cities failing to meet the standards for potable water recommended by the World Health Organization (WHO).[9]

In order to meet international targets set out under the Millennium Development Goals (MDGs) (especially goal 7 on Environmental Sustainability[10]), cities are required to build water supply and sanitation infrastructure, as well as to prevent current and future infrastructure from collapsing due to inadequate institutional arrangements, insufficient cost recovery, and poor operation and maintenance. In addition, the water and sanitation delivery have to be sustainable, implying the need to incorporate environmental considerations in planning and managing urban water.

By recognising the right to safe and clean drinking water and sanitation as a human right, the United Nations challenges countries to not only work towards meeting water-related targets under the MDGs, but also to ensure that the pace of urbanisation moves in tandem with the supply of safe drinking water and sanitation.

9. Potability is determined by physical and chemical factors, and by the contents of toxic substances in water. Details can be found in the WHO monograph, International Standards for Drinking Water.
10. Goal 7 of the MDGs includes target 7c which sets out to 'halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation', and target 7d which aims to 'by 2020, have achieved a significant improvement in the lives of at least 100 million slum-dwellers'.

CHALLENGES AND OPPORTUNITIES

Challenges to the supply of clean water and adequate sanitation in urban areas include:

- Inadequate knowledge and contested data about available water resources, often resulting from weak systems for monitoring, quality control and absence of data sharing mechanisms;
- Degradation of vital ecosystems such as watersheds, wetlands, lakes and rivers;
- Inadequate mechanisms for inter- and intra-sectoral planning;
- Weak legislative and institutional arrangements to support private sector participation;

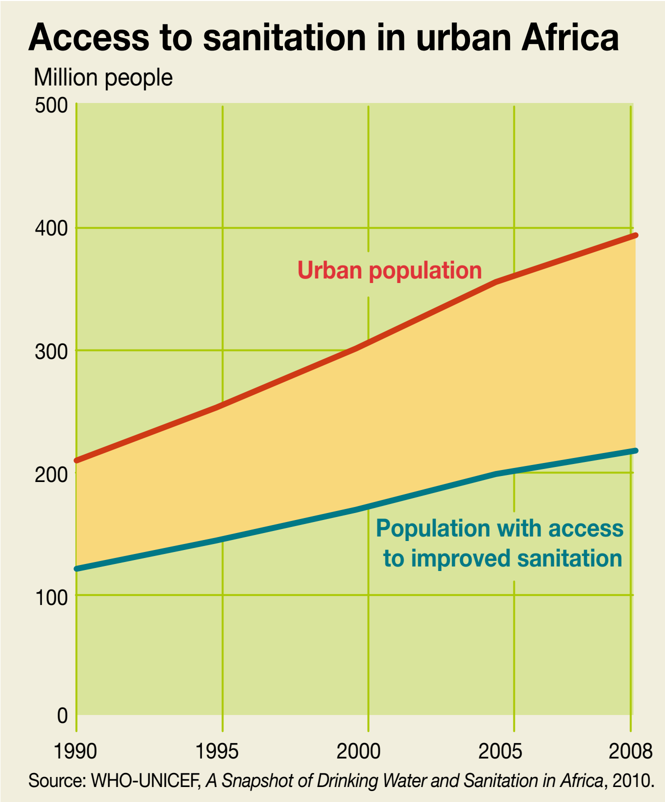


Figure 11: The number of people in Africa with access to improved sanitation, defined as "one that hygienically separates human excreta from human contact" (WHO/UNICEF 2010), has increased over the last two decades. Still, because of the rapid urbanisation, the proportion of the urban population with access to improved sanitation is on the decrease.

- Limited and unmonitored access to alternative sources of water such as groundwater and rainwater harvesting;
- Inadequate facilities for wastewater treatment, discharge and reuse; and
- Impact of climate change on urban water resources.

Despite the challenges, urbanisation provides an ideal framework for community engagement in finding long-term solutions to the provision of clean water and sanitation. In this regard urban areas represent an organised institutional structure to not only supply water and sanitation services, and to provide incentives and penalties in water use, but to also mainstream the environment through water sector management reforms such as integrated water resources management, water demand management and payments for ecosystem services. These reforms seek to reinforce the mutual and symbiotic relationship in the urbanisation – water – ecosystems nexus.

With their large populations, urban areas have the opportunity to not only work with each other and tap into surrounding ecosystems through intra-basin water transfer schemes, but to also generate electricity from waste and wastewater, and to feed this into regional electric power inter-connections. This can facilitate the processes of regional integration in the same way as economic corridors.

OPTIONS FOR POLICY

The improvement of access to safe drinking water and sanitation for urban areas in the long-term requires a holistic approach, which among other things is conscious of the connection between urbanisation, water and ecosystems. This requires policy interventions, including some options that:

- Prioritise water availability for basic needs of people and ecosystem services through policy and local level interventions that stimulate resource-conserving land use practices and improve water productivity for long term ecosystem sustainability;
- Recognise water as a human right, by ensuring that the right to water is guaranteed on the basis of non-discrimination, and that third parties, including the private sector, are prevented from interfering with this right;
- Acknowledge and support the role of small- and large-scale private sector activities in complementing government and

municipal authority efforts in the delivery of water and sanitation services, especially to the poor sections of urban areas;
- Take into account the generally high levels of income poverty in Africa by acknowledging that market-based approaches are not always the best option to supplying water in urban areas in a sustainable way;
- Understand how poor urban dwellers, including those living in slums and peri-urban areas, get, use and manage water, and what affects their decisions;
- Tailor water supply and sanitation services to the needs and capabilities of consumers, with variations in type, location and features of services;
- Pay attention to consumer values, lifestyle and budgets in order to set appropriate tariffs and payment options for different groups;
- Ensure that public health, the environment and the economy are protected, while all groups in society are covered;
- Take advantage of the opportunities provided by urban waste and wastewater through use in irrigation, generation of electricity and environmental flows;
- Recognise that urban areas will continue to grow, and that the demand for water and sanitation services will continue to outstrip service delivery for the foreseeable future;
- Inform residents about how the links between forests, protected areas and water supply could help build a constituency for good watershed management;
- Demonstrate that it pays to protect watersheds, instead of building expensive water purification systems;
- Raise awareness on the impact of poor water quality on health, economy and the environment; and
- Mainstream the environment into urban water management through approaches such as Payments for Ecosystems Services, Integrated Water Resources Management, and Water Demand Management.

CONCLUSIONS AND RECOMMENDATIONS

Africa is the fastest urbanising region in the world. The movement of human capital not only concentrates production and drives economic growth, but also brings into question if Africa's urban areas are on an unsustainable course that could be derailed. In assessing environmental stewardship with regards to urban water supply, sanitation and ecosystems services as potential destabilising factors in the urbanization process in the long term in Africa, this report concludes that:
- The need for water is increasing, further widening the disparity between demand and availability of safe drinking water and sanitation.
- If urban planning does not mainstream environment by acknowledging the urbanisation – water – ecosystems nexus, urban water quality will deteriorate, destroying ecosystems and spreading waterborne diseases to not only the communities downstream, but also to the cities themselves.
- There are unique water supply and sanitation challenges to the various cities in Africa, and these include:
  - dependence on ecosystems services that are outside city boundaries;
  - growing reliance on groundwater supplies, the quality of which is at times compromised by the poor management of wastewater;
  - growing participation of the private sector in complementing government and local authority efforts in water supply and sanitation levels; and
  - little use of alternative water sources, including rainwater harvesting.
- In light of the improving understanding of the urbanisation – water – ecosystems nexus, water sector management reforms that are being considered across Africa need to incorporate elements of water demand management, integrated water resources management and payment for ecosystem services.

RECOMMENDATIONS:

Cities must protect and restore ecosystems that are important as key water sources. This will provide cheaper, more efficient and flood resilient water supply systems for the fast urbanising region of Africa. Cities must reduce water consumption and recycle wastewater inside cities, restore adjacent watersheds and improve engineering solutions to supply water from well-managed ecosystems.

Tackle Immediate Consequences

1 Countries must adopt a multi-sectoral approach to water and wastewater management as a matter of urgency, by incorporating principles of ecosystem-based management from the watersheds into the sea, and connecting sectors that will reap immediate benefits from better water and wastewater management.

2 Ecosystem protection, management and restoration provide a central, effective, sustainable and economically viable solution to enhancing water supply and quality while mitigating effects of extreme weather events of too much and too little water.

3 Successful and sustainable management of wastewater to help support peri-urban agriculture is crucial for reducing water consumption, and requires a mix of innovative approaches that engage the public and private sector at local, national and transboundary scales. Planning processes should provide an enabling multi-scale environment for innovation, including at the community level with government oversight and public management.

4 Innovative financing of appropriate water and wastewater infrastructure should incorporate design, construction, operation, maintenance, upgrading and/or decommissioning. Financing should take account the important livelihood opportunities in improving wastewater treatment processes, while the private sector can have an important role in operational efficiency under appropriate public guidance, including ecosystem restoration projects.

Towards the Future

5 In light of rapid global climatic changes, communities should plan water management against future scenarios, including extreme events of too much and too little water combined with rapidly growing urban populations.

6 Solutions for smart water and waste management must be socially and culturally appropriate and acceptable, as well as economically and environmentally viable. Ecosystem protection, management and restoration are the cheapest, easiest and most effective ways of improving and securing water supply, filtration and quality including re-use of wastewater for irrigation.

7 Education must play a central role in water management and in reducing overall volumes and harmful content of wastewater so that solutions are sustainable.

ACRONYMS

AAEPA	Addis Ababa City Environmental Protection Authority
CAMWATER	Cameroon Water Utility Corporation
EPA	Environmental Protection Authority (Ethiopia)
GDP	Gross Domestic Product
IWRM	Integrated Water Resources Management
MDGs	Millennium Development Goals
NCWSC	Nairobi City Water and Sewerage Company
NEMA	National Environment Management Authority (Uganda)
NWSC	National Water and Sewage Corporation (Uganda)
PES	Payments for Ecosystem Services
PPP	Polluter Pays Principle
SID	Society for International Development (Kenya)
TDS	Total Dissolved Solids
UNEP	United Nations Environment Programme
UNICEF	United Nations International Children's Emergency Fund
USD	US Dollar
WHO	World Health Organization
WRMA	Water Resources Management Authority (Kenya)

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