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GROUPE DE LA BANQUE AFRICAINE DE DÉVELOPPEMENT
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GRID ARENDAL

SANITATION AND WASTEWATER ATLAS OF AFRICA




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This atlas is part of the Wastewater Management and Sanitation Provision in Africa Project, a partnership between the African Development Bank (AfDB), United Nations Environment Programme (UNEP) and GRID-Arendal. The project is supported by the AfDB through its Rural Water Supply and Sanitation Initiative (funded by the Governments of Burkina Faso, Canada, Denmark, France, Italy, Switzerland and the Netherlands), and the Multi-Donor Water Partnership Programme (funded by the Governments of Canada and Denmark). The project is also funded by the Government of Norway and UNEP, and technically supported by GRID-Arendal.

SANITATION AND WASTEWATER ATLAS OF AFRICA

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GRID ARENDAL

Foreword

Sanitation, including the proper management of wastewater, is central to ensuring human and ecosystem health, and economic and environmental benefits. While significant efforts are being made across Africa to ensure better access and services, many places still have inadequate infrastructure for sanitation and wastewater management. This is happening at a time of greater need due to population growth, rapid urbanization, improving lifestyles, and industrial and agricultural expansion – all in a region that has low resilience to climate change.

This atlas – a joint effort by the African Development Bank, the United Nations Environment Programme, and GRID-Arendal – profiles the state and trends in wastewater management and sanitation delivery in Africa; highlights the human health and ecosystem impacts of poor sanitation and wastewater management; and discusses the continent's policy and institutional arrangements. It benchmarks Africa's progress towards the Sustainable Development Goals (SDGs) and other aspirations, including Africa's Agenda 2063 and Africa's Water Vision 2025. The findings of the atlas will allow policymakers to track progress on sanitation and wastewater, making it a valuable tool to accelerate change.

The continent's efforts in this area are largely guided by SDG 6. Of particular concern are the sub-targets on access to adequate and equitable sanitation and hygiene – paying special attention to the needs of women, girls and vulnerable populations – and improving water quality by reducing pollution, eliminating dumping and halving the proportion of untreated wastewater. However, all other SDG 6 targets are linked to Africa's aspirations, including those on universal and equitable access to safe and affordable drinking water, efficient water use and integrated water resources management. Other SDGs – including those for health, education, cities and industry – will be boosted by better sanitation provision and wastewater management.

Providing adequate sanitation with proper wastewater treatment represents an opportunity to reclaim vital waste resources and lead the way towards the realization of a circular economy, as well as more sustainable services delivery. Solutions to increase sanitation coverage and improve wastewater treatment will help boost public health and secure the sustainability of Africa's natural resources. They can trigger investments in integrated wastewater management and offer employment opportunities while ensuring the integrity of water resources and water-related ecosystems. As the atlas discusses, industry and the private sector have a key part to play by investing in and innovating on solutions for sanitation and wastewater management.

We trust that the *Sanitation and Wastewater Management Atlas of Africa* will be of use to Africa's leaders, development allies and interested parties to guide and track the solutions needed to provide better sanitation and wastewater management services to Africa's people.

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Acknowledgements

The *Sanitation and Wastewater Atlas of Africa* is the outcome of a collaborative effort by the African Development Bank, the United Nations Environment Programme (UNEP), and GRID-Arendal. The three partners jointly fundraised for the preparation and production of the atlas, coordinated input from several players and provided technical support. The efforts by the three partners will not end with the atlas. Wide outreach will continue, taking advantage of the various networks that each partner brings.

The atlas is a result of the convergence of thought by Osward Mulenga Chanda and Maimuna Nalubega (African Development Bank), Thomas Chiramba and Birguy Lamizana-Diallo (UNEP), and Clever Mafuta and Bernardas Padegimas (GRID-Arendal), who acknowledged that part of the reason for the failure of the majority of African countries to meet their Millennium Development Goals was a lack of information that could inform policy direction. The atlas is therefore meant to benchmark Africa's progress towards key targets under the Sustainable Development Goals.

While acknowledging and appreciating the efforts of the three partners, it is important to note that big achievements are made through coordinated effort. The preparation of the atlas benefited from the expertise of several authors drawn from across Africa. The authors (see Appendix 1) provided draft content that went through several rounds of peer and government reviews. The peer reviewers (Appendix 2) were also drawn from across Africa. Two review workshops – held in Kigali, Rwanda, and Gaborone, Botswana – helped to fine-tune the content of the atlas through input mainly from government reviews (Appendix 3). Some case studies to support the chapters were compiled by scholars and researchers working on topics related to sanitation provision and wastewater management in Africa.

The process leading up to the printing of the atlas started in 2017 with the annual partners meeting of the African Development Bank, UNEP and GRID-Arendal. At the meeting, the partners agreed on the draft outline of the atlas and a list of possible authors. The commissioned authors met in April 2018 and further refined the outline to avoid overlaps and gaps. Initial drafts of the chapters were prepared and then subjected to peer review followed by chapter revisions. In May 2019, the chapters were subjected to a government and peer review process through another workshop held in Gaborone. The chapters were revised before undergoing technical edit and later copy edit.

The atlas is one of a suite of products that also includes various online outputs, including policy briefs, an explanatory video, photo-rich stories, and a multimedia presentation with interactive maps. Funding for the production of the atlas and the ancillary products was made possible through the support of the African Development Bank, UNEP's Environment Fund and Norway's Ministry of Foreign Affairs through the Norwegian Agency for Development Cooperation (NORAD). The African Development Bank funding came from the bank's Rural Water Supply and Sanitation Initiative, which was funded by the Governments of Burkina Faso, Canada, Denmark, France, Italy, Switzerland and the Netherlands, as well as the Multi-Donor Water Partnership Programme, funded by the Governments of Canada and Denmark.

The atlas benefitted from copy editing by Strategic Agenda and cartography by Studio Atlantis and GRID-Arendal.

Many other organisations and individuals contributed directly and indirectly to the Wastewater Management and Sanitation Provision Project in Africa whose main output is the *Sanitation and Wastewater Atlas of Africa*. While efforts have been made to acknowledge their input, it may be that not everyone has been credited by name. Please accept this acknowledgement of your role in this important publication.

Contents

1

OVERVIEW

1.1 Introduction

Africa's 29.65 million km^2 of land area is home to over 1.3 billion people (Worldometers 2019), with this population expected to reach 1.7 billion by 2030 – a huge increase from 480 million in 1980 (United Nations Children's Fund [UNICEF] 2017). Almost 60 per cent of the continent's population lives in rural areas (UNICEF 2017), where sanitation services and access to safe drinking water lag behind those offered in urban areas.

Africa's access to safe drinking water and sanitation provision face water availability challenges. The continent is the second driest in the world after Australia, with only 9 per cent of global renewable water resources (United Nations Environment Programme [UNEP] 2010). The sanitation and safe drinking water issue is most dire in sub-Saharan Africa, which is wetter than North Africa but suffers from a lack of infrastructure, weak governance systems and low levels of investment in the water sector.

Nearly 750 million people, representing 69 per cent of Africa's population, did not have access to basic sanitation services as at 2017. The majority of the 750 million people lived in sub-Saharan Africa, and had no sanitation facility that was not shared with other households, meaning an improved sanitation facility that is not shared with other households (World Health Organization [WHO] and UNICEF 2017). This is a challenging baseline for achieving some of the Sustainable Development Goals (SDGs) in Africa, where only a few of its 54 countries met the Millennium Development Goals (MDGs) target for sanitation. Nonetheless, SDG 6 offers renewed hope for not only improved sanitation across Africa, but also improved wastewater management that will promote human health and dignity, minimize the pollution of water resources, and protect the natural environment.

Africa is made up of 54 countries, which the African Union divides into five subregions: North, West, Central, East and South Africa, as shown in Figure 1.2.

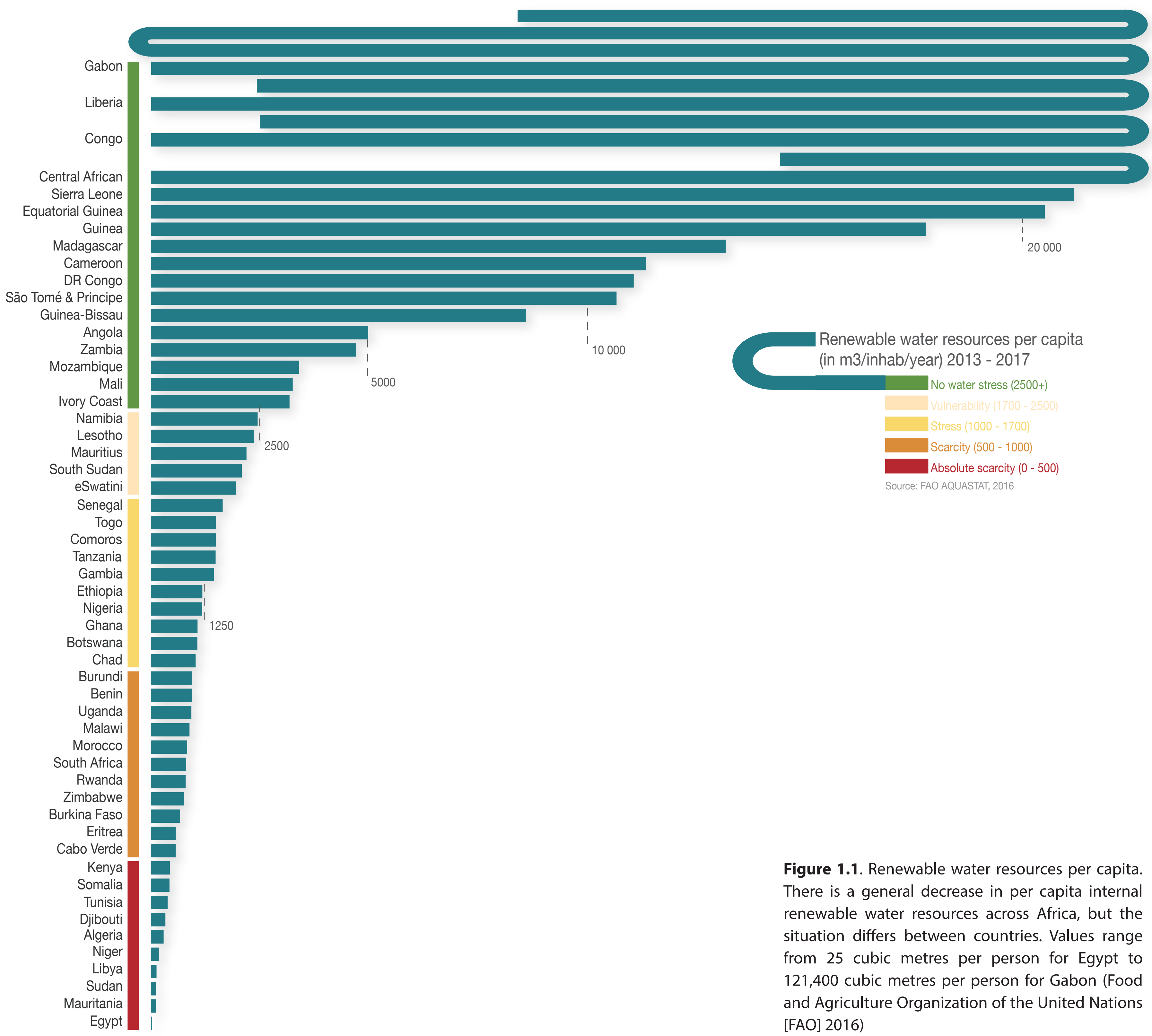


Figure 1.1. Renewable water resources per capita. There is a general decrease in per capita internal renewable water resources across Africa, but the situation differs between countries. Values range from 25 cubic metres per person for Egypt to 121,400 cubic metres per person for Gabon (Food and Agriculture Organization of the United Nations [FAO] 2016)

1.1.1 Africa's population dynamics

According to the Demographic Profile of African Countries (United Nations Economic Commission for Africa [UNECA] 2016), Africa's population has grown at an average annual rate of 2.6 per cent in the last 30 years, compared with the global average rate of 1.5 per cent. The same report further indicates that between 1980 and 2015, Africa's population increased by a total of 708 million, with Nigeria contributing on average an additional 3.1 million people per year to the continent's population. Projections are that Africa's population growth rate will even out at 1.5 per cent in the years up to 2025. Figure 1.2 further shows the 10 biggest contributors to population increase on the African continent, while Figure 1.3 shows population growth trends for the continent.

Africa's population grew at an annual average of 2.6 in the last three decades

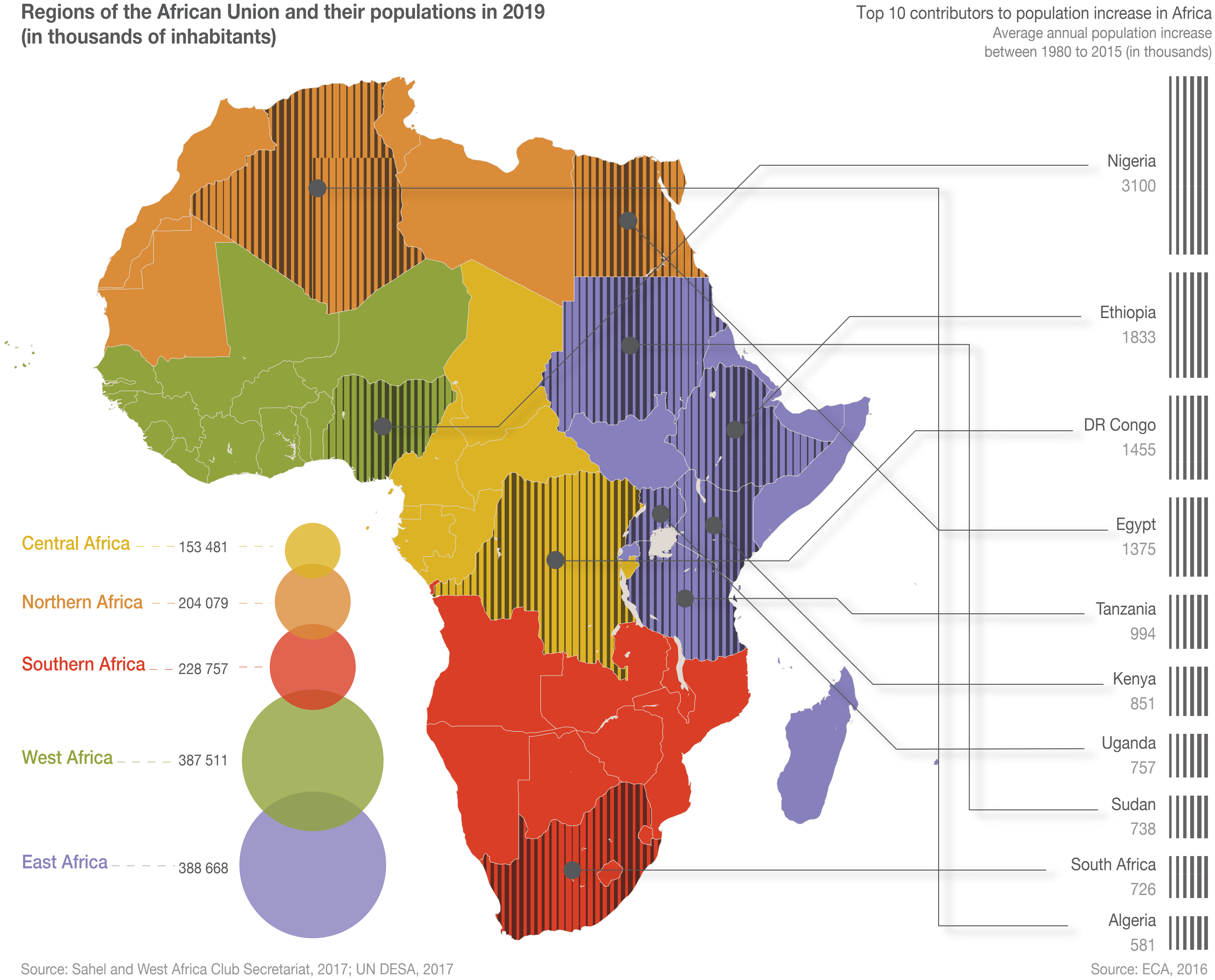


Figure 1.2. Regions of the African Union

Young people are the majority of Africa's population

As Figure 1.4 shows, Africa's population is predominantly youthful (UNECA 2016), with those between the ages of 15 and 24 making up 19.4 per cent of the continent's population (UNECA 2017). If youth are to be involved in sanitation and hygiene activities such as investment and awareness-raising, positive outcomes can be expected. However, if no new investment is made in water, sanitation services and hygiene, the current lack of access will become only more dire for youths, resulting in increased school dropouts and illnesses, among other consequences.

Africa is moderately densely populated, with 43 inhabitants per square kilometre (Worldometers 2019). As Figure 1.5 shows, population density varies across the continent. The island states of Mauritius,

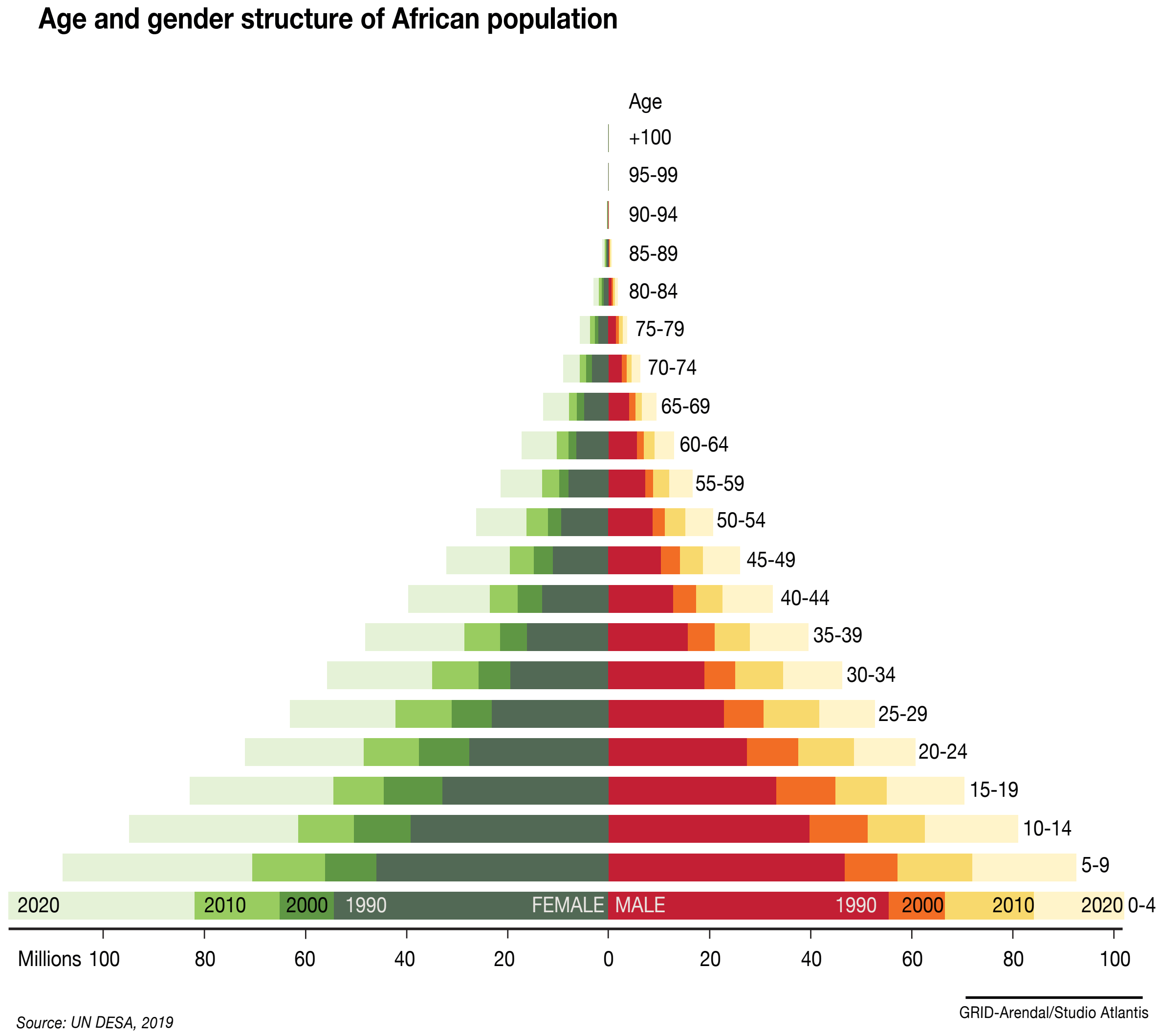


Figure 1.4. Age structure for Africa's population in 2018

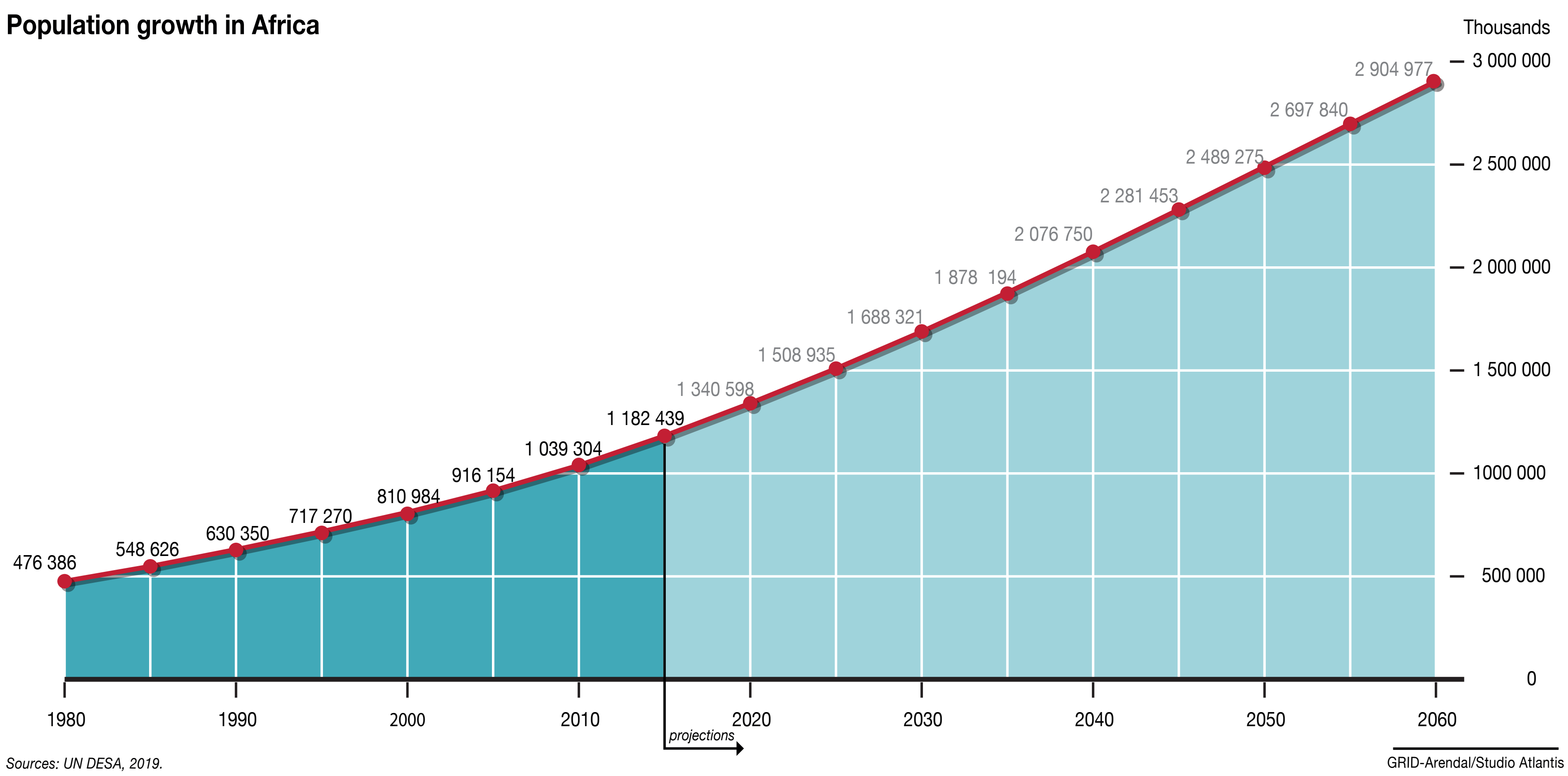
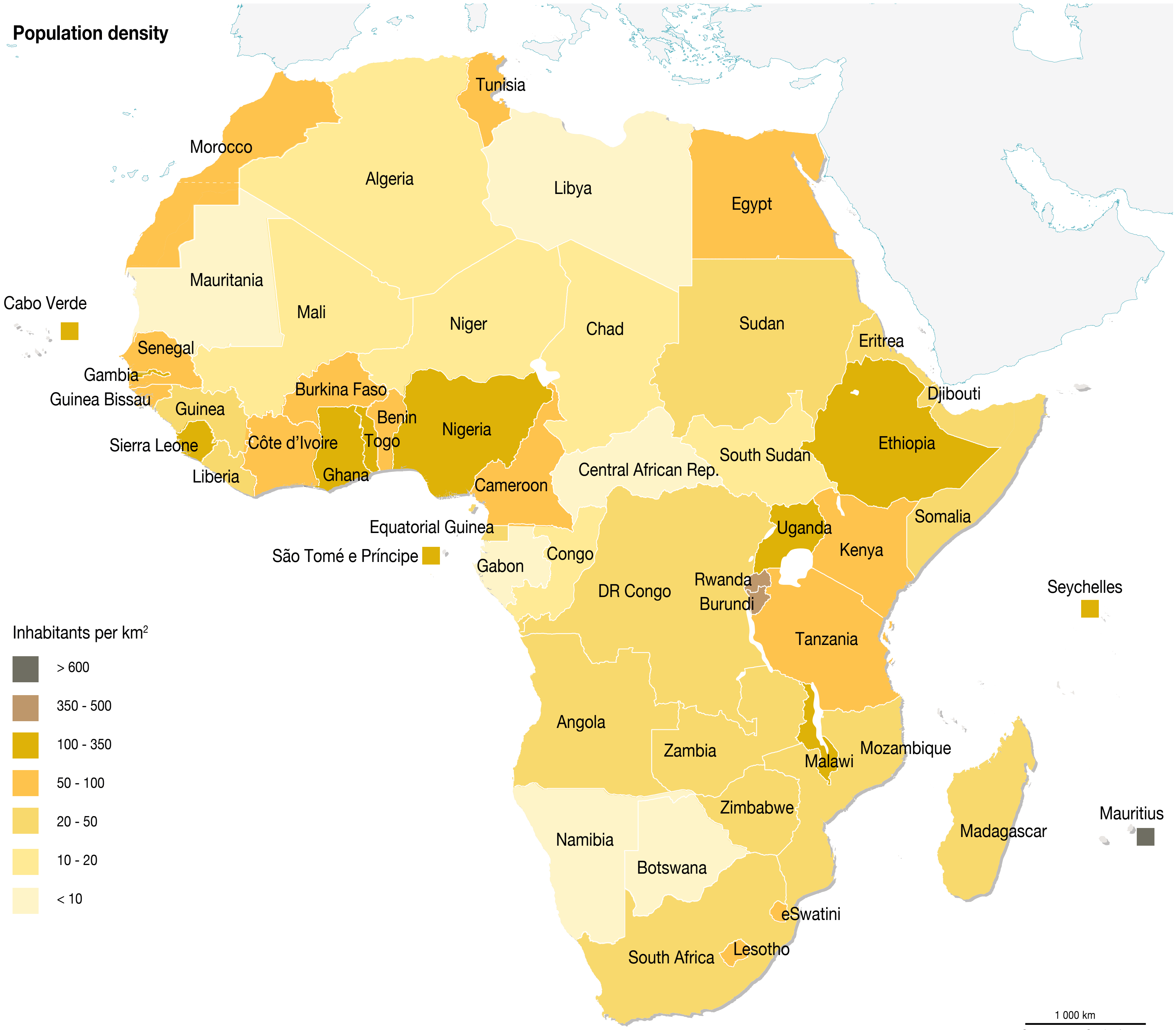


Figure 1.3. Population growth trends and projections in Africa for the period 1980–2065

the Comoros, Seychelles, and the Democratic Republic of Sao Tome and Principe are among the most densely populated countries in Africa. On the mainland, Rwanda, Burundi, Nigeria, The Gambia, Uganda and Malawi have the highest population densities (PopulationPyramid.net 2019).

In 2016, Africa's urban population was estimated at 40 per cent, having increased from 27 per cent nearly four decades prior (in 1980). The United Nations Economic Commission for Africa (UNECA) reports that the most urbanized countries on the continent are Algeria, Cabo Verde, Democratic Republic of the Congo, Djibouti, Gabon, Libya, Tunisia and South Africa (UNECA 2016). The proportion of the urban population in Africa's most urbanized countries is shown in Figure 1.6.

Close to 60 per cent of Africa's population live in rural areas



Source: UN DESA, 2017.

Figure 1.5. Population density in 2017

Nearly 56 per cent of Africa's population will be living in urban areas by 2050

The average growth rate in the urban population in Africa is estimated at 3.7 per cent and is projected to stabilize at 2.6 per cent during the 2025–2050 period, with nearly 56 per cent of the population expected to be living in urban areas by 2050 (UNECA 2016). Some of the fastest urbanizing countries in Africa are among the most populous, and this has significant implications for Africa's wastewater management in the quest for sustainable development, which will in turn impact the availability of freshwater resources. According to the Global Water Partnership, as cities expand they rely on more expensive, further away water sources whose quality can be compromised by upstream activities such as agriculture. Meanwhile, groundwater sources are often polluted by poor sanitation (Jacobsen et al. 2012).

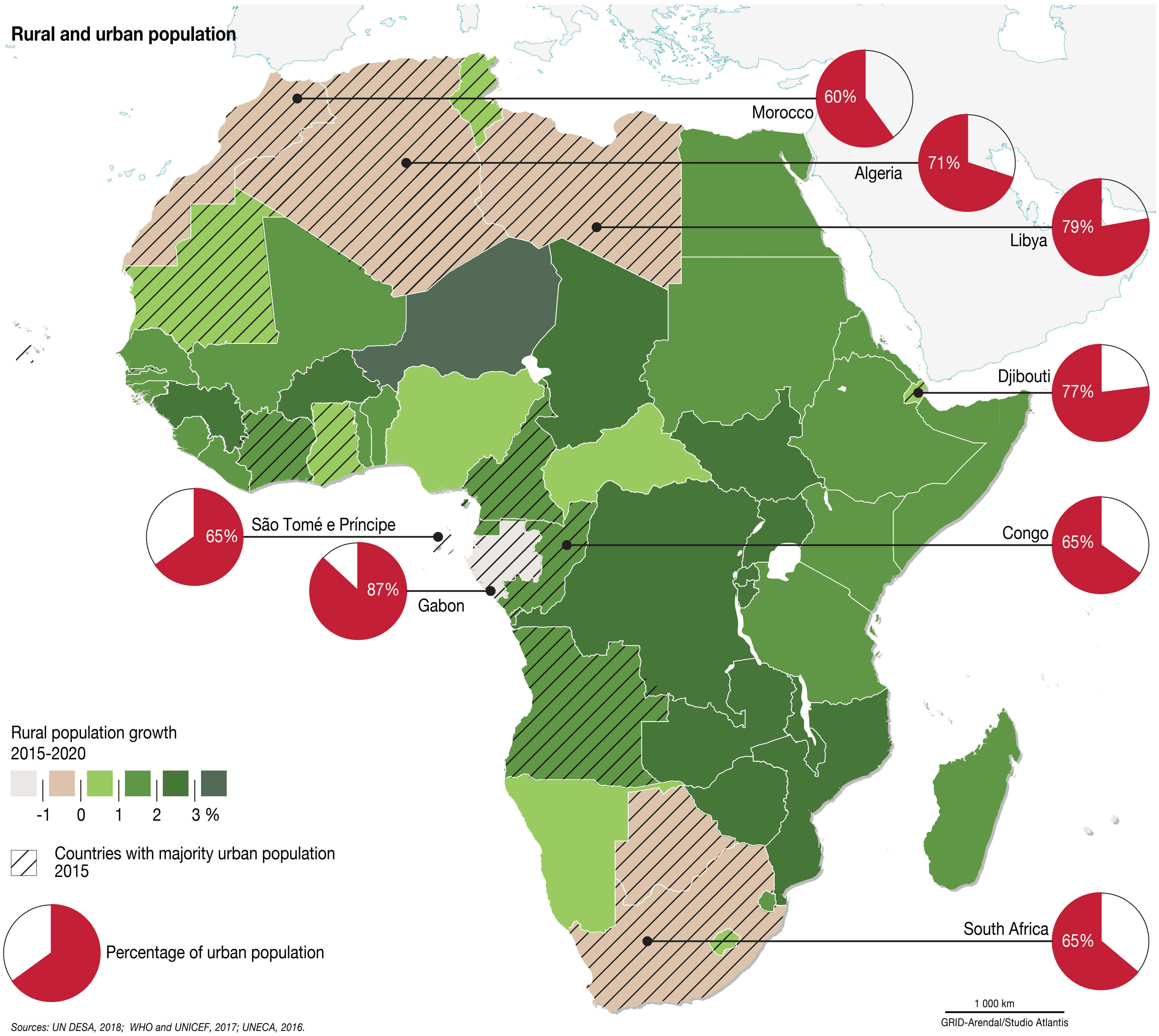
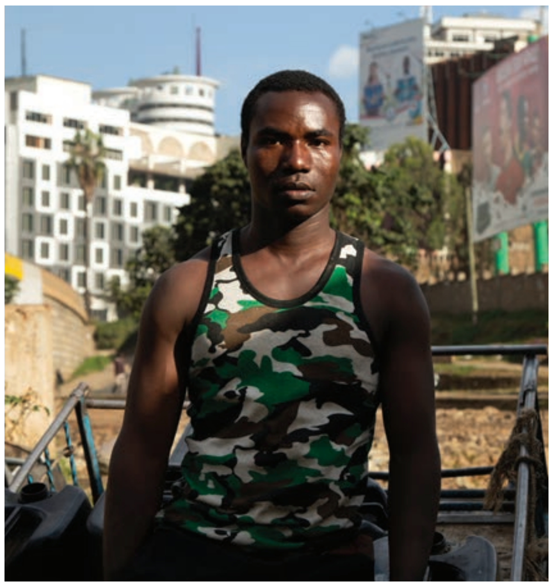


Figure 1.6. 2015 Rural population growth (annual percentage)

Despite high rates of urbanization, Africa still faces high rural population growth rates when compared to the rest of the world (Figure 1.6). Open defecation, lack of handwashing facilities and the poor siting and management of pit latrines – which often results in the contamination of shallow wells that are used for drinking water – are just some of the reasons why rural Africa lags behind urban areas in terms of safely managed sanitation.

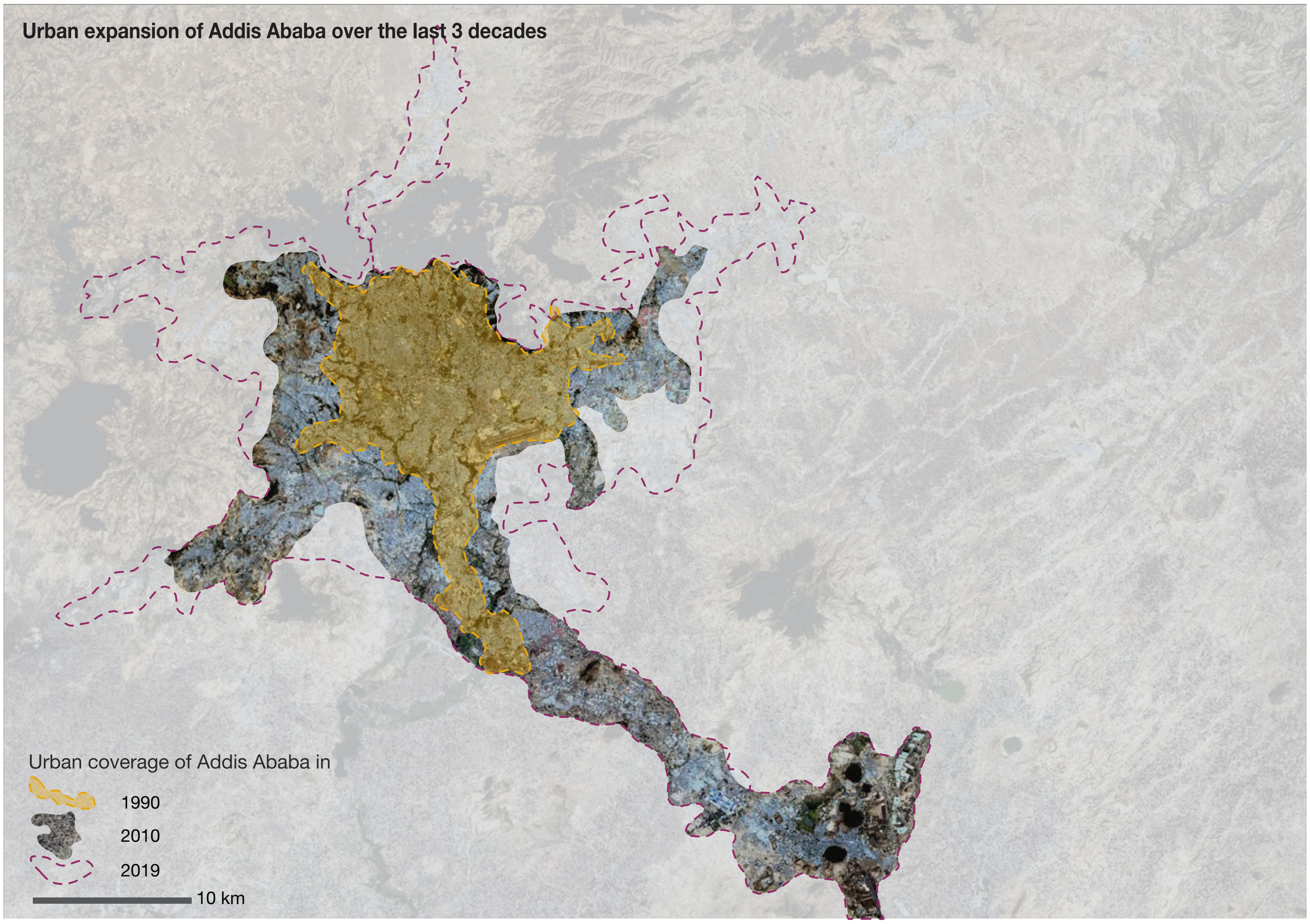
1.1.2 Implications of African population trends for sustainable development

Africa's young and rapidly growing population in both the urban and rural contexts calls on the continent to be innovative in its efforts to "reduce poverty, create employment, and provide food, water and energy security, while safeguarding the natural environment" (World Economic Forum [WEF] and United Nations Population Fund [UNFPA] 2012). As might be expected, increased population coupled with an increase in consumption patterns is leading to greater pressure on natural resources including water, land and forests (Organisation for Economic Co-operation and Development [OECD] 2012). The challenges of managing water resources and mitigating water allocation conflicts have gained increasing attention among policymakers and researchers, as population growth and changing consumption patterns are intensifying competition for limited freshwater resources (Hurni and Wiesmann eds. 2010). Development policies therefore need to reflect and respond to population dynamics and their relationships with social, economic and environmental factors (OECD 2012).



Many people in Africa lack access to safe drinking water and sanitation

Rural people on average spend a significant amount of time collecting water for household use



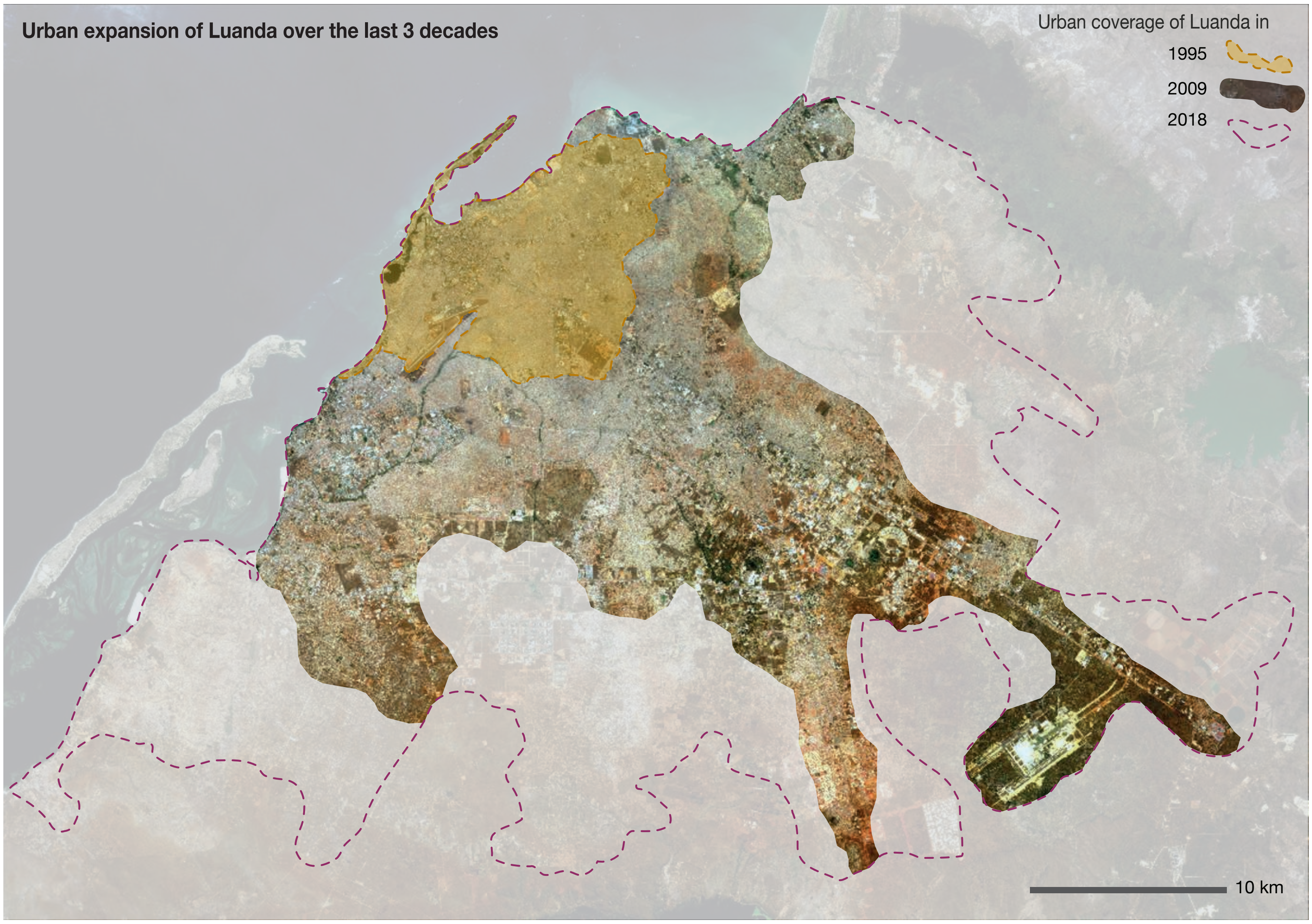
Addis Ababa is Ethiopia's capital and largest city. The city's population grew from an estimated 2.11 million in 1994 to 3.3 million in 2010 (UN-Habitat 2017). By 2017, the city's population had approached 4 million, while the area had expanded to 527 sq. km. (World Population Review 2020).

The expansion of Addis Ababa has not been matched with a growth in the infrastructure for sanitation provision and wastewater management. Unregulated urban growth and a proliferation of informal settlements make the assessment of the provision of sanitary conditions for Addis Ababa a difficult task. As a result the available data on the city's state of sanitation tends to be dated, but reflective of the current status. About 10 per cent of the urban area of Addis Ababa is sewered while the greater part of the city is served with pit latrines some of which dispose of their wastewater in the storm water drainage network (AAWSSA 2008).

Until recently, Addis had two sewage treatment plants, one at Kality with a designed capacity of 7 600 cu m per day or the capacity to serve a population of 200 000, and the other at Kotebe that only receives sludge from vacuum trucks that empty septic tanks. The Kotebe plant can handle an estimated annual volume of 85 000m^3 (NEDECO 2002).

About 75 per cent of households in Addis Ababa make use of pit latrines of which the majority are shared with other households. About 17 per cent depends on water-based flush toilet, while 6 per cent uses the bush (Van Rooijen and G. Taddesse 2008).

However, there are efforts to not only beautify and modernise Addis Ababa, but also to ensure that the city's growth and expansion meet environmental standards for sanitation and cleanliness. The USD 1 billion Sheger project is one such initiative.



Luanda is one of Africa's fastest growing cities, with an annual urbanization rate of 7 per cent. In 2016, the city's population reached 7 million (Cain 2018), and is currently estimated at 8.2 million (World Bank 2020). Half the city's population resides in musseques (informal settlements) (Cain 2018), with limited services, including safe drinking water and sanitation provision. In order to serve the housing needs of the growing population, Luanda continues to witness rapid expansion in area.

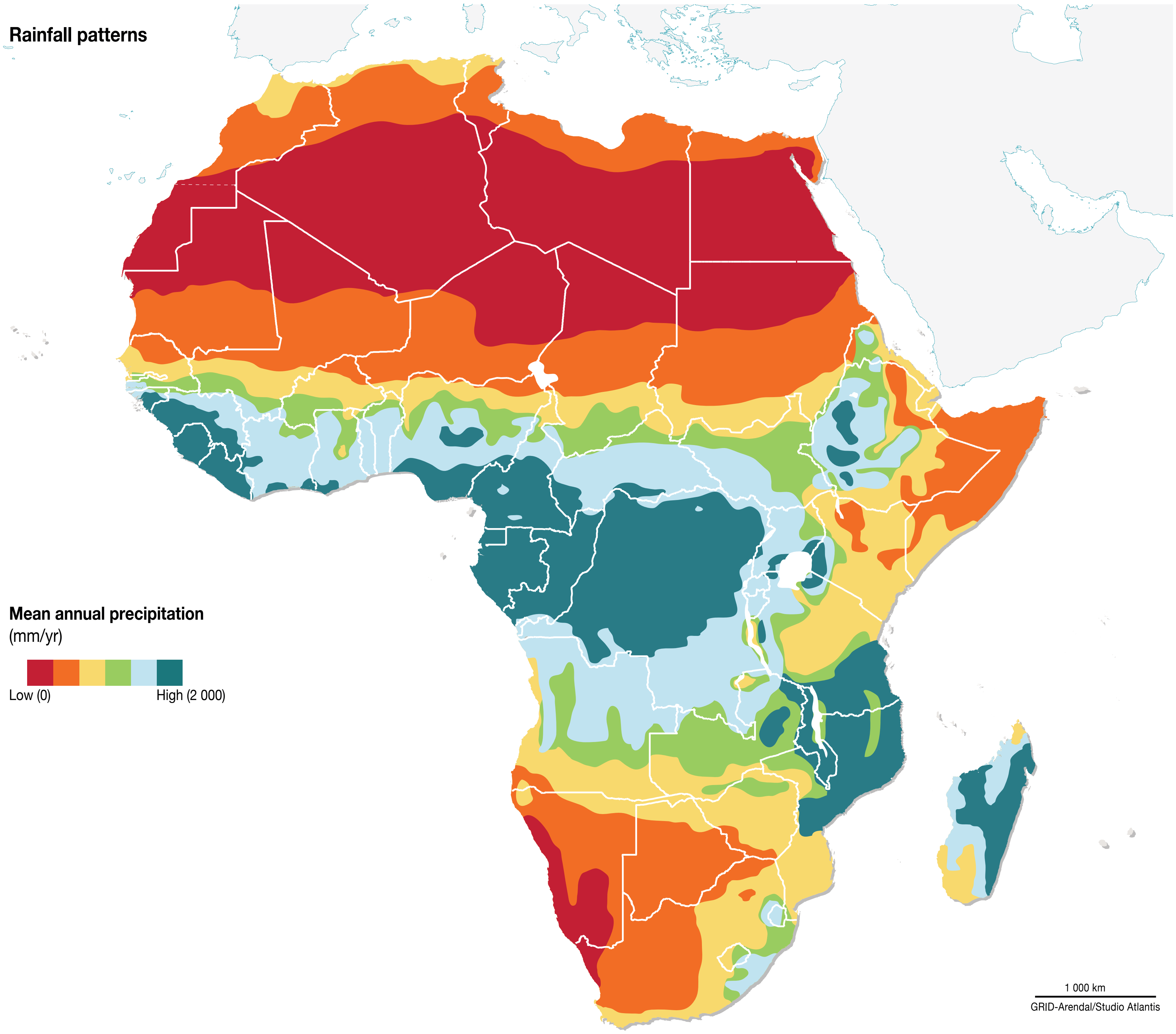
About one third of Luanda's population is not served with adequate sanitation facilities, and the majority of such people reside in informal settlements where open defecation is widely practiced. About 70 per cent of the residents of informal settlements buy water from vendors, the quality of which is often not good. The situation is compounded by the poor management of solid waste. People's health is greatly affected with outbreaks of cholera being common. For example, in 2006 more than 17,500 residents of Luanda contracted cholera (Médecins Sans Frontières 2006).

1.2 Water, Sanitation and Hygiene in Africa

1.2.1 Water resources

Africa is the world's second driest continent after Australia (United Nations Environment Programme [UNEP] 2010). Freshwater is unevenly distributed across its countries and regions, largely due to the variability of rainfall in different climatic zones (FAO 2003), as shown in Figure 1.7. The continent's renewable water resources average 3,930 cubic kilometres (Figure 1.8), representing less than 9 per cent of the global total (UNEP 2010). The majority of Africa experiences long dry seasons, exceeding five months in some cases (MacDonald and Calow 2009), which result in reliance on groundwater. In addition, there are over 1,270 dams built across Africa to store and supply water for agriculture and hydropower generation (UNEP 2008). Fifty-three large dams in Africa account for 90 per cent of the total amount of water retained in reservoirs on the continent (UNEP 2008). Much of the dam storage capacity is in South Africa, where there are 589 dams (Tatlock 2006).

Africa has swathes of natural water infrastructure in the form of wetlands, which are important as they contain water resources and provide ecological services to maintain ecosystem integrity. According to UNEP (2008), Africa's wetlands cover approximately 1 per cent of the continent's total surface area. Anthonj et al. (2017) acknowledge that in parts of sub-Saharan Africa, natural wetlands constitute the only accessible water resources, providing water, agricultural potential and livelihoods in otherwise uninhabitable landscapes, which is why they are being used extensively. The degradation and contamination of water resulting from the use of wetlands has the potential to spread disease-causing micro-organisms and enlarge the breeding habitats for disease vectors.

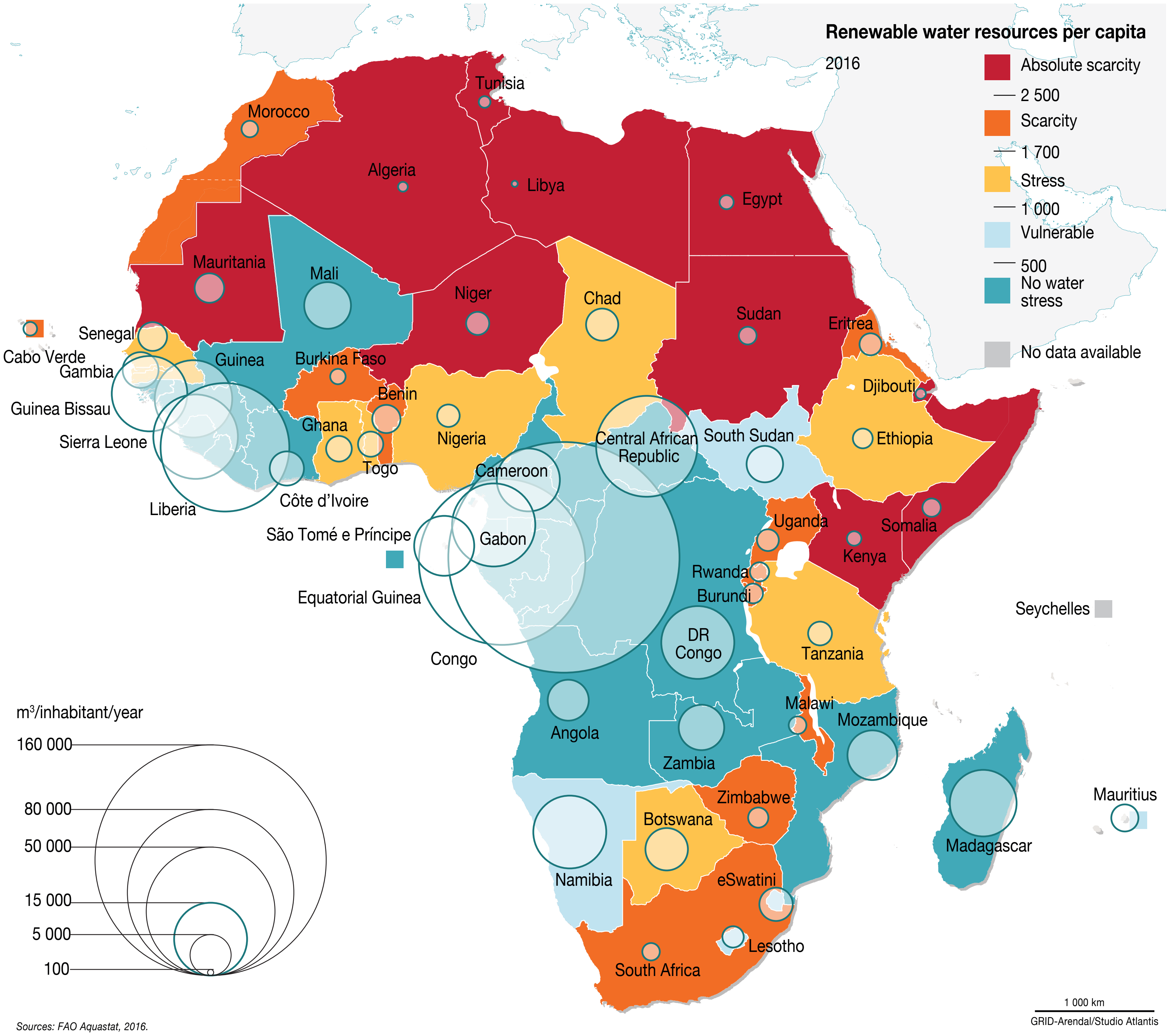


Source: Masih et al., 2014.

Figure 1.7. Rainfall patterns in Africa

Water can be contaminated in storage containers

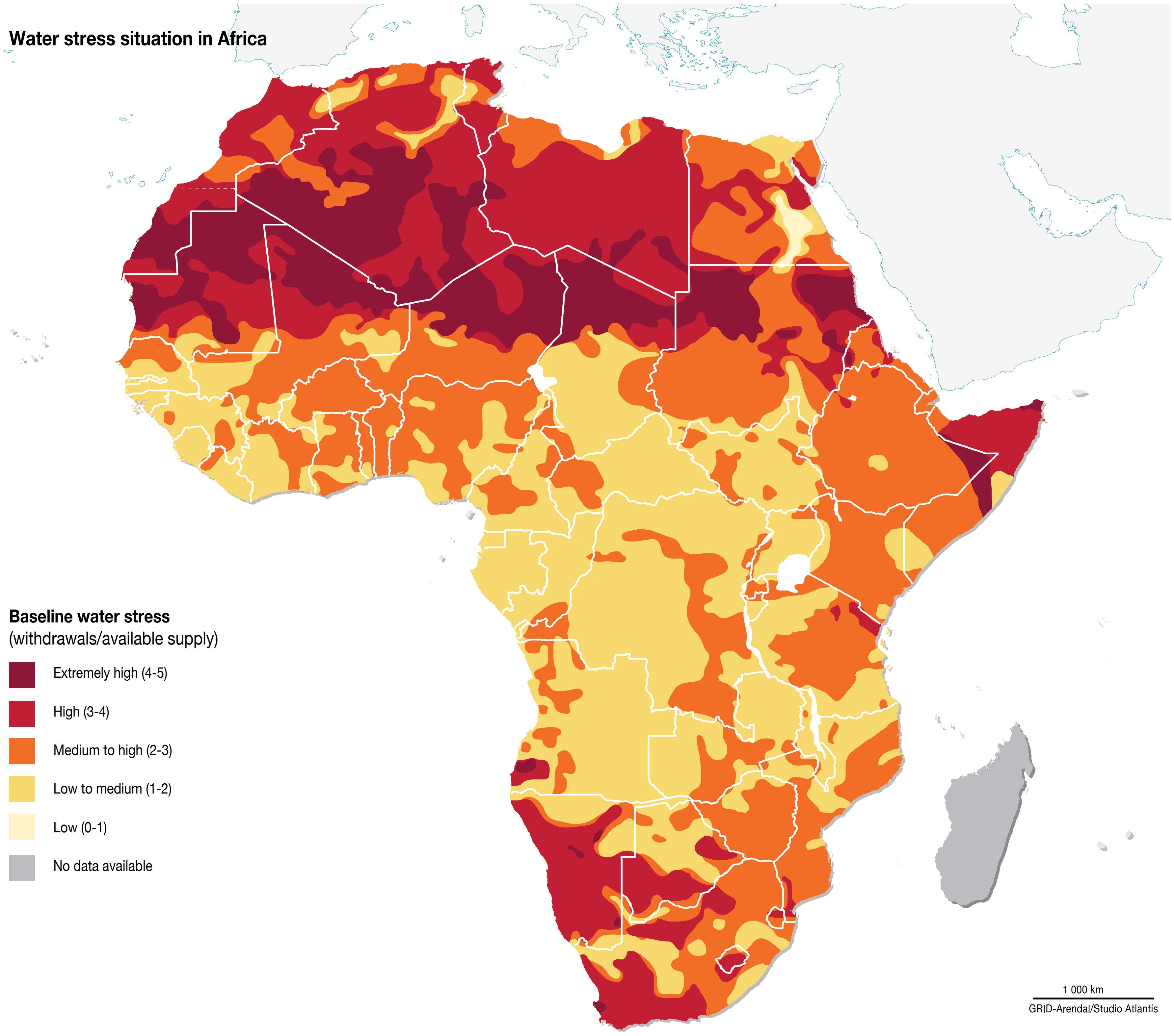
Improper disposal of waste degrades the environment, including water bodies



Sources: FAO Aquastat, 2016.

Figure 1.8. Africa's total renewable water resources

Water stress situation in Africa



Source: WaterHealth, 2019.

Figure 1.9. A detailed illustration of the water stress situation in Africa

Close to 75 per cent of Africa's population use groundwater sources for drinking

As Figure 1.9 shows, water stress and scarcity issues on the continent are complex and cross national boundaries. For example, the countries that use the most water by volume are Egypt, Sudan, Madagascar, South Africa, Morocco, Nigeria and Mali, but these are not necessarily the most water-rich nations (UNEP n.d). Egypt, for example, is in a climatic zone of low water availability, but is Africa's largest water consumer at 61.7 cubic kilometres per year (UNEP n.d.).

An estimated 75 per cent of the African population relies on groundwater as its major source of drinking water, especially in North and Southern Africa (UNEP 2010). However, groundwater represents only 15 per cent of the continent's total renewable water resources (UN Water 2015). As Figure 1.10 shows, North Africa is much richer in groundwater resources than the rest of the continent.

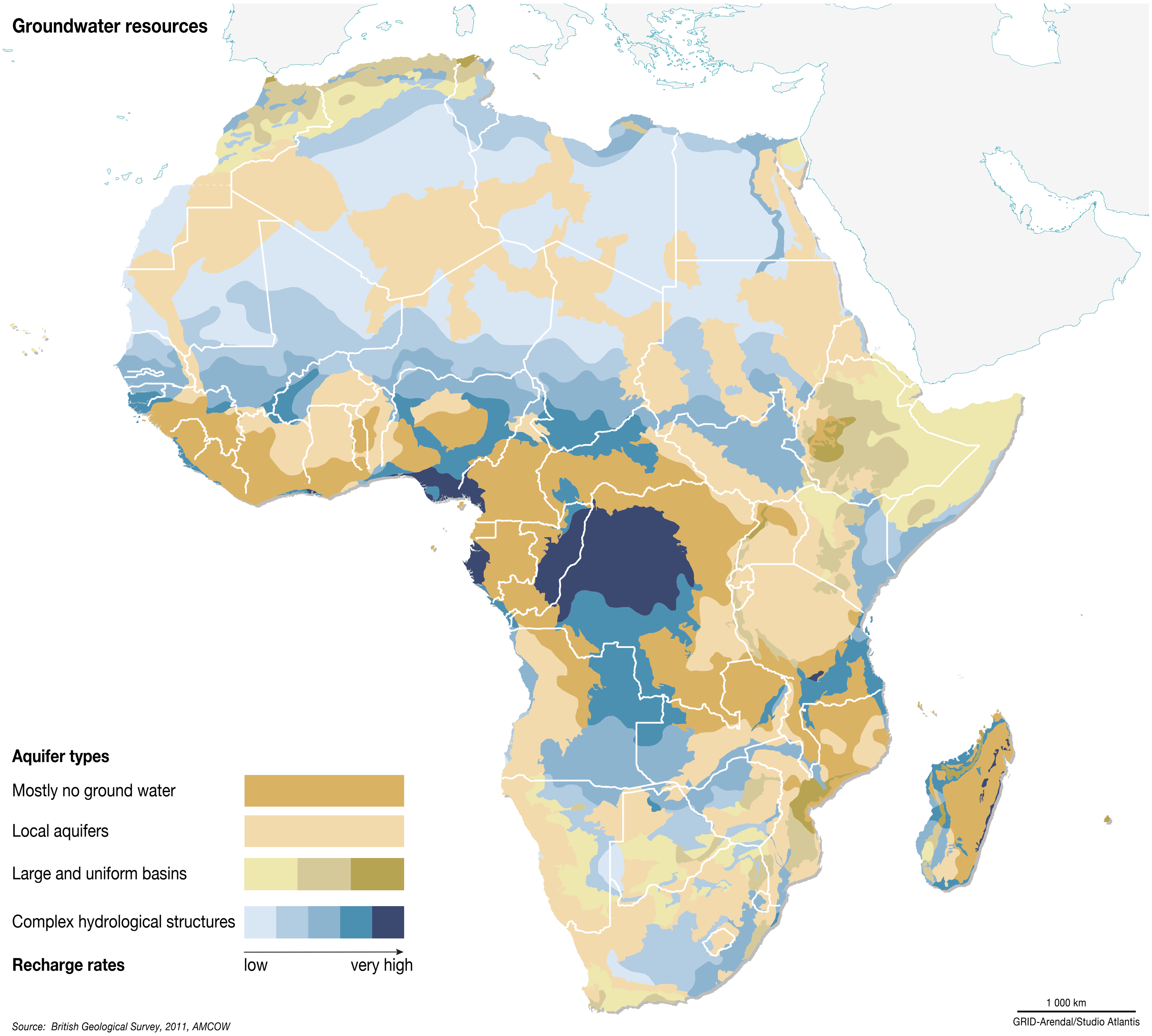


Figure 1.10. Africa's groundwater storage

Droughts are common in many countries in Africa

Wetlands play host to many species, including birds and fish

1.2.2 Sanitation

The World Health Organization (WHO) defines sanitation as "the provision of facilities and services for the safe management of human excreta from the toilet to containment and storage and treatment on-site or conveyance, treatment and eventual safe end use or disposal" (WHO 2018). An improved sanitation facility is one that hygienically separates human excreta from human contact. In addition, improved sanitation provides facilities and services to safely dispose of human urine and faeces, and maintains hygienic conditions through proper collection of garbage and wastewater. In urban areas, improved sanitation also entails the proper management of solid waste and drainage (WHO and UNICEF 2012). WHO acknowledges that given the key role that effective sanitation plays in breaking the cycle of infectious disease, the concept in its broader sense would also include the safe management of solid and animal waste. The post-2015 development agenda (the 2030 Agenda) aptly embraces this holistic view of sanitation and addresses sanitation as an ecosystem service to be managed sustainably for the benefit of both the natural environment and humanity. The 2030 Agenda and its Sustainable Development Goals (SDGs) employ a 'ladder' of definitions that recognizes a progression from access to improved facilities to a sustainably managed service. These are outlined below:

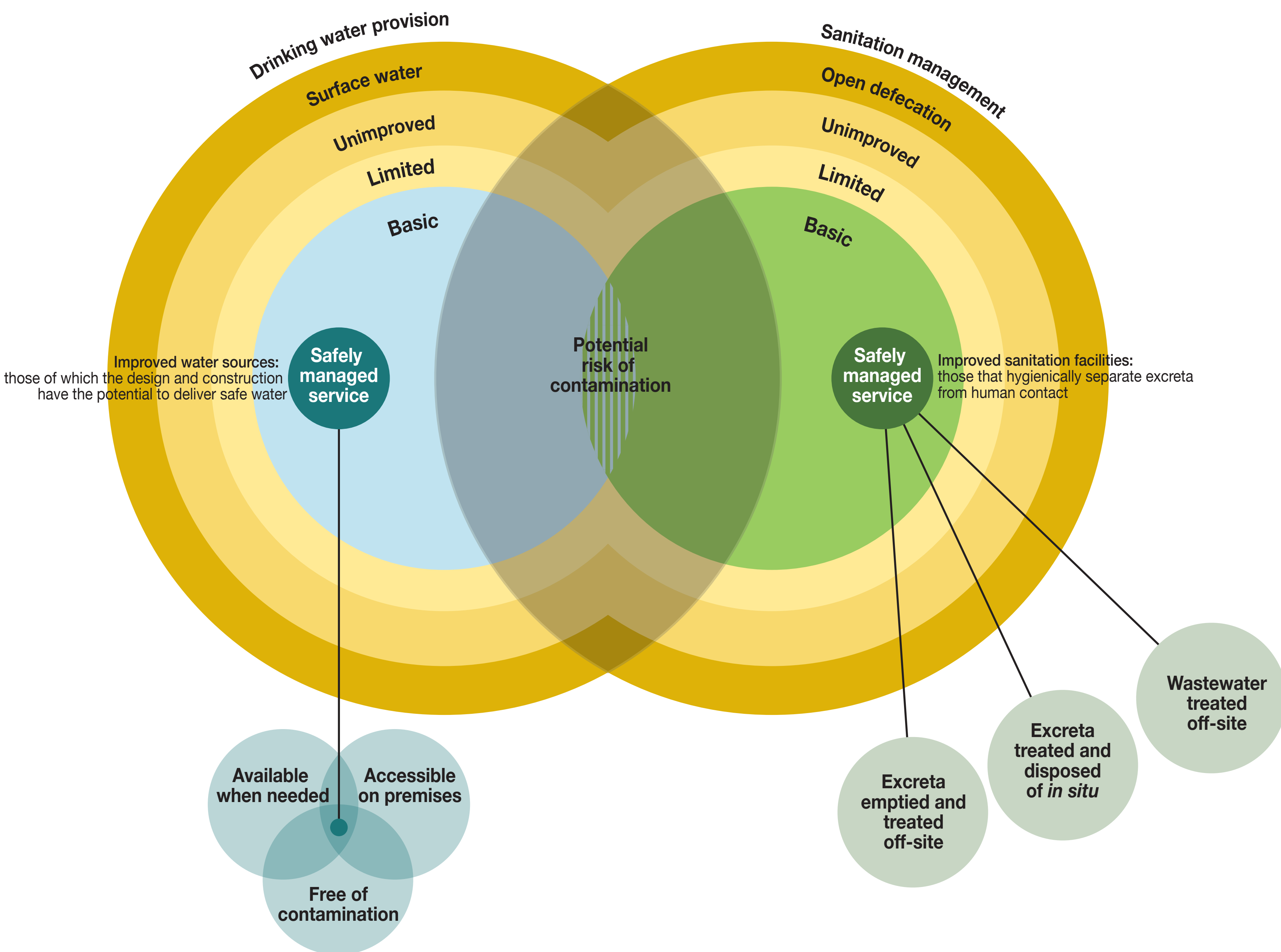
- **Limited sanitation service:** The use of improved sanitation facilities that are shared between two or more households
- **Basic sanitation service:** The use of improved sanitation facilities that are not shared with other households and
- **Safely managed sanitation:** The highest rung on the ladder, whereby excreta are safely disposed of *in situ* or transported and treated off-site.

SGD target 6.2 seeks to build on and address the shortcomings of the previous Millennium Development Goal 7C indicator that focused on "sustainable access to 'basic sanitation'". It does this by including aspects of "safely managed sanitation services" and addressing normative criteria of the human right to water including accessibility, acceptability and safety. The safe management of faecal waste in water-based sanitation is key, as discharges of untreated wastewater into the environment create public health hazards and ultimately impact access to safe drinking water by polluting raw water sources. In a safely managed system, excreta are disposed of in a manner that protects human health and the environment to ensure that there is enough freshwater available for potable uses and that the integrity of aquatic ecosystems is not compromised, as illustrated by Figure 1.11.

Millennium Development Goal 7: Ensure environmental sustainability

Target 7C: By 2015, halve the proportion of people without sustainable access to safe drinking water and basic sanitation

SDG GOAL 6. Ensure availability and sustainable management of water and sanitation for all



Sources: JMP Progress on drinking water, sanitation and hygiene – 2017 Update and SDG Baseline.

GRID-Arendal/Studio Atlantis

Figure 1.11. The excreta management tenets of a safely managed sanitation system

SDG 6: Clean Water and Sanitation

6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all

6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations

6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate

6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies

6.b Support and strengthen the participation of local communities in improving water and sanitation management

National targets to improve water quality are difficult to achieve due to dumping and pollution

1.3 Development Goals for the Water Sector

1.3.1 Access to safe drinking water

The Millennium Development Goals (MDGs) set the global development agenda during the period 2000–2015. The 2030 Agenda drew on the lessons and achievements of the MDGs era to frame the Sustainable Development Goals (SDGs), which were officially adopted in 2016. The MDGs served as a cornerstone of development policy around the globe following their adoption in 2000. Taking 1990 as the baseline, just under a quarter (24 per cent) of the African population – the lowest globally – gained access to an improved drinking water source by 2015. Furthermore, only 16 per cent had access to piped drinking water, again the lowest increase in the world (Economic Commission for Africa et al. 2014). There were also wide rural/urban disparities in access to safe drinking water that tended to bring down national aggregate performance figures in some countries. In Africa, the low 1990 baseline conditions combined with rapid population growth relative to the rest of the world exacerbated the challenge in meeting the targets. Apart from North Africa, Africa as a whole ranked lowest in the world on access to improved drinking water sources by 2015 (with only 64 per cent of the population using an improved source).

1.3.2 Access to sanitation

The world is urbanizing rapidly and the number of people living in cities is projected to increase by 50 per cent (from 4 billion to 6 billion) between 2016 and 2045. Much of this growth is occurring in low-income and lower middle-income countries (World Bank 2016), many of which are in Africa. Formal service providers often struggle to meet the demand for housing, infrastructure and services such as sanitation and safe drinking water that is created by rapid urbanization.

The MDG sanitation target called for halving the proportion of the population without basic

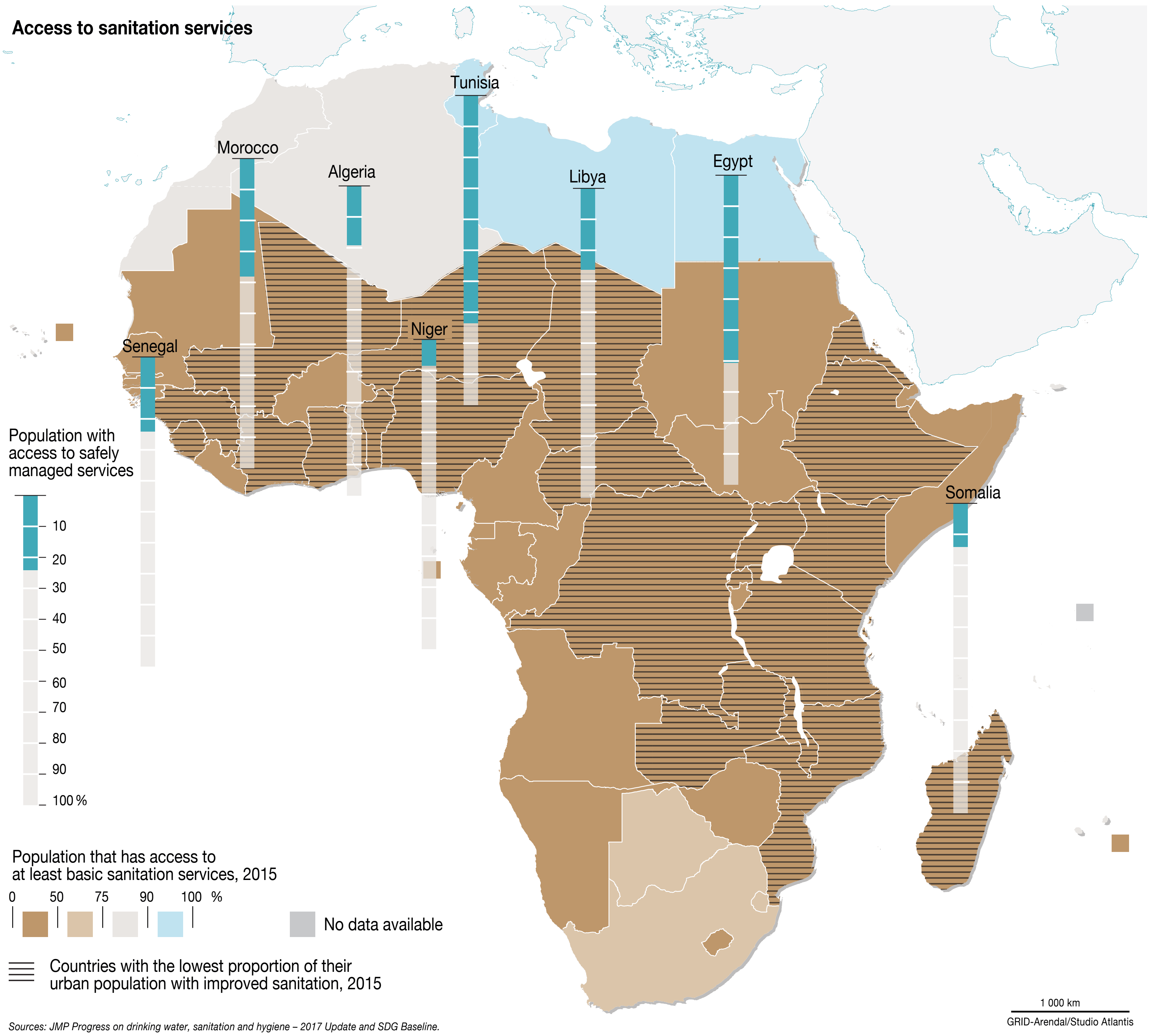


Figure 1.12. Proportion of the population that had achieved at least a basic level of sanitation service by 2015

sanitation. This would have increased access from 54 per cent to 77 per cent for the global population. Though some commendable progress was made, this target was not met across the globe. At the close of the MDGs era, it was estimated that 68 per cent of the global population was using an improved sanitation facility, nine percentage points below the target. The global target for sanitation was missed by almost 700 million people (WHO and UNICEF 2015).

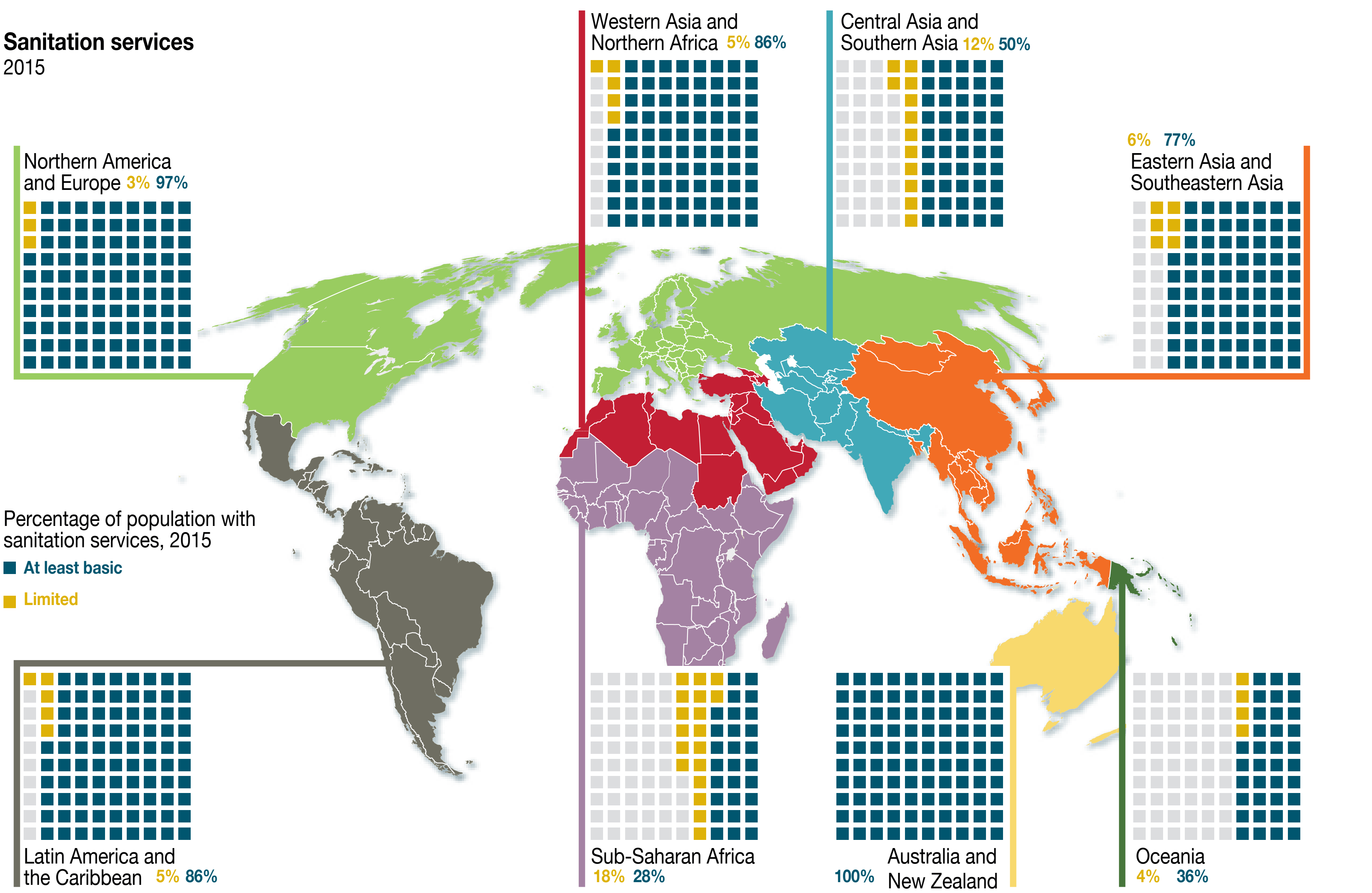
North Africa was the only region in Africa that met the sanitation target, with an additional 41 per cent of the population gaining access since 1990. The subregion started with a good baseline for access to improved sanitation facilities and this increased from 71 per cent to 89 per cent by 2015, surpassing the target set by three percentage points (UNICEF and WHO 2015), and with four countries (Algeria, Cabo Verde, Egypt and Tunisia) meeting the target. On the other hand, in sub-Saharan Africa, minimal progress was made, with less than 17 per cent of its population gaining access by the end of 2012. Due to a combination of population growth and slow progress, the number of people in sub-Saharan Africa without access to improved sanitation at the end of the MDGs was very high, at 695 million (WHO and UNICEF 2015).

In the post-2015 agenda, the targets focus not only on access to facilities but also to services. When the baselines for the SDG 6 targets were established, improved facilities that did not meet the requirements for the safe disposal and treatment of excreta were considered 'basic', as opposed to 'safely managed'. Using this definition, 5 billion people in the world had access to at least a 'basic' level service, that is, an improved facility not shared with other households, in 2015. However, most of the countries in sub-Saharan Africa had not ensured 50 per cent of their population had access to basic services. Figure 1.12 shows the countries that had achieved access to basic services by 2015 (WHO and UNICEF 2017).

As at 2015, less than a third of sub-Saharan Africa (28 per cent) had access to a basic level of service. A further 18 per cent had access to a limited service, while more than 20 per cent had no service at all and practised open defecation. After Central and Southern Asia, sub-Saharan Africa had the second greatest proportion of people practising open defecation. Furthermore, it is disturbing that sub-Saharan Africa reported an increase in the number of open defecators from 204 million to 220 million between 2000 and 2015 (WHO and UNICEF 2017). Of those with access to sanitation services, the greatest proportion has access to unimproved sanitation (WHO and UNICEF 2017), as shown in Figure 1.13.

Perhaps in recognition of Africa's poor access to improved sanitation services relative to the rest of the world, the continent's development road map, Agenda 2063, specifically refers to access to sanitation as an indicator of achievement (AU 2015). While this is commendable, it should be noted that the unsafe disposal of human excreta and industrial waste continues to place a huge burden on the continent's freshwater resources. As this threat needs to be addressed, the region must work towards ensuring a safely managed service.

Access to safely managed services, the highest rung on the SDG sanitation ladder, is reportedly rising but remains low, both globally and within Africa (African Union [AU] et al. 2018). Data availability is key to assessing and reporting on countries'



Source: JMP Progress on drinking water, sanitation and hygiene – 2017 Update and SDG Baselines.

GRID-Arendal/Studio Atlantis

Figure 1.13. Global sanitation coverage, 2015

Regular hand washing is one way to prevent the spread of germs

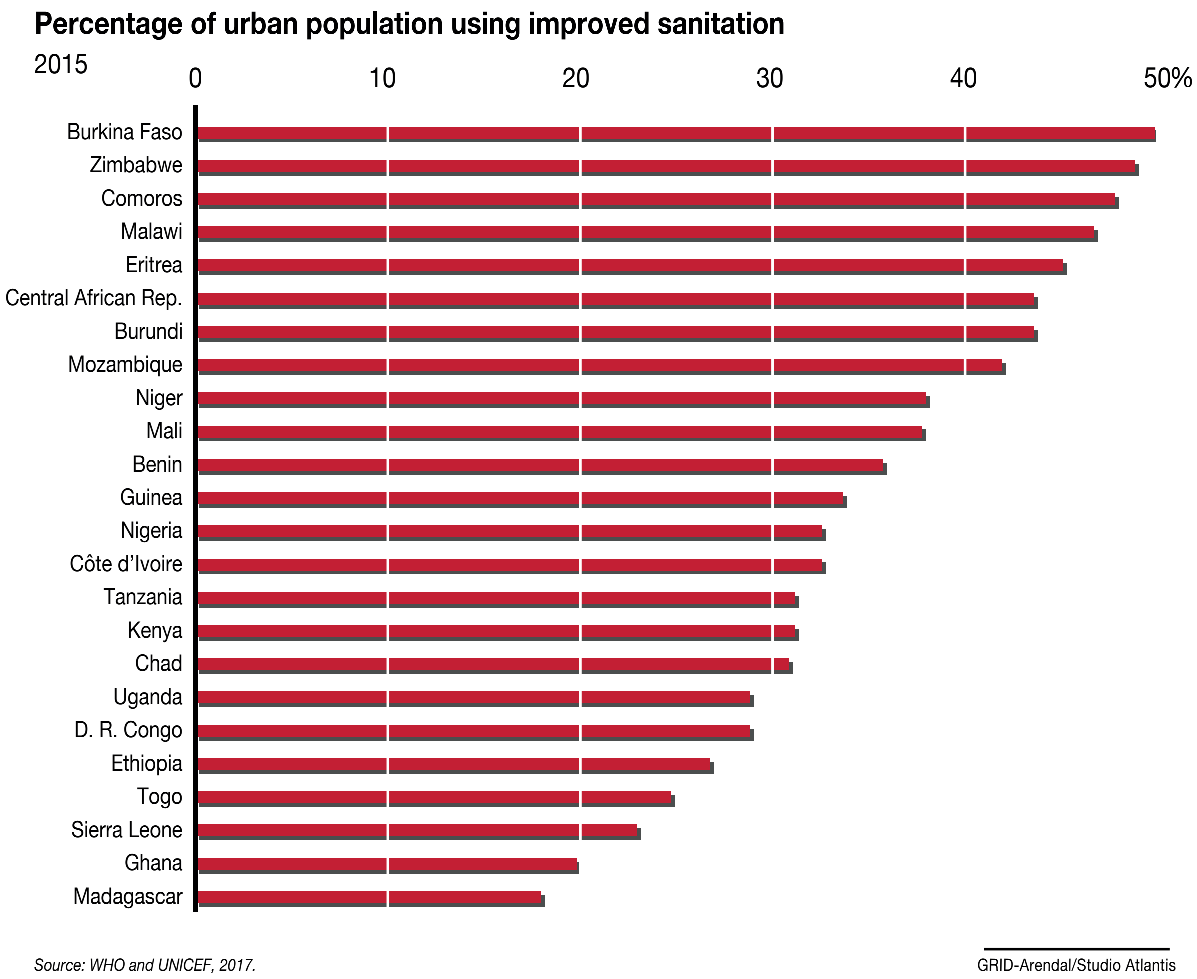


Figure 1.14. Countries whose urban populations had the lowest proportions of improved sanitation by 2015

progress, particularly when it comes to determining whether or not on-site sanitation services are safely managed. This is clearly demonstrated by the unavailability of baseline figures for sub-Saharan Africa due to the lack of data. In North Africa, where data are available, the proportion of people with access to safely managed sanitation services stood at 25.1 per cent in 2015. This was an increase from 18.1 per cent in 2005.

The 2017 Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) report indicates that 16 of the 24 countries in which at least 20 per cent of the population has limited sanitation services are in sub-Saharan Africa, where the majority of people with such access are found in urban areas (WHO and UNICEF 2017). Figure 1.14 shows which countries' urban populations had the lowest proportions of improved sanitation by the end of 2015, and all but Haiti are in sub-Saharan Africa.

Nevertheless, there are success stories in the region at the country level. Ethiopia achieved the largest decrease in the proportion of the population practising open defecation, which dropped from 92 per cent (44 million people) in 1990 to 29 per cent (28 million people) in 2015 (WHO and UNICEF 2015). Libya and Seychelles stagnated over the period and six countries experienced setbacks (Djibouti, Gambia, Nigeria, Sudan, Togo and Zimbabwe). The rural/urban divide, lack of adequate infrastructure and the poor situation of slum dwellers compounded the slow progress.

1.3.3 Improved hygiene

The MDGs agenda did not set a specific target on hygiene. However, adequate hygiene practices in water and sanitation have significant health benefits. Therefore, the 2030 Agenda includes a hygiene indicator, defined as access to handwashing facilities with soap and water at home. Other handwashing agents are considered as constituting a limited service due to their reduced effectiveness. JMP data from over 50 countries show low levels of handwashing in many countries. In sub-Saharan Africa, in 34 of the 38 countries for which data are available, access to basic handwashing facilities is at best 50 per cent (WHO and UNICEF 2017). As with access to water and sanitation, the disparities between North Africa and sub-Saharan Africa are apparent, as shown in Figure 1.15.

1.3.4 Wastewater

The UN-Water Wastewater Management Analytical Brief (UN-Water n.d.) turns to Raschid-Sally and Jayakody's 2008 research report and the 2010 assessment by Corcoran et al. to define wastewater as "a combination of one or more of: domestic effluent consisting of blackwater and greywater; water from commercial establishments and institutions, including hospitals; industrial effluent, storm water and other urban run-off; agricultural, horticultural and aquaculture effluent, either dissolved or as suspended matter".

1.3.4.1 The nature and state of Africa's wastewater streams

The World Water Development Report (WWDR) of 2017 acknowledges that the use of surface water as disposal sinks for solid and wastewater has directly resulted in the pollution of downstream water bodies (World Water Assessment Programme [WWAP] 2017). Despite advances in wastewater collection and treatment systems as well as innovations in solid waste management, the discharge of untreated wastewater into the environment continues, with the practice most frequently noted in developing countries. The lack of infrastructure for the collection, transportation, treatment and disposal of solid waste, proper solid waste management planning, insufficient financial resources, technical expertise and public attitude

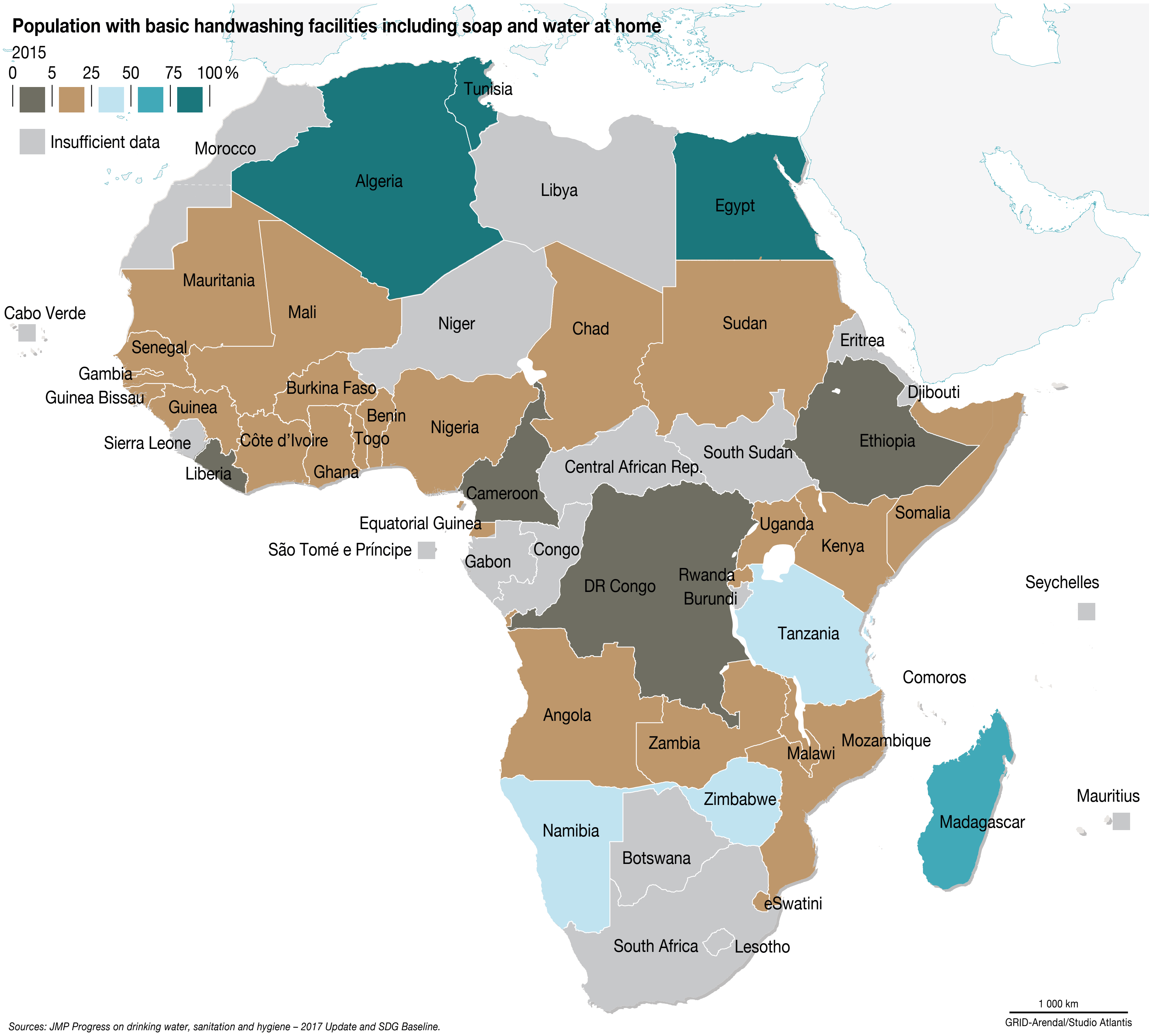


Figure 1.15. Proportion of population with access to handwashing facilities with soap and water at home in Africa, 2015

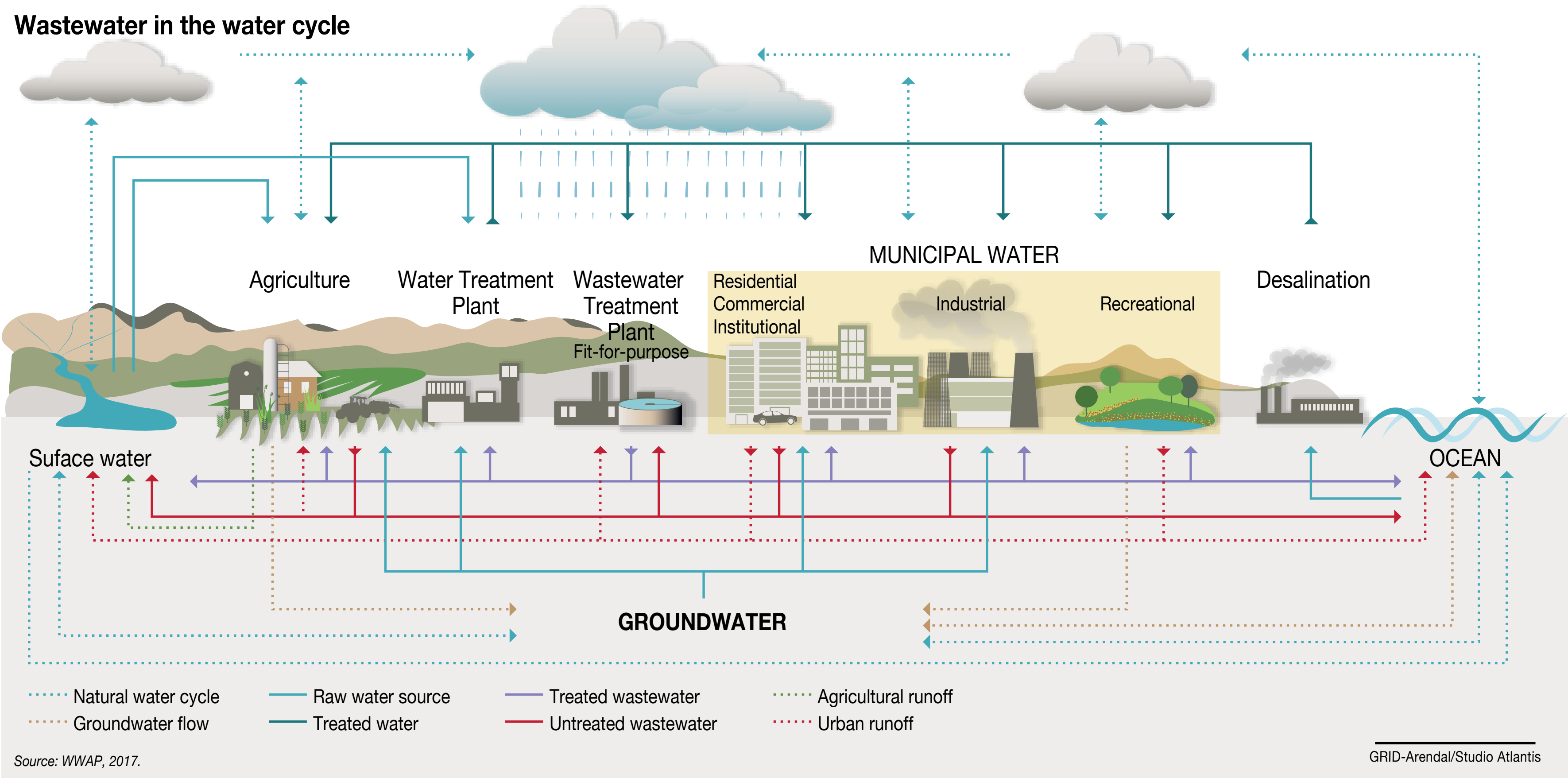


Figure 1.16. Wastewater in the water cycle

worsen the situation, resulting in an increase in environmental and health-related problems.

The WWDR stated that only 20 per cent of globally produced wastewater was receiving adequate treatment in 2012, adding that there seems to be a correlation between the treatment capacity and the income level of the country (WWAP 2017). Treatment capacity in 2012 was reported to be 70 per cent of the generated wastewater in high-income countries, compared to only 8 per cent in low-income countries (WWAP 2017). The consequence of such practices include increased disease burden as well as significant damage to key ecosystems. Studies have also revealed that contamination from these streams usually finds its way into freshwater resources, resulting in increased levels of eutrophication and loss of some ecosystem services. Wastewater can also easily pollute groundwater due to the percolation process, as shown by Figure 1.16.

Treated wastewater can be used for irrigation and replenishment of groundwater, among other uses

Sewage leaks and dumping of waste are common urban environmental hygiene problems in Africa

There are four wastewater streams that impact on freshwater and land resources in Africa: domestic, agricultural, industrial and solid waste (Wang et al. 2014).

Some key highlights with respect to these various streams are highlighted below:

Domestic: Domestic wastewater is a challenge from the perspective of an explosive growth of peri-urban informal settlements that lack sewer conveyance systems (Wang et al. 2014). In addition, ageing wastewater treatment plants are failing throughout the continent. In a review of wastewater treatment practices in seven African countries (Algeria, Burkina Faso, Egypt, Ghana, Morocco, Senegal and Tunisia), Nikiema et al. (2013) describe how treatment plants have to contend with high organic loads, uncontrolled input and power cuts, in addition to increasing wastewater flow rates. Other issues raised were poor plant operation and maintenance, high energy costs and lack of re-investments. These challenges culminate in treatment plants that often deliver insufficient effluent quality, which has negative environmental consequences and leads to poor perceptions of the treated water among stakeholders. In the rural African setting, non-sewered systems are the dominant, but not exclusive, technology. Leakages and poor handling of excreta in these facilities can pollute freshwater systems (United Nations 2018a). The use of on-site and non-waterborne sanitation technologies in rural and urban Africa can, at times, compromise the quality of water resources by contaminating groundwater. This is significant as groundwater is an important component of the drinking supply in water-scarce and stressed Africa.

Agricultural: Agricultural activities – both subsistence rain-fed and commercial – are key components of livelihoods in Africa and are widely recognised to contribute heavily to the pollution of freshwater resources. With a growing population and climate variability, agricultural flows and their impact on wastewater and freshwater resources will continue to be significant.

Industrial: Industrial activity contributes significant levels of chemical pollution to Africa's water flows. Wang et al. (2009) report measuring levels in excess of 2,000 mg/l of chemical oxygen demand in the influent of many pond systems in Africa. This is reportedly five times the levels found in other countries. With Africa on an industrialization drive, the nature, volumes and management of this wastewater stream will be impacted.

Solid waste: The solid waste management challenge in Africa is massive (Bello et al. 2016). Poorly managed solid waste and its decomposing by-products find their way into wastewater and freshwater flows through run-off and other means. Issues such as illegal dumping of waste, failure of municipal systems to act, as well as dumping of faecal matter or 'flying toilets' (plastic bags used to dispose of human waste) are all waste management challenges facing Africa (Wang et al. 2014; Li et al. 2011; Wang et al. 2012). Some entrepreneurs are finding business opportunities by turning some solid and human waste into raw materials for energy and organic fertilizers.

1.4 Galvanising for Action

At the continental level, Agenda 2063 is a "long-term development framework that aims to materialize the vision of: an integrated, prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in the world" (AU et al. 2016). The same report recognizes that Agenda 2063 is anchored by seven aspirations that are supported by corresponding goals, priority areas, targets and strategies. To this end, the Agenda 2063 priority areas address economic, social and environmental sustainability.

Significantly, Agenda 2063 emphasizes that economic transformation on the continent will depend on accelerated industrialization. The social development priorities on the other hand focus on health, education, water and sanitation as well as gender and social inclusion (AU et al. 2016). Environmental priorities focus on measures to address climate change, as well as to preserve and harness marine and terrestrial ecosystems. Specific to sanitation and wastewater, Agenda 2063 calls on Member States to ensure environmentally sustainable and climate-resilient economies and communities. Tied to this goal is the target to ensure at least 90 per cent of wastewater is recycled for agricultural and industrial use.

The SDGs seek to end poverty, protect the planet, and ensure peace and prosperity for all. One of the highlights of the transition from the MDGs to the SDGs was the effort to embrace a holistic approach to the provision of water and sanitation services within the framework of sustainable ecosystem management. This is reflected in the targets for the SDGs that regard access to water and sanitation not only as rights, but also as ecosystem services that must be sustained through generations. SDG 6 thus seeks to "Ensure availability and sustainable management of water and sanitation for all".

This is reflected in the range of indicators that go from access to improved sanitation facilities, protection of ecosystems, and increasing efficiency through to participatory planning and management at all levels (Figure 1.17).

Some key actions towards the realization of SDG 6 are taking shape throughout the continent, albeit with varying rates of success. The decade from 22 March 2018 to 22 March 2028 has been declared the International Decade for Action on Water for Sustainable Development (Water Action Decade). The decade's objectives are stated as a greater focus on (UNGA 2015):

- The sustainable development and integrated management of water resources for the achievement of social, economic, and environmental objectives
- The implementation and promotion of related programmes and projects, and
- The furtherance of cooperation and partnership at all levels to help achieve internationally agreed water-related goals and targets, including those contained in the 2030 Agenda.

Figure 1.17. The Sustainable Development Goals

The High-Level Panel on Water (HLPW) outcome document sets forth a framework of action for accelerated efforts towards the realization of SDG 6. The report outlines practical actions to catalyse change and build partnerships and cooperation, and advocates an integrated and inclusive approach that draws on different sectors and stakeholders to work towards sustainable management of water resources (HLPW 2018).

The reporting mechanisms for progress on the SDGs have evolved to embrace the new focus on an integrated and holistic approach to sanitation and wastewater management as ecosystem services in the context of population growth and climate variability. All the baselines indicators are now available from a number of platforms, but primarily the Global Enhanced Monitoring Initiative (GEMI). GEMI was established in 2014, as an inter-agency initiative whose focus is on integrating and expanding existing efforts on SDG targets 6.3 to 6.6(a) (See Table 1.1). The indicators are new at the global level and require increased awareness-raising and capacity-building at all levels. The GEMI component of SDG 6 monitoring and implementation will be harmonized with the JMP and the Global Analysis and Assessment of Sanitation and Drinking-Water (GLASS) as part of the UN-Water Integrated Monitoring Initiative for SDG 6. The first phase of the initiative focused on the development of monitoring methodologies and other support tools, including pilot testing, a roll-out of capacity-building efforts and the establishment of a global baseline for targets 6.3 to 6.6.

Further recognition of the central role of wastewater treatment is shown in the United Nations Environment Assembly resolution that addresses water pollution. The final resolution (UNEP/EA.3/Res.10) states "support countries in sustainable wastewater management (policies, guidelines, standards, etc) ... and collaborate with private sector to invest and upscale business models for wastewater management, prevention of water pollution, water quality monitoring, and innovative financing mechanisms. In addition, it encourages Member States to implement relevant actions to help attain the indicators for SDG 6 (IISD 2017).

1.4.1 Wastewater treatment and protection of ecosystems

Africa's wastewater is often inadequately treated and sometimes discharged untreated into

Water is central to personal hygiene

Table 1.1. SDG 6 targets and indicators

Target		Indicators	
6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all	**6.1.1**	Proportion of population using safely managed drinking water services
6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	**6.2.1**	Proportion of population using safely managed sanitation services, including a handwashing facility with soap and water
6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	**6.3.1** **6.3.2**	Proportion of wastewater safely treated Proportion of bodies of water with good ambient water quality
6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	**6.4.1** **6.4.2**	Change in water use efficiency over time Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
6.5	By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	**6.5.1** **6.5.2**	Degree of integrated water resources management implementation (0-100) Proportion of transboundary basin area with an operational arrangement for water cooperation
6.6	By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	**6.6.1**	Change in the extent of water-related ecosystems over time
6.a	By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies	**6.a.1**	Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
6.b	Support and strengthen the participation of local communities in improving water and sanitation management	**6.b.1**	Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management

Source: United Nations, General Assembly [UNGA] (2015)

freshwater and marine-receiving ecosystems. Many towns and cities on the continent do not have sewerage reticulation and treatment systems and, where these do exist, they are often confined to central business districts and high-income areas. In light of this situation, developers and individual households provide their own sanitation facilities (Strande et al. 2018; Tayler 2018). The inadequate sanitation infrastructure leads to pollution that compromises ecosystem integrity.

In an era of increasing water shortages, projections are already pointing to a dire global situation by 2030, with reduced availability of water resources for human and environmental needs. In addition, it is now increasingly becoming accepted that reuse of water – for various applications in different contexts – is an inevitable component of the world's water future.

The SDG 6 Synthesis Report on Water and Sanitation indicates that a modelling exercise showed that pollution of water resources, measured using the biochemical oxygen demand (BOD), increased between 1990 and 2010 because of growth in wastewater loadings into rivers and lakes (United Nations 2018b). There are limited data on the treatment of wastewater and faecal sludge in developing countries, despite these issues being important at the global level (Strande et al. 2014). Data on on-site treatment of wastewater is yet another area requiring attention. Freshwater quality is reported to be at risk globally and is worsening in Asia, Africa and Latin America (United Nations 2018b).

1.5 Sustainable Sanitation and Wastewater Management

1.5.1 Transitioning to the 2030 Agenda and Agenda 2063

The MDGs to Agenda 2063/SDGs Transition Report of 2016 acknowledges the convergence of Africa's Agenda 2063 and the SDGs (AU et al. 2016). The report argues that the adoption of the 2030 Agenda and Agenda 2063 provides Africa with a unique opportunity to take forward and complete the unfinished business of the MDGs, as both agendas provide the foundation for African countries to develop and strengthen their national long-term development visions (AU et al. 2016). Integrating the two agendas and ensuring that the countries' national development plans are aligned to the two developmental agendas will promote policy coherence and reduce the risk of duplication, as well as the burden of reporting on the two agendas separately (AU et al. 2016).

While cohesion depends on the extent to which African Member States understand the relationship between the global and continental agendas, there is also a need for:

- Enhanced integration and coordination of institutional arrangements for implementation of the two agendas
- Strengthened capacities for data collection and analysis and
- Development of a monitoring and evaluation system that is horizontally (sectoral) and vertically (national versus subnational) integrated (AU et al. 2016).

The Transition Report states:

> *Adoption of the two Agendas signals a two-pronged transition: a global-level transition from the MDGs to Agenda 2030 and a continent-level transition from NEPAD [New Partnership for Africa's Development] to Agenda 2063. Both Agendas are comprehensive, underpinned by an extensive consultation process, and share common aspirations of structural transformation and sustainable development. However, the two Agendas are not identical. Implementing them will require effective messaging about their content, coherent integration of both into national planning frameworks and an integrated results framework for follow-up (AU et al. 2016).*

1.5.2 The fourth industrial revolution and innovation

More than 30 of the world's 48 least developed countries are in Africa. The continent is on an industrialization drive, with all of its regional economic communities having identified industrial development as an important objective in their founding treaties, and most adopting explicit industrial development strategies. The African Union adopted the Plan of Action for the Accelerated Industrial Development for Africa in 2008, while the United Nations General Assembly adopted a resolution declaring 2016 to 2025 to be the Third Industrial Development Decade for Africa. Despite the importance that African leaders attach to industrial development on the continent, evidence indicates that most African economies do not yet have diversified industrial sectors, and that some of the early industrializing countries are de-industrializing (Stuart 2016).

In light of the environmental pressures that the continent is facing, the need for cleaner and more efficient production technologies has never been greater. There are already growing challenges from emerging contaminants and the impact of industrial flows on ecosystem integrity is well documented (Brooks et al. 2006). Innovation in all its forms and its uptake are therefore needed more than ever before.

The immense possibilities offered by big data and its associated expertise and capabilities, smart systems and artificial intelligence offer possibilities for improving sanitation and wastewater management in Africa. The SDG 6 Synthesis Report (United Nations 2018b) acknowledges the role that smart technologies could play. This calls for cross-sectoral collaboration to capitalize on these possibilities. Furthermore, Africa needs to urgently position itself to take advantage of these emerging opportunities and take its place on the global development platform. While there are many industrialization

Significant efforts are needed to ensure that wastewater is safely treated and economic opportunities for Africa, lack of infrastructure and water can be a stumbling block. In recent years, the World Economic Forum has identified water as a threat to economic development. As such, Africa needs to not only secure water supply for all its inhabitants' well-being but also to remain a competitive economic player (WEF 2019).

As shown in Box 1.1, efforts are under way in Africa to embrace information technology in the provision of sanitation services as well as improved wastewater management.

Box 1.1. Using technological applications to support the water and sanitation sector in Africa

Background

Information and communication technologies (ICT), in the form of mobile phones, are readily available in Africa, where mobile network subscriptions surpass those of wired connections (Baelden and Van Audenhove 2015). It has been suggested that ICT has the potential to support "the development strategy of 'leapfrogging', some of the processes of accumulation of human capabilities and fixed investment in order to narrow the gaps in productivity and output that separate industrialized and developing countries" (Steinmueller 2001). In particular, ICT can support crowdsourcing (Howe 2006a; Howe 2006b) and crowdsensing (Ganti et al. 2011) approaches, which consist of "taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call" (Howe 2006a).

These approaches have been applied to the development of smart cities (Kumar et al. 2018; Han and Hawken 2018); open and smart governance systems (Millard 2018; Barns 2018; Certomà et al. 2015); urban planning (Shen and Karimi 2016); geospatial data and hydro-geology (Nik-Bakht and El-Diraby 2016); infrastructure management (Ogie et al. 2018); flood monitoring (Wang et al. 2018); transportation planning (Majumdar 2017); wetland management (Sinclair et al. 2018); and energy planning (Bazilian et al. 2012).

For the particular case of water and sanitation services across Africa, "ICTs can be a key enabler for institutional transformation to address the demand for improved services for both rural and urban communities" (Ndaw 2015). ICT tools have been piloted to test their ability to address some of the most pressing challenges that the continent is facing, in particular the collection and storage of good-quality data to enable better decision-making; informing and giving a voice to the people; creating a driving force for safer and more affordable water and sanitation services; and simplifying payments.

Collect and store good-quality data

Data regarding water and sanitation service coverage are rarely readily available and are often gathered through city-wide household surveys that are typically funded by foreign donors – an approach that may not be sustainable in the long term. Furthermore, the quality of such data is sometimes questionable, given the low capacity and/or engagement of field operators. A permanent solution for gathering good-quality data would therefore greatly serve local decision makers and experts.

One such project is PULA, a VIA Water funded project, which is aiming to completely develop an app in Maputo for desludgers in Mozambique and Zambia that will gather valuable geo-referenced data regarding desludging practices and patterns across cities. These data will include location and type of systems, size of the household, emptying periodicity and emptied volume to support decision makers in improving sanitation planning and regulation and in better designing faecal sludge infrastructure, such as transfer stations and treatment plants. This will make a significant contribution towards achieving universal access to safe sanitation services in both cities.

The developers have identified two user groups: the desludgers and the (government) institutions that will need the data generated by the app.

Operating at a different stage of the service chain to PULA, another sanitation-related project is the Office National de l'Assainissement du Senegal's (National Sanitation Office of Senegal, ONAS) call centre for desludgers in Dakar, Senegal. The plan was for this call centre to boost usage of the more expensive, but more sanitary, mechanized desludging method. Unlike the typical situation whereby a household contacts a desludger directly, under this system households contact ONAS and then the various desludgers that are interested bid for the job. According to ONAS, households appreciate the ease of finding an emptying operator via the call centre, are satisfied with the service monitoring and compliance commitments, and typically recommend the call centre to neighbouring areas. On the other hand, operators (desludgers) appreciate the ease of using the call centre in connecting with customers, and also recognize that they learn more about how to deal with customers (location, timing, etc.).

Inform and give a voice to (urban) populations

The Mozambican company UX introduced MOPA, a Mozambican platform for participatory monitoring of the delivery of public urban services, including solid waste management. Using the platform, any citizen in Maputo can report on outstanding issues, such as full containers and overflowing garbage via their mobile phone, the app or the project's website. The problems reported in MOPA are passed on to municipal authorities and service providers, who use this information to optimize garbage collection routes and collection infrastructure and plan urgent actions. When the problem is resolved, the citizen receives a confirmation SMS. All problems, including outstanding issues, can be consulted on the project's website.

Similar to PULA, Map Action is an initiative that allows users to report issues related to water and sanitation in the city of Bamako, such as leaking water distribution pipes, non-functional standpipes and clogged or overflowing channels. Reporting is carried out through a mobile application and a preliminary analysis of each problem assesses its impact and severity. The information made available gives stakeholders involved in the water, sanitation and hygiene sector better insight into the current situation in the city.

Accra's increased urbanization has led to very frequent, dangerous flash floods, the effects of which a flash flood forecasting and communication app aims to minimize. Some areas of the city are flooded several times a year during the wet season, often with flash floods that arrive quickly and are dangerous, especially during the night. The aim of this project was to develop a flash flood warning system based on modern rain and hydrological models.

Create a driving force for safer and more affordable water and sanitation services

The PULA initiative also supports entrepreneurs in managing their truck fleets and in offering better and safer desludging services. The app will allow real-time tracking of all trucks in the fleet and direct communication between the owner, the truck driver and the requesting household.

The ONAS call centre has resulted in more affordable desludging services. It puts households in contact with several desludgers, who enter into a bidding process which has been shown to drive down the costs of the service. Furthermore, as expected, the reduced cost of the desludging jobs had led to an increase in terms of both the requests made to formal operators and the amount of faecal sludge treated at the designated treatment plant.

Countries will not meet their sanitation goals if toilets are not accessible to everyone, including children and the disabled

1.5.3 Pan-Africanism, politics and transboundary cooperation

The growing wave of pan-Africanism is an opportunity for shared regional agendas and cross-fertilization of ideas for innovation. The aspirations of the African people as set out in Agenda 2063 offer opportunities for collaboration that will accelerate progress towards the global development indicators, while transboundary platforms provide an opportunity to accelerate the pace in individual countries to work towards shared goals. Such transboundary cooperation requires political stability so that national goals and targets can be realized, and disruption of services such as sanitation and safe drinking water avoided.

Transboundary water resources management plays a key role in tackling pollution. For example, the East African Community Lake Victoria Basin Commission works to prevent the discharge of polluted wastewater into shared Lake Victoria. With the aim of achieving adequate clean water supplies, improving hygiene and environmental sanitation, and improving urban drainage for 15 towns in the lake basin, and financing from the AfDB, this commission has supported the construction of water treatment plants, toilets and water reticulation systems (East African Community Lake Victoria Basin Commission 2016).

1.5.4 Toilet revolution

It was estimated that in 2015, one in three people (2.3 billion) worldwide still used unimproved sanitation facilities, including 892 million people who still practised open defecation (Cheng et al. 2018). According to Cheng et al. (2018), "Even in urban areas, where household and communal toilets are more prevalent, over 2 billion people use toilets connected to septic tanks that are not safely emptied or use other systems that discharge raw sewage into open drains or surface waters."

There is a growing drive to develop and implement sanitation systems that respond to the environmental and socioeconomic challenges of not only Africa but also the rest of the world, including the need to protect the natural environment. One notable initiative is the Bill & Melinda Gates Foundation's Reinvent the Toilet Challenge, which brought to the fore possibilities for the next-generation sanitation system. Innovative efforts must also respond to the barriers that have emerged around reuse technologies on the continent, including unlocking the nutrient and energy potential in human excreta.

In setting highly desirable standards for 'on-site' sanitation systems, the recently finalized International Standard on 'Non-Sewered Sanitation Systems – Pre-fabricated integrated treatment units: General safety and performance requirements for design and testing' (ISO 30500) goes a long way towards addressing a number of challenges associated with contamination from pit latrines, poor management of excreta and the protection of human health.

1.5.5 Energy, food and water nexus

It is clear that Africa needs to produce more food in order to sustain the livelihoods of its growing population. There are opportunities for green design in an urbanizing Africa, where it is becoming increasingly apparent that a new norm is needed – one that invariably capitalizes on the energy, food and water nexus. Smart and resilient urban agriculture, in addition to nature-based solutions in cities and human settlements in general, present opportunities for the continent. Much of today's urban agriculture in Africa is watered with wastewater. A study by Njenga et al. (2011) established that the majority of households in Kenya's Kibera and Maili Saba owned an average of 2,000 square metre plots on which they grew food, used wastewater and also polluted the water with pesticides and chemical fertilizers.

Public toilets need a regular supply of water and their use must be affordable to all

1.6 Conclusion

The baseline metrics that are available for Africa with respect to progress on SDG 6 indicate that there is still an enormous amount of work to be done and resources that need to be invested for Africa to achieve the set targets. With a young and growing population, the effects of missing these targets would be catastrophic for the continent, including damage to its natural environment and ecosystems. Failure to roll out safely managed sanitation systems would lead to an unchecked increase in the amount of untreated wastewater that is released into the natural environment, making the risk of disease very high.

As a water-poor region, Africa must embrace opportunities for innovation in not only economic development, but also in the way services such as sanitation and safe drinking water are delivered. The continent must invest in the necessary policies, infrastructure and human skills capacities to operationalize actions towards the achievement of goals and targets in the 2030 Agenda, including those for sustainable sanitation and wastewater management.

Protected wells will ensure water is not contaminated by human and natural activities

2

WASTEWATER STREAMS

2.1 Introduction

Wastewater is a combination of one or more of: domestic effluent consisting of blackwater and greywater; effluent from commercial establishments; industrial effluent, storm water and other urban run-off; and agricultural, horticultural and aquaculture effluent, either dissolved or as suspended matter (Sato et al. 2013). Population growth, urbanization and economic activities have resulted in an increase in wastewater volumes across the world, with this trend expected to continue (Sato et al. 2013), including in Africa, which has experienced the highest population growth rate in the world of 2.51 per cent during the period 2000–2015 (United Nations Department of Economic and Social Affairs [UNDESA] 2019).

A growing economy coupled with changing lifestyles on the continent has resulted in increasing water consumption and discharge of wastewater, causing extensive pollution (Omosa et al. 2012). The wastewater streams responsible for the bulk of water pollution in Africa can be classified as municipal wastewater, agricultural wastewater, industrial wastewater, urban storm water run-off and hospital wastewater (Wang et al. 2014; Laffite 2016). The release of untreated or partially treated wastewater into the environment contaminates freshwater ecosystems, threatening food security, access to safe drinking and bathing water, and posing a major health and environmental management challenge (Corcoran et al. 2010).

According to United Nations estimates, the current population of Africa (measured in 2017) is around 1.3 billion. This is expected to reach 1.7 billion by the year 2030, 48.4 per cent of whom will be living in urban areas (UNDESA 2017). The quality of various water resources in Africa is expected to deteriorate further in the coming decades, which will increase threats to human health and the environment unless something is done to manage the generated wastewater appropriately.

The discharge of wastewater into water bodies is one of the major sources of pollution

2.2 Municipal Wastewater and Faecal Sludge

2.2.1 Sanitation coverage

The percentage of the population with access to improved sanitation varies between countries in Africa. Improved sanitation facilities ensure that human excreta is hygienically separated from human contact, for example: cistern flush/ pour flush (to piped sewer system, septic tank, pit latrine), ventilated improved (VIP) latrine, pit latrine with slab, and composting toilet (World Health Organization [WHO]/United Nations Children's Fund [UNICEF] 2013). While 90 per cent of North Africa's population has access to improved sanitation facilities, sub-Saharan Africa has startlingly low coverage, at 30 per cent. This is a serious concern because of the associated massive health burden, as many people who lack basic sanitation engage in unhygienic activities such as open defecation and poor wastewater disposal.

Most people in Africa rely on on-site sanitation facilities such as pit latrines and septic tanks, which generate faecal sludge that may require emptying when full. Less than 20 per cent of the population in sub-Saharan Africa is connected to a sewerage network, which is mainly found in urban high-income areas (Strande 2014). Connection to sewers or on-site sanitation technologies depends on a number of factors, such as the availability of a sewer network in the vicinity of a household, a household's income status, and connection to water supply, as discussed in Table 2.1.

Sewered sanitation depends entirely on water supply, making connection to sewers expensive compared to the average incomes of most households. For example, in Accra, Ghana, more than 45 per cent of households preferred a ventilated latrine to a water-flushed toilet, because the former does not depend on water, is simple and is less vulnerable to breakages (Obeng et al. 2015). The situation is similar in other African countries such as Uganda, Senegal, Burkina Faso, Rwanda, Kenya, Tanzania and Malawi.

Both on-site sanitation facilities and sewerage systems are potential sources of pathogens, organic matter and nutrients, which need to be well managed, as explained in Table 2.1. Poor sanitation management is one of the root causes of many diseases that afflict Africa, leading to high infant and maternal mortality rates (Fuhrimann et al. 2014) and contributing to stunted growth.

Untreated wastewater exposes people to health risks due to infection from germs such as salmonella, dysentery and hepatitis

Open defecation is a result lack of basic sanitation facilities

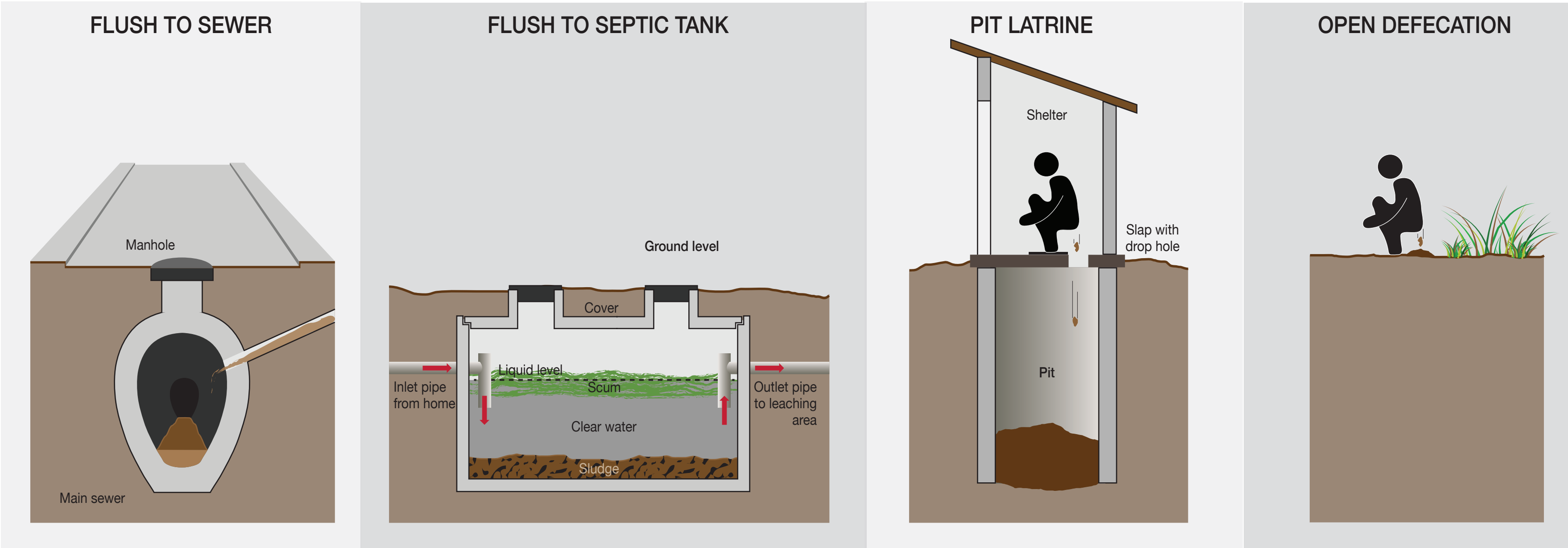


Figure 2.1. Visual presentation of existing household sanitation facilities in Africa

Table 2.1. Overview of existing household sanitation facilities in Africa

	Flush to sewer	**Flush to septic tank**	**Pit latrine**	**Open defecation**
Use: • Geographical	Preferably where there is a constant downhill gradient to maintain self-cleansing flows.	Appropriate in urban/peri-urban areas where there is a way of disposing of the effluent and at a location where an emptying truck can easily access it. This is the preferred option for waterborne sanitation in areas where there is no sewer network.	Two options: (1) Unlined pits that allow infiltration, applicable in areas with a low water table; and (2) Lined latrines with sealed walls and bottom to prevent infiltration, applicable in areas with a high water table and/or congested areas.	Common in areas where people are too poor to build latrines, lack government support in providing such facilities or where there are cultural issues related to sharing toilets.
• Number of people	City or municipality level	Household and institutional level	Household level	Individual level (Not recommended)
Common location	Urban	Urban/peri-urban	Rural/peri-urban	Not recommended
Typical: • Positives (+)	+ Very hygienic and comfortable for users + Greywater and storm water can be managed concurrently, where applicable + Can handle grit and other solids, as well as large volumes of flow	+ Simple and robust technology + No electrical energy is required + Low operating costs + Long service life + Small land area required (can be built underground)	+ Built and repaired using locally available materials + Low capital costs + Small land area required	
• Negatives (–)	– Very high capital costs; high operation and maintenance costs – A minimum velocity must be maintained to prevent the deposition of solids in the sewer – Requires deep excavations – Difficult and costly to extend when a community changes and grows – Requires expert design, construction and maintenance – Leakages pose a risk of wastewater exfiltration and groundwater infiltration and are difficult to identify	– Regular emptying should be ensured – Effluent and sludge require further treatment and/or safe disposal	– Flies and odours are normally noticeable – Potential groundwater contamination – High emptying costs – Secondary treatment/ management of sludge required	– Could easily lead to outbreak of communicable diseases such as cholera, typhoid and diarrhoea – Causes air and water pollution when human faeces are washed away during the rainy season

Table 2.1. Overview of existing household sanitation facilities in Africa *(continued)*

	Flush to sewer	Flush to septic tank	Pit latrine	Open defecation
'Externals' required for the system to work	• Presence of a centralized treatment facility • Planning, construction, operation and maintenance requires expert knowledge • Coordination between authorities, construction companies	• Requires a constant source of water • Regular emptying of the system • Treatment plant for secondary treatment of faecal sludge	• Land to dig new pits for unlined latrines • Regular emptying of lined pit latrines • Treatment plant for secondary treatment of faecal sludge	Not applicable
Personal knowledge required	• Flush with water after use • Avoid disposal of used sanitaryware such as pads and diapers in toilets • Regular cleaning • Wash hands after use	• Flush with water after use • Avoid disposal of sanitaryware such as pads and diapers in toilets. • Regular cleaning • Wash hands after use	• Regular cleaning • Wash hands after use	• Awareness of the dangers of open defecation to human health and the environment
Typical contaminants	Pathogens, nutrients, organic matter, solids, heavy metals, micropollutants	Pathogens, nutrients, organic matter, solids, scum	Pathogens, nutrients, organic matter, solids	Pathogens, nutrients, organic matter, solids
Use of treated water	• Liquid fraction after treatment can be used for irrigation purposes in agriculture	• Safely managed groundwater recharge	• Solid fraction of sludge used for energy recovery, building material and animal protein	Not applicable
Economic opportunities	• Employment in operation and maintenance of the plant and network system	• Service provision jobs (i.e. emptying) • Construction of the tanks	• Service provision jobs (i.e. emptying) • Construction of the latrines	Not applicable
Where does wastewater end up and who is affected?	• Wastewater transported by sewers to treatment plant • Effluent discharged to mainly water bodies • Often affects the water body users and staff at the plant	• From the septic tank, it goes through soak pits to the surrounding soils • Any possible contamination of groundwater affects nearby communities • When full facilities are emptied, the effluent is discharged into water bodies	• Leachate ends up in soils surrounding unlined pits • Lined pits can be emptied and treated at the plant, where the effluent joins water bodies • Some African countries next to oceans directly discharge untreated sludge into the ocean	• Ends up in the fields/ surrounding environment • Affects communities near fields where open defecation is practised
Recharge	• Treated effluent can potentially recharge groundwater	• Effluent from soak pit can potentially recharge groundwater	• Leachate highly polluted, hence not permitted to join groundwater	Not applicable
Policies, regulations and institutional frameworks	• Presence of regulating bodies on effluent discharge • Standards on discharge of treated effluent are available in many African countries • Presence of government organizations responsible for wastewater transport and treatment	• In some African countries, standards are available for design, location and construction • Standards are poorly enforced in many countries • Municipal authorities are responsible for on-site sanitation	• In some African countries, standards are available for design, location and construction • Standards are poorly enforced in many countries • Municipal authorities are responsible for on-site sanitation	• A UNICEF strategy to eliminate open defecation by 2030
Cost	• Capital costs of US$42.6/ capita/year • Operating costs of US$11.98/ capita/year	• Capital costs of US$4.05/ capita/year • Operating costs of US$ 7.58/ capita/year	• Capital costs of US$1.5 to 4.0/ capita/year	Not applicable

Sources: Mara (1982); Dodane et al. (2012); Tilley et al. (2014)

2.2.2 Conveyance of wastewater and faecal sludge

After generation, wastewater is transported to the treatment plant through a system of sewers. Sewer collection systems can either be separate or combined. In the latter case, municipal wastewater is transported together with the storm water to the treatment plant (Metcalf and Eddy 2003). Combined sewers are practical in African countries because of their relatively low costs and ease of maintenance compared to separate collection systems. However, combined sewers frequently overflow during wet seasons, flooding streets and increasing people's exposure to pathogens. The risk of overflows poses a challenge since most of the countries in Africa have both dry and wet (averaging five months a year) seasons, with some receiving in excess of 1,000 mm annual rainfall (Hoscilo et al. 2014).

Since over 80 per cent of the population in sub-Saharan Africa depends on pit latrines and septic tanks, these often get full, and the options available are either to abandon the existing facilities and dig new pit latrines or to empty and reuse the existing facilities (Strande 2014). Emptying is done with the help of a number of technologies, which are chosen based on the accessibility of the sanitation facilities, income levels and the nature of the faecal sludge. Mechanized technologies such as vacuum emptying trucks are commonly used where facilities are easily accessible and faecal sludge is emptiable (i.e. limited presence of solid wastes and facilities are lined, such as septic tanks or lined pit latrines) (Thye et al. 2011). On the other hand, manually aided technologies such as the Gulper hand pump have proved useful for emptying thick sludge from unlined pit latrines in Uganda, Tanzania (Case study 2.1), Zambia and South Africa. Faecal sludge is loaded onto a vehicle or tricycle after manually aided emptying and transported to the treatment plant. However, there are reports of some truck operators in Ghana and Senegal disposing of sludge in the manholes leading to wastewater treatment plants or directly into the environment, such as oceans, in order to save on the costs charged at treatment plants (Murray et al. 2011; Obeng et al. 2015).

2.2.3 Treatment of wastewater and faecal sludge

Wastewater and faecal sludge require treatment so that the contaminants in them reach an acceptable level before they are discharged into receiving environments such as lakes, rivers or oceans, without having huge negative repercussions on the environment. Discharge standards for treated wastewater vary between African countries, although not significantly. Where reuse practices are permissible, treatment of wastewater and faecal sludge will depend on the anticipated qualities of the end product. For example, if wastewater is to be used for irrigation, treatment should aim to retain certain nutrients required by the plants.

Wastewater and faecal sludge can either be co-treated or separately treated (Strauss et al. 1997). Even before 2000, most African countries had wastewater treatment plants in operation. The most common method is co-treatment of faecal sludge in wastewater treatment plants. However, this is done without considering the properties of faecal sludge, which is reported to be between 10 and 100 times more polluted than wastewater (Strauss et al. 1997). This leads to a number of treatment plants failing to meet the required effluent standards, for example in South Africa (Kengne et al. 2015). Co-treatment plants that consider faecal sludge properties are currently being designed, for example in Kampala, Uganda and Kumasi, Ghana. Treatment plants that treat only faecal sludge are in operation in, for example, Senegal, Burkina Faso, Ghana, Malawi and Cameroon.

The discharge of faecal sludge, even in volumes as low as 0.25 per cent strong faecal sludge in the total sewage flow, can easily lead to high contaminant loads (such as solids, chemical oxygen demand [COD] and nitrogen) that exceed the designed plant capacity. These can result in increased operational costs and severe operational problems such as incomplete carbon removal, termination

Case Study 2.1. Pit latrine emptying in Tanzania using the Gulper

Tanzania's capital city, Dar es Salaam, is one of Africa's fastest-growing cities and is predicted to soon become a megacity. The city has over 4 million inhabitants, 70 per cent of whom reside in informal settlements where homes are closely packed together along narrow streets, with limited access to basic services. Over 90 per cent of the population rely on on-site sanitation facilities for their excreta disposal, of which 32 per cent are unimproved. When toilets are full, several parts of these areas can only be accessed by small vehicles and some homes are accessible only on foot. This makes it difficult for large mechanized emptying trucks to empty sanitation facilities in several locations. Gulper technology has therefore been introduced, whereby faecal sludge is emptied using buckets and transported to the treatment plant using tricycles. A business model considering the operator's operating costs, fuel and dumping fees leaves a net profit of about US$14 per day per tricycle. Profit would increase if decentralized faecal sludge treatment systems were constructed to serve nearby informal settlements and transfer stations were built to minimize distances and operation costs.

Source: Reuter and Velidandla (2017)

Some contaminants are removed from wastewater through treatment processes of nitrification, high sludge generation, decreased aeration capacity for aerobic systems and severe overloading of secondary settling tanks, leading to loss of solids. Furthermore, faecal sludge has high concentrations of soluble unbiodegradable organics and nitrogen compounds, which can have a serious effect on the treated effluent quality and, in turn, compliance with the required effluent standards (Strande 2014).

Adding faecal sludge to pre-existing municipal sewage treatment plants has had limited success, but co-treatment could provide an alternative for the faecal sludge generated in towns where specialized treatment plants are not available. The allowable faecal sludge volumes will need to be restricted to low volumes so that sewage treatment plants are not overloaded. Additionally, faecal sludge loading needs to be added gradually and as slowly as possible to avoid shocks and overloads (Strande 2014). For newly designed faecal sludge treatment plants, consideration of co-treatment with sewage could help reduce concentrations of faecal sludge, reduce loads on infrastructure and hence improve treatment performance.

2.2.4 Challenges in wastewater and faecal sludge treatment

Several challenges influence the operation of wastewater and faecal sludge treatment plants, including:

- Population increase has led to insufficient infrastructure capacity to cope with increasing wastewater and faecal sludge loads. If there is a large gap between wastewater collection and treatment capacity, a substantial part of untreated wastewater is released into the environment, for example from the Camberene wastewater treatment plant in Senegal. Release of insufficiently treated wastewater into the environment also happens when treatment plants are dysfunctional or temporarily disconnected, which is common in Ghana, for example.

- Most wastewater treatment plants in Africa receive pollution loadings that they were not designed for (e.g. from industrial discharges) due to non-enforced regulations. These loadings can compromise the treatment processes, which could eventually lead to poor performance of plants.

- Financial challenges in all African countries negatively affect the construction (for example, unfinished wastewater treatment plants in Morocco (Mandi and Ouazzani 2013)), operation and maintenance, or upgrading of wastewater treatment plants.

- There is limited skilled human capacity and motivation to maintain the treatment plants. This, in addition to pollutants overloading, results in treatment plants often delivering effluent of insufficient quality, which not only causes complaints from stakeholders, but also poses a risk to public health and the environment.

- Operation and maintenance of plants in all African countries are faced with high energy costs.

- There is inadequate regulation and enforcement of laws in many countries in Africa.

Lack of waste collection services forces people to dump waste in undesignated places

2.2.5 Disposal of wastewater and faecal sludge

There is little information on sludge handling practices, although it is suspected that most of the sludge accumulates on site at treatment plants. This is true of the plants surveyed in South Africa, which are still dominated by on-site disposal methods, including direct land application and stockpiling sludge on site (Snyman 2002). Regulations on treatment standards and effluent discharge requirements differ between African countries and are not always enforced on a regular basis. Upstream enforcement of regulations (e.g. for the industries connected to the sewerage system) is almost non-existent in most African countries.

Case Study 2.2. Eutrophication of Lake Victoria

At 68,800 km^2, Lake Victoria is Africa's largest freshwater lake, whose shoreline is shared by the East African states of Kenya (6 per cent), Uganda (45 per cent) and Tanzania (49 per cent). Pollution, mainly resulting from increased human activities such as discharge of wastes, has resulted in severe eutrophication and dramatically low dissolved oxygen levels, with up to half of its 500+ species of endemic cichlid fish likely to become extinct. Eutrophication-related loss of deep-water oxygen started in the early 1960s, and is believed to have contributed to the 1980s collapse of indigenous fish stocks by eliminating suitable habitat for certain deep-water cichlids. The Kenyan side of Lake Victoria has high organic loads from municipal wastewater, exceeding those from combined industrial wastewater for all the riparian countries bordering the lake. Management policies should be directed primarily towards reducing pollution from municipal wastewater discharges. Through effective operation of existing treatment facilities alone, organic loads on the Kenyan side could be reduced by 50 per cent. Such continuing degradation of Lake Victoria's ecological functions has serious long-term consequences for the ecosystem services it provides and poses a threat to social welfare in the countries bordering its shores. Policies for sustainable development in the region, including restoration and preservation of the lake's ecosystem, should therefore be directed towards improved land-use practices and control of discharges of untreated or poorly treated wastes.

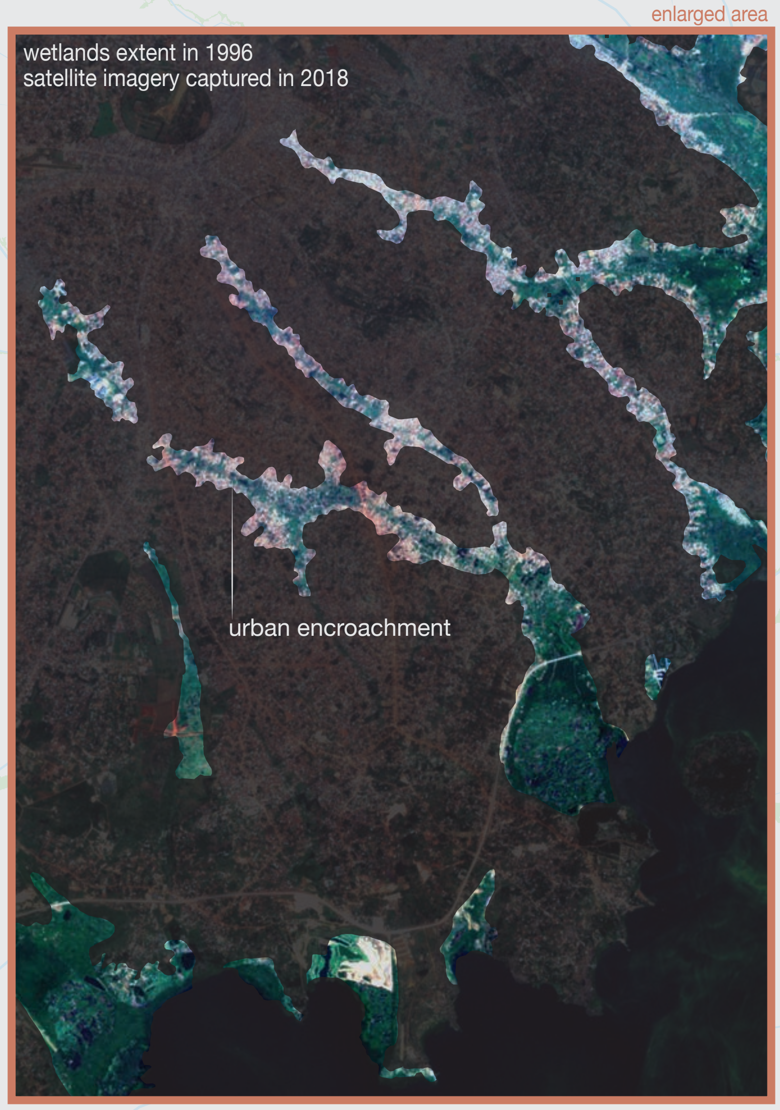
Sources: Verschuren et al. (2002); Scheren et al. (2000)

Pollution in the Murchison Bay, Lake Victoria

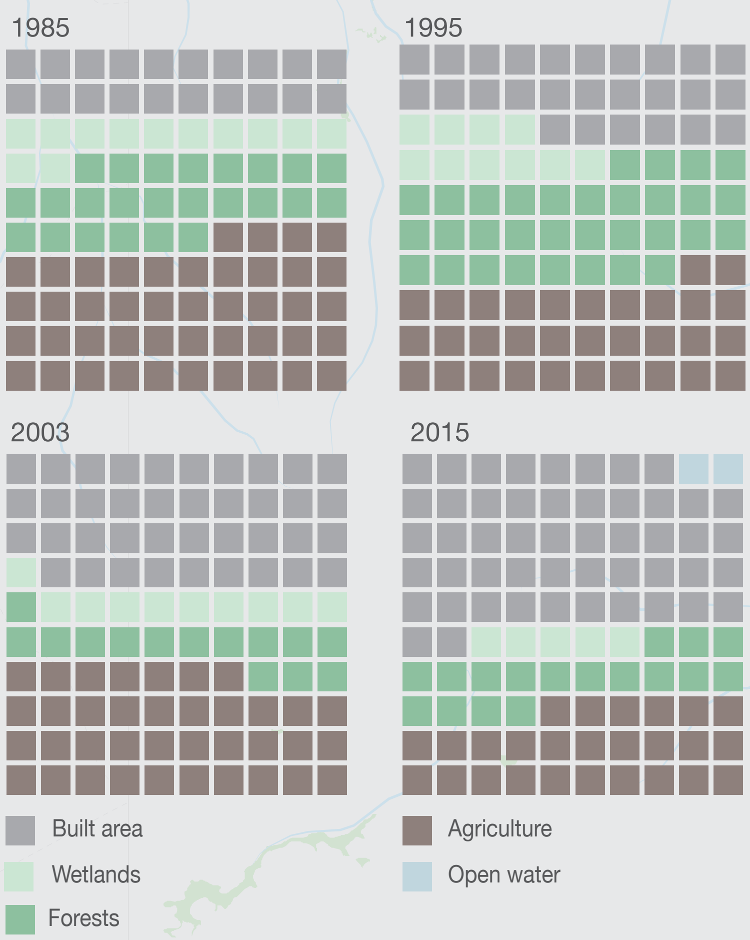
Algal blooms are a natural phenomena, but the species that bloom are not all native. In the Murchison Nay algal blooms are driven by an increase in nutrient loading of the lake caused by point pollution and non-point pollution .

imagery: sentinel data captured 04 feb 2018

enlarged area



Land use and land cover in the Murchison bay catchment area:

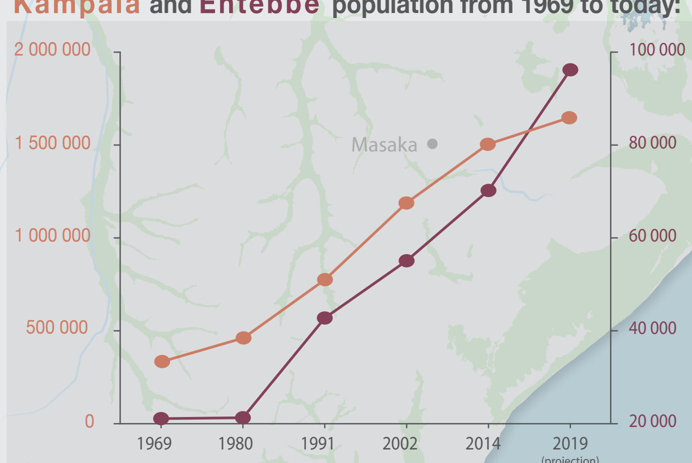


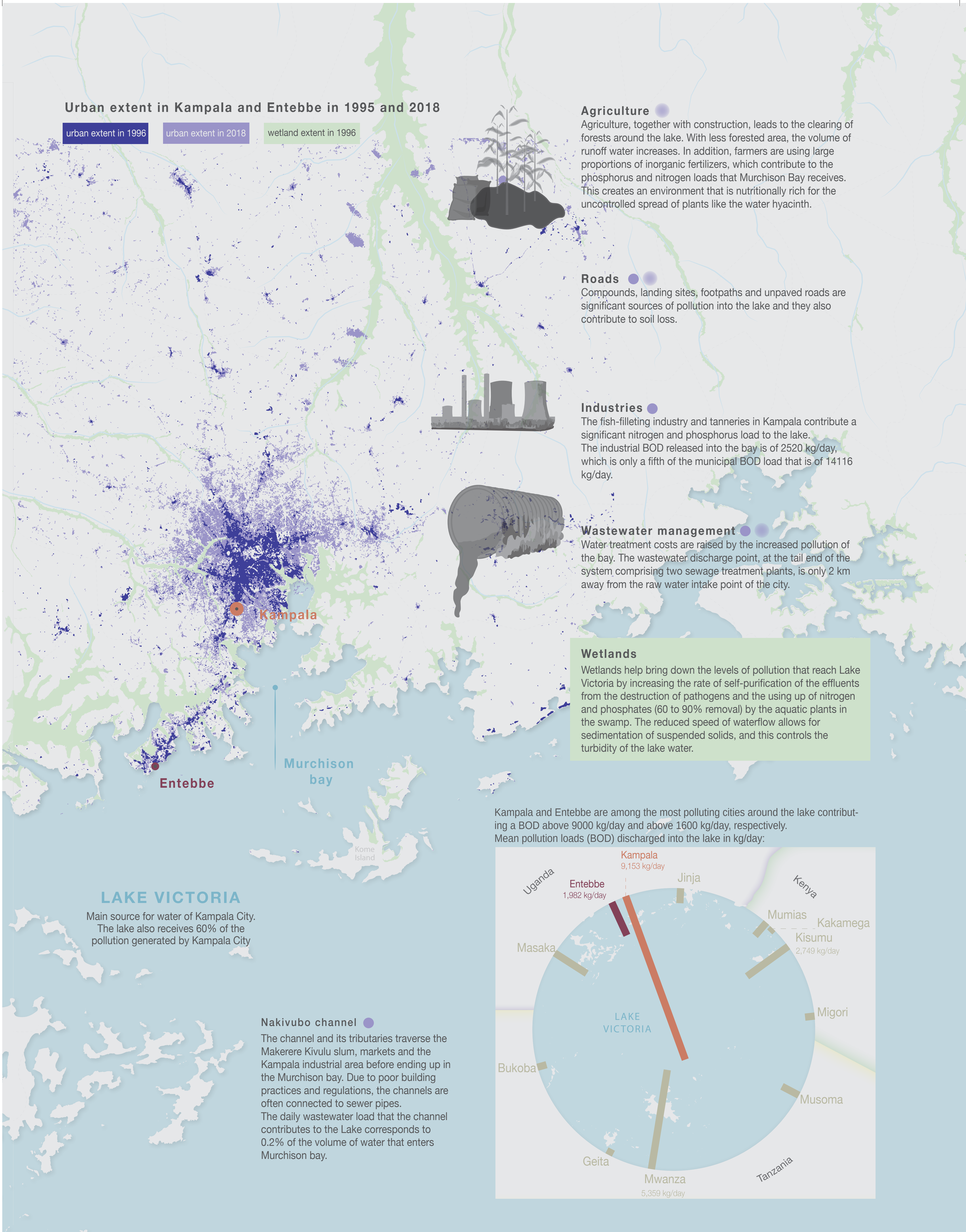
Urban expansion

The expansion of the builtup areas in Kampala, Entebbe as well as surrounding smaller settlements is causing the loss of forested and wetland area, and increasing imprevious surfaces, which in turn increases runoff and reduces the capacity of the land to absorb pollution.

The population of Kampala and Entebbe has more than quadrupled in the last 50 years. However, the wastewater treatment infrastructure has not expanded at the same pace.

Kampala and Entebbe population from 1969 to today:




Urban extent in Kampala and Entebbe in 1995 and 2018
urban extent in 1996
urban extent in 2018
wetland extent in 1996
Agriculture
Agriculture, together with construction, leads to the clearing of forests around the lake. With less forested area, the volume of runoff water increases. In addition, farmers are using large proportions of inorganic fertilizers, which contribute to the phosphorus and nitrogen loads that Murchison Bay receives. This creates an environment that is nutritionally rich for the uncontrolled spread of plants like the water hyacinth.
Roads
Compounds, landing sites, footpaths and unpaved roads are significant sources of pollution into the lake and they also contribute to soil loss.
Industries
The fish-filleting industry and tanneries in Kampala contribute a significant nitrogen and phosphorus load to the lake.
The industrial BOD released into the bay is of 2520 kg/day, which is only a fifth of the municipal BOD load that is of 14116 kg/day.
Wastewater management
Water treatment costs are raised by the increased pollution of the bay. The wastewater discharge point, at the tail end of the system comprising two sewage treatment plants, is only 2 km away from the raw water intake point of the city.
Kampala
Wetlands
Wetlands help bring down the levels of pollution that reach Lake Victoria by increasing the rate of self-purification of the effluents from the destruction of pathogens and the using up of nitrogen and phosphates (60 to 90% removal) by the aquatic plants in the swamp. The reduced speed of waterflow allows for sedimentation of suspended solids, and this controls the turbidity of the lake water.
Murchison bay
Entebbe
Kome Island
LAKE VICTORIA
Main source for water of Kampala City. The lake also receives 60% of the pollution generated by Kampala City
Nakivubo channel
The channel and its tributaries traverse the Makerere Kivulu slum, markets and the Kampala industrial area before ending up in the Murchison bay. Due to poor building practices and regulations, the channels are often connected to sewer pipes.
The daily wastewater load that the channel contributes to the Lake corresponds to 0.2% of the volume of water that enters Murchison bay.
Kampala and Entebbe are among the most polluting cities around the lake contributing a BOD above 9000 kg/day and above 1600 kg/day, respectively.
Mean pollution loads (BOD) discharged into the lake in kg/day:
Kampala
9,153 kg/day
Uganda
Entebbe
1,982 kg/day
Jinja
Kenya
Mumias
Kakamega
Kisumu
2,749 kg/day
Masaka
LAKE VICTORIA
Migori
Bukoba
Musoma
Geita
Mwanza
5,359 kg/day
Tanzania

Case Study 2.3. Wastewater discharge and reuse in Addis Ababa (Ethiopia)

Most wastewater generated in Addis Ababa (about 35.5 million cubic metres of wastewater annually) is disposed of in the rivers and streams flowing through the city, such as the Akaki River, which many people also use to irrigate their vegetables. The main concerns are water pollution and the health hazards related to the use of untreated wastewater for irrigation purposes. Studies have reported increased prevalence of intestinal illnesses among farmers as river pollution worsens, although awareness-raising and protective clothing have been shown to have a significant positive impact on farmers' health. In addition, industrial wastewater discharges such as from coffee refineries have greatly contributed to the deterioration of river water quality, for example in rivers in south-western Ethiopia (Ejeta and Haddis 2016). The regulatory framework on pollution in Ethiopia is inadequate to solve the increasing water quality deterioration problems. Moreover, the "implementers of the existing policies are not fully aware of the policies and their inefficiency to avert the reported pollution status". There are current efforts to ensure that future expansion of Addis Ababa meets environmental standards. For example, the city's Riverside Project will be developed along the city's two river systems in such a way that sanitary conditions are met.

Sources: Bahri et al. (2008); Ejeta and Haddis (2016); Awoke et al. (2016)

Traditional beliefs and laws are often used to guard against use of wastewater to irrigate root crops

Common methods for wastewater disposal in African countries include evaporation and evapotranspiration; surface water (oceans, rivers or lakes) discharge; subsurface wastewater infiltration (soakaways); land application; and natural/constructed wetlands. Subsurface soil absorption through soakaways is the best and most commonly applied method of wastewater disposal for single dwellings/on-site waterborne treatment facilities in Africa because of its simplicity, stability and low cost. These are usually covered excavations filled with porous media, with a means for introducing and distributing the wastewater throughout the system (United States Environmental Protection Agency [USEPA] 2002). However, usage of such systems is challenging in areas with highly permeable soil, since insufficiently treated wastewater can easily reach the groundwater table.

Effluents from treatment plants and raw wastewater generated near water bodies such as rivers, lakes, oceans and seas are often discharged with or without treatment, as Figure 2.2 shows. For example, countries such as Ghana, Morocco, Tanzania and Senegal reportedly discharge treated and/or to a larger extent untreated (raw) wastewater into water bodies (Qadir et al. 2010). It is reported that over 60 per cent of the sludge collected – partially untreated – from on-site sanitation facilities in Ghana is dumped directly into the ocean (Murray et al. 2011; Obeng et al. 2015). Such practices pollute water bodies and increase risk to public health.

As Figure 2.2 shows, in the majority of cities in Africa, less than 30 per cent of the population is connected to sewers, largely relying instead on on-site sanitation facilities. When the facilities are full, some are left unemptied (i.e. 'contained') and abandoned. Only a small fraction of the emptied sludge is reported to be treated and safely discharged or used. A greater fraction is

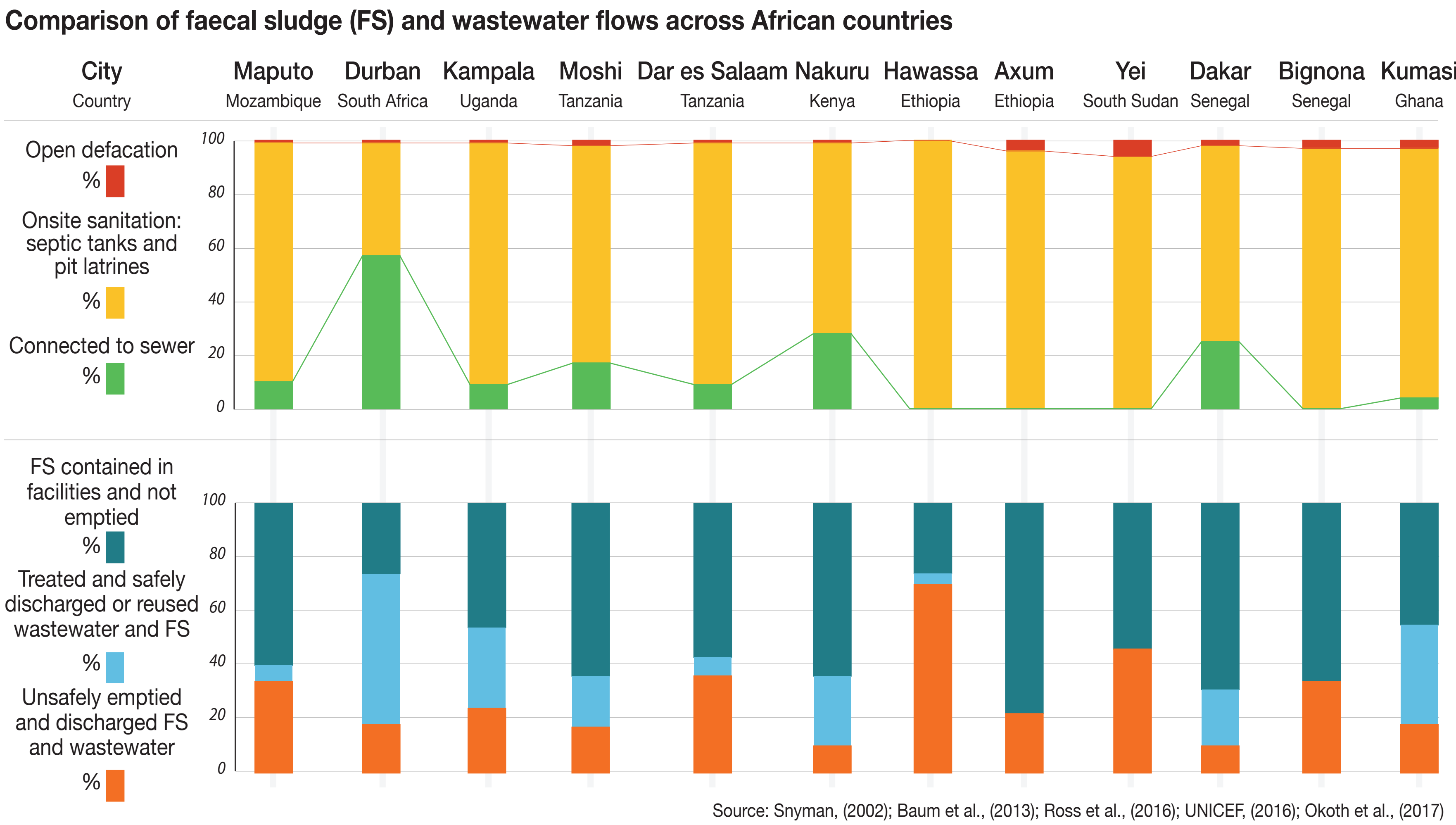


Figure 2.2. Comparison of faecal sludge and wastewater flows across African countries

In an attempt to avoid paying fees, private waste emptiers often dump raw sewage into water boides

Case Study 2.4. Faecal sludge disposal in Hawassa, Ethiopia

In Hawassa, great attention is given to providing and promoting toilet facilities. The current extent of 'treatment and disposal' of faecal sludge is on-site, where containment relies on local soils continually absorbing leachate from pits and septic tanks. This may be satisfactory for now, but as the city becomes more densely populated and soil infiltration capacity is eventually surpassed, increased risks of localized surface ponding of effluent and pit collapse are expected. Residents' concerns over decreasing space to build new pits and natural conditions – such as areas prone to flooding and a high water table – make such on-site sanitation facilities difficult to sustain. To improve faecal sludge management services in Hawassa as a whole, the extent to which sewerage must be implemented in high-density areas and areas where on-site facilities constitute a clear risk to polluting Lake Hawassa needs to be investigated. Where on-site systems are to remain, a greater variety of small-scale faecal sludge emptying options (such as the Gulper for low-income areas) should be explored. Steps also need to be taken to identify and plan for the future land requirements of more conveniently located treatment plants, including co-located wastewater treatment and faecal sludge treatment plants, that can incorporate market-based end-use options of treated sludge.

Source: Scott et al. (2016)

emptied and unsafely discharged into drainage channels, residential areas and receiving waters and onto land. Unhygienic disposal practices not only expose people to risk of diseases, but they also contaminate the environment. This is a major challenge when it comes to cities with no access to wastewater or faecal sludge treatment facilities.

2.2.6 Use of municipal wastewater and faecal sludge

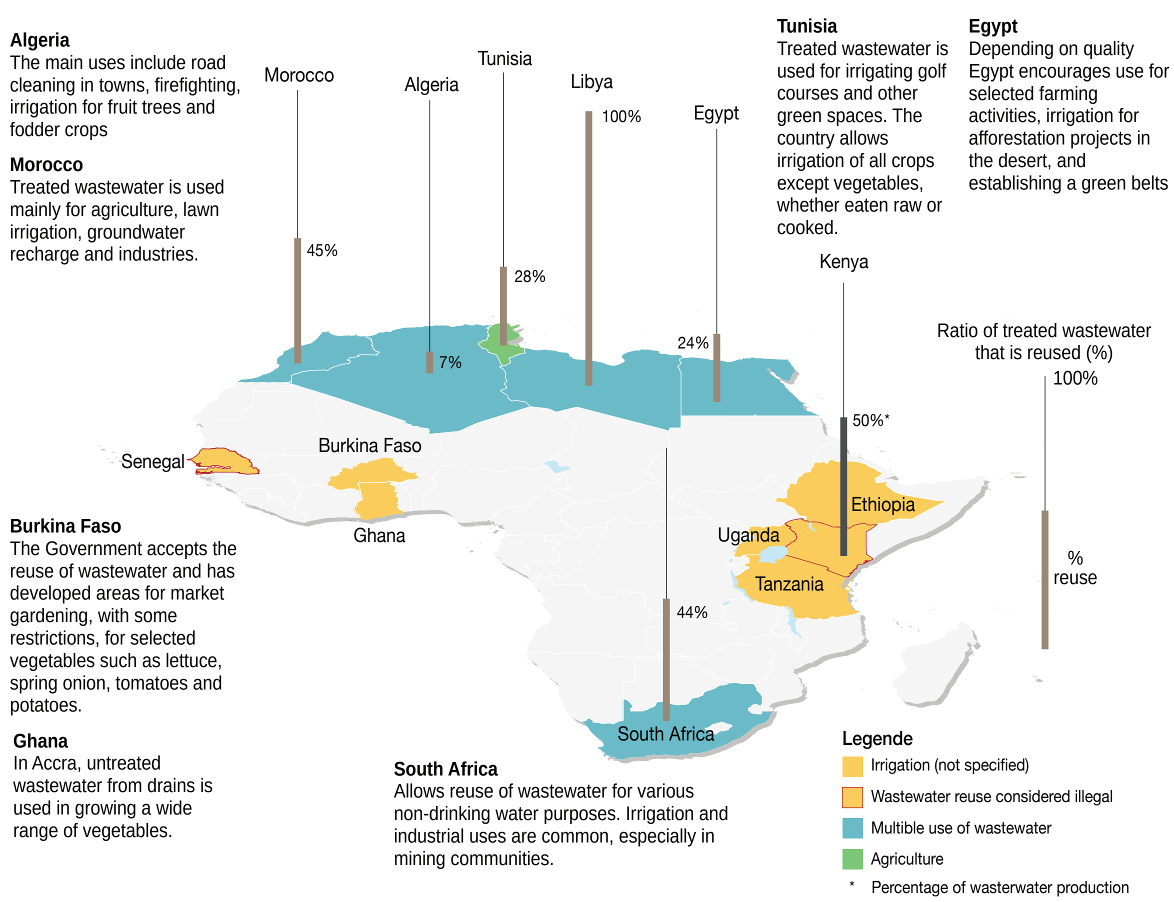
Dewatered sludge and effluent from municipal wastewater are considered a renewable resource from which water, energy (from anaerobic digestion processes) and fertilizers are derived (Bennamoun et al. 2013). Some African countries have ventured into innovative uses of dewatered sewage sludge/faecal sludge (Herselman et al. 2008), such as:

- generation of compost for crop production,
- production of fuel such as biogas or briquettes for energy recovery,
- bricks from dewatered sludge,
- bricks, cement, and artificial aggregates from sludge, and
- use of vermin (worms) or black soldier fly larvae to produce animal feeds (mainly protein) and compost residue.

An important issue in sludge use is the accumulation of pollutants such as heavy metals including lead, cadmium, zinc and mercury; toxic chemicals such as insecticides, pesticides and pharmaceuticals; and microplastics. Such pollutants are mainly found in sewage sludge (as opposed to faecal sludge), which occasionally receives industrial wastewater (World Health Organization [WHO] 2016). These pollutants often pose considerable health risks and are difficult to control or eliminate. Toxic chemicals and heavy metals may persist and potentially accumulate in water, soils and livestock (Samolada and Zabaniotou 2014).

The World Health Organization [WHO] (2016) recommends characterizing sewage/faecal sludge

Trends in wastewater reuse in selected countries



Sources: Adewumi et al. (2010); Bahri et al. (2008); Fatta-Kassinos et al. (2016); Herselman et al. (2008); International Water Association [IWA] (2018); Korbéogo (2017).

Figure 2.3. Trends in wastewater reuse in selected countries

Countries across Africa have different guidelines for the reuse of wastewater

before use to determine the type and concentration of pollutant(s). This is followed by assessing the suitability of using sludge as a soil conditioner, where the maximum tolerable soil concentrations of various toxic chemicals and heavy metals based on human health protection must not be exceeded.

Wastewater effluent reuse (before or after treatment) varies significantly within Africa and is influenced by a number of factors such as the area's aridity; population's proximity to the wastewater source; retrofitting versus new installations; quantity of reuse; pricing; source quality; public health; political will; public trust and knowledge; and regulations and guidelines for reuse in the particular country. In some countries, wastewater reuse is practised without much legal control. For example, in Accra, Ghana, untreated wastewater from drains is used in growing a wide range of vegetables. In Burkina Faso, the Government accepts the reuse of wastewater and has developed areas for market gardening, with some restrictions, for selected vegetables such as lettuce, spring onion, tomatoes and potatoes (Korbéogo 2017). In Senegal, wastewater reuse is not always practised, even though there is the potential for it. Reasons include the unsuitable location of the treatment plants, making the treated wastewater inaccessible to potential users.

The biggest challenges surrounding the acceptability of wastewater reuse are observed in North Africa. Egypt encourages it for selected farming activities, depending on its quality. Although officially Morocco limits this practice to agriculture, in practice 45 per cent of treated wastewater in Morocco is reused, mainly for lawn irrigation, groundwater recharge and by industries. In Tunisia, it is used for golf courses and for irrigating other green spaces. In Algeria, the main uses include road cleaning in towns and firefighting (Adewumi et al. 2010; Fatta-Kassinos et al. 2016).

Regulations in Tunisia allow the use of treated wastewater irrigation on all crops except vegetables, whether eaten raw or cooked (Bahri et al. 2008). However, rigorous by-laws should be developed for use by relevant authorities to permit and monitor appropriate wastewater uses. In Kenya and Senegal, wastewater reuse is considered illegal, although it is widely practised (Herselman et al. 2008). South Africa's Water Services Act of 1997 has no objection to the reuse of wastewater for various non-drinking water purposes. The country also has guidelines on wastewater sludge management (Herselman et al., 2008).

2.2.7 Policies and regulatory frameworks for wastewater and faecal sludge

In most African countries, there are few national guidelines on managing faecal sludge at on-site sanitation facilities. Guiding documents have been developed on an international scale, using experiences from African countries such as Ghana and Senegal. These include the strategic planning of faecal sludge management developed by the Department for Sanitation, Water and Solid Waste for Development at the Swiss Federal Institute of Aquatic Science and Technology (Eawag) (Klingel et al. 2002). In the majority of low-income sub-Saharan African countries, effluent discharge legislation and standards (with a focus on wastewater) exist, although they are rarely enforced. There is therefore a gap between the guidelines for disposal and reuse of faecal sludge and the treatment products. WHO has developed several guidelines that can be adopted in African countries without national guidelines. These include: use of excreta in agriculture (WHO 2006); sanitation safety planning to assess the acceptable risk of using soil conditioner from faecal sludge (WHO 2016); and sanitation interventions along the faecal sludge management chain, in order to protect the public from the associated health impacts (WHO 2018).

Poor management of waste and wastewater creates conditions that are favourable for disease outbreaks

Case Study 2.5. **Regulatory and institutional framework for scaling up faecal sludge management in Kenya**

The Water Act, 2002 was passed in Kenya to introduce institutions to govern water and sanitation. Under this law, which was revised in 2016, the Ministry of Water and Irrigation set up several institutions, including the Water Services Regulatory Board and Water Services Providers. The Ministry developed a paper to guide implementation of sanitation services, where the Water Services Providers (mandated water and sanitation service providers in urban areas) were to take the lead in implementation, including strengthening faecal sludge management services. The Water Services Regulatory Board was set up to provide guidelines for solid and liquid waste management. The Water Services Providers were expected to take on the role of faecal sludge management, but argued that they were responsible for only municipal wastewater and not faecal sludge management. Also, the Water Services Providers did not possess the required emptying trucks to provide the service, leaving the faecal sludge management services largely to the private sector, with the public sector's role being reduced to regulation and oversight.

Source: Okoth et al. (2017)

Case Study 2.6. **Regulation of faecal sludge management in Cameroon**

Expertise in urban sanitation in Cameroon is scattered or overlaps between different ministries and different municipalities (urban council and district municipalities), without well-coordinated operational structures. Existing policies are general and tend to focus on governing environmental and community health management, without specifically mentioning liquid and waste sanitation. There are overlapping sanitation roles, with the Ministry of Urban Development and Housing and the Ministry of Town Planning both involved in sanitation. This overlap hinders the collection, removal and treatment of waste – activities that also fall under the jurisdiction of the municipalities. Similarly, the Ministry of Energy and Water is involved in wastewater management, control and maintenance of sanitation facilities.

Source: Global Water Partnership and World Bank (2011)

In most urban centres, there is a lack of clearly assigned duties and responsibilities for stakeholders to manage faecal sludge. An organizational structure and staff responsibilities would play a role in improving faecal sludge management in African countries. Although some countries have documented regulations to be followed by private emptiers of latrines and septic tanks, there is reluctance to monitor the operators to ensure proper adherence to these regulations. Data with regard to toilet coverage, toilet typology and number of households are often lacking in many cities, including Yaoundé, Cameroon (Letah Nzouebet 2018), and this hinders effective planning of faecal sludge management. The assessment of the initial situation, which is the first step in the planning process for such management, is crucial as it provides baseline information for decision-making. The main goals of this initial assessment are to set the scene, understand the context, get to know the stakeholders and provide enough information to start elaborating the faecal sludge management scenarios, including context-specific design parameters. Therefore, this stage is characterized mainly by data collection via various means (Parkinson et al. 2011).

Municipal wastewater collection, transportation and treatment are generally regarded as public services. Hence they attract far more public finance by way of capital and recurrent subsidies compared to faecal sludge management, which is seen as a private good, whereby commercial services are provided directly to users. Attempts to make faecal sludge management services profitable in the private sector may render the service too expensive for key beneficiaries and owners of sanitation facilities (Scott et al. 2016).

The infrastructure for waste management in many parts of Africa is either inadequate or broken

2.3 Industrial Wastewater Management

Typical industries that generate significant amounts of wastewater in Africa include mining, pulp mills, tanneries, textiles and food and beverages

Water is an important daily requirement for industrial processes, with the global industrial demand for water for the year 2017 estimated at 5.5 billion m^3 (Thierno and Asplund 2009). As such, industry generates a substantial proportion of wastewater. Africa's industry is still underdeveloped, with a slow rate of growth in most countries, particularly in terms of manufacturing as Figure 2.4 shows. Only a few African countries have significant industry, and these include South Africa, Egypt, Morocco and Tunisia (United Nations 2012). Industrial wastewater discharge can contain a wide range of contaminants. Typical industries in Africa that generate the biggest portion of toxic waste include mining, pulp mills, tanneries, textiles, food and beverage, sugar refineries, oil production and pharmaceutical production.

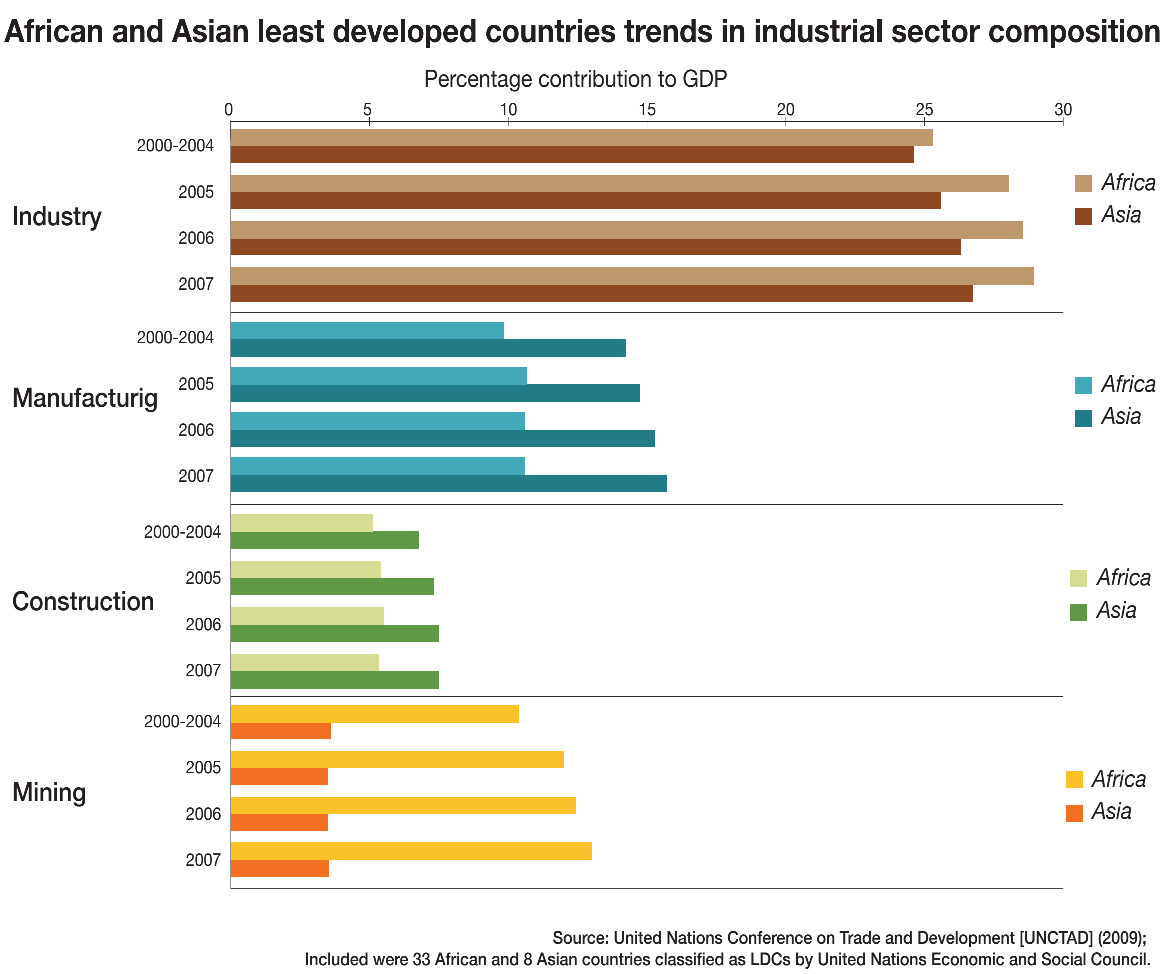


Figure 2.4. African and Asian least developed countries (LDCs)*: Trends in industrial sector composition (2000-2007) – Percentage contribution to GDP

2.3.1 Regional trends in industrial wastewater management

Wastewater management is the process of taking wastewater and treating/managing it in order to reduce the contaminants to acceptable levels so as to be safe for reuse or discharge into the environment (United Nations Economic and Social Commission for Asia and the Pacific [ESCAP], United Nations Human Settlements Programme [UN-Habitat] and Asian Institute of Technology [AIT] 2015). Key practices of the wastewater management process include water conservation and water and wastewater quality

Case Study 2.7. Impact of industrial effluents on water quality of streams in Nakawa-Ntinda, Uganda

A study was undertaken in 2009–2010 to investigate the physicochemical parameters of streams that receive effluents from industries in the Nakawa-Ntinda industrial area of Kampala and drain the area into the Kinawataka wetlands, which are linked to Lake Victoria. Industries in this area include fish filleting, food and beverages, plastics, chemicals, pharmaceuticals, iron and steel, and paints. At the time of the study, none of the industries had an effluent treatment plant. Untreated effluents from these industries were discharged into the streams, posing a threat to these streams, Lake Victoria and public health through downstream water usage (washing vehicles, laundry, irrigation of vegetables, drinking (wildlife) and recreation).

The water quality of the sampled streams confirmed that they were recipients of wastewater discharges. For example, they contained high levels of organic content (BOD5 and COD values of up to 326 mg/l and 1351mg/l, respectively), total dissolved solids (up to 4.6dS/m), apparent colour (up to 958 TCU), total nitrogen (up to 33 mg/l), metals (lead and copper up to 0.256mg/l and 0.52mg/l, respectively). Wastewater from the food and beverage industries did not comply with the national (Uganda) effluent discharge standards with regard to the aforementioned parameters (apart from heavy metals), while chemical and pharmaceutical industries did not comply with the discharge standards as regards heavy metals.

This study reveals a scenario that is typical of most industries in developing countries where environmental regulations are not effectively enforced. To avoid pollution, regulatory authorities should closely monitor industries' compliance with related regulations.

Source: Walakira and Okot-Okumu (2011)

Trends in industrial effluent management in African regions

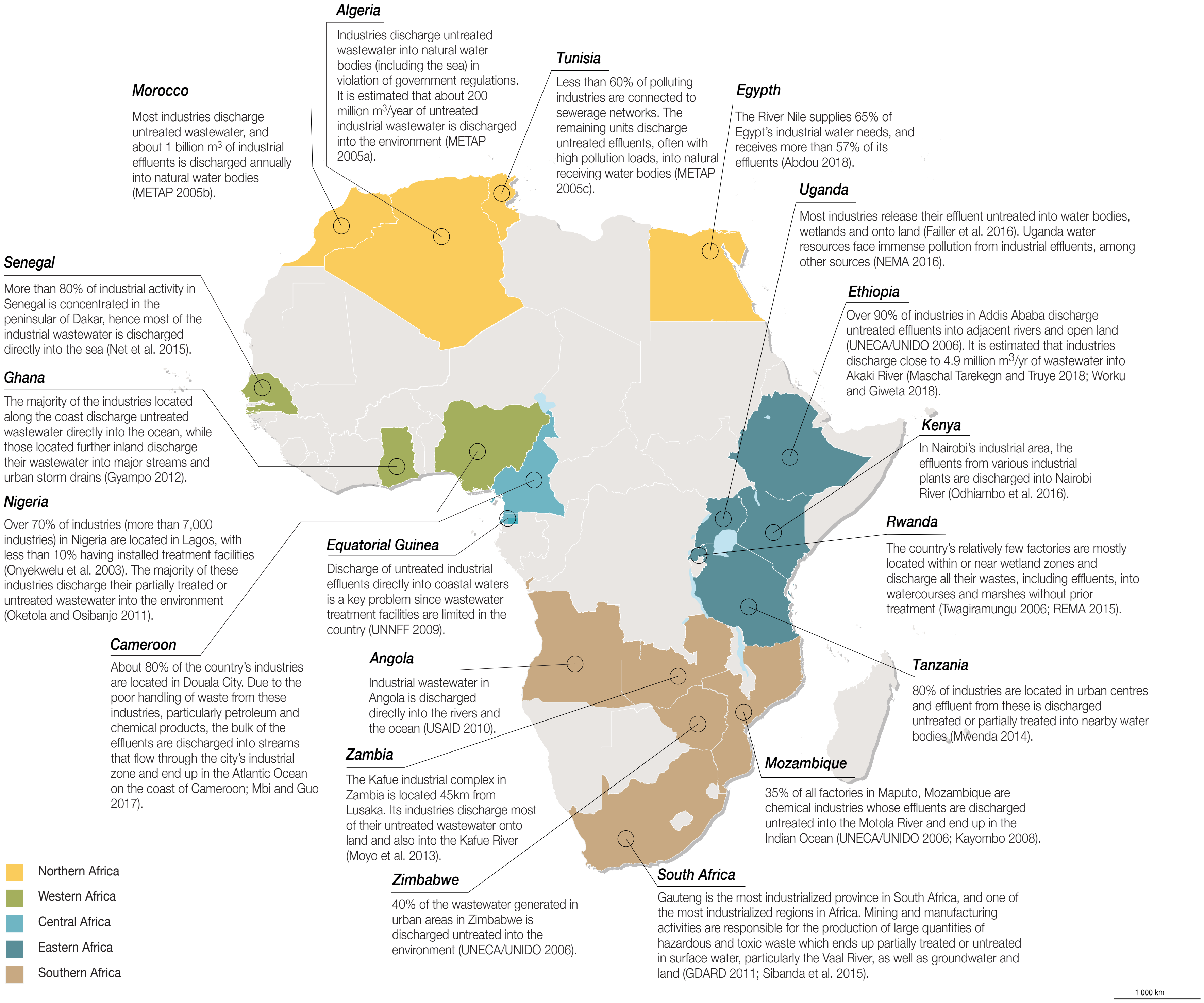


Figure 2.5. Industrial effluent management in African regions

monitoring (International Financial Cooperation [IFC] – World Bank [WB] Group 2007). In Africa, most industries discharge their effluents untreated into water bodies and onto open land (see Figure 2.5), contributing to pollution of these resources. Most of the water bodies around some cities in Africa are the end points of such effluents. For example, industrial effluents have been reported to be one of the main pollution sources of Lake Victoria in Uganda (Muwanga and Barifaijo 2006). Unfortunately, information on the quantities and qualities of these discharged effluents is unavailable for most countries in Africa. Where wastewater treatment plants exist, the treatment is often inefficient either due to poor design, construction or poor operation and results in discharge of inadequately treated effluents.

The industrial wastewater treatment process (physical, chemical and biological) removes pollutants and organic matter from wastewater. The aim of this treatment is to produce an effluent (and sludge)

The low electricity generation capacity in many African towns and cities negatively affects wastewater treatment

Table 2.2. Effluent characteristics of key industries in Africa and wastewater treatment and reuse

Industries in Africa	**Textile**	**Pharmaceutical production**	**Pulp and paper**	**Tanneries**	**Food and beverage**	**Sugar refineries**
Amount of water use*	0.5 to 300 cubic metres/tonne of cotton and 4–84 cubic metres/ tonne of synthetic textile wet finishing operations (Shakih 2009)	About 200 cubic metres per day (for annual capacity of 700 million packets of tablets, 130 million capsules; 297 cubic metres syrup mill vials, 79 mill ampoules; and 32 tonnes ointment at full capacity utilization) (Development Studies Associates [DSA] 2008)	About 150 to 250 cubic metres per tonne of product (Central Pulp and Paper Research Institute [CPPRI] 2008)	34–56 cubic metres/tonne of raw hide (conventional technology) (Infogate/GTZ 2002)	0.2 to 1,000 cubic metres/day (Kayode et al. 2018)	Approx. 2 cubic metres per tonne of cane crushed (Gunjal and Gunjal 2013)
Characteristics (quality, key pollutants present) **	pH, total suspended solids (TSS), true colour, biodegradable organic matter (BOD5 and COD), phenols, and heavy metals (Pb, chromium (VI), Cd, Zn, Ni, Fe, Cu)	BOD5, COD, pH, true colour, pharmaceuticals and emerging contaminants	BOD5, COD, true colour, total suspended solids, chlorinated organic compounds	pH, suspended solids, true colour, total dissolved solids (TDS), biodegradable organic matter (BOD5 and COD), total kjeldahl nitrogen (TKN), chromium (IV), oil and grease, sulphates, chlorides	pH, TSS, BOD5, COD, nitrogen	BOD5, COD, pH, TDS, nutrients, oil and grease, true colour, suspended solids, total nitrogen, total volatile solids, sulphates
Treatment options	Constructed wetlands (Stefanakis 2018) Primary treatment which involves physicochemical processes (grit removal, oil and grease removal, flocculation, coagulation and ozonation) followed by secondary treatment (biological processes under aerobic or anaerobic conditions e.g., stabilization ponds, advanced oxidation processes). Lastly, tertiary treatment (e.g. electrodialysis, reverse osmosis and ion exchange) (Ghaly et al. 2014).	Sewage treatment plants (primary, secondary and biological processes) can partly remove pharmaceuticals (Lockwood et al. 2016). Ozone/ granular activated carbon combination is found to be effective in removing most antibiotics (Guillon et al. 2015).	Integrated systems that use a combination of either two physicochemical processes; a physicochemical and a biological process; or two biological processes. Physicochemical treatment (sedimentation, ultra-filtration, flotation, screening, coagulation and flocculation, ozonation and electrolysis) and biological treatment (activated sludge and aerated lagoons, Upflow Anaerobic Sludge Blanket [UASB] reactor) (Ashrafi et al. 2015).	Pre-treatment – physicochemical (grease removal, sulphide removal, chromium precipitation), primary treatment (equalization, chemical treatment, sedimentation), biological treatment (primary or chemical with extended aeration and/or nitrification and denitrification, and constructed wetlands (Stefanakis 2018)	A combination of biological (secondary activated sludge, anaerobic digestion) and physical chemical treatments (flotation, coagulation, sedimentation, filtration, adsorption, membranes, primary settling) (Cotruvo 2018)	Pre-treatment (grease removal), primary treatment (equalization – first stage stabilization pond), biological treatment (aerobic lagoon or anaerobic contact process/ UASB reactor/ anaerobic filter followed by waste stabilization ponds) (Kushwaha 2013) The treatment scheme that seems to be the most economical consists of anaerobic pre-treatment followed by aerobic polishing (Macarie and Le Mer 2006).

* Water consumption varies drastically, depending on the type of applied technology (conventional or advanced) (Infogate/GTZ 2002)
** Characteristics of industrial effluents vary greatly and depend upon the size of the industry, chemicals used for specific processes, amount of water used and type of final product produced.

of the appropriate quality to be released into the environment or reused. The requirements for the treatment and effluent quality are established in the legislation of each country (United Nations Environment Programme [UNEP] 2015). Table 2.2 highlights the effluent characteristics of key industries in Africa and uses for wastewater following treatment.

Wastewater reuse is associated with several benefits, including the reduction of pollution ending up on land and in water sources. The benefits and details on estimates of the potential of waste streams in Africa such as water, nutrients and energy can be found in Chapter 6 on the circular economy.

Table 2.2. Effluent characteristics of key industries in Africa and wastewater treatment and reuse *(continued)*

Industries in Africa	Textile	Pharmaceutical production	Pulp and paper	Tanneries	Food and beverage	Sugar refineries
Wastewater uses or by-product	Sludge can be used as a building material (flooring tiles, solid and pavement blocks, and bricks) (Balasubramanian et al. 2006). Treated effluent water (using microfilters and advanced membrane technologies [with higher investment cost] and natural material zeolite to change hardness and conductivity) can be used in the textile finishing processes, without a negative impact on the product (Erdumlu et al. 2012).	Aquifer recharge (Lockwood et al. 2016)	The treated wastewater can be recycled for reuse in the pulp and paper industry, if its quality permits (Ashrafi et al. 2015)	Tannery effluents are largely not used because of the potential risks to public health, agriculture and livestock (Adewumi and Oguntuase 2016). Recovery is undertaken for chrome and biogas generation.	Recovery of methane (biogas) for energy, treated residues can be used as soil amendments or fertilizers (Cotruvo 2018).	Wastewater with simple anaerobic treatment can be reused for washing cane or for irrigating crops (Macarie and Le Mer 2006).

Waste stabilization ponds are designed to remove organic matter and pathogens from wastewater

2.3.2 Regulation of industrial effluents

Governments enact mainly environmental quality and pollution mitigation legislation to regulate discharges from industry, with the primary purpose being to control pollution of the receiving environment. Criminal sanctions are often used in the event of non-compliance with the conditions issued on an effluent discharge permit, in order to discourage pollution. The legislation is enforced through administrative structures (Edokpayi et al. 2017). Several laws and policies geared towards protecting the environment from industrial activities exist in African countries, including in South Africa (Edokpayi et al. 2017), Uganda (Kulabako and Okurut 2014), Ethiopia (Ghebretekle 2015), Nigeria (Ladan 2016) and Algeria (Gherbi 2012). Additionally, these countries subscribe to global environmental goals on water resources management that seek to protect freshwater resources, including the Johannesburg Plan of Implementation (Paragraph 25d) and the UN Convention on the Law of the Sea, article 196 (Paragraph 1) to prevent marine pollution (UNEP 2016).

The fact that Africa is still facing challenges in managing waste streams, including the industrial pollution of its water resources, exposes a glaring gap between the existence of laws and policies and the reality of their implementation. Enforcement of industrial pollution control legislation in most African countries remains inadequate and, as in other developing regions, suffers major setbacks due to the dire need for industrialization to create jobs and foster economic development (which might be hampered by the costs of pollution control to the private sector); inadequate technical experts to deal with pollution from the manufacturing sector; insufficient funds for the construction, operation and maintenance of effluent treatment plants as well as monitoring; low deterrent effects of fines and other penalties; and lack of collaboration among regulatory institutions (Ghebretekle 2015; Edokpayi et al. 2017). There are ongoing efforts to address these issues in some African countries, such as the Pollution Task Force in Kampala, Uganda, as explained in Case study 2.8.

Off-site conveyance systems for excreta, faecal sludge and wastewater serve multiple households

Case Study 2.8. Kampala Pollution Task Force

The Kampala Pollution Task Force was established by the Kampala Capital City Authority as part of the Reform of the Urban Water and Sanitation Sector Programme in 2012. Kampala Capital City Authority coordinates this multi-institutional task force. Members include the Directorate of Water Resources Management, the National Environment Management Authority and the National Water and Sewerage Corporation – institutions responsible for the regulation of water resources, environment and municipal wastewater management, respectively. Uganda Manufacturers Association and Uganda Cleaner Production Centre were brought on board in order to improve engagement with the industrial sector through a public–private dialogue regarding cleaner production and improved resource recovery and reuse efficiency, with a focus on water, waste and energy optimization.

The task force's key priorities are to establish a platform for information exchange and collaboration among key government agencies and the public and private sectors regarding legal provisions and regulations on wastewater discharge and pollution control; to initiate campaigns to increase industrial compliance with permit regulations regarding wastewater discharge; to conduct joint industrial assessments and disseminate pollution monitoring information to the public and private sectors; to engage major polluters and the public sector in a public–private dialogue on wastewater management and pollution control as a way of increasing awareness and trust; and to encourage stakeholders to act as partners of Government and its agencies by promoting transparency in policymaking, regulation and enforcement.

Since its inception, the Pollution Task Force has assessed 37 industries every quarter for pollution control and monitoring compliance. The task force offers subsidized cleaner production audits to polluting industries to support them in identifying their main pollution sources and affordable mitigation measures. At least eight industries have taken up this offer since 2016. Every year, the Pollution Task Force holds a public–private dialogue with industries (the Public–Private Kampala Wastewater Dialogue) on wastewater management and pollution control to share and discuss experiences, successes, challenges and potential solutions for sustainable industrial development and environmental sustainability. In 2016, the Pollution Task Force launched the Kampala Green Industry Campaign, a competitive and incentive-based approach to contribute to the improvement of industrial practices regarding safety, environmental pollution control, waste management, water and energy conservation, recycling and reuse within Kampala City. The task force provides capacity-building for its members, such as study tours and training in inspection and monitoring.

Source: Kampala Capital City Authority [KCCA] (2019)

2.4 Hospital Wastewater Management

Hospital wastewater contains significant amounts of hazardous chemicals and organic and mineral materials, with its pathogenic load making it one of the most important sources of water resources pollution (Meo et al. 2014). This wastewater is generated from discharges from medical wards and operating theatres, including body fluids, excreta and anatomical waste; from laboratories whereby the waste includes microbiological cultures, which can be infectious agents; from pharmaceutical and chemical stores; from cleaning operations; and from X-ray development facilities (Aththanyaka et al. 2014; Aukidy et al. 2017). Hospital wastewater may also result from waste management technologies and techniques, including autoclaving, microwave irradiation and chemical disinfection.

2.4.1 Characterization and quantification of hospital wastewater

The quantity and characteristics of hospital wastewater vary between and within African countries depending on the size of establishments, proportion of in- and out-patients, type of institution and specialization, available waste collection options, wealth of users, and the country's prosperity. For example, privately owned hospitals constitute close to 90 per cent of hospitals in many African countries, while the rest are state-owned (Meo et al. 2014), some of which are more concerned with maximizing profits than waste management.

There are very few studies on hospital wastewater in Africa, hence the limited data on its characteristics and management. Studies from countries such as Nigeria, Morocco, South Africa, Congo, Egypt and Ethiopia show that hospitals generate large amounts of wastewater, estimated at 362 to 745 litres per occupied bed per day (Meo et al. 2014). As already mentioned, this wastewater contains high levels of organic matter, pathogens and heavy metals such as copper, chromium, lead, cadmium, mercury, nickel and zinc. A number of hazardous compounds contained in hospital wastewater such as ammonia can lead to fish mortality, while organic compounds (such as polycyclic aromatic hydrocarbons) and heavy metals persist in the environment and accumulate in dangerous concentrations. Chemical emerging contaminants, such as pharmaceuticals and personal health-care products, can potentially impact ecosystems (Luo et al. 2014). These can end up in the environment through the potential transmission pathways of soil and food. Even if the wastewater ends up in treatment plants, these plants are not designed to eliminate such chemical emerging contaminants, so they find their way into the receiving environment where effluent is finally discharged.

2.4.2 Treatment and disposal practices for hospital wastewater

According to WHO, 15 to 20 per cent of waste (including wastewater) originating from a hospital poses a high risk and therefore requires special handling and treatment (Meo et al. 2014). The uncontrolled discharge of hospital wastewater or solid waste into water bodies or the environment can lead to the transmission/outbreak of communicable diseases such as diarrhoea, leptospirosis, typhoid, cholera, human immunodeficiency and hepatitis B. In addition, it may give off a foul odour and attract flies, cockroaches, rodents and vermin in the receiving environment (water, soil and air) (Aukidy et al. 2017).

Hospital wastewater undergoes different treatments in different countries. These include specific treatment (treatment at the hospital), co-treatment with municipal wastewater, and direct disposal into the environment (which can be before or after treatment). In areas where sewerage services exist and hospitals are connected to the sewer network, hospital wastewater is discharged into the sewer systems, where it mixes with other effluents and finally reaches the sewerage treatment plant for co-treatment (Iweriebor et al. 2015). However, co-treatment in low-income countries is reported to be unsuccessful in removing some contaminants such as pharmaceutical and personal care products, as these can be found in municipal wastewater effluents (Azar et al. 2010). Table 2.7 presents hospital wastewater treatment and disposal scenarios in selected African countries for which information is available and documented.

As Table 2.3 shows, many countries do not treat hospital wastewater at all, a few co-treat it with municipal wastewater, while all the countries practise disposal to the environment without proper treatment. Even where sewer lines exist, hospital wastewater would ideally be treated with chemical disinfectants, neutralized and then flushed into the sewage system. Treated effluent being discharged into the sewer lines should conform to the limits stipulated within standards for effluent discharge into public sewers for a given country. Connecting hospital wastewater to the municipal sewage network may create problems such as public health risks and imbalance of the microbial community, which in turn affects the biological treatment process. Furthermore, hospital wastewater has a negative influence on the microbiological and physicochemical parameters of the environment (Ekhaise and Omavwoya 2008). The microbial load as well as the high densities of the physicochemical parameters mean that hospital wastes are a major health and environmental threat that require proper regulatory systems and disposal.

Table 2.3. Hospital wastewater generation rates and treatment

Country	Generation rate (Litres/bed/day)	Specific treatment/ Pre-treatment at the hospital	Disposal into municipal sewers	Co-treatment at municipal wastewater plant	Disposal into the environ-ment
Algeria	NA	X	X	X	√
Cameroon	NA	X	X	X	√
Congo	NA	X	X	X	√
Egypt	500	√	√	√	√
Ethiopia	NA	X	X	X	√
Ghana	NA	X	X	X	√
Kenya	NA	X	√	√	√
Morocco	NA	X	√	√	√
Nigeria	350-700	X	X	X	√
Tanzania	NA	X	X	X	√
Tunisia	NA	√	√	√	√
Senegal	NA	X	X	X	√
South Africa	NA	X	√	√	√

√ = Yes X = No action NA = 'No available information'

Sources: Ekhaise and Omavwoya (2008); Ojo and Adeniyi (2012); Aththanyaka et al. (2014); Iweriebor et al. (2015); Aukidy et al. (2017).

2.5 Agricultural Wastewater

Agriculture is the main source of income for the African economy (New Partnership for African Development [NEPAD] 2013). In order to support the continent's increasing population, large-scale commercial farming is expanding, which is in line with the SDGs of zero hunger and poverty reduction. The bulk of agricultural farmland in sub-Saharan Africa is rain-fed (UNEP 2010), while in North Africa, irrigated farming – which accounts for 70 per cent of the total extracted water volume – is widely practised throughout this water-scarce region (French Agricultural Research Centre for International Development [CIRAD] 2010). Modern agro-chemical inputs such as inorganic fertilizer and pesticides (insecticides, herbicides and fungicides) have the potential to help farmers boost productivity, particularly in regions such as sub-Saharan Africa, where modern input uptake has historically been limited and crop yields remain low (Sheahan and Barret 2017).

2.5.1 Management of agricultural wastewater in Africa

Run-off from rain-fed and irrigated agriculture and farmlands presents a major threat to rivers, lakes and aquifers, as well as the coastal and marine environment, causing eutrophication, dead zones and coral bleaching. Agricultural run-off results in pollution of water bodies from fertilizers and pesticides (Case study 2.9), pathogens, manure, animal bedding and wasted feed (Mateo-Sagasta et al. 2017). Private wells can become polluted by toxins from farm factory operations. Case study 2.10 illustrates the environmental risks associated with excessive nutrients (nitrates) in drinking water, while Table 2.4 shows some of the health impacts of agro-chemicals.

Agricultural practices vary between the subregions in Africa. Many of the differences are related to the continent's environmental diversity and its great range of landscapes and climates. Pastoral and agropastoral systems are vital to North Africa, West Africa, East Africa and Central Africa. More and more of Africa is becoming irrigated (International Water Management Institute [IWMI] 2016), as irrigation is an important means for increasing food security in the region. Also fertilizer use is increasing in the various regions of Africa (see Figure 2.6), with implications on water quantity and quality.

Case Study 2.9. Contamination of surface and groundwater by pesticides in the Western Cape, South Africa

A study undertaken in three intensive agricultural areas in Western Cape, South Africa – Hex River Valley, Grabouw and Piketberg – reveals widespread contamination of groundwater, surface water and drinking water sources in these areas by agricultural pesticides, mostly endosulfan. The contamination in drinking water, albeit at low levels, regularly exceeded the European drinking water standard of 0.1µg/l. The two most contaminated sites were a subsurface drain in the Hex River Valley and a dam in Grabouw with 0.83 ± 1.0 µg/L ($n = 21$) and 3.16 ± 3.5 µg/L ($n = 13$) average endosulfan levels, respectively. Other pesticides detected included chlorpyrifos, azinphos-methyl, fenarimol, iprodione, deltamethrin, penconazole and prothiofos. Endosulfan was most frequently detected in Grabouw (69 per cent) followed by Hex River (46 per cent) and Piketberg (39 per cent). Detections were more frequent in surface water (47 per cent) than in groundwater (32 per cent) and coincided with irrigation and, to a lesser extent, to spraying and trigger rains

Source: Dalvie et al. (2003)

Case Study 2.10. Drinking water nitrate and prevalence of blue baby syndrome among infants and children in Moroccan areas

Two cross-sectional studies carried out in Salé, Morocco in two neighbouring areas with similar air quality, available vegetables and medicines but with different drinking water quality (nitrate-contaminated groundwater wells versus municipal water) found that the prevalence of blue baby syndrome (methemoglobinemia) was higher (36.2 per cent) in the exposed area than in the non-exposed area (27.4 per cent). In the exposed area, nitrate levels were higher than 50mg/l in 69.2 per cent of the surveyed wells and 64.2 per cent of the participants were drinking nitrate-contaminated well waters. The study children (aged between 1 and 7 years) drinking well water with a nitrate concentration of >50mg/l (World Health Organization drinking water guideline value) were significantly more likely to have methemoglobinemia than those drinking well water with a nitrate concentration of <50mg/l ($p=0.001$ at 95% CI=[1.22-2.64]) or than those drinking municipal water ($p<0.01$ at 95% CI=[1.16-2.21]). The mean methaemoglobin (MetHb) level in the study children in the exposed area increased with age, whereas in the unexposed area, the mean MetHb level remained relatively stable in the first six years of life. Ingested nitrate is reduced to nitrite, then the nitrite binds to haemoglobin to form MetHb, which at high levels interferes with the oxygen-carrying capacity of blood. In waters with nitrate concentrations less than 50mg/l, the mean MetHb was found to be normal, reaching an abnormal level when the nitrate concentration in water ranged between 50 and 90mg/l.

Source: Sadeq et al. (2008)

Wastewater from agriculture contains pesticides and fertilizers, among other contaminants

Table 2.4. Pollutants and contaminants in wastewater and their potential impacts through agricultural use

Pollutant/ Constituent	Parameter	Impacts
Plant food nutrients	Nitrogen, Phosphorous, Potassium, etc.	• Excess N: potential to cause nitrogen injury, excessive vegetative growth, delayed growing season and maturity, and economic loss to farmer • Excessive amounts of N and P can cause excessive growth of undesirable aquatic species (eutrophication) • Nitrogen leaching causes groundwater pollution, with adverse health and environmental impacts
Suspended solids	Volatile compounds, settleable, suspended and colloidal impurities	• Development of sludge deposits, causing anaerobic conditions • Plugging of irrigation equipment and systems such as sprinklers
Pathogens	Viruses, bacteria, helminth eggs, faecal coliforms etc.	• Can cause communicable diseases (discussed in detail later)
Biodegradable organics	Biochemical Oxygen Demand, Chemical Oxygen Demand	• Depletion of dissolved oxygen in surface water • Development of septic conditions • Unsuitable habitat and environment • Can inhibit pond-breeding amphibians • Fish mortality • Humus build-up
Stable organics	Phenols, pesticides, chlorinated hydrocarbons	• Persist in the environment for long periods • Toxic to environment • May make wastewater unsuitable for irrigation
Dissolved inorganic substances	Total Dissolved Solids, Sodium, Calcium, Magnesium, Chlorine, Boron	• Cause salinity and associated adverse impacts • Phytotoxicity • Affect permeability and soil structure
Heavy metals	Cadmium, Lead, Nickel, Zinc, Mercury, Arsenic, etc. bioaccumulate in aquatic organisms (fish and planktons)	• Subsequent ingestion by humans or animals • Possible health impacts • May make wastewater unsuitable for irrigation • Accumulate in irrigated soils and the environment • Toxic to plants and animals • Systemic uptake by plants
Hydrogen ion concentrations	pH of particular concern in industrial wastewater	• Possible adverse impact on plant growth due to acidity or alkalinity • Impact sometimes beneficial on soil flora and fauna
Residual chlorine in tertiary treated wastewater	Both free and combined chlorine	• Leaf-tip burn • Groundwater, surface water contamination (carcinogenic effects from organochlorides formed when chlorine combines with residual organic compounds) - greenhouse effect

Source: Partly adapted and updated from Asano et al. (1985)

Irrigation is important for increasing food security in Africa

Trends in agricultural fertilizer use per region for the period 2000-2015

Agriculture fertilizer consumption - Grand Total Nitrogen & P2O5 (1,000 metric tons)

Source: IFASTAT database available at https://www.ifastat.org/databases/plant-nutrition

GRID-Arendal/Studio Atlantis

Figure 2.6. Trends in agricultural fertilizer use per region for the period 2000-2016

2.5.2 Regulation and management of agricultural wastewater

Like elsewhere in the world, agriculture in Africa uses and manages land, water and energy resources (NEPAD 2013). Hence agricultural development and the sustainable development of natural resources are inextricably linked. Interventions on crop production in most African countries have focused on increased crop yields, but some of the modern farming methods adopted (e.g. involving intensive use of agrochemicals) by most farmers pose a threat to the environment (agriculture water pollution), sustainable agricultural production and the health and functional capacity of agro-ecosystems (Agula et al. 2018). Current programmes and policies are therefore keen to sustain farmland fertility and maintain ecosystem resilience, for example, the Comprehensive Africa Agriculture Development Programme (CAADP) and ECOWAS Agricultural policy (ECOWAP) (Economic Community of West African States [ECOWAS] Commission 2009; Zimmermann et al. 2009). The response to these policies and programmes, particularly in sub-Saharan Africa, has been low (Abdul-Hanan et al. 2014).

Agriculture is the largest consumer of water in Africa. Much of the agriculture rainfed, supplemented with small-scale irrigation

Case Study 2.11. **Reuse of wastewater in agricultural irrigation: Lessons from the Western Cape, South Africa**

In water-scarce countries, wastewater is an important alternative source of water especially for agriculture, which has different water quality requirements. South Africa has included water reuse as a policy option. Wastewater use comes with trade-offs and hence a study aimed at understanding farmers' preferences regarding water reuse for irrigation was carried out in the rural hinterland of Cape Town, South Africa, a water-scarce area whose agricultural sector is highly dependent on rainfall for both dryland and irrigation farming.

The study used a choice modelling approach to identify the defining elements in the associated frameworks, to quantify their relative importance among farmers and hence to estimate farmers' willingness to pay for changes under this framework. Farmers in the study area had some experience of water reuse, as some were already using treated wastewater (or treated effluent) from a municipal treatment plant to irrigate crops. The results showed that the farmers in the rural hinterland of Cape Town had a positive perception of water reuse for irrigation, largely because they were aware of the problem of water scarcity. This is important as public perceptions and acceptance of water reuse are recognized as the main components of success for any reuse project. In addition, farmers prefer options that have strict water quality standards (hence guarantee good quality water) and low levels of restrictions on use practices.

Another finding was that farmers who were already using treated wastewater preferred a privately managed scheme over a public scheme (Vásquez 2011). Trust in the authorities to provide safely treated effluent has already been identified as a fundamental issue in determining public acceptance of water reuse (Po et al. 2003). In the Western Cape, farmers are willing to pay for a privately managed scheme, probably because of a lack of trust in service reliability from the publicly managed scheme. This suggests that the management model for implementing such water reuse schemes is important and offers lessons for policy formulation in a developing country context.

Source: Saldías et al. (2016)

Considering that agriculture is the largest consumer of water on the continent, there is a need for policies that consider improved water management while promoting safe wastewater use to drive agricultural growth. Wastewater use in agriculture has associated benefits, such as reduced pressure on available freshwater resources, provision of water and nutrients for the cultivation of crops and ensuring food supply to cities. However, wastewater is also a source of pollution, and can affect the health of users, consumers and the environment if safe practices are not applied. Whereas the international community recognizes that the safe use of wastewater in agriculture is an important water resource issue that needs to be addressed (with the globally accepted World Health Organization guidelines for wastewater reuse), efforts are still needed to advance it in national policies and to implement safe use guidelines and practices, especially in most African countries (Liebe and Ardakanian 2013).

There is a need to design agricultural management practices that reduce pollution from farming and livestock grazing/rearing and at the same time increase agricultural productivity. Hence improvements to management practices must be approached on multiple levels, from individual households to basin management to national law and policy on water use (Case study 2.11).

2.6 Storm Water Run-off

Africa currently has the highest rates of urbanization in the world. The urban population in sub-Saharan Africa is projected to exceed the rural population by 2050 (Dos Santos et al. 2017). During this period, sub-Saharan Africa's urban population will have tripled, triggering a significant increase in surface water run-off. High run-off results in an increase in flooding and a significant decrease in water quality, primarily due to the accumulation of pollutants in storm water run-off (Braune and Wood 1999). Common pollutants in storm water include nitrogen, chloride, copper, zinc, manganese, nickel, cadmium, pathogens, oil and grease (Hwan et al. 2016). The source of pollutants can be natural – such as mineral dissolution and vegetable decomposition – or anthropogenic – such as fertilizer application, wastes, automobile parts, vehicle emissions, gasoline products, industrial discharges, paints, insecticides and home-care products (Tsihrintzis and Hamid 1997; Hwang et al. 2016). Storm water run-off, especially in urban areas, must be managed in order to prevent further degradation, mitigate the damage already done to the environment and avoid public health problems related to poor water quality (Ondieki and Kebaso 2017).

Storm water management in several urban areas across the continent predominantly focuses on collecting rainfall run-off and channelling it into the nearest water bodies. Though such practices can manage run-off quantity, they have little to do with preserving the environment (Armitage et al. 2013). Several municipalities, particularly in South Africa and a few in Nigeria, are reported to be involved in sustainable drainage systems for storm water management approaches in line with best international practice (Armitage et al. 2013; Charlesworth et al. 2016). Sustainable drainage systems involve treating storm water as close to the source as possible, in as natural a manner as possible. This approach can be used to manage storm water in a more holistic manner and unlock the multiple benefits that conventional systems do not offer (Fisher-Jeffes and Armitage 2012; Charlesworth et al. 2016). The most commonly implemented sustainable drainage systems technological options in South Africa include permeable pavements, vegetated/green roofs, sustainable drainage systems and treatment trains (Armitage et al. 2013). In addition, vegetable rain gardens (in an urban farming context) have the potential to manage storm water at the household level (Richards et al. 2015).

2.6.1 Regulation of storm water

There are limited documented local or national regulations on storm water management for most African countries. In South Africa, some municipalities have moved towards sustainable drainage systems and drafted by-laws to this effect, yet some pre-existing by-laws may still be in force that are counter to sustainable drainage systems, such as by-laws that enforce the channelling of storm water run-off from properties to the road (Armitage et al. 2013). This situation must be reviewed in order to embrace the sustainable drainage systems approach, since for a storm water programme to be effective, it must be easy to enforce.

Several storm water management programmes in Africa have failed legal tests for a variety of reasons (Barbosa et al. 2012). National legislation may be required to establish a local regulatory authority to levy taxes or fees to finance such storm water management programmes, but the fees and taxes should be flexible, based on local characteristics, and should consider temporal, spatial and administrative factors and laws, among other issues (Debo and Reese 2003; Barbosa et al. 2012). Many other governments outside Africa have established legal frameworks and institutional capacity to charge service fees for storm water management (Fisher-Jeffes and Armitage 2012), with successful results in countries including Australia, Brazil, Canada, Ecuador, France, Germany, Poland and the United States of America (Tasca et al. 2018).

Charging storm water fees can be a successful mechanism for protecting the environment, but municipalities in Africa normally prioritize funding for other pressing needs over storm water management. Internationally, an increasing number of municipalities are setting up separate storm water utilities that have begun charging the public directly for storm water management services, in order to secure the necessary funding to better manage storm water and the associated water pollution (Debo and Reese 2003). As cities across African have, in many instances, managed to charge people for potable water and sewerage, they may be able to do similar for storm water management. It would be advisable to mention the fees after a year-long public education campaign, starting with those who had experienced floods, in order to generate adequate support for the idea and minimize public repulse (Campbell 2018). A storm water fee can provide a steady stream of funding for storm water management. In particular, an impervious-area-based storm water fee provides a fee structure that attributes costs in proportion to how much storm water run-off a property generates.

Storm water drainage is a key part of wastewater management

Case study 2.12 highlights the fact that storm water management is a public good that should be adequately and fairly funded. Municipalities in African cities can learn from these efforts so as to address storm water issues strategically, empowered by a well-structured storm water fee.

Case Study 2.12. The potential of storm water fees in funding storm water management – the case of Baltimore City

Since 2013, Baltimore City has operated a storm water utility that is funded by the city's property owners. The Storm water Remediation Fee Regulations outline the terms of Baltimore City's storm water fee, which are based on the amount of impervious area on a property. Impervious surfaces, such as roofs, sidewalks and driveways, block water from infiltrating the ground. They increase run-off to storm drains, and transport a variety of pollutants to bodies of water.

Steps to reduce storm water run-off involve the use of large-scale green infrastructure solutions, which help stop run-off pollution by capturing rainwater and either storing it for use or letting it filter back into the ground, where it replenishes vegetation and groundwater supplies. Storm water management is considered a public good and hence the storm water fee appears as a line item on a property's monthly water bills. Single-family properties are charged one of three rates: Tier 1 properties have no more than 820 square feet of impervious surface area, and pay $40 per year ($3.33 each month), Tier 2 properties have more than 820 square feet but no more than 1,500 square feet of impervious surface area, and pay $60 per year ($5 each month) and Tier 3 properties have more than 1,500 square feet of impervious surface area, and pay $120 per year ($10 each month). Non-single family properties are billed based on a measure called an Equivalent Residential Unit (ERU), which is the size of the impervious surface area (1,050 square feet) of the median-sized house in Baltimore City. The larger the impervious surface area of a parcel, the higher the storm water fee for the property. Non-single family properties pay $60 per ERU per year.

The primary expenses covered by the storm water fee are maintaining, operating and improving the storm water management system, and reducing pollutants. This includes capital improvements for storm water management, operation and maintenance of storm water management systems and facilities such as green infrastructure.

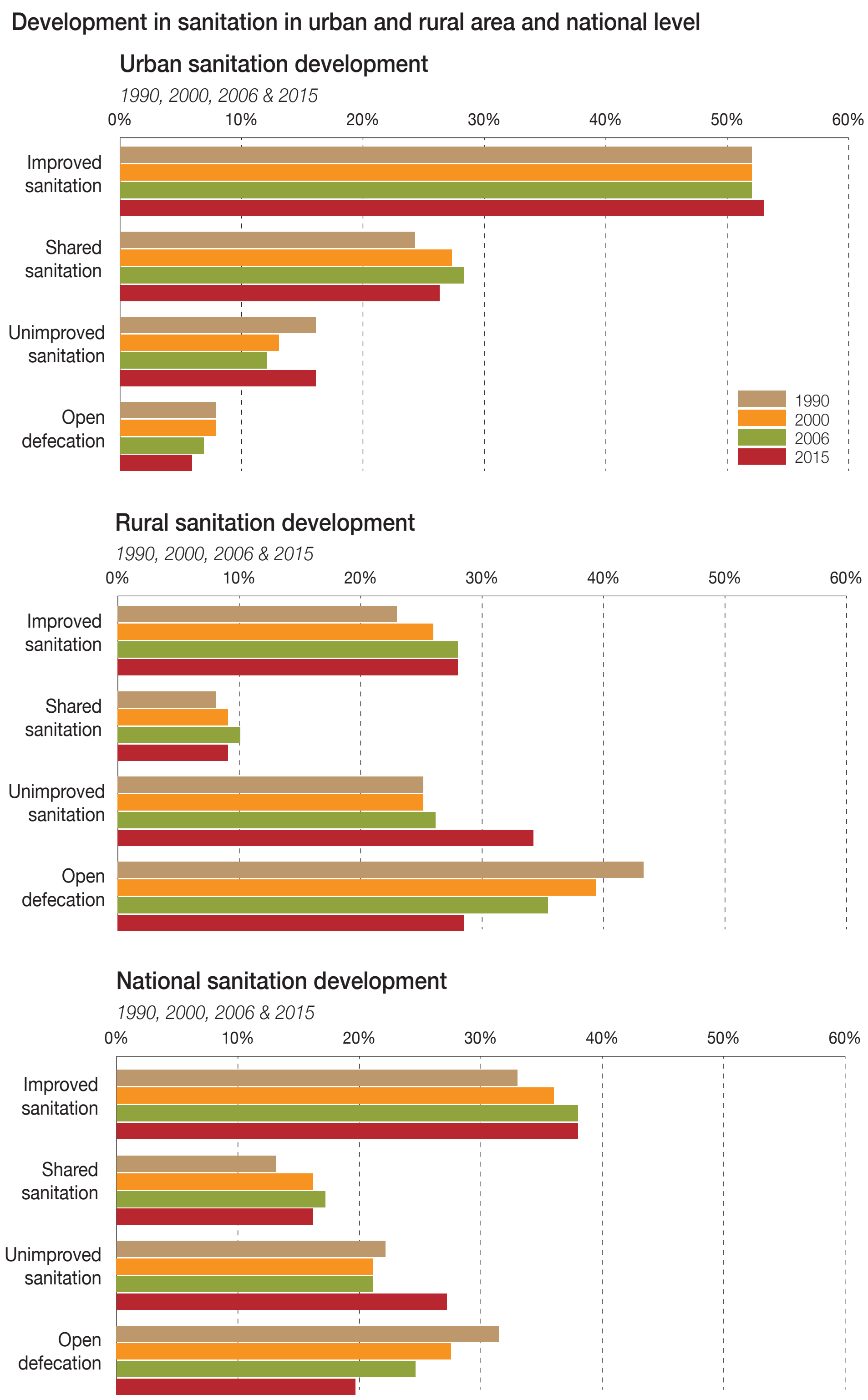
Source: https://publicworks.baltimorecity.gov/storm water-fee

2.7 Rural Water, Sanitation and Hygiene

Despite Africa's rapid urbanization trends, rural populations are also growing quickly. By 2030, an estimated 530 million people will be living in rural areas (Worldometers 2019). In many cases, migration to urban areas and peri-urban areas diverts the focus of water, sanitation and hygiene (WASH) development in rural areas to addressing the surging needs of urban and peri-urban areas, resulting in disparities in access to water and sanitation between these areas (see Figure 2.7).

2.7.1 Rural WASH services and facilities

Some rural areas in Africa have scattered settlements of basic housing or shelters that lack the minimum infrastructure for sewered and water-based sanitation. In such areas, the higher cost per capita of amenities such as water and sanitation compared to their counterparts in urban areas makes investing in them a challenge. Even in clustered rural settlements where it is comparatively cheaper than in scattered rural settlements to provide infrastructure for shared sanitation and water provision, these amenities are often absent due to the harsh realities of rural poverty. Rural communities usually rely on surface and groundwater sources for their water supply needs. Examples of surface water sources include ponds, dugouts, dams, ephemeral streams and rainwater harvesting from roofs. Groundwater supplies to rural areas include hand-dug-wells, with or without hand pumps, boreholes fitted with hand pumps, springs and motorized boreholes. These are classified as improved drinking water sources if they are designed and constructed to provide safe water.



Source: UNICEF/WHO, 2008; UNICEF/WHO, 2015.

Figure 2.7. Basic facts and figures: all Africa

2.7.2 Economic, social and geographic inequalities

Unequal access to WASH services between different communities in the same province or region can arise when 'elite', privileged communities are nearer – and disadvantaged communities are further from – decision-making centres. Also, more organized (urban) communities that are able to effectively communicate and demand their right to WASH services are likely to be well-off: just one of many economic factors associated with poor access to WASH services in rural areas (UN Women 2017; Water and Sanitation Programme [WSP] 2010). According to the World Bank (2013), sparsely populated areas are unable to benefit from economies of scale that reduce the unit costs of network infrastructure services, especially along the entire sanitation value chain. In addition, in some cases inaccessible roads or difficult terrain prevent adequate access to rural locations. An estimated low of 10% of total WASH finance is commited to rural areas (WHO/UNICEF 2014).

2.7.3 Inadequate resources to finance sector activities

Despite the plethora of policies and reforms in many African countries, few have found adequate resources to implement sustainable WASH facilities and services. Most governments of African countries fund rural WASH infrastructure from central government sources, with significant contributions from development partners, most of which are largely bilateral and multilateral agencies and Non-Governmental Organisations. These external sources of financing have been influenced by external shocks and shortfalls, hence they are dwindling and becoming less predictable. Water, sanitation and hygiene are not prioritized by African governments, with political leaders not allocating much resources as necessary to rural WASH. The fact that many countries are currently experiencing slow or stunted economic growth, coupled with rising public debts in some countries, is a threat to the WASH sector as it is likely to further squeeze the already low levels of resources made available to the rural subsector.

2.7.4 Poorly informed WASH sector decisions

African countries report that only 38 per cent of urban or rural sanitation and drinking-water sectors are informed by reliable monitoring and information systems (WHO 2012), which hinders progress in rural WASH service delivery. In addition, rural and urban areas are treated as separate and unrelated entities by both national governments and international development actors. This not only ignores the importance of various types of linkages between rural and urban areas, but also does not ensure a fair, balanced approach to WASH sector development.

2.7.5 Impact of poverty

It is estimated that almost a quarter of the continent's population, about 220 million people in sub-Saharan Africa alone, live in conditions of poverty. Rural economies in Africa are mostly subsistence and at times nomadic. This results in rudimentary facilities constructed from meagre rural household income that lack the resilience to withstand extreme weather variations. According to the World Bank (2013), poverty has been reducing more slowly in rural than urban areas and job availability has not kept pace with the increased number of entrants in the labour force market following population growth. In response to this situation, individuals and families regularly move between rural and urban centres, which can result in temporary structures for sanitation and safe drinking water provision.

2.7.6 Factors driving successful rural WASH in Africa

The spearheading roles of WHO, UNICEF and other United Nations organizations in WASH, the emergence of key international networks such as the Rural Water Supply and Sanitation Initiative (RWSSI) hosted by the African Development Bank, and support from key agencies including the World Bank Group and other affiliates such as the Water and Sanitation Programme (WSP) are but a few examples of the propelling force behind rural WASH delivery in Africa. For example, RWSSI is reported to have helped extend water supply and sanitation access to 135 million and 90 million people, respectively, in over 24 countries (AfDB 2016).

Growing teams of experts have worked with various countries and assisted in building local capacities to achieve more than would otherwise have been possible. The active participation of rural communities in sub-Saharan Africa is also worthy of mention. Building on the increasing use of mobile phones and the Internet in Africa, it is expected that technology will help promote WASH in rural Africa by making new knowledge increasingly available to a wider audience.

2.7.7 Strategic approach to ensuring sustainable delivery of WASH

Going forward, a strategic and sustainable approach to delivering rural WASH in Africa is important in order to avoid far-reaching negative implications on the health of the populations, economic development and the environment. Governments in Africa must decide how to incorporate and align the universally applicable targets set within the context of the SDGs into national planning processes, policies and strategies based on national realities, priorities, capacities and levels of development.

Given that the current delivery of WASH facilities and services are skewed in favour of urban populations, improved rural WASH access in Africa will require a radical departure from current measures if they are to make a difference. This will include introducing the innovative and appropriate use of technologies that are context-specific and suitable to the rural WASH subsector and encouraging private-sector involvement and subsidies by governments to address and promote rural sanitation. When formulating and implementing coherent rural WASH policies and interventions, the following considerations must be taken into account:

- Make a clear distinction between rural and urban areas (that nevertheless takes into account the linkages between these areas) in order to properly establish needs before addressing WASH services and infrastructure.

- Unravel existing distortions and inequities associated with the delivery of rural and urban WASH and establish the population sizes and differences between rural and urban WASH requirements.

- Learn and apply lessons associated with building resilient WASH infrastructure and services to ensure WASH facilities in rural areas can withstand extreme weather conditions, including floods and droughts.

- Construct resilient rural WASH services and facilities to limit their vulnerability to armed conflicts.

Water storage is key in achieving good sanitation and hygiene practices

2.8 Emergency Sanitation

Emergencies, many of which stem from disasters, are a global phenomenon with almost half of the world population having lived through a disaster at some point in the past decade (Aliyu 2015). Africa is vulnerable to a wide range of disasters and emergencies, some of which have forced large-scale displacements. For example, Uganda, Ethiopia and Kenya together host up to 2.8 million refugees (Signe et al. 2019). Other disasters common to Africa include tropical cyclones, windstorms, wildfires, drought, floods and earthquakes.

It is widely acknowledged that provision of potable water and proper sanitation are among the most critical interventions required to safeguard the well-being and dignity of affected persons during emergencies (Sikder et al. 2018). Although emergency sanitation is always implemented within the context of water, sanitation and hygiene (WASH), it often also deals with the management of human excreta and wastewater (Brown et al. 2012; WHO 1999). Emergency sanitation services are often plagued with inadequacies in many areas, including funding and appropriate technical standards (Day et al. 2018). It is common for the occurrence of regular outbursts of sanitation-related diseases such as cholera in refugee and internally displaced persons camps. For example, during the Rwanda disturbances in 1994, more than one million Rwandans fled to neighbouring Democratic Republic of Congo where it was reported that up to 60 000 died from cholera (Cronin et al. 2008).

Disasters such as droughts, floods often lead to the displacement of people, and this negatively affects their access to water and sanitation

Emergencies lead to the displacement of large number of people into provisional camps or communities either as internally displaced people (IDP) or refugees. Often, these temporary camps are overcrowded with rudimentary shelters. Local government authorities and relief agencies are usually responsible for the provision of basic amenities to support the IDPs and refugees in their camps. Due to limitations the camps are usually serviced with the minimum basic amenities (Signe et al. 2019). Depending on the urgency, sanitation services may range from a delineated defecation area where people are encouraged to do "simple cat hole" to bury their faeces to having trench

Box 2.1. **COVID-19, Sanitation and Hygiene**

Coronavirus disease 2019 (COVID-19) is an illness caused by a virus , and can be transmitted from person to person. The virus, which was first recorded in China in December 2019, rapidly spread throughout the world, causing symptoms that ranged from no to mild to severe illness. During the first and second quarters of 2020, the disease overwhelmed many health care centres in the world, and caused many deaths. During this period, the virus had spread to all but one of the 54 countries in Africa, and much of the rest of the world. The most affected countries in Africa at the time were Egypt and South Africa, with Lesotho having recorded no case of the disease. COVID-19 has a zoonotic source, with evidence showing bats or pangolins as possible ecological origins of the virus.

The COVID-19 virus is mainly transmitted through respiratory droplets and direct contact. Any individual in close contact with an infected person is at risk of being exposed to potentially infective respiratory droplets. Droplets may also land on surfaces where the virus could remain viable. As such the immediate environment of an infected individual can serve as a source of transmission.

Safe water, sanitation and good hygiene are essential for protecting human health against infectious diseases, including COVID-19. Some important facts about COVID-19 and water, sanitation and hygiene are that:

- Regular and correct hand hygiene is one of the most important measures for the prevention of infection with the COVID-19 virus. Hand hygiene at all times, using the correct technique with either alcohol-based hand rub or soap and water, is critical. However, as much as 69 per cent of Africa´s population, especially in rural Africa and in urban slums have no access to basic sanitation. Access to safe water and to hand washing facilities is also low.
- Water disinfection and safely managed sanitation can reduce the load of viruses and other disease-causing organisms.
- Many health co-benefits can be realized by safely managing water and sanitation services, and by applying good hygiene practices.

Although the presence of the COVID-19 virus in untreated drinking-water is said to be possible, the virus has not been detected in drinking-water supplies. Other coronaviruses have also not been detected in surface or groundwater sources, making the risk of the presence of coronaviruses in water supplies very low, and underscoring the value of handwashing with soap and water.

The infectious COVID-19 virus may be excreted in faeces, regardless of diarrhoea or signs of intestinal infection, with reports of COVID-19 viral RNA fragments having been found in the faecal matter of patients. While concerns have been raised on the possible transmission of the virus through human excreta, the risk of transmission from the faeces of an infected person appears to be low.

There is no evidence that the COVID-19 virus can be transmitted via sewerage systems with or without wastewater treatment. However, as viral fragments have been found in excreta and because of other potential infectious disease risks from excreta, wastewater should be treated in well-designed and well-managed treatment works.

World Health Organisation (WHO). (2020). Water, sanitation, hygiene and waste management for the COVID-19 virus: interim guidance. WHO. Geneva. Downloaded on 11 May 2020 https://apps.who.int/iris/bitstream/handle/10665/331846/WHO-2019-nCoV-IPC_WASH-2020.3-eng.pdf

and/or pit latrines that are covered frequently with earth, among others. The Sphere Handbook, which describes the minimum standards needed for affected populations to survive and recover in stable conditions and with dignity, recommends that toilets be situated no greater than 50 metres from a household and be shared by up to 20 individuals (The Sphere Project 2012). It also requires that a minimum volume of 15 litres of water be used for drinking and domestic hygiene per person per day. For neighbourhood or communal waste collection points, the Sphere Handbook recommends that a 100-litre container be provided for every 40 households and one container per ten households in the longer term, as household waste production is likely to increase over time (The Sphere Project 2012).

2.8.1 Example 1 – Maiduguri, Nigeria

The insurgence of Boko Haram in Northern Nigeria, since 2011, resulted in massive population displacement (both internal and across international borders). Currently about 2.2 million IDPs are distributed across the country's seven states of Borno, Yobe, Adamawa, Bauchi, Taraba, Nasarawa, and Gombe, and in Abuja Federal Capital Territory. Borno state hosts 1.4 million IDPs; Yobe state is home to 131 000 IDPs and Adamawa to 136 000. The vast majority of IDPs (92 per cent) live within host communities in urban settings, predominantly in family houses; the remaining 8 per cent are distributed across 50 sites, of which 6 are camps, and 43 collective centres (mostly schools) (Forni et al. 2016). Women and children (79.3 per cent) of IDPs are disproportionally affected by the conflict through forced marriages, abductions, and lack of access to basic services (Owoaje et al. 2016).

Water, sanitation and hygiene were already a challenge in Borno State prior to the insurgency in 2009 (KAP Survey report 2017) and the persistent increase in the population of IDPs in Maiduguri metropolitan has made the situation even worse. Due to the insurgence, a significant number of displaced persons in Maiduguri shelters had difficulty in accessing water, existing sanitation facilities became dilapidated, and there was an invariable increase of open defecation in the IDP host communities.

Open defecation and poor waste management resulted in a cholera outbreak in Borno, which claimed 61 lives and affected a total of 5,365 between August and December 2017 (UNICEF 2018).

Emergency sanitation facilities provided included emergency latrines and rehabilitated ventilated improved pit latrines and showers, as well as laundry and bathing soap. Solid waste management committees were established and trained at different locations and provided tools for collection and safe disposal of waste. During a cholera outbreak, UNICEF intervened by providing access to safe chlorinated drinking water, clean latrines, as well as cleaning and removing garbage in affected areas.

2.8.2 Example 2 – Beira City, Mozambique

In March 2019, a tropical cyclone, Idai, hit Beira city in central Mozambique. Over 3,000 km^2 of land, including 700,000 hectares of farmland were flooded. This incident led to the dislocation of more than 400,000 inhabitants. In total, over 1.5 million people were affected including 600 deaths and 1,600 injuries. In April, a second cyclone, Kenneth, hit the country, exacerbating the initial crisis caused by cyclone Idai (PDNA 2019). This led to the destruction of about 71,450 and 118,600 latrines in rural and urban areas, respectively. In some districts, incidents of open defecation increased to 46 per cent from 25 per cent. Water became scarce, resulting in about 200,000 people having limited access (IFRC 2019).

The Mozambique Red Cross (CVM) and other agencies moved to ensure that households had clean toilets and potable water by providing storage facilities and water treatment tablets. In addition, the CVM provided affected families with 50 emergency latrines (IFRC 2019). Measures were put in place to decommission the latrines whenever they were full to prevent the spread of diarrhoeal diseases. In addition to a supply of 3,000 buckets (2 per household), 1,500 collapsible jerry cans (1 per household), 6,000 bars of soap (4 per household), 1,000 boxes of water purification tablets, and 50 temporary latrines were set up in the accommodation centre while an equal number of latrines were decommissioned in the camps (IFRC 2019). The CVM volunteers also conducted hygiene promotion activities focused on teaching families how to best teach their children to use latrines built by the teams.

2.8.3. Example 3 – Kakuma Refugee Camp, Kenya

Kakuma refugee camp is located on the outskirts of Kakuma town, in Turkuna West, North-western Kenya. The camp was established in 1992 to provisionally cater for 20,000 refugees from Sudan and Ethiopia. By April 2014, the number or camp residents had exceeded 150,000 refugees from 19 different nations. Somali and South Sudanese refugees account for more than a third each of the camp's total population (Nyoka et al. 2017). New groups of refugees from Democratic Republic of Congo, Somalia, Sudan and South Sudan continued to arrive at Kakuma refugee camp because of unrest in the neighbouring countries, and this puts further strain on the existing sanitation system (Nyoka et al. 2017; UNEP 2018). The camp is made up of informal settlements made of thatch, mud or iron sheets (Nyoka et al. 2017; Alix-Garcia et al. 2018).

Sanitation and water scarcity were the biggest challenges at Kakuma refugee camp. As a result of inadequate latrines at the camp, 10 households, including children and adults, shared one latrine most of which filled up within a month (Nyoka et al. 2017). Most latrines emitted foul odour and served as breeding ground for insects. Also, the unpleasant smell from the latrines got into the houses of the refugees making it very unbearable. The dirty latrines were due to their communal use which made it difficult to clean. The sole solution for faecal sludge management (FSM) in Kakuma in the past twenty years has been to dig pit latrines. New pits were dug in the next available space when these pits, measuring 5 meters, got filled with human excreta. Unfortunately, the camp used up all open spaces after digging new pits in 22 years (Kuklov 2018).

Emergency sanitation in the wake of disasters

Imagery source: Digital Globe, 26/03/2019

2.9 Conclusion

There is little information and data on wastewater generation, collection and treatment for the various waste streams, especially industrial and agricultural streams, in the majority of African countries. Where some datasets are available, they are rather old (more than five or six years).

Data on treated wastewater reuse following treatment of various waste streams (i.e. proportions of water treated and for which reuse options) are also limited.

Whereas there are ongoing efforts to address the pollution problems in the various subregions of Africa (for example, through appropriate wastewater treatment technologies, institutional and policy reforms) under specified programmes, there is hardly any documented information on their progress and impacts. Appendix 2.1 summarises the key sources of wastewater, and the commonly used treatment technologies.

Avoidable diseases such as cholera and dysentery are the result of poor sanitation, including broken sewers

Rural areas where the majority of Africa's population lives, remain underserved by water supply and sanitation due to the sparse settlements, and in some cases the nomadic lifestyles of some rural dwellers. The available infrastructure for sanitation is not only inadequate, but is often not durable and resilient enough to stand bad weather.

3

ECOSYSTEMS

3.1 Introduction

Although Africa is home to 15 per cent of the world's population, it only has 9 per cent of the global water resources (Wang et al. 2014; United Nations Environment Programme [UNEP] 2010). Africa's scarce water resource situation is compounded by wastewater pollution. It is estimated that well over 80 per cent of the wastewater worldwide is released into the environment without treatment (United Nations Water [UN-Water] 2017). In low-income countries, an average of only 8 per cent of domestic and industrial wastewater is treated, compared to 70 per cent in high-income countries. As a result, in many regions of the world, water contaminated by bacteria, nitrates, phosphates, pharmaceuticals, microplastics and other chemicals is discharged into rivers and lakes, and ends up in the oceans, with negative consequences for the environment (UN-Water 2017). The relative lack of water on the African continent highlights the need to treat wastewater to improve surface and groundwater quality, enhance the natural water supply and reduce "stress and pressure" on available water resources (Omosa et al. 2014).

Untreated wastewater has implications for the health of both humans and ecosystems. In the seas and oceans, deoxygenated 'dead zones' caused by nutrient loading and the discharge of untreated wastewater are rapidly growing, affecting an estimated 245,000 sq km of marine ecosystems and affecting fisheries, livelihoods and food chains (UN-Water 2017). Freshwater ecosystems are also being impacted in similar ways. Waterborne illnesses from contaminated freshwater supplies and the degradation of freshwater systems have far-reaching implications for the well-being of communities and their livelihoods. Figure 3.1 is a schematic diagram showing the key natural and anthropogenic factors responsible for water contamination.

The Sustainable Development Goals (SDGs) call for universal access to clean water and sanitation for all. SDG 6 on clean water and sanitation aims at substantially improving the health of people, reducing water pollution and increasing recycling and reuse. Clean water and sanitation are one of the most fundamental goals, since water is the foundation of healthy ecosystems, thriving communities and therefore stable economic development. Water availability and quality are

Poor water and wastewater infrastructure, inadequate solid waste management and poorly managed faecal sludge management lead to land and water contamination

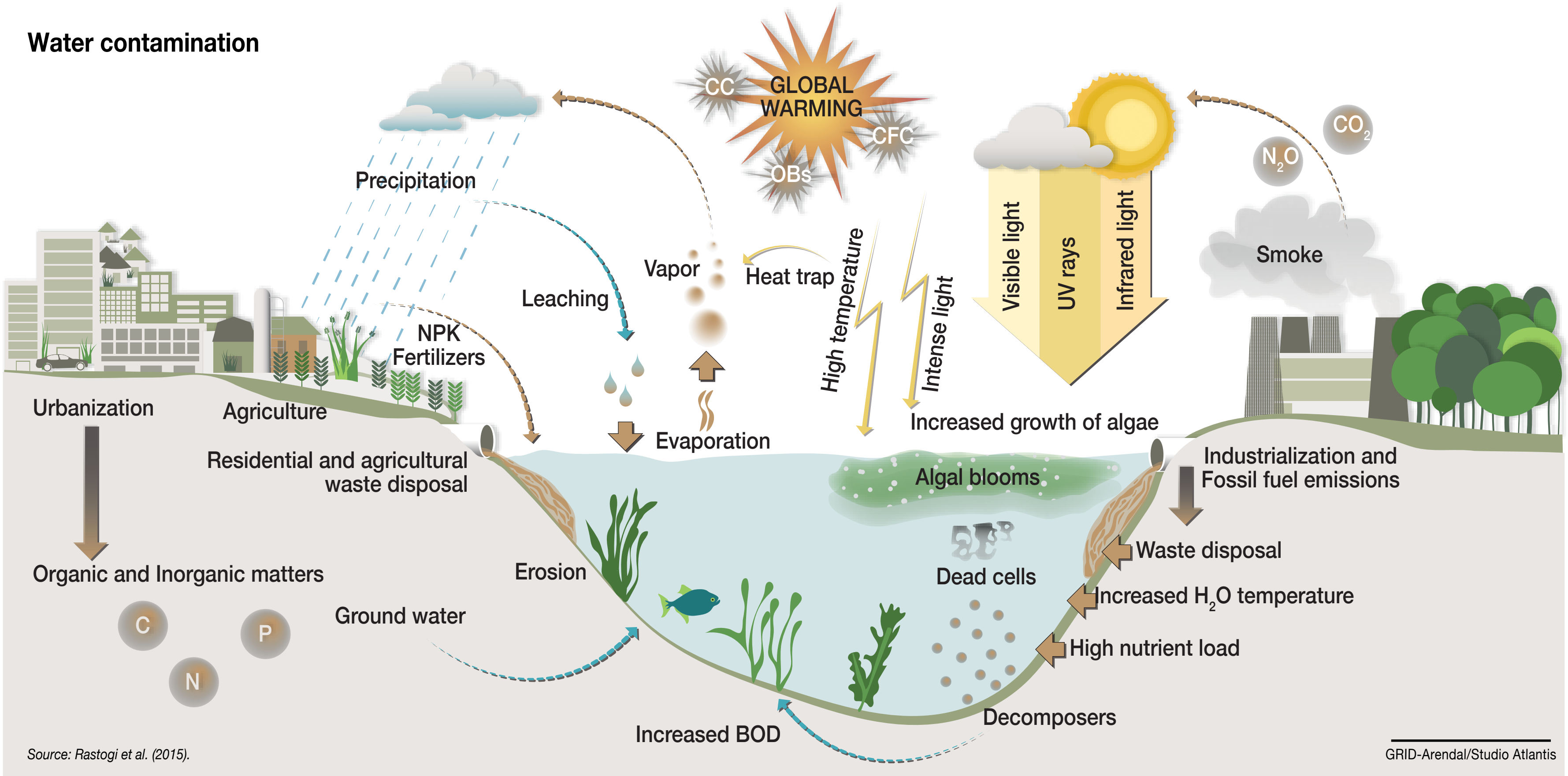


Figure 3.1. Water contamination

especially threatened by pollution, the impacts of climate change, population growth and increasing consumption (Brookes and Carey 2011).

Rapid urbanization, poor water and wastewater infrastructure, inadequate solid waste management and poorly managed faecal sludge management in urban areas lead to land and water contamination, with associated risks to the environment and human health. Africa has the largest percentage of households without access to improved sources of drinking water when compared to other continents, with the highest percentage located in rural areas (Bain et al. 2014).

Adequate wastewater treatment, proper sanitation provision and solid waste management are essential for preventing degradation of the environment and the potential consequences on human health. The consequences of releasing untreated or inadequately treated wastewater include harmful effects on human health, negative environmental impacts, and negative impacts on economic activities (UN-Water 2017). Figure 3.2 provides an idea of the number of water treatment or reuse plants in major countries around the world, with Africa generally lagging behind the rest of the world.

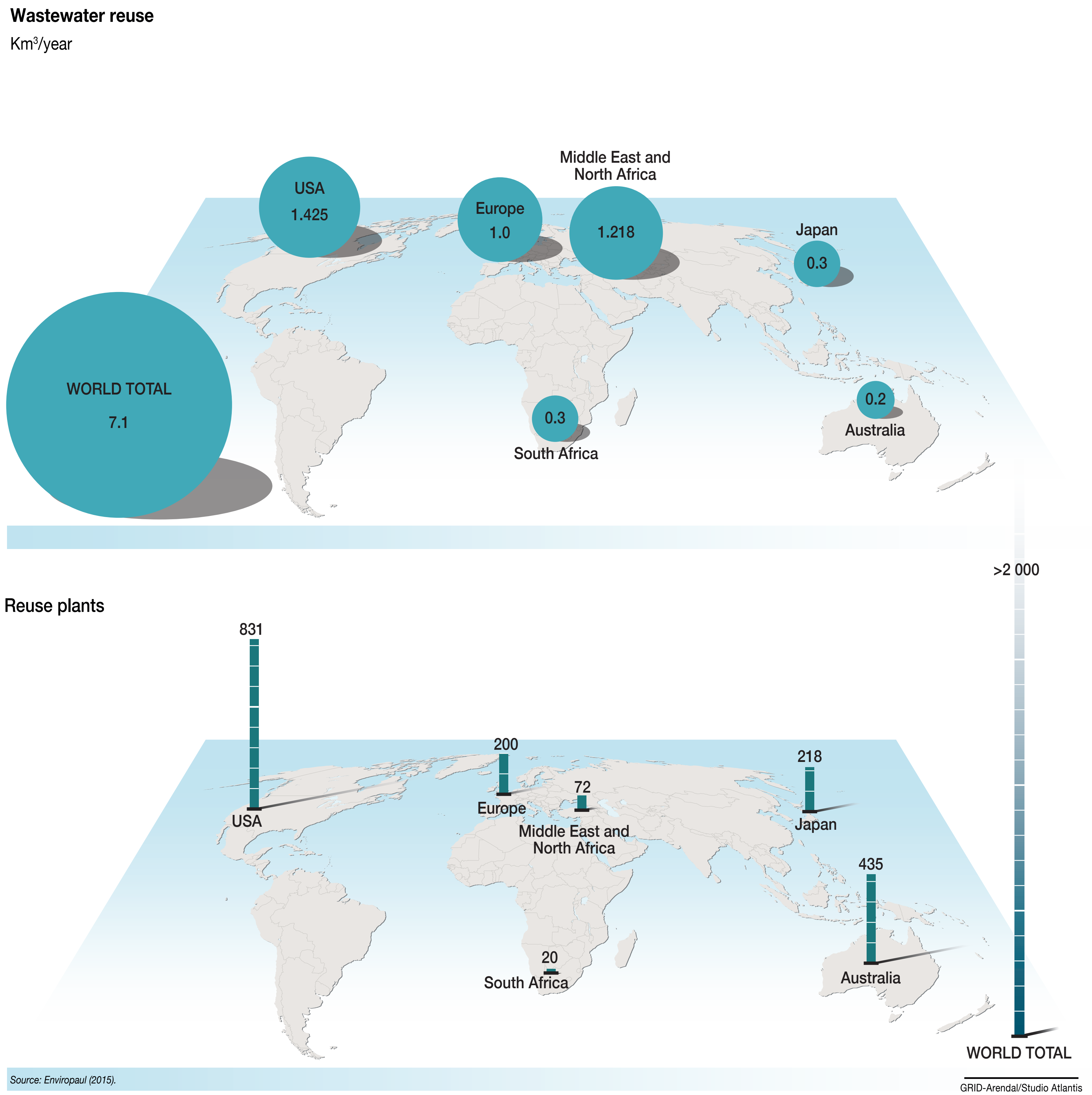


Figure 3.2. Wastewaster reuse in the world

3.2 The Concept of Ecosystems Health

A healthy ecosystem is stable and sustainable, and resilient to stress

An ecosystem consists of living organisms (biotic components), including humans interacting with their physical environment (abiotic components), which includes elements such as soil, water, climate and atmosphere (Van Jaarsveld et al. 2005). These biotic and abiotic components interact to form stable systems and are regarded as linked together through nutrient cycles and energy flows. Such ecosystems include agroecosystems, forest ecosystems, grassland ecosystems and aquatic ecosystems.

The productivity of an ecosystem depends on how organized and coordinated interactions among the components of these systems are. A healthy ecosystem is one that remains organized and autonomous over time – one that is stable, sustainable, active, free from 'distress syndrome' and resilient to stress (Costanza 2012). In a healthy ecosystem, there is balanced interaction among the various components and the whole natural system functions together to provide the many life-sustaining benefits we receive from nature which contribute to environmental and human health and well-being (Myers et al. 2013). Furthermore, a healthy ecosystem is stable and sustainable in its provision of goods and services used by human societies (Bukhard et al. 2008). It maintains its organizational structure, its vigour of function and resilience under stress and continuously provides quality ecosystem services for present and future generations in perpetuity (Lu et al. 2015). Healthy aquatic ecosystems are characterized by high species diversity and good water and habitat quality, among other aspects.

Ecosystem health is usually defined in terms of the non-appearance of pathological signs in a particular natural system. For example, lakes, ponds and rivers are healthy if they show no signs of diseased conditions such as contamination, loss of aquatic species or algal blooms (Rapport et al. 2001). High contamination, low aquatic species diversity, algal blooms due to eutrophication as a consequence of high nutrient input are indications of unhealthy freshwater ecosystems.

In a healthy ecosystem the whole natural system functions together to provide the many life sustaining benefits

3.3 Ecosystem Services

The many and varied benefits that humans freely gain from the natural environment and from properly-functioning ecosystems are known as ecosystem services (Redford and Adams 2009). These benefits include tangible products such as food and water, as well as non-tangible but important services such as climate regulation, recreational and cultural benefits. Ecosystems provide essential services that are necessary to maintain optimal ecosystem health. Ecosystem services are grouped into four broad categories: provisioning, such as the production of food and water; regulating, such as the control of climate and disease; supporting, such as nutrient cycles and oxygen production; and cultural, such as spiritual and recreational benefits (Millennium Ecosystem Assessment 2005). For example, freshwater ecosystems such as rivers and wetlands provide services such as clean drinking water, proteins (from fish/shrimp/crabs), fertile land for flood-recession agriculture and grazing, populations of wildlife for harvest, growing fruits and vegetables, fibre/organic raw materials, medicinal plants, inorganic raw material, flood mitigation and disease control (Forslund et al. 2009).

Savannah graslands are home to some of the world´s iconic species

Freshwater ecosystems such as rivers provide services such as clean drinking water and food

3.4 Untreated Wastewater and Ecosystem Health

Wastewater management – or lack of it – has a direct impact on the biological diversity of aquatic ecosystems. Disruption of the integrity of these ecosystems negatively affects their capacity to provide ecosystem services. The composition of municipal wastewater can vary considerably, reflecting the range of contaminants released by various domestic, industrial, commercial and institutional sources. There are growing concerns about emerging pollutants in domestic wastewater which include detergents, microplastics and medications that even at low concentrations may have long-term impacts (United Nations Educational, Scientific and Cultural Organization World Water Assessment Programme [UNWWAP] 2017). Figure 3.3 shows the sources and description of wastewater. The frequency indicates the rate of occurrence of the components.

Discharge of untreated wastewater can compromise the resilience and functioning of ecosystems. Untreated wastewater and farmland run-off often contain large amounts of plant nutrients, among others. When they reach rivers, lakes and coastal waters in high concentrations they can radically alter how ecosystems function, boosting the growth of aquatic plants, changing the composition of the flora and fauna and starving organisms in the water below – including fish – of oxygen. Untreated effluent can also lead to blooms of toxic algae that can make shellfish and freshwater dangerous to humans.

Low levels of contamination, high species diversity and high dissolved oxygen (DO) levels are associated with healthy ecosystems. In a broad sense, healthy ecosystems have the capacity to maintain social and biological functions that contribute towards the SDGs. The combined effect of ecosystem health is to sustain communities and provide economic opportunities, as well as human and biotic health. Untreated wastewater contaminants (Table 3.1) compromise the ecological health of aquatic media by contributing high amounts of nutrients and high biochemical oxygen demand (BOD) with resultant low levels of oxygen in the water column. This results in symptoms such as eutrophication, foul odours and fish kills, among others. The impacts of this make it impossible for aquatic ecosystems to support community livelihoods and contribute towards the sustainable goals of humanity.

Excessive macrophyte biomass blocks waterways, clogs drainage systems, impedes access to rivers and dams and contributes to flooding and the destruction of canals.

Macrophytes such as the common water hyacinth (Eichhornia crassipes) have a rapid growth rate and are highly adaptable to extreme conditions that contribute to its high degree of invasion. It is particularly dominant in the tropics and subtropics due to improper wastewater management and high nutrient loading in these areas (Villamagna and Murphy 2010). Water hyacinth spreads in the form of dense mats due to its complex root system and thus

Table 3.1. Typical composition of untreated domestic wastewater

Contaminants	Unit	Composition
Solids, total (TS)	mg/L	390–1230
Dissolved solids, total (TDS)	mg/L	270–860
Suspended solids, total (TSS)	mg/L	120–400
Five-day biochemical oxygen demand (BOD5)	mg/L	110–350
Total organic carbon (TOC)	mg/L	80–260
Chemical oxygen demand (COD)	mg/L	250–800
Nitrogen	mg/L	20–70
Phosphorus	mg/L	4–12
Chlorides	mg/L	30–90
Sulfate	mg/L	20–50
Oil and grease	mg/L	50–100
Volatile organic compounds (VOCs)	mg/L	<100–>400
Coliform, total	No./100 mL	106–1010
Faecal coliform	No./100 mL	103–108
Cryptosporidium oocysts	No./100 mL	101–102
Giardia lamblia cysts	No./100 mL	101–103

Source: Crittenden et al. (2012).

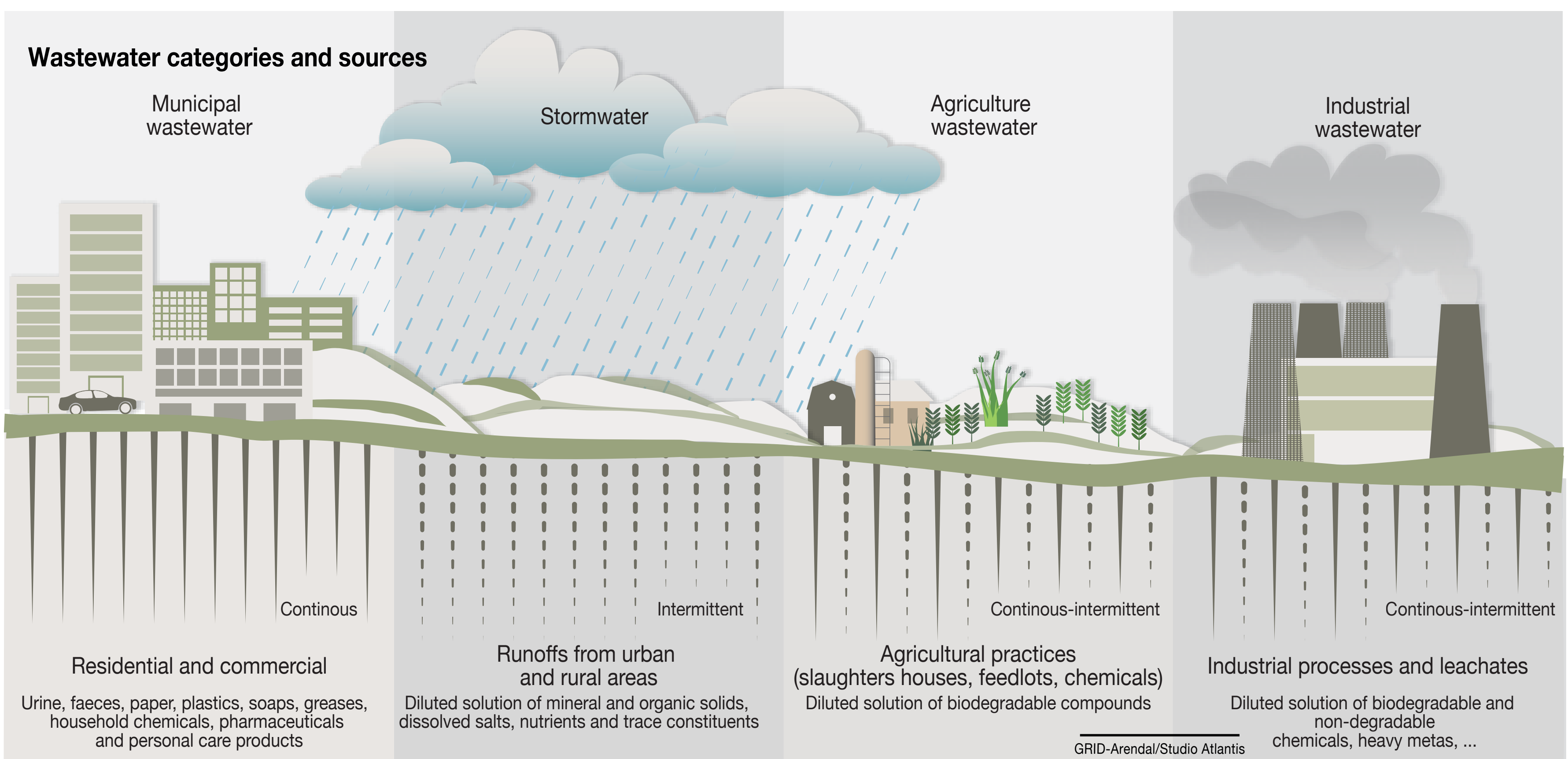


Figure 3.3. Wastewater categories and sources

Box 3.1. Threats to ecosystem health

Control of water hyacinth (*Eichhornia crassipes*) in South Africa alone costs several millions of rand per year – an average of R277 (US$20) per hectare (Van Wyk and Van Wilgen 2002). The widespread economic damage is almost the same as the ecological effects that result in the displacement of indigenous flora and fauna through habitat alteration (Byrne et al. 2010). A peri-urban mangrove area of the Mikindani forest on the banks of Tudor Creek near Mombasa Island in Kenya is primarily affected by the sewage discharge from the Mikindani residential estate and the Municipality of Mombasa. The site receives nitrogen and phosphorus that are discharged through sewage into the mangrove system on a daily basis, with negative effects on ecosystem functionality, eventually leading to dense growth of algal blooms in the aquatic environment (Bartolini et al. 2011).

interferes with boat navigation and fishing. It also blocks canals and further reduces the penetration of light, dissolved oxygen and other nutrients, adversely affecting the ecology of water bodies. Thus, pollutants from wastewater can be a threat to both ecosystem and human health.

Often, the discharge of untreated effluent results in the deposition of large amounts of organic matter, pharmaceuticals and chemical substances such as heavy metals that have major detrimental effects on the present micro- and macrofauna. Excessive nutrient loading can lead to eutrophication and oxygen deficiencies that ultimately alter the energy relationship and water balance, disrupting the structure and function of the biotic community. Excessively turbid effluent discharge can also result in the deposition of sand and grit into the aquatic system, disrupting sediment characteristics and hindering natural water flows. In addition, the overall hydrological and physicochemical environment is often affected by many of the micro- and macrofauna within these water bodies, exhibiting distinct physiological tolerance levels.

The discharge of untreated effluent into water bodies results in the deposition of organic matter which supports the proliferation of water weeds

Water weeds thrive in nutrient rich water bodies

3.5 Contamination/Degradation of Ecosystems

Although wastewater could be an important source of essential nutrients for plants, many environmental, sanitary and health risks are also associated with the use of wastewater for crop irrigation due to the presence of toxic contaminants and microbes (Khalid et al. 2018). The use of wastewater for crop irrigation in the agricultural sector has the potential for both negative and positive effects on the soil quality/productivity, crop production, and human health (Qadir et al. 2010).

There are some environmental risks associated with the use of untreated or partially treated wastewater in irrigation, including soil contamination, groundwater pollution and surface water degradation (Connor et al. 2017).

Wastewater for irrigation adds nutrients, dissolved solids, salts and heavy metals to the soil. Over time, excessive amounts of these elements may accumulate in the root zone with possible harmful impacts on soil. The long-term use of wastewater could result in soil salinity, waterlogging, breakdown of soil structure, overall reduction in productive capacity of soil and lower crop yields. Impacts depend on factors such as the source, use intensity and composition of wastewater, as well as soil properties and the crops' own biophysical characteristics (UN-Water 2017). Wastewater application changes some physicochemical properties of the irrigated soil. Studies have shown that the application of wastewater significantly changes the soil's physical, chemical, and biological properties (Becerra-Castro et al. 2015), which can, in turn, alter the biogeochemical behaviour (mobility and bioavailability) of metals and other nutrients. In addition, wastewater may also carry viruses, bacteria, nematodes and protozoa, which can cause different diseases (Uyttendaele et al. 2015).

In summary, the variation in soil properties as a result of wastewater application can have a significant impact (both positive and negative) on the soil quality and crop productivity.

3.5.1. Soil

Wastewater is used in agriculture in many parts of Africa and this practice has implications for both human and ecosystem health. In several African cities, agriculture based on wastewater irrigation accounts for 50 per cent of the vegetable supply to urban and rural areas (Drechsel and Keraita 2014). Farmers are generally not concerned about environmental hazards associated with wastewater irrigation resulting in both soil and eventually vegetable contamination – their main focus is on maximizing their yields and profits. Heavy metals in contaminated wastewater pose several risks to humans through assimilation pathways such as the ingestion of plant material (in the food chain). Heavy metals also destroy soil organisms that are responsible for nitrogen fixation, increase drainage and soil aeration. Although the metal concentrations in domestic wastewater effluents are usually relatively low, long-term irrigation with wastewater can eventually result in heavy metal accumulation in the soil (Wuana and Okieimen 2011). These metals are important as they can decrease crop production due to the risk of bioaccumulation and biomagnification in the food chain. They also pose the risk of superficial and groundwater contamination through water seepage from the contaminated soils. Cultivation of Spinach using wastewater in Zamfara State, Nigeria contains (in descending order): high levels of iron, (Fe), cadmium (Cd) and copper (Cu) (Salawu et al. 2015). Similarly, carrots, green peppers and lettuce sold in some markets in Accra, Ghana contain high levels of arsenic (As), Cd, chromium (Cr), copper (Cu), Fe, palladium (Pd) and zinc (Zn). These vegetables were cultivated using wastewater from major drainage systems spotted close to the vegetable farms (Addae 2015). Figure 3.4 illustrates the sources and sinks of heavy metals.

Box 3.2. Soil contamination with wastewater in the Niger Delta, Nigeria

A rural community in the Niger delta experiences soil contamination as a result of wastewater discharge from a cassava processing plant. Cyanide and magnesium levels were harmful to the soil when measured against the safe levels for agricultural and other purposes. The presence of the metals decreases the production of the affected area (Izonfuo, Bariweni and George 2013). Cassava processing activities are now extensively carried out in many rural and urban centres in Nigeria. Its wastewater has been reported to be toxic and poisonous. Cyanide in cassava wastewater is another major cause for concern, as when cyanide interacts with (soil) water, it produces a weak acid. Cyanide in soil has been reported to be herbicidal.

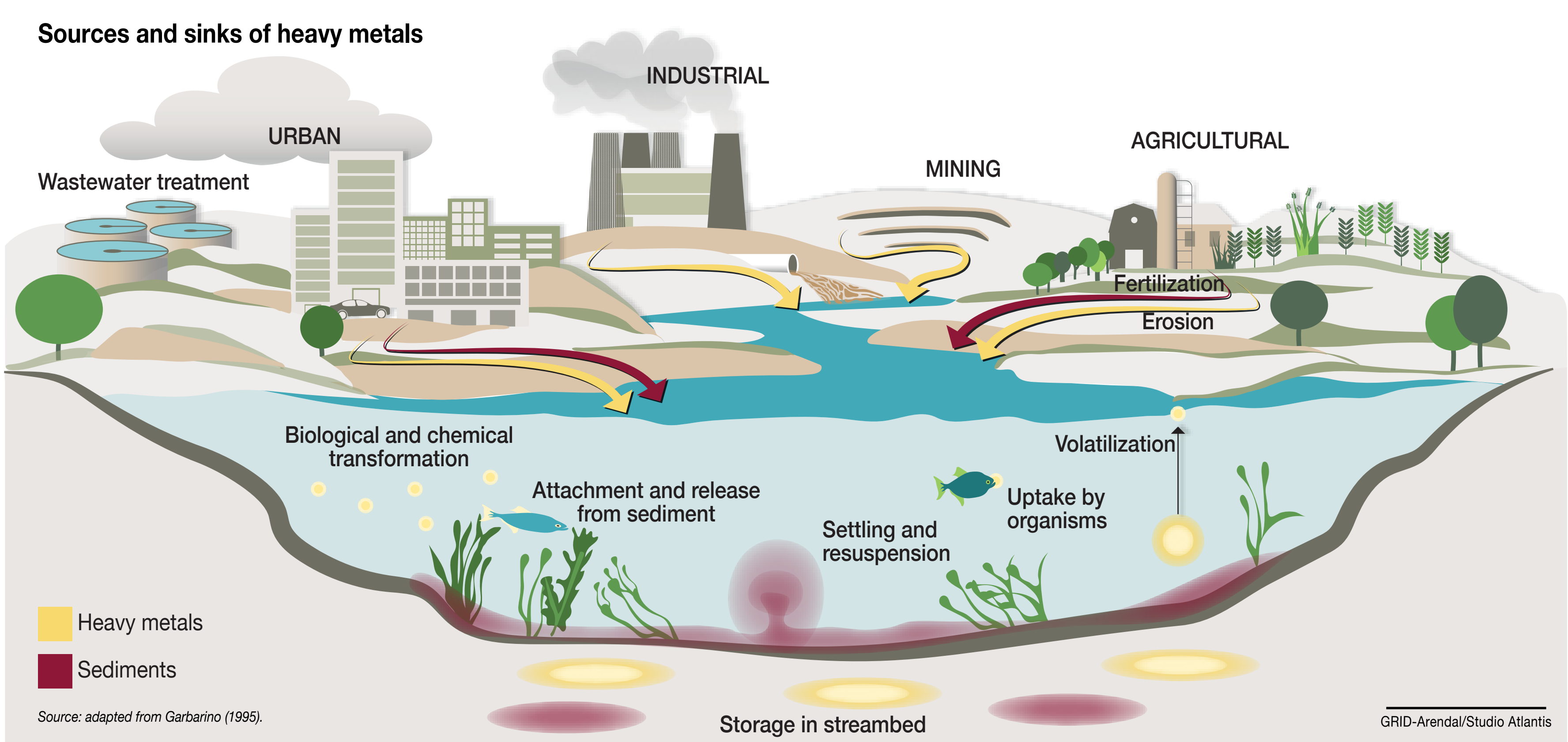


Figure 3.4. Sources and sinks of heavy metals

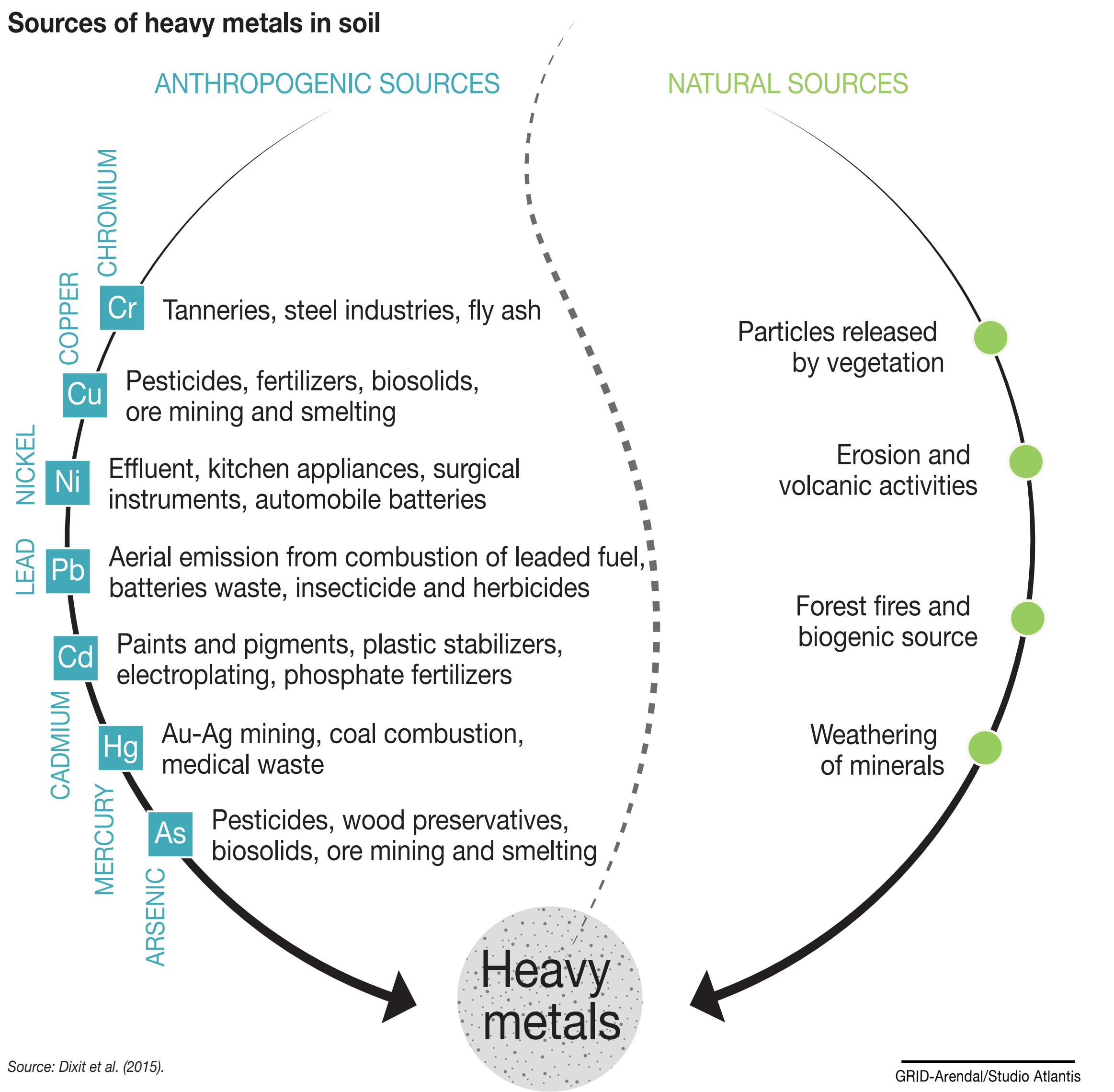


Figure 3.5. Sources of heavy metals in soil

Wastewater use in agriculture can result in the contamination of soil, crops and water sources. There is an inherent risk of contamination having harmful effects on exposed soil organisms. Even when soil acts as an efficient living filter to remove, deactivate and transform the pollutants contained in wastewater, there are some pollutants that it cannot fully eliminate. Moreover, sludge from wastewater may contain synthetic substances such as microplastics, microfibers and heavy metals, and when used as compost, it may negatively impact the effectiveness of soil as a treatment system by poisoning the degrading microorganisms, destroying the physical structure of the soil or damaging the natural cycles occurring within the soil (Durán–Álvarez 2014). Figure 3.5 shows the various sources of heavy metals in soil.

3.5.2. Air

The operation of wastewater treatment plants (WWTPs) results in direct emissions of greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Some of these emissions are released in the course of biological processes employed in the treatment plants. In addition, there are indirect emissions resulting from the generation of the energy used in the plants.

Methane and nitrous oxide are potent GHGs with a higher global warming potential than carbon dioxide (Intergovernmental Panel on Climate Change [IPCC] 2013; Delre 2018). Although there are international guidelines for estimating the methane and nitrous oxide emissions from WWTPs, how well these estimations resemble actual estimates at specific treatment plants is unknown; and GHG emissions from WWTPs may actually be higher than is estimated (Delre 2018). Greenhouse gas emissions from WWTPs must be reduced, as climate change poses risks to humans and to the environment.

Box 3.3. Recovery of greenhouse gas emissions

The emission of greenhouse gases (GHGs) resulting from the various types of treatment of municipal solid waste found in the town of Yaounde was analysed by researchers. Four management systems were taken as the basis for analyses. System 1 was the traditional collection and landfill disposal of refuse, while in System 2, the biogas produced in the landfill was recovered to produce electricity. In Systems 3 and 4, in addition to the collection, a centralized composting or biogas plant was introduced before the landfill disposal. A life cycle inventory of the four systems was made, enabling the quantification of the flux of matter and of energy consumed or produced by the systems. Landfilling without recovery of methane emitted the most amount of GHGs. It led to the emission of 1.7 tons of carbon dioxide equivalent (tCO_2E) per ton of household waste. Composting and methanation allowed for a comparable level of emission reduction of 1.8 and 2 tCO_2E/t of municipal solid waste (MSW), respectively. In order to reduce the emission of GHGs in waste management systems, it is advisable to, first of all, avoid the emissions of methane coming from the landfills. System 2 seemed to be a low-cost solution to reduce the emissions of GHGs (2.2 to 4 $/$tCO_2E$). System 2 was calculated to be the most effective at the environmental and economic level in the context of Yaounde. Therefore, traditional collection, landfill disposal and biogas recuperation to produce electricity is preferable in moist tropical climates (Ngnikam et al. 2002). The Gabal el Asfar is another example of a plant designed to recover greenhouse gases. The Gabal el Asfar wastewater treatment plant does not only have capacity to serve 12 million people by treating 2.5 million m^3/day of wastewater, but also to generate 18.5 MW of power which is enough to meet 70% of the plant's electricity demand.

Sunderland wastewater treatment plant in South Africa emitting gases into the atmosphere

3.5.3. Surface water

The discharge of untreated or partially treated wastewater into the environment results in the pollution of surface water, and this in turn affects the amount of water resources available for direct use. Since 1990, water pollution has been increasing in most rivers in Africa, due to the increasing amounts of wastewater (UN-Water 2017).

Organic pollution (measured in terms of BOD) can have significant impacts on inland fisheries, food security and livelihoods, severely affecting poor rural communities that rely on freshwater fisheries. Severe organic pollution already affects around one-seventh of all river stretches in Africa, Asia and Latin America and has been steadily increasing for years (UNEP 2016; UNWWAP 2017).

Table 3.2 highlights the problems, causes and effects of poor sanitation on ecosystem health.

Factors contributing to the contamination of freshwater include overexploitation of both water and organisms, water pollution, habitat destruction (modification of natural flow regimes) and wetland drainage for agriculture, all of which are linked to human activities. Habitat destruction and modification includes deforestation, urbanization and agricultural impacts such as leachates of agrochemicals from farmlands. Other factors contributing to the decline of surface water are global environmental processes such as climate change, global warming and acidic deposition. It is envisaged that if lake sediments become warmer and hold less oxygen in response to climate change, the contribution of phosphorus from lake sediments may increase as phosphorus is released under anaerobic conditions (Gibbons 2015). This will thereby enhance the likelihood of increasing the release of nutrients into water bodies resulting in eutrophication. Damming modifies the natural flow of rivers and is considered one of the greatest threats to the health of freshwater.

Box 3.4. Degradation and oxygen depletion in freshwater sources

Many freshwater sources in Africa are polluted due to encroachment and other anthropogenic activities. In Kwara State, Nigeria, the Moro Lake – the second largest dam in Ilorin – has very low levels of Dissolved Oxygen (DO), indicating a decline in ecosystem health. This is as a result of the cumulative effect of human activities such as sewage disposal where oxygen is used in decomposing organic matter, resulting in high BOD (the amount of oxygen required by microorganisms to degrade organic matter) and low DO concentration (Mustapha and Omotoso 2005). Likewise, in the Odaw river basin of Ghana, DO levels decrease from the upstream to the downstream portion of the river, confirming high solid and organic matter pollution downstream. BOD also increases from upstream to downstream. The Odaw River is one of the rivers in Africa that are highly polluted (Ansa et al. 2017) due to human activities. High levels of DO, lower levels of BOD and the absence of coliform bacteria are essential for aquatic life forms and are an indication of a healthy ecosystem. Contaminated freshwater affects the health of humans and organisms that depend on it for survival.

Organic pollution can negatively affect the health of fish and other aquatic life

Table 3.2. Common freshwater ecosystem problems, causes and effects

Problem	Causes	Effect
Excess algae	High nutrient loads (elevated amount of nutrients in wastewater)	Produces unsightly algal blooms
Exotic species	Introductions; high nutrient load	Reduces native species and use of lakes or reservoirs
Shallow water depth	Several causes, including dead algae and sediment input within wastewater from catchment areas	Restricts boating and swimming
Turbid water	Silt and sediment load into water bodies	Reduces aesthetic value
Toxins	Heavy metals in wastewater	Restricts fish and seafood consumption
Acidity	Wastewater containing acidic substances	Leads to low pH that restricts the biological community
Salinity	Wastewater containing salts	Leads to high salt levels that restrict the biological community

Source: Crittenden et al. (2012).

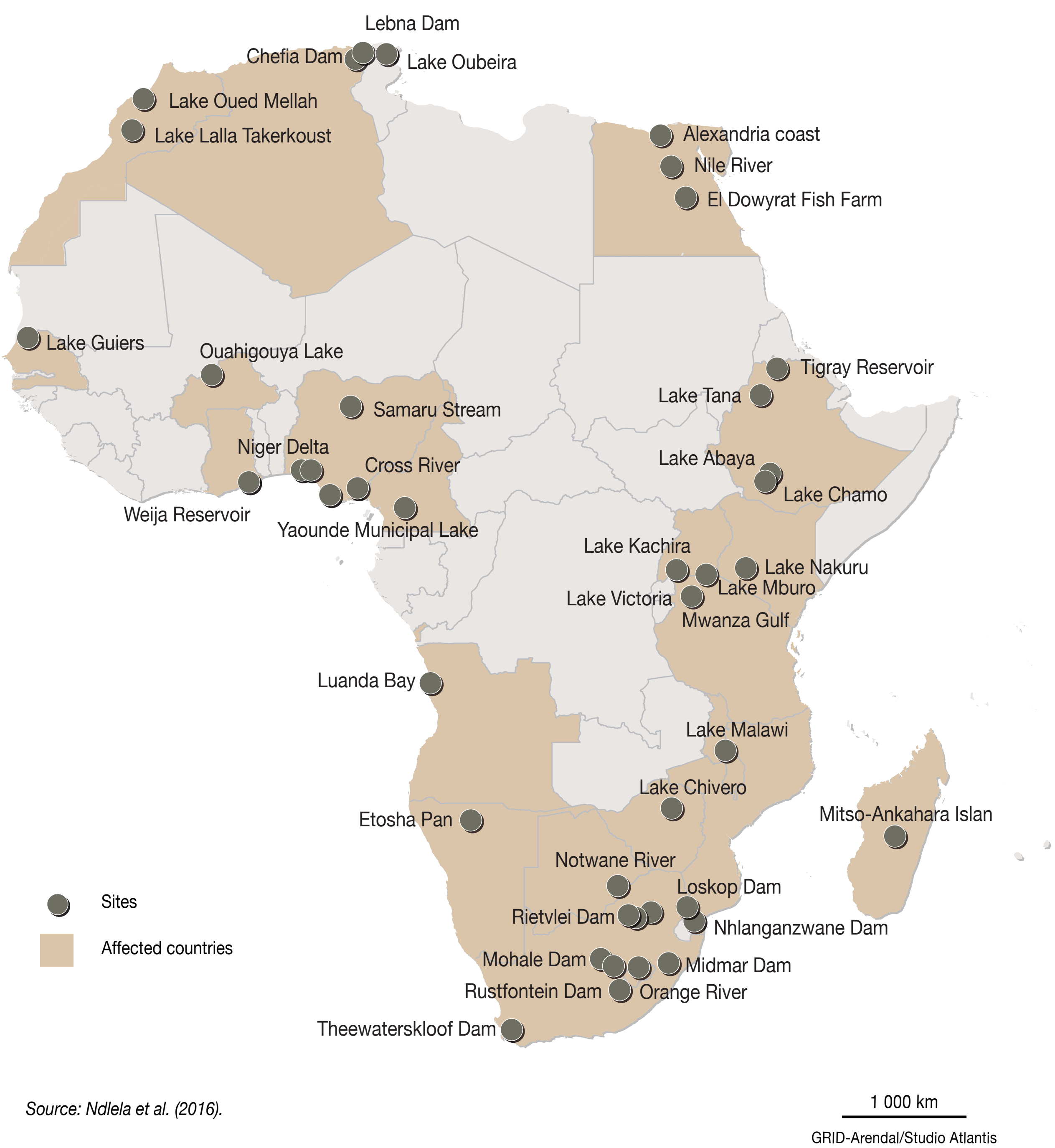
Water is contaminated by both natural and human activities

3.5.3.1. Eutrophication of streams and lakes

Eutrophication is the process of nutrient enrichment and the associated excessive plant growth in water bodies. It is part of the natural ageing process of lakes and is normally accelerated by human impacts. In their most basic forms, these nutrients are nitrogen and phosphorous, and they favour overgrowth of algae and grazing on bacteria, which then results in oxygen depletion. Eutrophication either occurs naturally or is either artificially or culturally human-induced. Natural eutrophication depends only on the local geology or the natural ageing of lakes and streams that takes about a thousand years to occur. It also depends on the natural features of the catchment. Artificial eutrophication is normally caused by nutrients from agricultural fields, domestic sewage and industrial waste. Eutrophication caused by agriculture is mainly a result of the use of fertilizers on farms and urban lawns.

Excessive amounts of the nutrients (nitrogen and phosphorus) contained in untreated or partially treated wastewater sometimes invade water sources, causing eutrophication. Eutrophication is characterized by a rapid increase in plant life that can lead to algal blooms that stop sunlight from penetrating the water body, causing plants below the surface to die. The decomposition of dead plants uses up oxygen in the water. Algal blooms are therefore dangerous to fish because they use up a lot of the oxygen in the water. They can also have a strong, objectionable smell and can affect the taste of water, hence they render the aquatic ecosystem unfit for other uses. Eutrophication increases the cost of water treatment and puts pressure on the water supply budget of African countries. Eutrophication of freshwater habitats increases their vulnerability to invasive alien species such as water hyacinth, which thrives under high nutrient conditions (Reddy et al. 1989; Coetzee and Hill 2012). Water hyacinth is considered one of the world's most problematic weeds, causing siltation, increased acidity and deoxygenation, among other effects. Several coastal and inland areas of Africa are affected by cyanobacterial (algal) blooms, as shown in Figure 3.6.

Summary of areas affected by cyanobacteria blooms



Source: Ndlela et al. (2016).

Figure 3.6. Summary of areas affected by cyanobacteria blooms in Africa

Eutrophication does not only result in the increase in water weeds but also increased costs for water purification

Box 3.5. The effects of eutrophication

Problems of eutrophication are felt most strongly where human, economic and public health interests are affected by its consequences. The key effects of eutrophication are on:
- The water supply
- The economy
- Ecosystems
- Public health and community

Water supply
Effects on the water supply include the blockage of water filter systems by algal biomass. Filamentous algae are able to penetrate water filters (for example, Oscillatoria sp.). Penetration of these algae into water supply systems affects the taste and odour of the water, impacting its quality. Algal breakdown products, mainly mucopolysaccharides, are able to chelate the iron (Fe)/aluminium (Al) added as coagulants, leading to increased numbers of metal complexes entering the water supply (Hayes and Greene 1984). Precipitation of metals under low pH conditions causes industrial use problems such as problems in the production of carbonated water for the soft drinks industry.

Economic impact
Eutrophication also results in increased costs of treating drinking water due to the need to dose reservoirs with copper sulfate. It has been reported that in Ghana, due to encroachment and dumping of raw sewage into the Weija Reservoir, the Ghana Water Company Limited – operators of the Weija treatment plant – spend close to GHC 40,000.00 a day (US$2,000.00 at the 2011 exchange rate) to treat water at the dam before it is supplied to consumers. It has been suggested that the cost of treating water from Weija far exceeds the cost of treating water at the Kpong WWTP, where water from the Volta lake is treated. At the Weija WWTP, alum, chlorine and lime are used to treat the water, whereas at the Kpong WWTP, only chlorine and lime are used. The addition of alum in the water treatment process at Weija is to remove excessive pollutants (Awuku-Apaw 2011).

Ecosystem impact
Eutrophication can result in very low levels of oxygen that cannot support aquatic life forms. The increased nutrient load leads to increased phytoplankton productivity. This can result in increased detritus on lake bottoms followed by increased sediment oxygen demand, leading large areas of the lake bottom to experience a lack of oxygen, a condition known as becoming 'anoxic'. When a lake bottom becomes anoxic, nutrients may be released from the sediment, further causing the water body to remain in a eutrophic state. Increased use of aluminium sulfate as the primary coagulant in water treatment – particularly during times of high algal crop presence – results in higher levels of dissolved aluminium in the water supply. There are perceived links between aluminium levels and encephalopathy in renal dialysis patients (Hayes and Greene 1984). Cyanobacteria (or 'blue-green algae') produce toxins such as neurotoxins and hepatotoxins produced by species of microcystis, oscillatoria and anabaena. Deaths of birds, mammals, amphibians and fish due to cyanobacterial toxins have been reported around the world. Cyanobacterial toxins can cause swimmers in freshwater lakes and other water bodies to experience gastrointestinal upsets and skin rashes through contact and ingestion of water containing scum.

3.5.4. Groundwater

Groundwater is the main water source for meeting growing demand for domestic and livestock rearing in rural, dispersed communities and small urban towns across Africa (Masiyandima and Giordano 2007; Adelana and MacDonald 2008). Figure 3.7 shows the pattern of groundwater productivity in Africa.

Although groundwater quality is highly dependable in many parts of Africa, wastewater contamination is putting it at risk. Percolation of excess nutrients, salts and pathogens from wastewater through the soil may lead to the degradation of groundwater (UNWWAP 2017). The actual impact is, however, dependent on a range of factors, including the scale of wastewater use, the quality of the groundwater, the depth of the water table, soil drainage and soil characteristics (for example, porous or sandy). In irrigated areas with shallow groundwater tables, the impact of irrigation with inadequately treated wastewater on groundwater quality is likely to be substantial (UNWWAP 2017). There are several pathways through which wastewater contaminates groundwater, including irrigation, seepage from wastewater treatment facilities and landfills.

Wastewater may contain pathogenic bacteria and viruses and has the potential both to recharge groundwater aquifers (a positive aspect) and to pollute groundwater resources (a negative externality). There is a link between groundwater and surface water, as groundwater contributes to surface water and vice versa. Groundwater contributes to stream flow generation in the form of baseflow, which is the contribution of groundwater discharge to streamflow. Furthermore, streamflow contributes to the recharge of groundwater (Todd and Mays 2005). Groundwater plays a crucial role in the health of ecosystems in rivers and wetlands, thereby offering valuable ecosystem goods and services such as water supply, flow regulation, contaminant removal and food, as well as recreation and aesthetic value (Weight 2008). Interactions between groundwater and surface water play a fundamental role in the functioning of riparian ecosystems (Kalbus, Reinstorf and Schirmer 2006).

Some of the common contamination sources of groundwater include untreated waste from septic tanks, toxic chemicals from underground storage tanks and seepage from leaky landfills (see Figure 3.8). In addition, pesticides and fertilizers also find their way into groundwater supplies over time. Road salt, toxic substances from mining sites and used motor oil find their way into wastewater and leach into underground water (Groundwater Foundation 2018). Furthermore, rocks that contain certain minerals such as fluoride may gradually dissolve, altering the chemical composition of aquifers and rendering the water unsafe for consumption.

Groundwater is the main water source for meeting the growing demand for domestic and livestock rearing in rural, dispersed communities and small urban towns across Africa

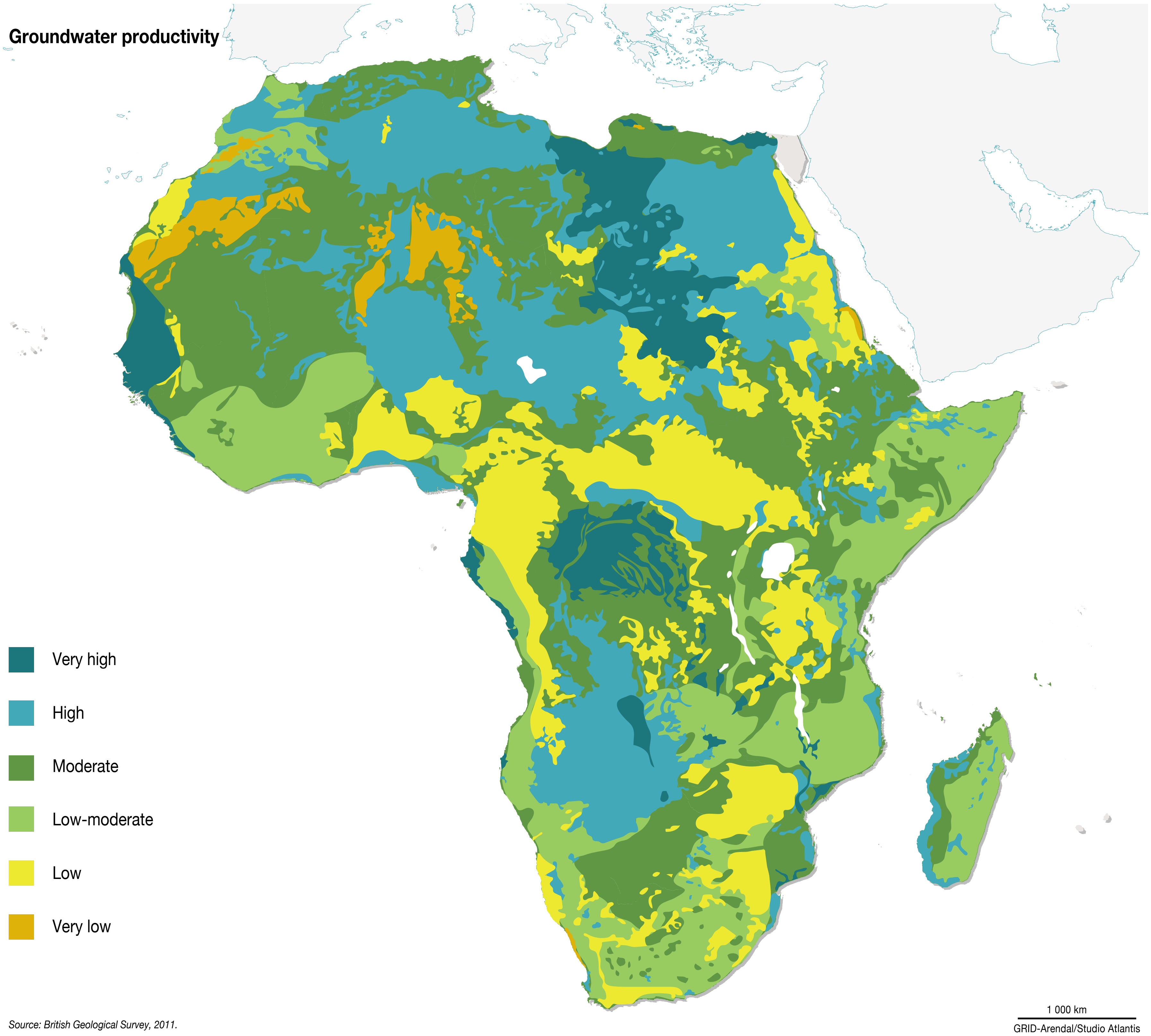


Figure 3.7. Groundwater productivity in Africa

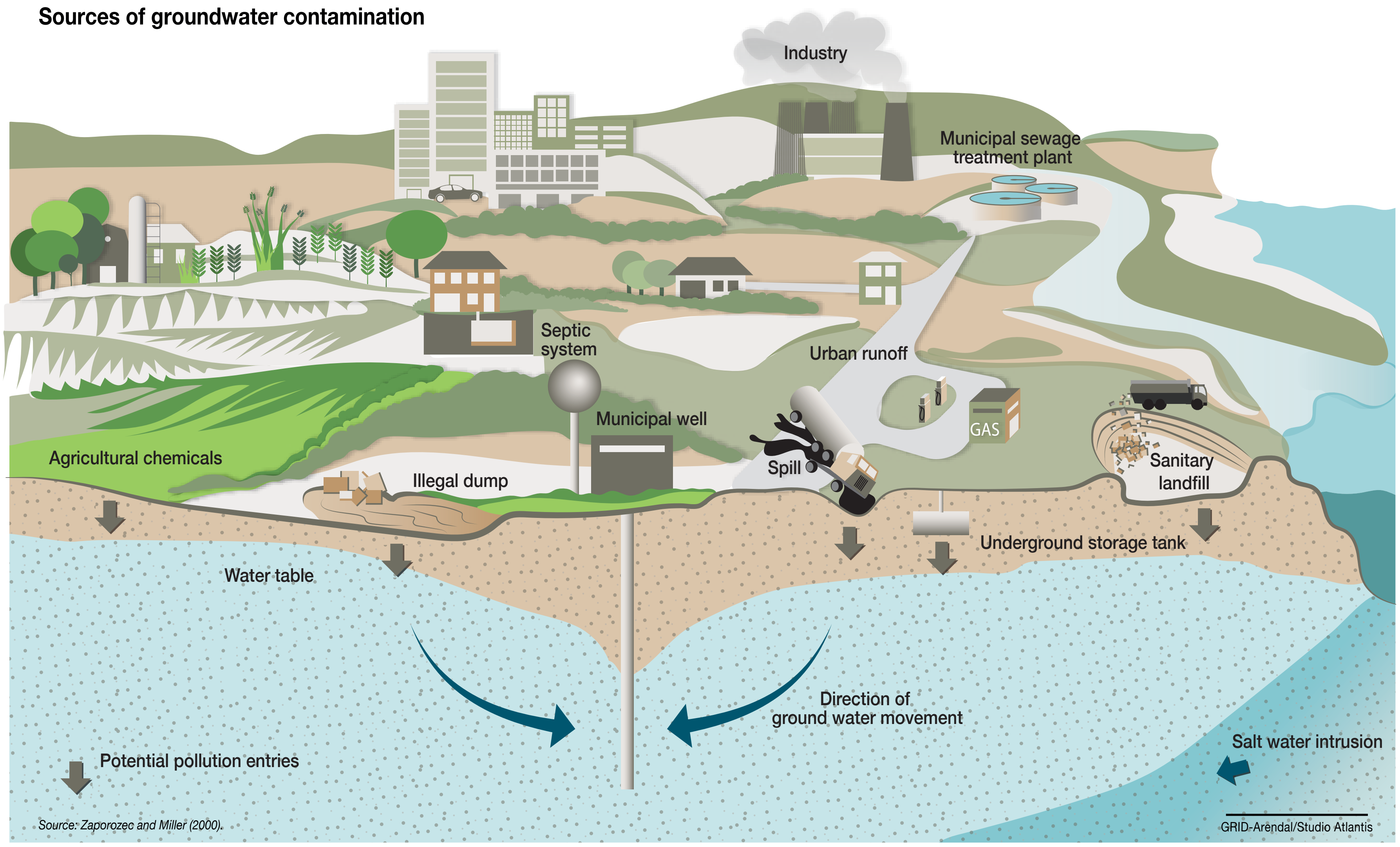


Figure 3.8. Sources of groundwater contamination

3.5.4.1. Septic tanks/Pit latrines

Septic tanks and pit latrines can contaminate groundwater. Septic tanks are on-site wastewater disposal systems used in homes, offices or other buildings that are not connected to a city sewer system. This method is widely used in many parts of Africa. Septic systems are designed to slowly drain away human waste underground at a slow, harmless rate. However, improperly designed or poorly maintained septic systems can leak bacteria, household chemicals and other contaminants into groundwater.

In some West African and Middle Eastern countries, the majority of the rural population uses pit latrines and countries where pit latrine use is prevalent also tend to have high rates of groundwater use (Tillet 2013). Studies have associated pit latrine use with the transport of microbes (typically faecal coliforms) and chemicals (for example, nitrate, phosphate, chloride, and ammonia) through soil into water sources. Most groundwater contamination occurs downstream of pit latrines (Groundwater foundation 2018).

Groundwater in unsewered urban areas could be heavily contaminated by on-site sanitation activities and could be an important source of nutrients exfiltrating into streams. For example, in Kampala City, Uganda, it was evident that substantial amounts of wastewater originated from the pit latrine and infiltrated an aquifer. As a result, nutrient concentrations down gradient of the pit latrines were found to be very high, which affected groundwater quality (Nyenje et al. 2013).

In Addis Ababa, Ethiopia, most households (about 75 per cent) have pit latrines that are either emptied when full or discharged to open drains, and the effluent gradually seeps into groundwater (Debela et al. 2018). Both shallow and deep wells found in the city are rich in nitrate, suggesting that faecal sludge, farms, livestock and wastewater from surrounding drains may contaminate the groundwater. Even protected spring waters that are usually assumed to be free from contamination were also found to be rich in nitrate. There was a fourfold increase in nitrate concentration at sites where there is high volume of sewage discharge (Debela et al. 2018). Over 80 per cent of the city's population lives in slum districts with very poor housing that is overcrowded and has little or no urban service provision (United Nations Human Settlements Programme [UN-Habitat] 2014).

Example of an unimproved pit latrine (see arrow) in Bambui, Northwestern Cameroon.

Only a small proportion of the city is served by conventional sewerage systems, while most areas rely upon on-site sanitation (Beyene et al. 2015). Open defecation remains a common practice, especially in urban-slum areas in most Sub-Saharan African countries. Most households have pit latrines that are either emptied when full or discharged to open drains. There are also flush toilets and septic tanks, again often discharging to open drains (Nakagiri et al. 2015). Public toilets are not common but communal pit latrines that are shared between several households are widespread, while others resort to open defecation.

3.5.4.2. Landfills

Landfills are sites where waste materials are deposited and buried. Waste management in Africa is often characterized by uncontrolled dumping and open burning, with limited cases of disposal to sanitary engineered landfills, or diversion of waste away from landfill towards reuse, recycling and recovery (Mwesigye et al. 2009; Mohammed et al. 2013).

According to UNEP (2015), 19 of the world's 50 biggest dumpsites are located in Africa, all in sub-Saharan Africa. Uncontrolled dumping of waste in African cities has the potential to cause significant direct and indirect impacts on communities and receiving environments (UNEP 2018).

Groundwater can be contaminated by leachate from waste

Leachate from landfills can contaminate groundwater. Engineered sanitary landfills are lined at the bottom to prevent groundwater pollution and also include features such as leachate collection and treatment systems; and groundwater monitoring, among others. However, if there is no bottom layer or the surrounding rocks are fractured, contaminants or effluents from the landfill (car battery acid, paint, household cleaners, among others) can make their way down into groundwater (Groundwater Foundation 2018).

3.5.4.3. Run-off

Storm water or run-off from urban and industrial areas usually contains substances such as oil, heavy metals, chemicals, sediment and other hydrocarbons infiltrating the soil to contaminate groundwater. If infiltrated into the soil, these contaminants have the potential to degrade soil and groundwater quality and, therefore, are cause for concern. Nutrients and sediment washed from farm lands are also leached through soil into groundwater (Groundwater Foundation 2018). Despite the gloomy picture of groundwater contamination with polluted water, South Africa and Namibia are making progress by treating storm water and wastewater and injecting it into aquifers.

Studies have shown that contaminant concentrations in urban run-off can vary widely by season, location, traffic volumes and rainfall volumes and intensity. If infiltrated into the soil, these contaminants have the potential to degrade soil and groundwater quality. Poor storm water quality can potentially contaminate surface and groundwater potable water supplies, making these water sources unusable, or more expensive to treat. Run-off from urban areas negatively impacts water quality in downstream aquatic ecosystems. Increased toxins, nutrients and other contaminants, as well as higher water temperatures and changes in stream flow rates, can impact the health of aquatic ecosystems.

Storm water or run-off from urban and industrial areas contains substances such as oil, heavy metals, chemicals and sediments that can infiltrate and contaminate groundwater

McCarthy et al. (2012) noted that urban storm water is one of the largest sources of contaminants for surface waters. The microbiological pollution most often found in urban storm water originates from failing or non-existent sanitation systems, as well as inappropriate waste disposal and hygiene habits, with the single most frequently encountered pollutant being raw sewage, followed by household greywater ('sullage'). Urban storm water run-off is an important conduit of microbial pathogens and other hazardous substances, and has the potential to disseminate diseases quite widely given that the destination of much of the urban storm water is the nearest river or other watercourses such as lakes, marshes and wetlands (Neil et al. 2014). Figure 3.9 shows the percentage of the global population with access to improved sanitation. Sub-Saharan Africa falls within the lowest percentage band.

3.5.5. Coastal and marine environment

The coastal zone has come under immense pressure due to population increase, among other factors. As much as 40 per cent of the world's population lives within 100 km of the coast, resulting in substantial development pressure for infrastructure, housing and roads, among others (Hewawasam 2002). Population increase in the coastal zone results in a high amount of waste generated with concomitant pollution of the coastal and marine ecosystems. Also, the contaminative effect of increasing technological development and industrialization has been known to disrupt and destroy the fragile coastal ecology via indiscriminate discharge of industrial and municipal waste into coastal waters and the sea (Sawant and Bhave 2014). Despite the substantial progress made in reducing fuel oil contamination, persistent organic pollutants and radioactive substances in the coastal and marine environment (UNEP/ Global Programme of Action [GPA] 2006), other problems have grown worse. Physical alteration and destruction of habitats, nutrient over-enrichment, marine litter and untreated wastewater discharge are the four problems identified for priority action (UNEP/GPA 2006). Increased nutrient load to coastal and marine waters leads to increased phytoplankton productivity. Algae and autotrophs use up oxygen and begin to die off. Aerobic decomposers

Box 3.6. Wastewater discharge on coral reefs

Run-off and sewage discharges from tourist resorts can have serious adverse impacts on coral reef communities. These impacts result from both the contaminants contained in the discharges and from the freshwater carrier itself. Of the many components of sewage, the nutrients nitrogen and phosphorus appear to have the most severe adverse impacts. The main effects of nutrients on corals appear to be indirect. The higher nutrient levels result in increased algal growth, which can ultimately lead to complete destruction of the delicately balanced coral reef ecosystem. The available evidence implies that denitrification and phosphorus removal are necessary treatment requirements if acceptable levels (after dilution) of these components are to be achieved (Hawkins and Roberts 1992).

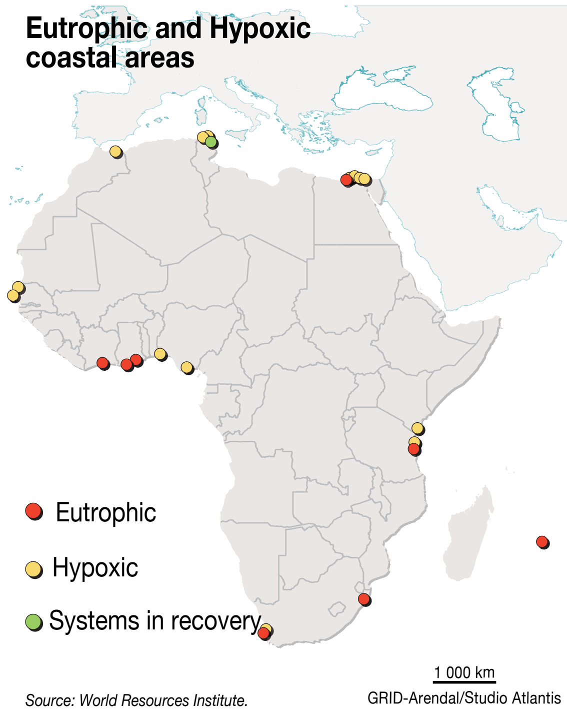


Figure 3.10. Eutrophic and hypoxic coastal areas of Africa

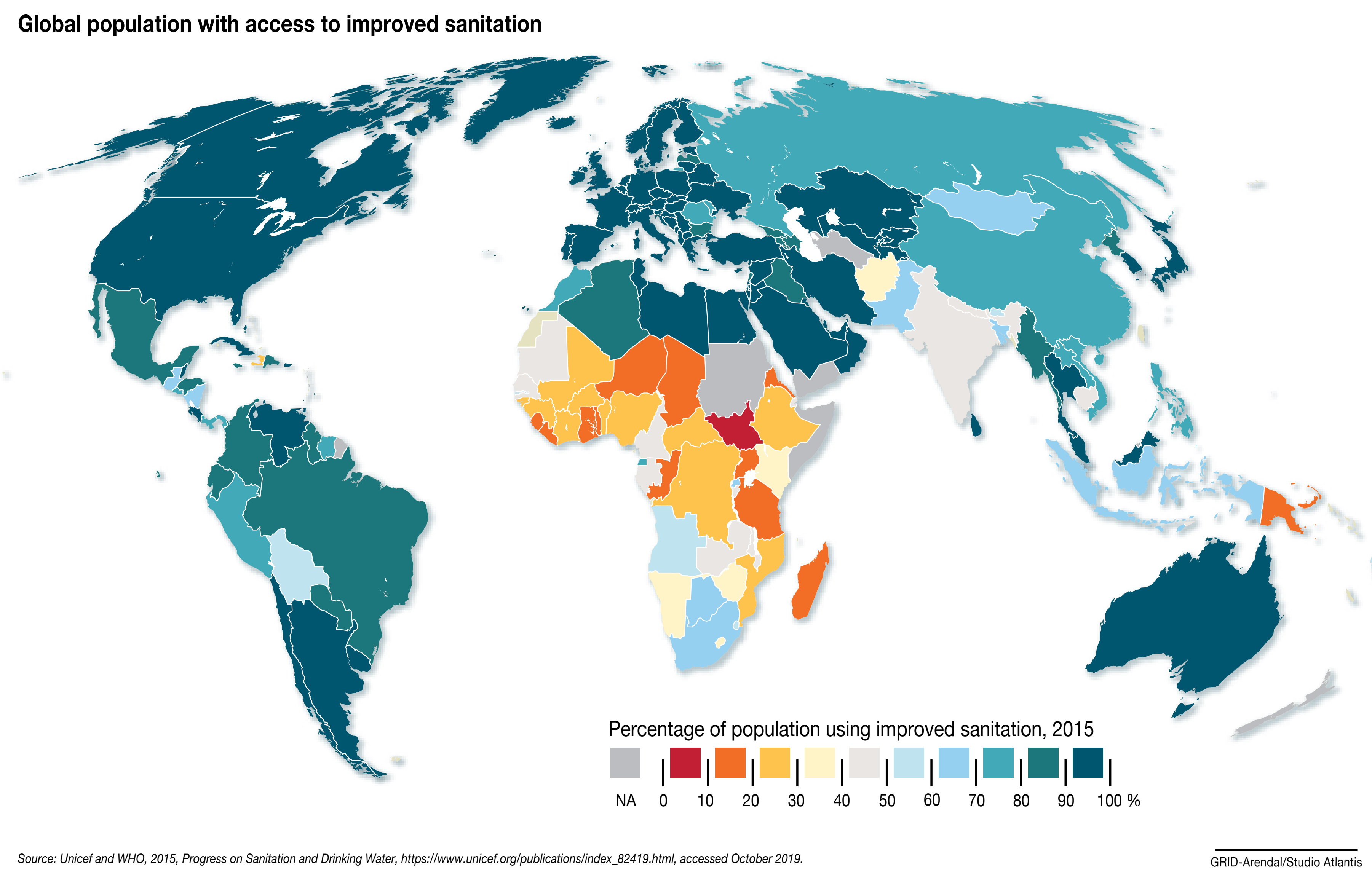


Figure 3.9. Percentage of global population with access to improved sanitation (2015)

(bacteria) multiply and use up even more oxygen. As a consequence, the entire water column is devoid of oxygen (a phenomenon known as 'hypoxia'), causing aerobic organisms (for example, fish) that rely on oxygen to die. Figure 3.10 shows eutrophic and hypoxic coastal areas of Africa.

There is rising concern over the increasing damage and destruction of essential and economically important coastal ecosystems like mangrove forests, coral reefs and seagrass beds. The number of oxygen-deficient 'dead zones' has doubled every decade since 1960, with the rise linked to nutrient run-off (nitrogen and phosphorus) originating from sources like farming and animal waste (Mehta et al. 2015). Nutrient over-enrichment has also triggered toxic algal blooms in different offshore waters of the world (Lam and Kuypers 2011). Despite national and international efforts to reduce marine litter, this problem has steadily grown worse. Around 70 per cent of marine litter ends up on the seabed, 15 per cent on beaches and a further 15 per cent is floating (Macic et al. 2017).

3.5.6. Wetlands

Wetland ecosystems provide a variety of services vital for human well-being. They serve a number of purposes, including water purification, water storage, climate regulation, flood regulation, coastal protection, recreational opportunities, processing of carbon and other nutrients, stabilization of shorelines, and support of plants and animals (Millennium Ecosystem Assessment 2005). Wetland systems are directly linked to groundwater and are crucial regulators of both the quantity and quality of water found below the ground. Groundwater, often recharged through wetlands, plays an important role in water supply, providing drinking water to an estimated 1.5–3 billion people (Millennium Ecosystem Assessment 2005). The ability of wetland systems to store or remove nutrients and to trap sediment and associated metals is highly efficient and effective but each system has a threshold. An overabundance of nutrient input from fertilizer run-off, sewage effluent or non-point pollution will cause eutrophication. The capacity of wetland vegetation to store heavy metals depends on the particular metal, oxygen and pH status of wetland sediments and overlying water, water flow rate ('detention time'), wetland size, season, climate, type of plant and other factors.

Wetlands filter and clean water through physical (e.g. sedimentation and sorption), chemical (including absorption and oxidation) and biological processes (mostly uptake by macrophytes). They slow down the flow of water so that any sediment in the water settles, thereby clarifying the water. Therefore, water flowing through a wetland area may be considerably cleaner upon its exit from the wetland. Some wetlands have been found to reduce the concentration of nitrate by more than 80 per cent (Millennium Ecosystem Assessment 2005). However, wetlands can become 'hotspots' of contamination – waste can build up to concentrations high enough to have detrimental effects on wetland functions. Unfortunately, the threshold between where pollution loadings are tolerated and where they will do damage to wetlands is not easily determined. As a consequence of pollution, the capacity of many wetlands to provide clean and reliable sources of water has been reduced.

Wetlands are increasingly being destroyed at a fast rate in several parts of Africa. For example, about 60 per cent of South Africa's wetlands have been destroyed or degraded as a result of indiscriminate ploughing and overgrazing, application of chemicals and fertilizers, damming and the removal of vegetation (Kulani 2006). The Niger Delta in Nigeria – one of the largest, most important wetland systems in the world – has experienced severe environmental degradation due to the extraction of natural resources. Additionally, residents who depend on the deteriorating wetland now struggle to earn basic living amenities (Adam 2016). The wetlands of Lake Chad continue to disappear due to drought and intensified anthropogenic use. Concern for life extends not only to the migratory birds which seasonally inhabit the area or the various flora and fauna found among the shallow lake, but also to the livelihoods of the local people, located on the borders of Cameroon, Chad, Niger and Nigeria. The Lake Chad Basin Commission (LCBC) regulates and controls the resources of the area and is actively seeking new methods of water management to restore the lake to normal levels. The LCBC explains that the significant decrease in the water flow will require new management techniques that promote efficient use, with additional research to find new sources of freshwater for the region (Food and Agriculture Organization of the United Nations [FAO] 2009).

A degraded wetland in Uganda

Box 3.7. Nature-based purification of wastewater

Wetlands only cover about 2.6 percent of the planet but play a disproportionately large role in hydrology. They have a direct impact on water quality by filtering toxic substances from pesticides and from industrial and mining discharges. Natural wetlands, woodlands (also called 'riparian forests'), and manmade or constructed wetlands, which are freshwater ecosystems, filter out pollutants including metals, sediments, nitrogenous compounds, oils and viruses that make their way into freshwater sources. Wetlands are able to eliminate 20–60 percent of metal, 70–90 percent of nitrogenous compounds and 90 percent of sediment from freshwater sources (Mitsch et al. 1999). Wetlands reduce the incidence of flooding by absorbing and hindering the movement of floodwaters towards nearby residential areas. Wetland ecosystems also serve as habitats for microbes, flora, fauna and migratory birds and vary in type from saline coastal lagoons in West Africa to fresh and brackish water lakes in East Africa (Schuijt 2002). However, ecosystems alone cannot perform the totality of water treatment functions. They cannot filter out all types of toxic substances discharged into water and there is a limit to their capacity. There are tipping points beyond which the negative impacts of contaminant loading to an ecosystem becomes irreversible, hence the need to recognize thresholds and manage ecosystems accordingly.

As previously noted, there are natural limits to the assimilative capacity of wetlands, beyond which they are threatened and can no longer perform a purifying role. Once the concentration of contaminants in run-off reaches critical thresholds, there is a risk of abrupt and irreversible environmental change (Steffen et al. 2015; UN-Water 2017). From this perspective, several degraded wetlands are unable to filter out contaminants in wastewater before its discharge into water bodies. Although natural wetlands are used for wastewater treatment or disposal in some countries such as Uganda, more and more natural wetlands are weakened or diminished due to increasing pollutant loads (Maclean, Boar and Lugo 2011).

The extensive degradation of existing wetlands further highlights the need for protecting remaining natural wetlands through better sanitary practices and improved wastewater management to protect human and ecosystem health. This means more household and industrial wastewater has to be treated before it is discharged into the aquatic ecosystem. This way, the assimilative capacity will not be exceeded and wetlands can continue to play their purifying roles.

3.6 Contaminants of Emerging Concern

Wastewater can be a source of emerging contaminants and can adversely affect the health of aquatic ecosystems and other environmental media. Such emerging contaminants are derived from pharmaceuticals, personal care products, household products, industrial and agricultural chemicals, microplastics and microfibers. Pharmaceutical waste in the environment arises from manufacturing sites, hospital waste, excretion by livestock treated with antibiotics, growth promoting agents and flushing of old and unwanted prescriptions. The increasing occurrence of active pharmaceutical ingredients in aquatic environments adversely affects living organisms on different organizational levels and alters the ecological function of rivers and lakes (Rzymski, Drewek and Klimaszyk 2017).

Household products such as organic waste and detergents, and industrial and agricultural chemicals such as fertilizers, pesticides, biosolids and manures are hazardous waste, mostly released directly into the environment through a range of point and non-point sources. Other sources of hazardous waste include oil exploration and mining activities. Detrimental effects of wastes on aquatic biota are evident at all levels (molecular, cellular, tissue, organ and ecosystem levels), depending on the magnification of the hazardous substance in fresh and marine waters and its accompanying biota, including sediments. For example, at certain concentration levels, substances with endocrine disrupting properties have been shown to impair reproduction in fish and shellfish, raising concerns for their fertility and population survival. Organochlorines have also had impacts on sea birds and marine mammals. Such impacts diminish the services provided by aquatic ecosystems, and consequently the returns derived from them (Greenfacts 2017). The effects of household products on aquatic biota are normally minimal but may accumulate or magnify over time.

Centralized treatment plants receive wastewater through a network of pipes

Box 3.8. Methemoglobinemia

Methemoglobinemia is characterized by reduced ability of the blood to carry oxygen due to reduced levels of normal haemoglobin. Infants are most often affected: they may seem healthy but show signs of blueness around the mouth, hands and feet, hence the common name 'blue baby syndrome'. These children may also have trouble breathing and may also experience vomiting and diarrhoea. In extreme cases, there is marked lethargy, an increase in the production of saliva, loss of consciousness and seizures. Some cases may be fatal.

In the body, nitrates are converted to nitrites. The nitrites react with haemoglobin in the red blood cells to form methaemoglobin, affecting the blood's ability to carry enough oxygen to the cells of the body. Bottle-fed infants less than three months of age are particularly at risk. The haemoglobin of infants is more susceptible and the condition is exacerbated by gastrointestinal infection. Older people may also be at risk because of decreased gastric acid secretion.

Controlling nitrate levels in drinking water sources to below around 50mg/litre is an effective preventive measure (WHO 2013).

There is scientific evidence that many chemicals recognized as emerging pollutants can potentially cause endocrine disruption in humans and aquatic wildlife, causing birth defects and developmental disorders and affecting fertility and reproductive health, even at very low concentrations (Poongothai et al. 2007). They also have the potential to cause cancerous tumours and the development of bacterial pathogen resistance, including multi-drug resistance (UN-Water 2017).

Emerging pollutants are found in varying concentrations in treated and untreated municipal wastewater, industrial effluents and agricultural run-off that seeps into rivers, lakes and coastal waters (UN-Water 2011). They have also been detected in drinking water (Raghav et al. 2013), as conventional wastewater treatment and water purification processes are not effective in removing them. Advanced wastewater treatment technologies (membrane filtration, nanofiltration, ultrafiltration and reverse osmosis) can partially remove some chemicals and pharmaceutically active compounds. However, these treatment technologies are costly and most developing countries cannot afford them (González et al. 2016).

Box 3.9. Hazardous substances

Hazardous substances are chemical substances that are either toxic (poisonous), reactive (capable of producing explosive or toxic gases), corrosive (capable of corroding steel), or ignitable (flammable). If improperly treated or stored, hazardous substances can pollute the environment.

Contamination of water resources by hazardous substances harms living organisms and ecosystems. It harms human health through bioaccumulation, contamination of public water supply and recreational use of contaminated water resources. In higher concentrations, they kill fish and shellfish in the lakes, reservoirs, rivers and ocean waters. The contamination of water and soil can hinder the growth of agricultural products and the contaminants can accumulate in the products.

Agricultural chemicals are one class of hazardous substances that cause contamination. These are organic chemicals that include organochlorine compounds. They are extremely toxic and when humans are exposed to them, they can suffer from internal and neurological diseases. They include many substances that are suspected of being carcinogens or mutagens. Because agricultural chemicals are generally highly soluble, they contaminate the environment by seeping into the ground with rainwater, while those on the ground's surface can be transported into river by rainwater (Engelking 2009).

3.7 Efforts at Reducing Ecosystem Health Risk Through Wastewater Treatment

Ecosystems impacted by discharge of untreated wastewater and human excreta have less capacity to provide a number of important services on which humans rely. In South Africa, it has been reported that more than two-thirds of the wastewater treatment facilities examined did not meet the minimum quality-control standards. In South Africa, fish death as a result of the negative impacts of wastewater on ecosystems has been reported in the Vaal – a major river – and the Vaal Dam, into which untreated sewage is discharged. This highlights the need for wastewater treatment.

Several countries in Africa including Egypt, Morrocco, Namibia, South Africa and Tunisia are relatively advanced as regards practising wastewater reuse or having wastewater treatment plants that produce safe effluent (Bahri, Drechsel and Brissaud 2008). Wastewater has been reclaimed for potable use in Windhoek, Namibia (Box 3.12). However, in many other countries on the continent, urban wastewater is either untreated or partially treated before discharge into water bodies. This is due to a lack of – or simply partially functioning – WWTPs.

It has been estimated that 90 per cent of untreated wastewater in Africa is released directly into rivers, lakes and oceans (UN-Water 2017). Challenges facing the WWTPs include insufficient technical capacity to cope with increased wastewater load due to population increase, pollution load variation caused by uncontrolled discharge into the sewage network and power cuts where treatment processes require energy (Nikiema et al. 2011). The most significant challenge is funding wastewater treatment plants. In developed countries, a lot of money is invested in wastewater treatment and in designing and building systems for wastewater collection. However, this is not the case for many African countries because collection and treatment of wastewater is less prioritized and obtaining funding is also a challenge (Grayson 2013).

Fish death as a result of the negative impacts of wastewater on ecosystems

3.8 Ecosystem Health Risk Reduction and SDG 6

3.8.1. Use of value-recovery technologies or principles

If regarded as a resource, wastewater can be treated, recycled and reused to minimize its adverse effect on the ecosystem and the health of humans. This will result in improved water quality by drastically reducing the proportion of hazardous chemicals and materials that end up in the water bodies, thus contributing towards achieving SDG 6: ensuring availability and sustainable management of water and sanitation for all.

Well managed wetlands have the capacity to absorb some pollutants

Table 3.3. Opportunities and challenges associated with source-separated domestic wastewater

Waste stream	Opportunities	Challenges
Urine	Nutrient recovery (nitrogen, phosphorus, potassium)	Heavy to transport mechanically: risk of precipitation and clogging when transported in pipes; ammonia evaporation and odour
Faecal matter	Energy (biogas) production; soil amendment	Small volumes produced per person; transport and logistics may be difficult; high pathogen levels; odour
Blackwater (flush water, urine and faeces) or brownwater (flush water and faeces with no urine)	Energy (biogas) production; nutrient recovery; soil amendment; will flow under gravity	Amount of water affects transport (clogging) and energy production value; pathogens; odour
Greywater (water used in shower, bath, handwashing, dishwashing and laundry)	Heat recovery; water recovery	Treatment required to prevent regrowth of bacteria; generation of parallel products (sludge and foam); impact of salinity and chemicals on soils; source separation; pathogens; odour
Faecal sludge (sludge collected in on-site systems, containing excreta and possibly other waste)	Soil amendment; fuel source	Collection and transport; identifying institutions responsible for management; pathogens; odour

Source: Adapted from Tilley (2013).

There are different options available to reduce wastewater contamination. Wastewater can be reduced in volume and can also be treated to remove pathogens and pollutants that make it hazardous. Additionally, it can become a source of energy, plant nutrients and other agricultural inputs, as well as a source of water and many other valuable resources, bringing sizeable economic, social and environmental benefits, as inferred from Table 3.3.

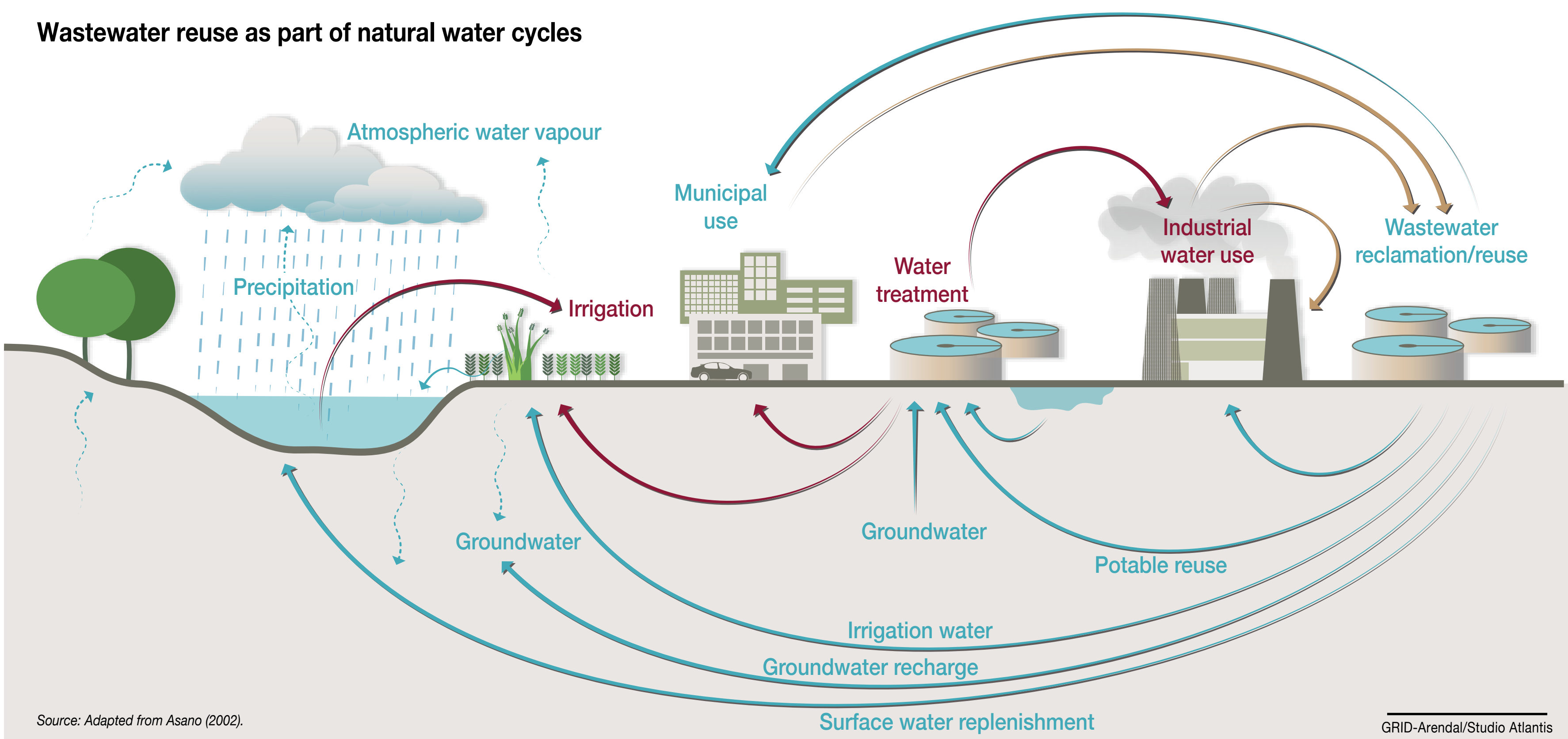


Figure 3.11. Wastewater reuse as part of natural water cycles

3.8.2. Managed aquifer recharge through wastewater reinjection: The case of Atlantis, South Africa

The South African model of storm water and wastewater injection into aquifers provides an opportunity for other African countries to adopt this technology. Indirect recycling of storm water and treated wastewater for potable purposes has formed an integral part of the Atlantis Water Resource Management Scheme for the past 30 years (Bugan et al. 2016). This augments the limited natural groundwater supplies along the semiarid west coast, north of Cape Town. Figure 3.13 shows the sequence of operations of the Atlantis Water Resources Management Scheme.

The Atlantis model is based on artificial groundwater recharge as a water management tool for bulk water supply in southern Africa. This involves management of large volumes of storm water from urban areas aimed at controlling impacts on surface water. Managed aquifer recharge ensured the sustainability of the Atlantis groundwater supply over more than two decades and will continue to play a key role. Indirect recycling of storm water and treated domestic wastewater via the aquifer as a means to augment supplies has been adopted by the public. The various processes for wastewater treatment of the Atlantis Water Resources Management Scheme are shown in Box 3.11. The groundwater scheme provides a cost-effective water supply option when coupled with strict management of the resource.

Wastewater reclaimed for use in agriculture

Box 3.10. Wastewater reclamation for potable use in Windhoek, Namibia

Windhoek in Namibia is home to the world's longest operational wastewater reclamation plant. The scheme has been in operation since 1968 and was previously known as the Goreangab Water Reclamation Plant (GWRP). Prior to this, reuse of sewage effluent in Namibia had only been considered for supply to power stations, an idea which was never implemented. An integrated number of factors led the water utility in Windhoek to seek other alternatives to meet water demand. These factors included rising population growth, a significant decline in annual rainfall and increased evapotranspiration. With the lack of perennial rivers in Windhoek and the impractical costs of water transportation from other regions, wastewater effluent was again considered, but this time for potable purposes. The GWRP was commissioned to implement a solution and after rigorous pilot testing (1960–1968), in 1968, secondary treated sewage effluent was reclaimed, blended with dam water and added directly into the city's water supply to meet up to 12 percent of the daily demand (Van 2016).

Figure 3.12. Technical functions in a sustainable sanitation and wastewater value chain

Box 3.11. Storm and wastewater recharge of the aquifer in Atlantis, South Africa

The large volumes of storm water run-off that would be generated after urbanization and the associated hardening of surfaces was seen as a valuable water source for augmenting water supplies and it prompted the construction of a storm water collection system. This consists of 12 detention and retention basins and the necessary interconnecting pipelines with peak flow reduction features. The storm water system at Atlantis was designed with the flexibility to control water flows of differing salinity and to collect the best quality water for infiltration into the aquifer.

Initially, all wastewater was treated in a single wastewater treatment plant and all the treated effluent was used for artificial recharge. In 1986, this practice was discontinued due to water quality considerations and separate treatment plants were constructed for domestic and industrial wastewater treatment. These came online in the mid-1990s. The domestic wastewater undergoes full secondary treatment with nitrification-denitrification steps (anaerobic-anoxic-aerobic). The effluent from the secondary settling tanks is polished in a series of maturation ponds (see Figure 3.14 below). The maturation pond effluent is blended with the urban storm water run-off before discharge into the main recharge basins.

Source: Tredoux et al. (2009).

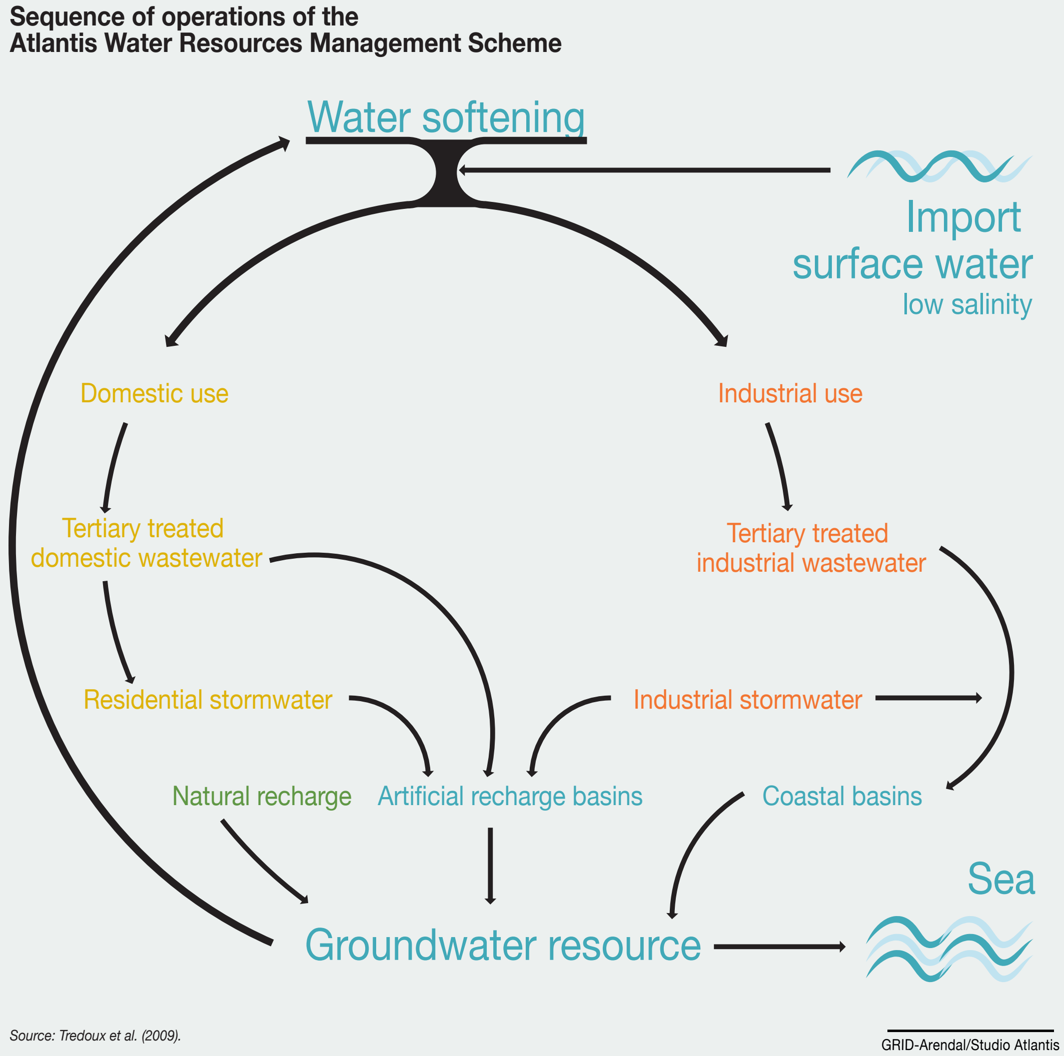


Figure 3.13. Sequence of operations of the Atlantis Water Resources Management Scheme

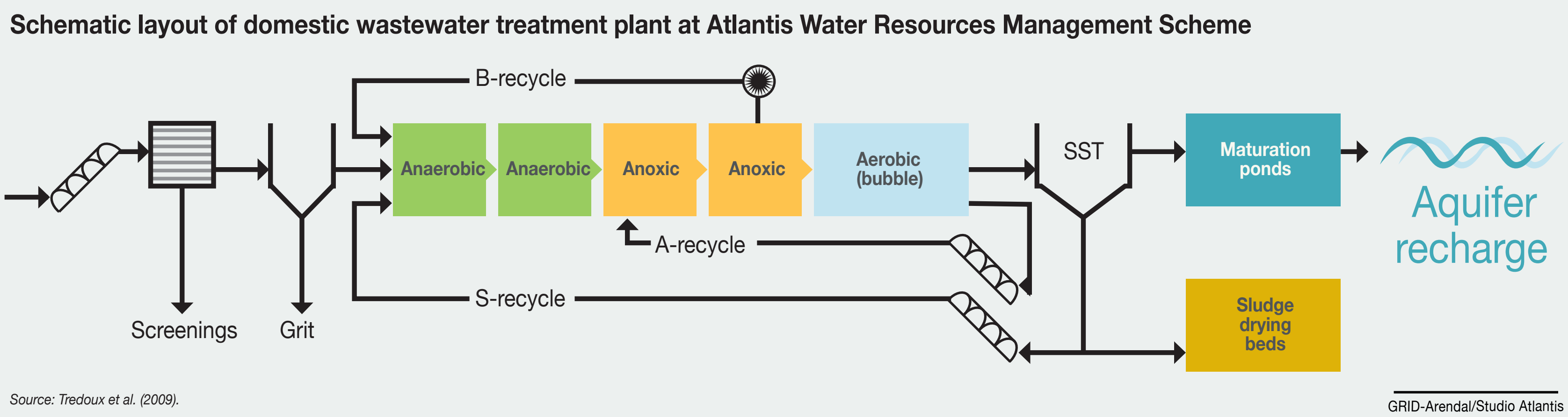


Figure 3.14. Schematic layout of domestic wastewater treatment plant at Atlantis

3.9 Conclusion

Ecosystems provide types of essential services that are necessary to maintain optimal ecosystem health, including provisioning, regulating, supporting, and cultural (Millennium Ecosystem Assessment 2005). Although wastewater is an important source of essential nutrients for plants, many environmental, sanitary and health risks are also associated with the use of wastewater for crop irrigation due to the presence of toxic contaminants and microbes (Khalid et al. 2018).

Wastewater management – or lack of it – has a direct impact on the biological diversity of aquatic ecosystems. It can disrupt the integrity of these ecosystems by negatively affecting their capacity to provide ecosystem services. This underscores the need for its treatment and reuse. Wastewater is an important resource that can be used to recharge aquifers and reduce water scarcity. However, it contains components that have negative effects on ecosystems.

Wastewater treatment will make a substantial difference to the health of key ecosystems, including rivers, lakes, soil, groundwater and wetlands. Substantial investment is needed to help improve the health of ecosystems on the African continent to protect the important ecosystem services they provide. If regarded as a resource, wastewater can be treated, recycled and reused to minimize its adverse effect on the ecosystem and the health of humans. This will result in improved water quality by drastically reducing the proportion of hazardous chemicals and materials that end up in the water bodies; thus contributing to achieving SDG 6: ensuring availability and sustainable management of water and sanitation for all. The integration of wastewater into the natural water cycle should be encouraged and more resources should be invested into WWTPs and into the protection of freshwater ecosystems such as wetlands.

A healthy ecosystem can provide for both wildlife and people

4

HUMAN HEALTH

4.1 Introduction

Contaminated water and poor sanitation are linked to the transmission of many preventable diseases, the most common of which are diarrhoeal diseases. Diarrhoea is one of the leading causes of morbidity and mortality in children under the age of five, and the leading cause of death in sub-Saharan Africa (SSA) (Global Burden of Disease [GBD] 2016; Prüss-Ustün et al. 2014). Repeated childhood diarrhoeal infections have been associated with growth and cognitive impairment and early death (Mokomane et al. 2018). Research indicates that four pathogens are responsible for the majority of moderate-to-severe diarrhoea cases. These are Rotavirus, *Cryptosporidium* spp., *Shigella* spp. and *Escherichia coli*, all of which are largely preventable with improved water, sanitation and hygiene (Kotloff et al. 2013).

Sustainable Development Goal 6

ENSURE AVAILABILITY AND SUSTAINABLE MANAGEMENT OF WATER AND SANITATION FOR ALL

TARGET 6.1
By 2030, achieve universal and equitable access to safe and affordable drinking water for all.

INDICATOR 6.1.1
Proportion of population using safely managed drinking water services.

TARGET 6.2
By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.

INDICATOR 6.2.1
Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water.

Figure 4.1. Sustainable Development Goals 6

Universal access to safe drinking water and adequate sanitation and hygiene (collectively referred to as WASH) are the focus of Sustainable Development Goal (SDG) targets 6.1 and 6.2 as Figure 4.1 shows. The ongoing disease burden in many parts of Africa is a major impediment to sustainable development. Poor WASH is acknowledged as the main cause of diarrhoeal infections (which are mainly spread by exposure to contaminated faeces) and is also strongly associated with other deadly or debilitating diseases, such as malaria, polio, guinea worm, schistosomiasis and trachoma (United Nations Children's Fund [UNICEF] 2016).

Improving WASH involves creating barriers to limit the spread of pathogens, especially those contained in human and animal faeces. These barriers include managing faeces with effective sanitation systems (the toilet barrier), improving or protecting water supplies to provide safe drinking water (the safe water barrier), establishing effective hygiene practices such as handwashing (the hygiene barrier) and the effectively treating and managing wastewater (the wastewater barrier) (Figure 4.2).

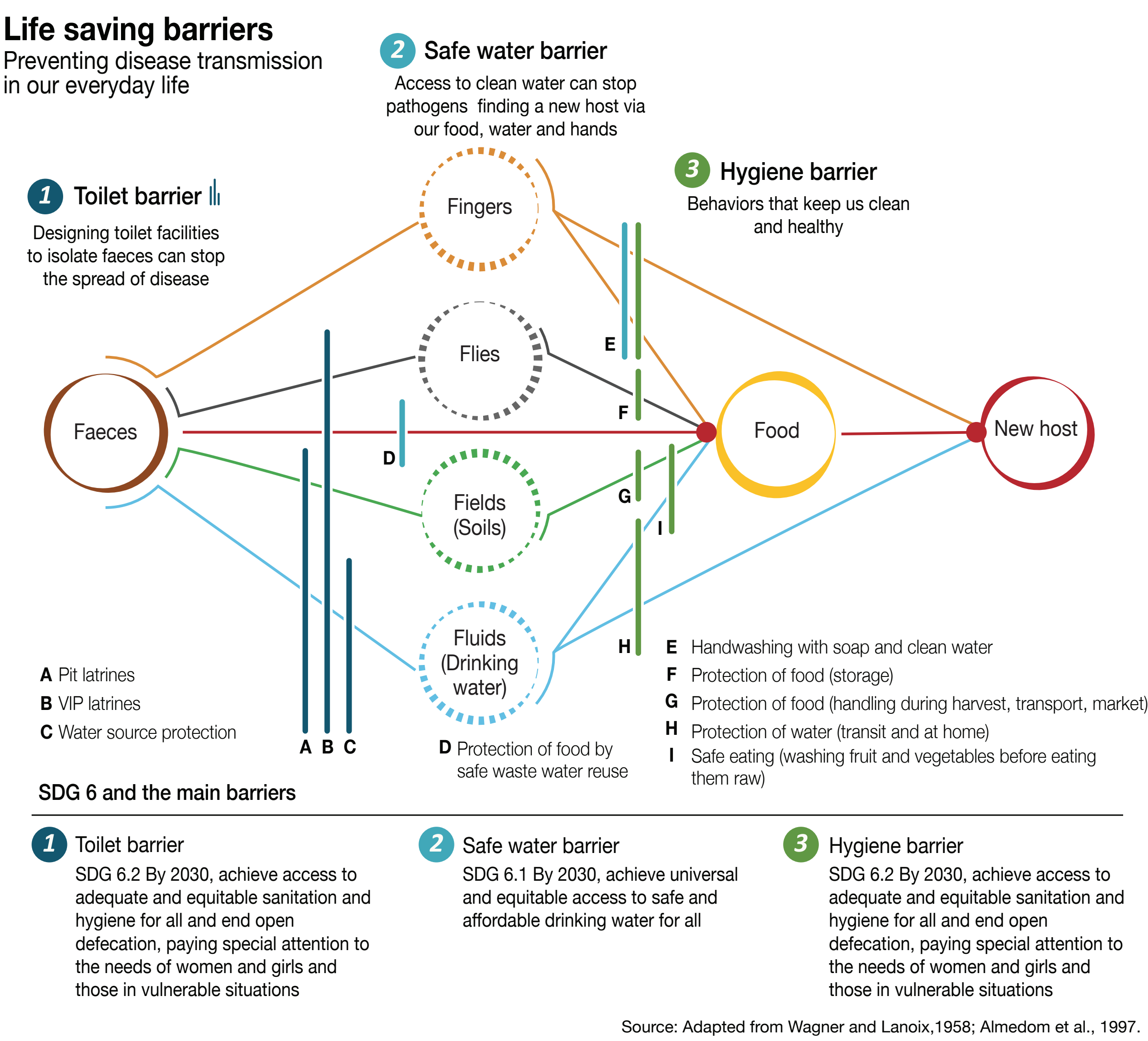
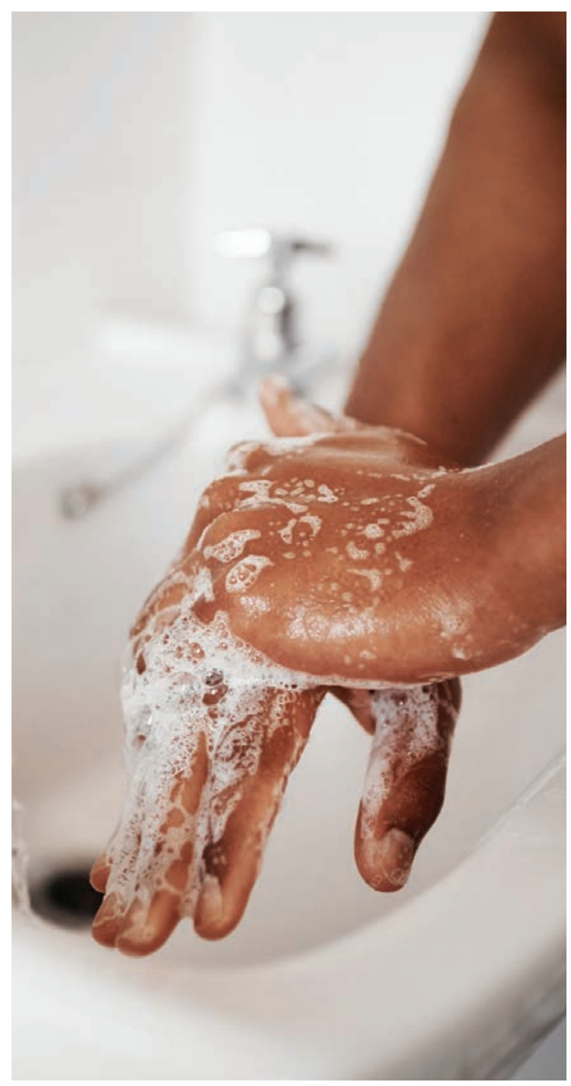


Figure 4.2. The pathways for faecal-oral disease transmission



Hand washing at all times is key to good health

4.2 Toilet Barrier: A Clean Functioning Toilet

Many people in parts of Africa have substandard toilets, toilets shared by many, or no toilet at all. For example, in Nigeria, 52 per cent of schools have no toilet (WaterAid 2018a). A good toilet provides a healthy, safe and dignified place for people to relieve themselves, as well as an environmentally sound method of waste disposal. The Joint Monitoring Programme (JMP) (UNICEF and World Health Organization [WHO] 2017) identifies five categories on a "best to worst" ladder of sanitation service – with 'safely managed' at the top and 'open defecation' on the lowest rung as Figure 4.3 shows.

The JMP ladder has open defecation (classified as 'unimproved sanitation') at the bottom rung, recognizing it as the least desirable option. Given that it facilitates the faecal contamination of water sources and provides breeding grounds for insects and worms that spread the disease-causing microbes contained in faeces, eliminating open defecation is a key action for stopping the spread of disease.

Open disposal of children's faeces from nappies and potties is also a common practice in areas with low latrine coverage and is considered the most important source of contamination in the household environment (Gil et al. 2004). A study in a rural village in Kenya found that the most common disposal method was to throw excreta on the ground adjacent to the house to dry (Okullo, Moturi and Ogendi 2017).

Pit latrines are the most basic form of improved sanitation and are widespread in both rural and urban areas of Africa. Improved latrine designs start with a pit dug into the ground, a simple concrete slab or floor and a cover over the hole to stop insects. These dry toilets only require water for cleaning the slab. More complex dry systems include ventilated and composting pits that are more costly and difficult to construct. In areas where there is a reliable source of water, a pour-flush pit latrine system that uses one to three litres of water per flush may be an option (WHO 1996).

Confining excreta to pit latrines is a positive step, but in many areas in Africa, a single pit latrine may be used by many people. If not properly designed and constructed, the pit latrine may leak or overflow during wet weather and contaminate water supplies or surrounding soil and crops. Latrines need to be constructed and maintained to prevent groundwater contamination. Determining an appropriate site to locate a latrine is often complicated by soil type, rainfall, drainage patterns, capacity requirements and local groundwater use (Graham and Polizzotto 2013). There are numerous guidelines for latrine construction, and most suggest that the latrine should not be located within six metres of a kitchen or house, nor within 15 metres of a well or spring that is used for drinking water (see Lifewater 2011; WASHplus 2015). While the availability of toilets often translates to use of the facilities, there are situations where toilets are hardly used for various reasons as Figure 4.4 explains. Where toilets are not available or not used, there are not only poor health implications but also economic costs (Figure 4.5).

Box 4.1. Accessible toilets

In many parts of Africa, disabled children, adults and the infirm are isolated by the lack of accessible toilets. Providing toilets for the able-bodied is often difficult enough, so making them accessible to the less mobile is often not a consideration. Disability disproportionately impacts women, girls and the poor (Disability Africa 2018). Data on disability in Africa is scarce, but a report in 2011 estimated that 6.4 per cent of children aged zero to 14 years in sub-Saharan Africa have a disability and 1.2 per cent are severely disabled (WHO and World Bank 2011). The inability to access facilities stops many disabled children from attending school (WHO 2015) or obtaining appropriate health care. Public toilets need to be built in accordance with good design principles and in emergencies, the disabled need to be located close to accessible WASH locations (UNICEF 2016).

Why isn´t there a toilet and why not use the toilet if it´s there?

Lack of funds - 75% cite this reason [1]	Long queues - many households may share a single facility [5]
Construction may be seen as a government responsibility [2]	Dilapidated (non maintained) facilities
Lack of space in household	Open defecation is a childhood practice that continues[6]
Lack of knowledge	Limited understanding of health and hygiene[7]
Cultural practices	Available open space for defecation[8]
Household latrine seen as reducing the purity of the home [3]	Pit latrine is full
A low-quality toilet is an embarrassment so better to have none [4]	Source: 1, 2 and 8 Okullo et al. 2017; 2 and 3 Coffey et al., 2014; 4 Flynn 2015; 5 Banerjee & Morella, 2011; 6 Galan et al. 2013, 7 Geetha et al., 2014.
Lack of water	

Figure 4.4. Availability and use of toilets

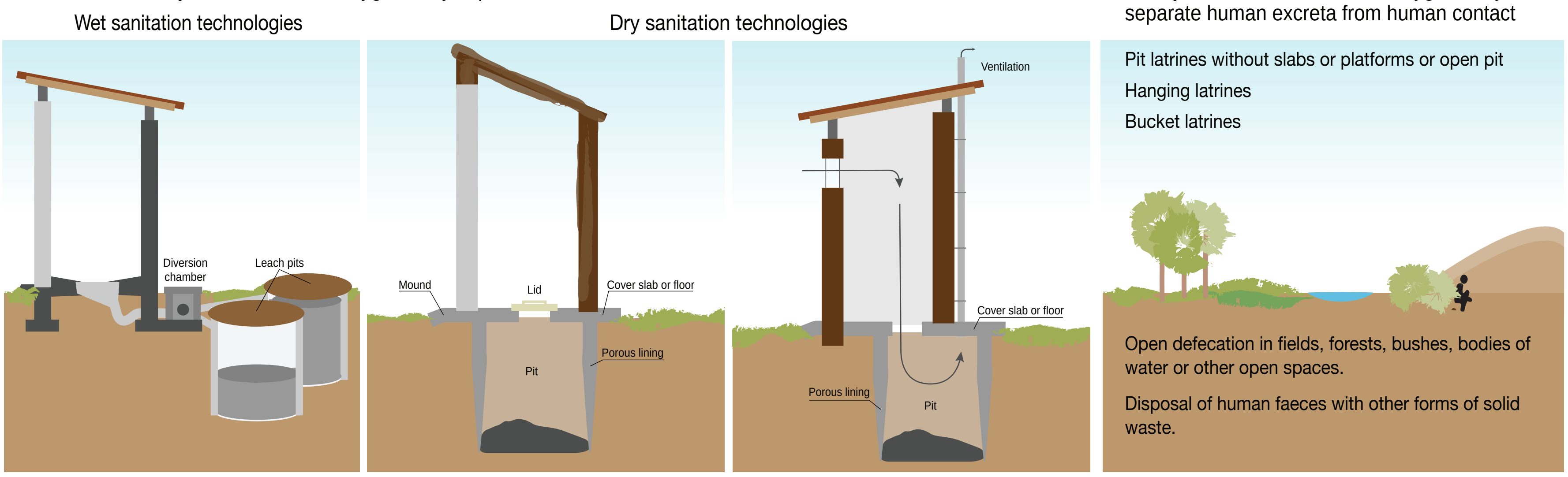
Improved versus Unimproved Sanitation

Improved Sanitation hygienically separate human excreta from human contact

Unimproved sanitation do not hygienically separate human excreta from human contact

Wet sanitation technologies

Dry sanitation technologies



Flush and pour flush toilets connecting to sewers, septic tanks or pit latrines

Ventilated improved pit latrines; pit latrines with slabs; composting toilets

Source: OpenLearn, Stockholm Environment Institute, 2007; WHO and IRC, 2003; JMP, 2017.

Figure 4.3. Improved versus unimproved sanitation

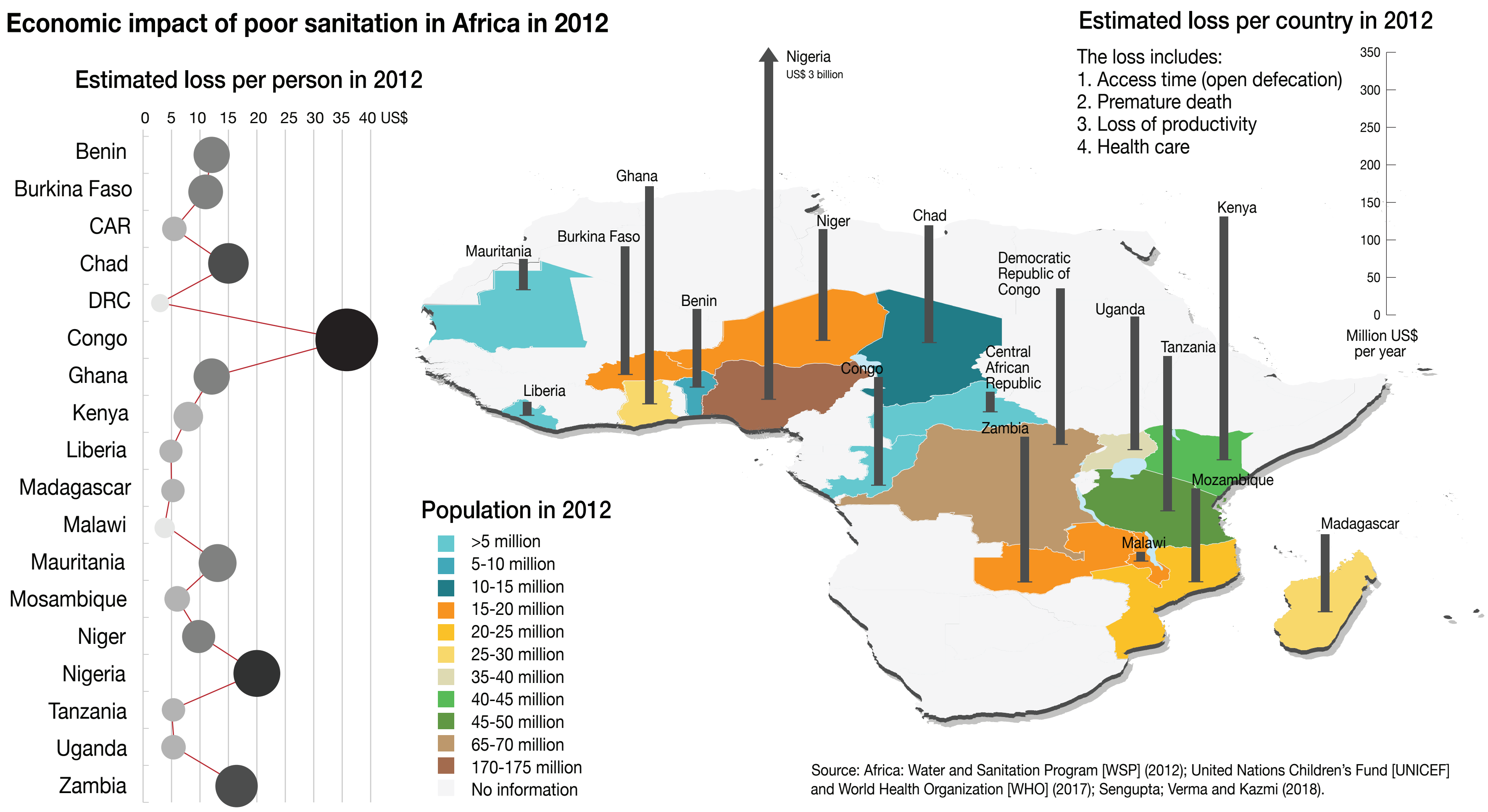


Figure 4.5. The cost of missing toilets

Box 4.2. Toilets for women and girls

Improving access to safe sanitation facilities can be especially beneficial to women and girls, as they are more vulnerable to violence when using public facilities or seeking privacy for open defecation. It can also increase school attendance, as without proper facilities, menstruating girls may stay home in order to more easily manage menstrual hygiene (Burt, Nelson and Ray 2016). The best toilets are the ones that people will use and maintain. Toilets for women will be most successful if, as shown in Figure 4.6, they consider:

Design – Responsive to the needs of women and girls. Apart from the universal requirement for cleanliness, odour control, water and soap and the disposal or reuse of menstrual hygiene products, among other needs, there may also be special culturally prescribed design requirements, such as a concealed entrance, or in the case of shared facilities, toilets separated by gender (Schmitt et al. 2018).

Privacy – Encourage daytime use. Cultural expectations regarding modesty may increase privacy requirements. Women and girls may restrict the intake of food and water during the day, possibly risking dehydration, so they can wait for the privacy of darkness. Holding on can lead to anxiety, increased urinary tract infections, constipation, reduced productivity and isolation.

Security – Safe and not too distant. Going off the beaten track or using public or shared

Figure 4.6. Improved versus unimproved sanitation

facilities at night increases vulnerability to attack and sexual violence.

Affordable – Women are poorer than men (United Nations Entity for Gender Equality and the Empowerment of Women [UN Women] 2018) and having to pay to use the toilet can be an added financial burden that encourages open defecation.

Source: Schmitt et al. (2018).

4.3 Safe Water Barrier: Clean Water to Drink and Cook with

Improving health and halting the spread of infection requires access to safe water for drinking, cooking and washing. A contaminated water supply can cause acute and chronic diarrhoea and other non-diarrhoeal diseases. Water quality and quantity vary across Africa, with rural populations and slum residents generally the most disadvantaged (UNICEF and WHO 2017).

Most diarrhoeal diseases and many parasitic infections are spread by pathogens found in human faeces (some may also be spread in animal waste). The faecal-oral mechanism of transmission involves the faeces of an infected person coming into contact with the mouth of another person, and contaminated drinking water or food are common routes. Run-off from sites of open defecation, overflowing and poorly designed pit latrines and agricultural plots where excreta are used as fertilizer can spread faecal material into surface and groundwater supplies (Ngoran, Dogah and Xue 2015). Leachate from poorly managed solid waste and human and animal wastewater can also be a source of faecal pollution (Delahoy et al. 2018).

In many areas in Africa, water systems are under stress as a result of rapid population growth, increasing pollution and changing rainfall patterns. UNICEF and WHO (2017) classify sources of drinking water into improved – those that have the potential to provide safe drinking water – and unimproved – those that potentially have unsafe levels of disease-causing contamination (Figure 4.7). The most recent estimates from the JMP (UNICEF and WHO 2017) indicate that 7 per cent of urban dwellers and 27 per cent of people in rural areas of sub-Saharan Africa rely on an unimproved water source.

Unfortunately, access to an improved water source does not necessarily correlate with improved health outcomes and this has been recognized in the updated JMP ladder for drinking water. Water at the point of supply may be safe but additional factors, such as transport, storage and reliability can be important (Gundry et al. 2006; Chalchisa, Megersa and Beyene 2017). For example, survey results collected from an informal settlement in Burkina Faso during the rainy season found that despite residents having access to improved water sources, many children still suffered from frequent incidents of diarrhoea (Dos Santos, Ouédraogo and Soura 2015). Physical distance and time required to collect water is important, as water quality has been shown to deteriorate between collection at the source (even if it is an improved source) and storage in the home (Shields et al. 2015).

In households without running water, vessels are used to store water for drinking, cooking and washing. Numerous studies have shown that water stored in wide mouth containers can have higher microbial concentrations than the source water (see Mølbak et al. 1989). Deterioration in the quality of stored water can occur through contact with hands (Pickering et al. 2010), ladles and insects, so an appropriately sealed container is an essential step in preventing contamination after collection (Jensen et al. 2002).

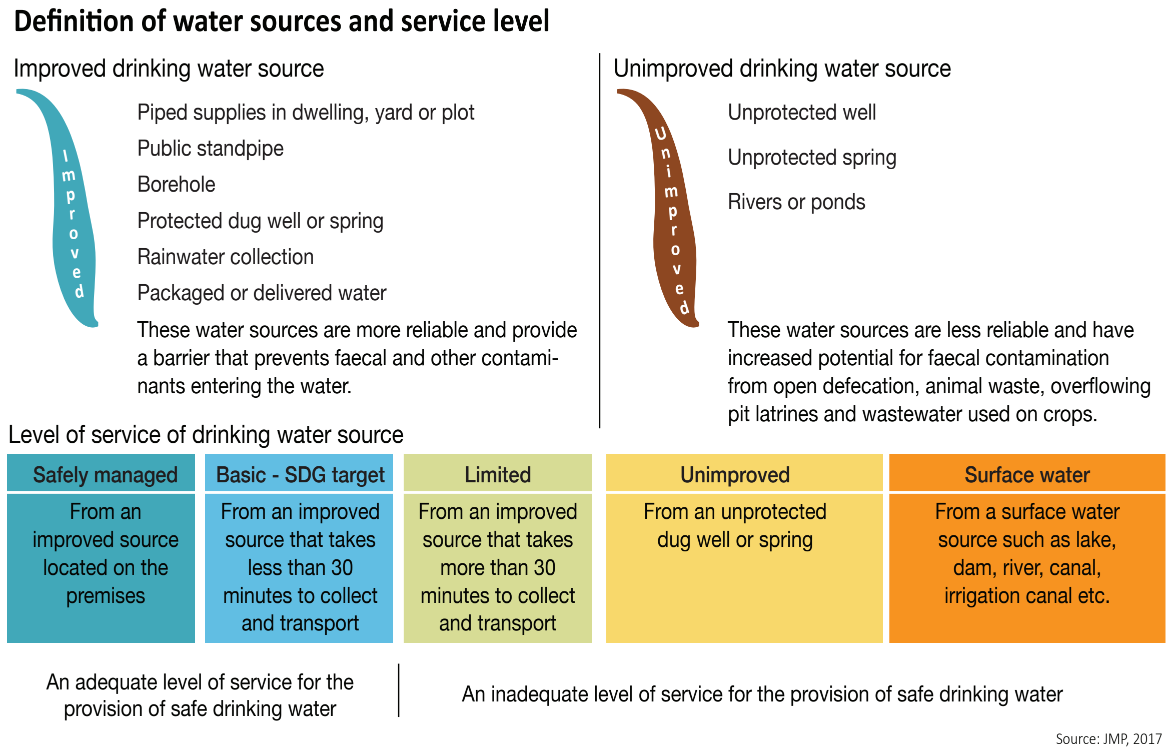


Figure 4.7. Definition of water sources and service level

Figure 4.8 shows examples of poor and good practices in handling and storage of water in the household.

Poor handling of water stored in the home can contaminate previously safe water (Shields et al. 2015). Studies have shown that stored water can contain more than 100 times the number of faecal indicator bacteria than the original waste source (Pickering et al. 2010).

Many pathogens in drinking water can be killed with disinfectant and residual disinfectant can limit the growth of bacteria during storage. However, not all disease-causing agents are eliminated by common treatments such as chlorine. WHO (2017) suggests that common bacteria such as *Cryptosporidium* spp. and some viruses can survive treatment and that murky water may require higher levels of disinfectant, as turbidity can protect microorganisms.

Poor handling of water can result in contamination

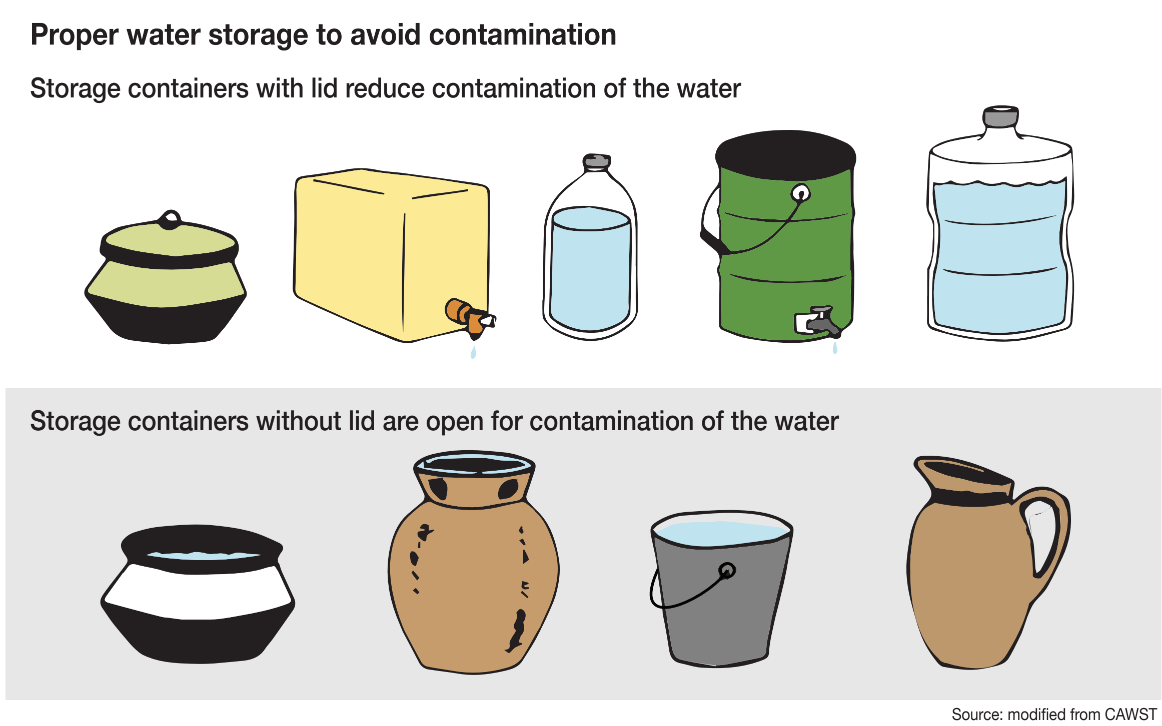


Figure 4.8. Handling and storage of water in the household

4.4 Hygiene Barrier: Water for Washing and Cleaning

The SDGs call for universal access to water and sanitation and have upgraded the Millennium Development Goals (MDGs) to include hygiene, recognizing the essential role that hygiene plays in the prevention of disease. People need an adequate supply of clean water for personal hygiene – a minimum of six to seven litres per person per day for handwashing and personal hygiene (excluding water necessary for consumption, laundry and bathing) (WHO 2017).

Handwashing with soap after going to the toilet or coming into contact with children's excreta is the most important barrier to the faecal-oral spread of disease (Pickering et al. 2010; Freeman et al. 2014). Handwashing before touching food and handling drinking water is also important in reducing the transmission of the pathogens that cause a significant number of deaths related to diarrhoea, such as Rotavirus and *Cryptosporidium*. Having access to enough water for washing the face and body also reduces the likelihood of contracting water access-related diseases, such as trachoma and schistosomiasis (Esrey et al. 1991).

Box 4.3. Water for childbirth – the 'six cleans'

WHO defines clean birth and postnatal practices as the 'six cleans' – handwashing of the birth attendant before birth, clean birth surface, clean perineum, cutting of the umbilical cord using a clean implement, clean cord tie, and a clean cloth for drying (WHO 1997).

In sub-Saharan Africa, significant progress has been made in reducing risk of death in children under five, but progress has been slower for newborns. The region accounts for 38 per cent of global neonatal deaths and has the highest newborn death rate (34 deaths per 1,000 live births in 2011). There are many causes of this high mortality rate, but poor hygiene during birthing could be responsible for up to 15 per cent of neonatal deaths (UNICEF 2017). Lack of access to water and sanitation is linked to neonatal infection and maternal mortality. It is estimated that clean childbirth practices could avert 6 to 9 per cent of the 1.16 million annual newborn deaths in countries in sub-Saharan Africa (Lawn and Kerber 2006).

Many women who give birth at home do not have access to clean water and sanitation (less than 10 per cent according to a study that examined data from 22 countries in west and central Africa (Gon et al. 2016). Even women who attend a health care facility may not be guaranteed acceptable hygiene standards. A WHO survey of health care facilities in a selection of low- and middle-income African states revealed that 42 per cent did not have an improved water source within 500 metres of the facility, 16 per cent did not have improved sanitary facilities and more than 45 per cent lacked adequate handwashing facilities (UNICEF and WHO 2015).

It is estimated that entrenching handwashing habits in Sub-Saharan Africa could save the lives of up to 500,000 children each year (UNICEF 2018). However, only 15 per cent of homes in the region have handwashing facilities with soap (UNICEF and WHO 2017), and 42 per cent of African health care facilities such as clinics and hospitals lack access to improved water for hygiene (UNICEF and WHO 2015).

Studies have shown that handwashing with soap is a cost-effective mechanism for reducing the spread of faecal borne diseases – more effective than improving water quality or waste management (Cairncross et al. 2010).

The handwashing message – school toilet door in Kibera, Kenya.

Box 4.4. Water and HIV/AIDS

HIV/AIDS is a major public health concern and one of the leading causes of death in Sub-Saharan Africa. It is estimated that more than 6 million people in the region were living with HIV and 75 per cent of new infections are among girls aged between 15 and 19 (UNAIDS 2018).

Providing clean water and sanitation is particularly important for people with compromised immune systems as they are susceptible to diarrhoeal diseases and skin infections (Obi et al. 2006). By reducing the risk factors for diarrhoeal diseases, people living with HIV experience better nutrition and can have an improved quality of life.

Evidence suggests that households that include people living with HIV/AIDS require and use more water than those without the infection, and therefore suffer most during periods of water scarcity (Mbereko, Scott and Chimbari 2016). Mothers with HIV/AIDS feed their infants with formula, which requires the addition of safe water, and antiretroviral drugs require at least 1.5 litres of clean water to be effective (WaterAid 2018b).

4.5 The Wastewater Barrier

The use of wastewater in agriculture can have significant benefits, increasing yields and providing a year-round source of water in areas of water scarcity. However, there are potential risks to human health and the environment, as shown in Figure 4.9, need to be considered. Those at risk from disease include farmers who are exposed to wastewater and consumers of contaminated produce, as well as people living near wastewater-irrigated properties. The WHO guidelines for the use of wastewater, excreta and greywater in agriculture (2006) include a number of risk management approaches that acknowledge different technical and institutional capacities. In areas where there is no or inadequate wastewater treatment, options to decrease the risk of infection from pathogens include both cultivation and post-harvest actions (Amoah et al. 2011):

- Treating wastewater with sand filtration or pond networks
- Stopping irrigation before harvest to allow pathogens to die off
- Applying wastewater to roots rather than leaves
- Choosing crops that minimize the chance of infection, such as vegetables that need to be peeled and cooked
- Washing vegetables during preparation
- Washing salad vegetables with disinfectant
- Ensuring cooking temperatures and times are sufficient to kill pathogens

These interventions generally target risks from pathogens, but in areas of rapid urbanization and industrialization, there are also potential chemical and heavy metal risks associated with wastewater use (Dickin et al. 2016). Because these contaminants are less likely to cause acute illness compared to pathogens, they have not been significantly investigated. A recent study of long-term (more than 50 years) wastewater-irrigated vegetable plots in Addis Ababa found faecal contamination above safe levels but heavy metal concentrations in the vegetables were at levels that posed no risk to human health (Woldetsadik et al. 2017).

Always wash vegetables when preparing them for a meal

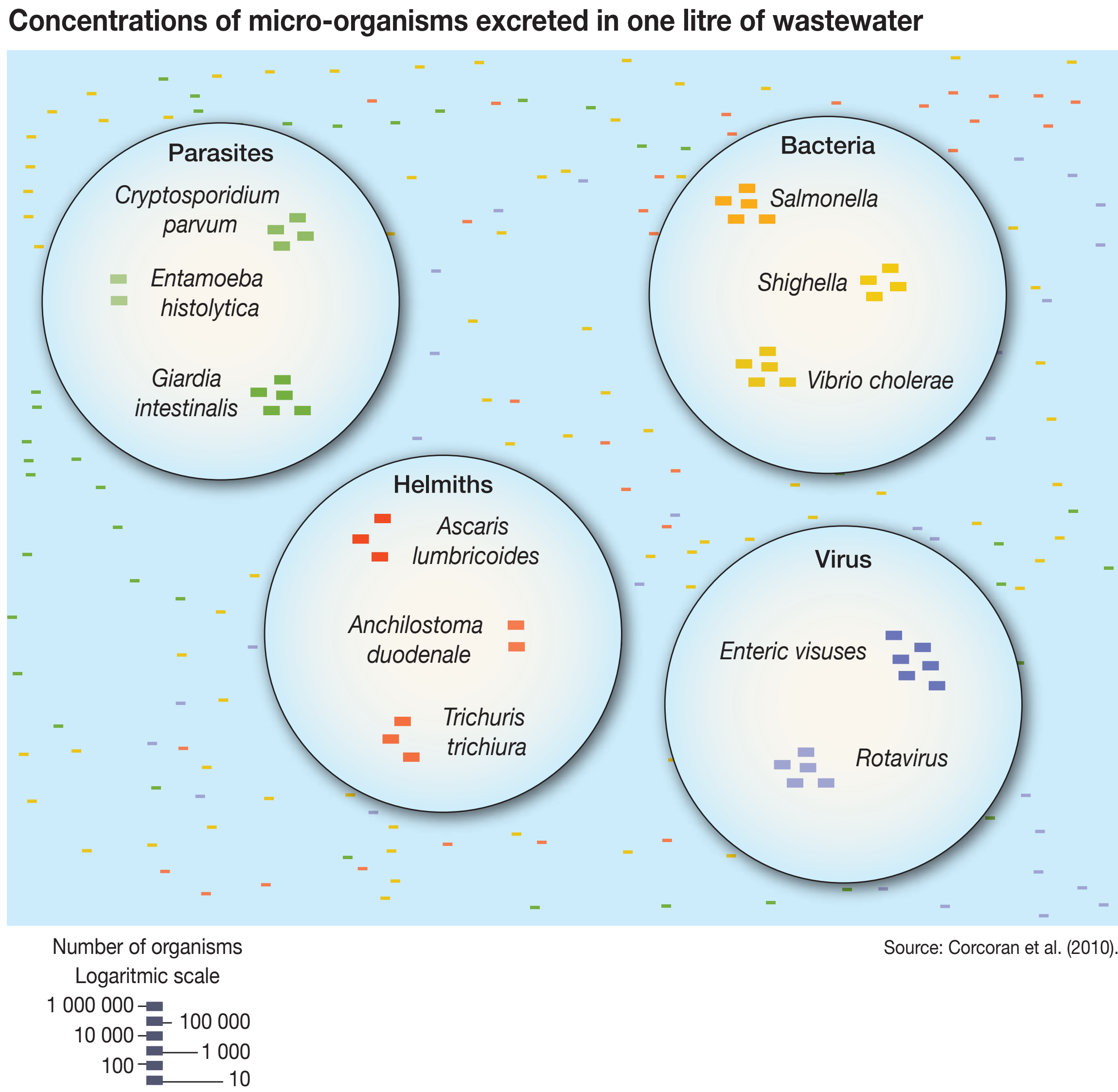


Figure 4.9. Potential environmental and health risks of using wastewater

4.6 Disease Related to WASH

Poor access to WASH is devastating for communities, especially the young, pregnant women and the immune-compromised. Inadequate WASH has significant economic, environmental and social impacts. The most significant pathways for faecal-oral disease transmission are water, soil, flies, fingers and food. Contracting an illness from exposure to pathogens depends on the dose, the infectiousness of the pathogen, and the health of the exposed person. Table 4.1 lists the most common WASH-related diseases and exposure pathways.

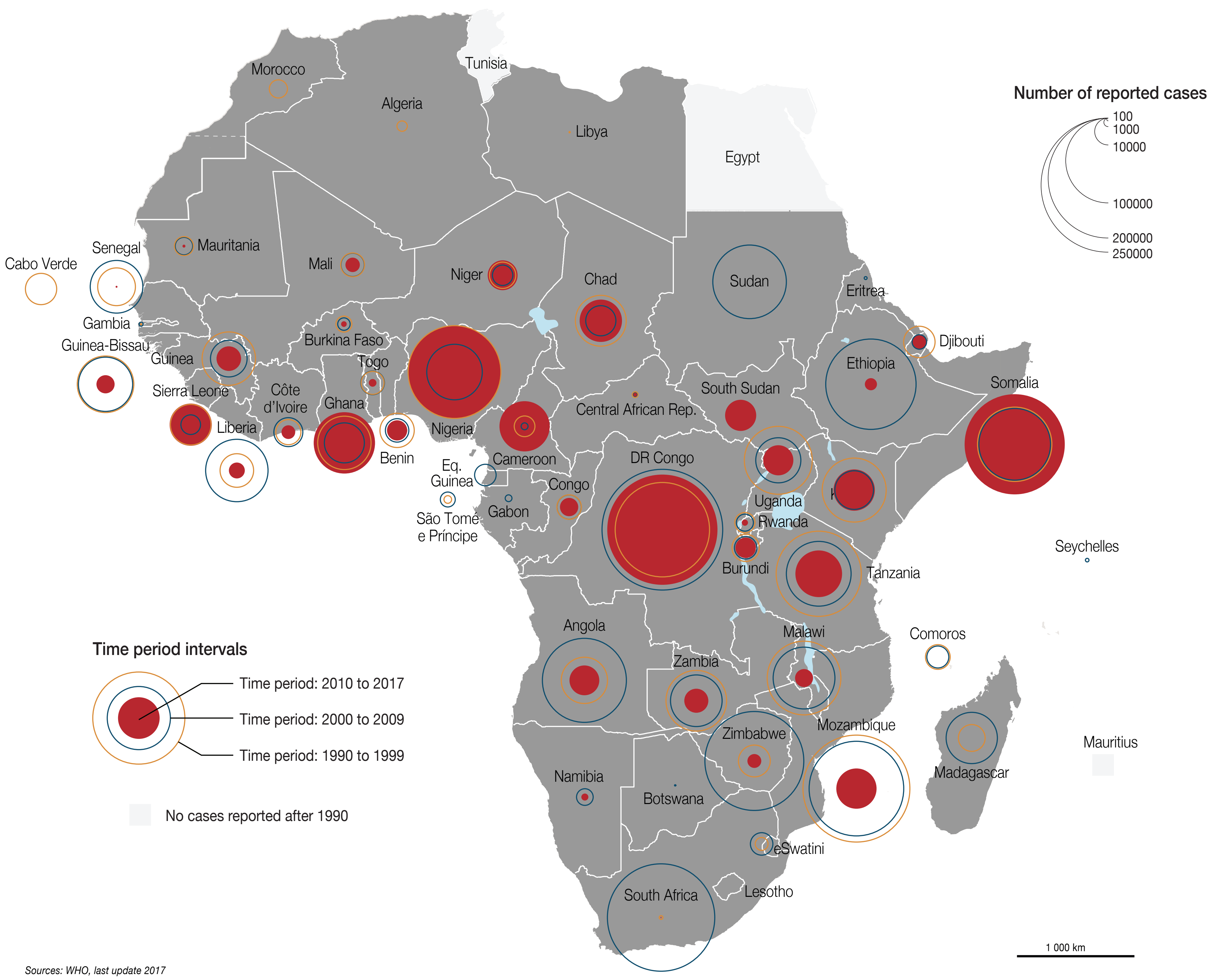
While the global incidence of many of the diseases listed in Table 4.1 is declining, many are still prevalent in Africa, where they overlap geographically and can be co-endemic (Hotez et al. 2018). Examples include:

Cholera cases are decreasing worldwide, but in Africa both endemic occurrences (continual cases) and periodic epidemics persist as Figure 4.10 shows. Sub-Saharan Africa bears the biggest cholera burden (Ali et al. 2015) and also has the highest mortality rate per case (WHO 2019c). The oral cholera vaccine (OCV) can be used to prevent outbreaks during crisis situations as it provides protection for approximately three years. However, long-term control involves a combination of vaccination and WASH (WHO 2019c). Focusing targeted interventions in countries with the highest incidences (Democratic Republic of the Congo, Ghana, Nigeria, Somalia and Sierra Leone) could reduce cases by almost 40 per cent across the region (Lessler et al. 2018).

Epidemics are often associated with natural disasters, most notably floods or periods of heavy rain, when sanitation systems overflow and contaminate water sources and the environment. Prolonged drought can also increase the risk of infection, as limited water availability reduces both water quality and hygiene (Rieckmann et al. 2018). Natural disasters are expected to increase in scale and frequency as a result of climate change and population growth in disaster-prone regions, which may further increase the risk of high-mortality cholera epidemics

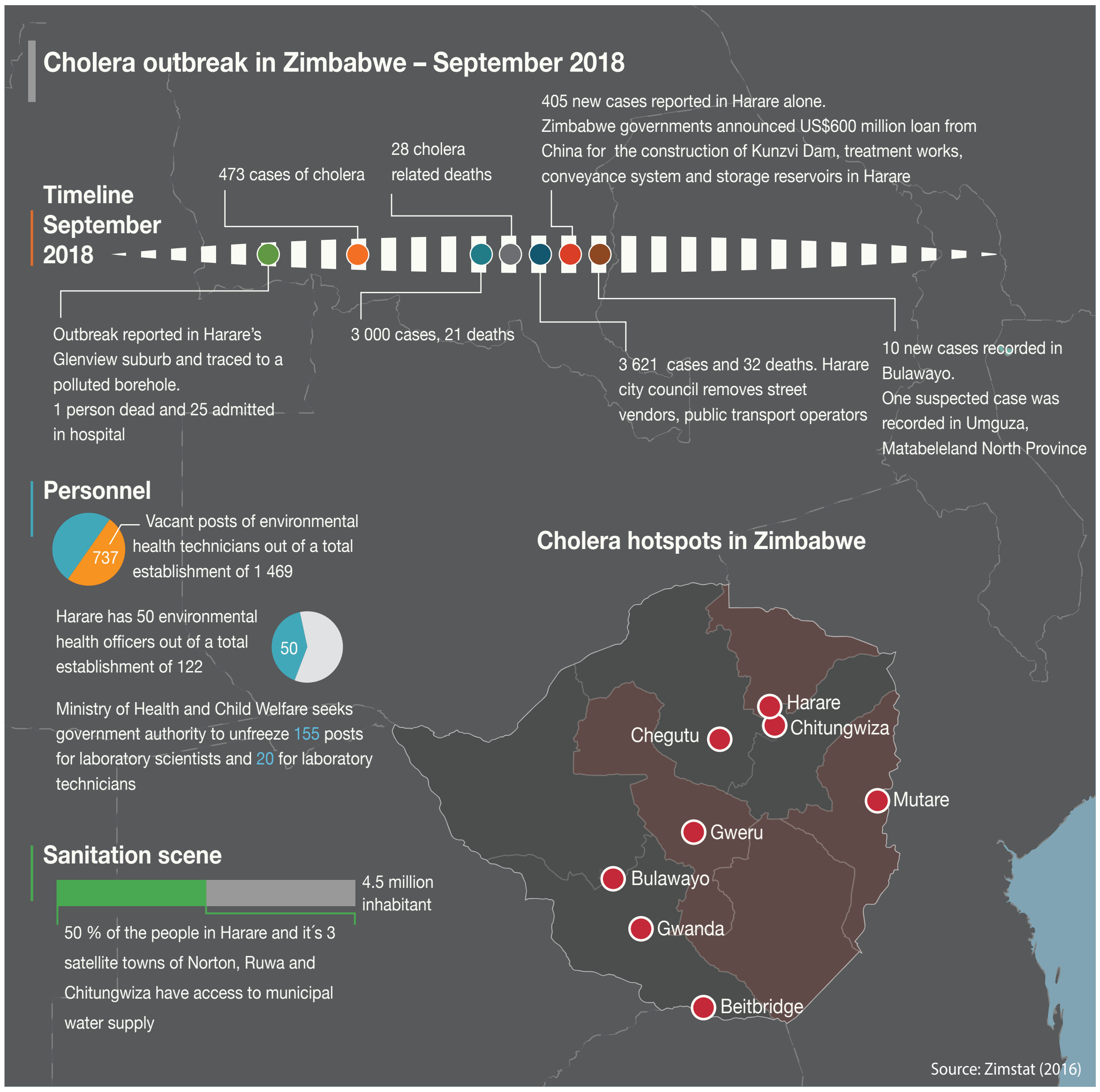
Country reported cases of cholera by time intervals

Time periods 1990 to 1999, 2000 to 2009 and 2010 to 2017



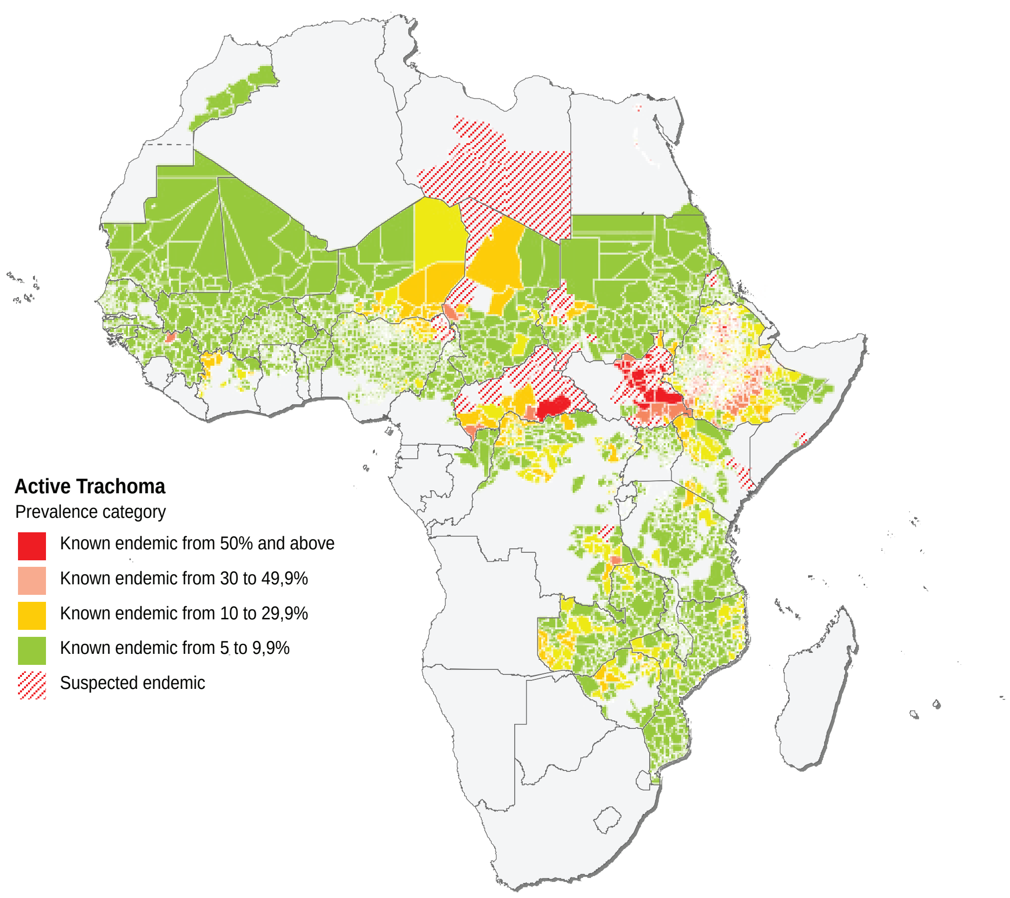
Sources: WHO, last update 2017

Figure 4.10. Cholera incidences in Africa



Cholera is a medieval disease that has been eradicated in many countries through good sanitation practices

Trachoma prevalence in children at the aged of 1 to 9 in 2019



Source: Trachoma Atlas (n.d.). See http://www.trachomaatlas.org/.

Figure 4.11. Trachoma prevalence in children aged 1-9

(Serdeczny et al. 2016). Cyclone Idai struck central Mozambique in March 2019. A second cyclone hit the northern region in late April. Both storms resulted in widespread flooding and contamination of water supplies. During the week following the first cyclone, officials in Mozambique declared a cholera outbreak, with more than 6,000 cases reported by the beginning of May 2019 (Reliefweb 2019). Thousands of people have received the OCV in an effort to halt the spread of the disease.

Trachoma is a bacterial eye infection that is responsible for vision impairment in about 1.9 million people globally (WHO 2018d). The global trend of vision impairment from the disease has fallen rapidly due to a concerted eradication programme, although Africa remains the most affected region, with the endemic disease evident in 26 countries as Figure 4.11 shows (WHO 2018d; Herricks et al. 2017). The disease typically infects children, but without treatment the most serious impacts begin around 30 years of age for both men and women, with women losing vision at a higher rate. The bacteria are present in discharge from the eyes and nose of infected people and are easily spread via hands, cloths and insects. Its transmission can be halted by treating the infection with antibiotics and through improved access to water for facewashing (Nwabor et al. 2016).

Table 4.1. Water-related diseases

Waterborne pathogens

- improve water quality

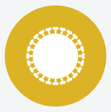
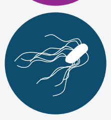
Class	Pathogen name	Shape	Disease	Infection source	Control strategy
Virus - a small infectious agent that replicates only inside the living cells of an organism.	Hepatitis A & E		Viral hepatitis - liver inflammation and damage	Faeces	Vaccination; safe drinking water and food; handwashing
	Rotavirus		Diarrhoea	Faeces	Handwashing; vaccination
	Adenovirus		Diarrhoea	Faeces Respiratory secretions	Handwashing
Bacteria - are microscopic, single-celled organisms that thrive in diverse environments. These organisms can live in soil, the ocean and inside the human gut.	*Campylobacter*		Diarrhoea	Intestinal tract of warm-blooded animals	Thoroughly cooking food Handwashing
	Vibrio cholerae		Cholera Diarrhoea	Faeces	Safe drinking water and food
	Shigella dysenteriae		Shigellosis Diarrhoea	Faeces	Handwashing
	Salmonella enterica		Diarrhoea	Faeces	Thoroughly cooking food Handwashing
	Escherichia coli		Diarrhoea	Faeces	Handwashing Safe drinking water and food
Protozoa - are single celled organisms. They live in a wide variety of moist habitats including freshwater, marine environments and the soil.	*Entamoeba*		Amoebic dysentery	Faeces	Handwashing
	Crytosporidium		Watery diarrhoea	Faeces	Handwashing Safe drinking water and food
	Cyclospora cayetanensis		Diarrhoea	Faeces	Safe drinking water and food
	Enterocytozoon bieneusi		Diarrhoea	Animal faeces; human faeces; inhalation	Handwashing Safe food
	Giardia		Watery diarrhoea	Faeces	Handwashing Safe food
	Isospora belli		Mild diarrhoea; abdominal discomfort; low-grade fever	Faeces	Safe drinking water and food
Helminths - are worm-like parasites that survive by feeding on a living host to gain nourish-ment and protection, sometimes resulting in illness of the host.	*Ascaris lumbricoides* (roundworm)		Intestinal worm infection	Faeces	Handwashing
	Enterobius vermicularis (pin worm)		Intestinal worm infection	Faeces	Handwashing
	Hymenolepis (tape worm)		Intestinal worm infection	Faeces	Handwashing

Table 4.1. Water-related diseases *(continued)*

Water - access related pathogens

- increase water accessibility and reliability; improve hygiene practices

Class	Pathogen name	Shape	Disease	Infection source	Control strategy
Mite Mites are very small, ranging from 0.5 to 2.0 mm in length; there are thousands of species.	*Sarcoptes scabiei*		Scabies – itchy rash	Skin-to-skin contact	Thorough cleaning
Bacteria - are microscopic, single-celled organisms that thrive in diverse environments. These organisms can live in soil, the ocean and inside the human gut.	*Treponema pertenue*		Yaws – skin, bone and joint infection	Faeces	Improve cleanliness and sanitation
	Chlamydia trachomatis		Trachoma – roughening of inner surface of eyelids, blindness	Contact with secre-tions; spread by flies	Improve personal hygiene

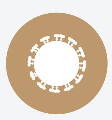
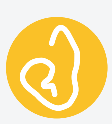
Water-based: contact with water, for example, bathing or swimming

-control vector populations; reduce surface water contamination

Class	Pathogen name	Shape	Disease	Infection source	Control strategy
Helminths - are worm-like parasites that survive by feeding on a living host to gain nourish-ment and protection, sometimes resulting in illness of the host.	*Schistosoma*		Bilharzia	Contaminated water (snails)	Clean drinking water
	Dracunculus medinensis		Guinea-worm disease	Urine, faeces	Clean drinking water

Water - related vector diseases from biting insects that breed in water

- control breeding sites and use preventative measures such as mosquito netting

Class	Pathogen name	Shape	Disease	Infection source	Control strategy
Virus - a small infectious agent that replicates only inside the living cells of an organism.	Flaviviridae Flavivirus		Yellow fever – fever, Liver damage; Dengue fever; West Nile fever	Mosquito bite	Insect control
Protozoa - are single celled organisms. They live in a wide variety of moist habitats including freshwater, marine environments and the soil.	*Plasmodium falciparum*		Malaria – fever	Mosquito bite	Insect control; reduce uncovered stagnant water
	Trypanosoma brucei		African sleeping illness – fever; Joint pain; later stage neurological symptoms	Tsetse fly bite	Insect control
Helminths - are worm-like parasites that survive by feeding on a living host to gain nourishment and protection, sometimes resulting in illness of the host.	*Onchocerca volvulus* (oarasitic worm)		River blindness	Black fly bite	Insect control
	Wuchereria bancrofti (round worm)		Lymphatic filariasis – painful lymph nodes; Lymphedema; Elephantiasis	Faeces	Insect control; improve personal hygiene

Source: Adapted from White, Bradley and White (1972); Mara and Feachem (1999) and WHO (2017).

Percentage range of people infected with Schistosomiasis

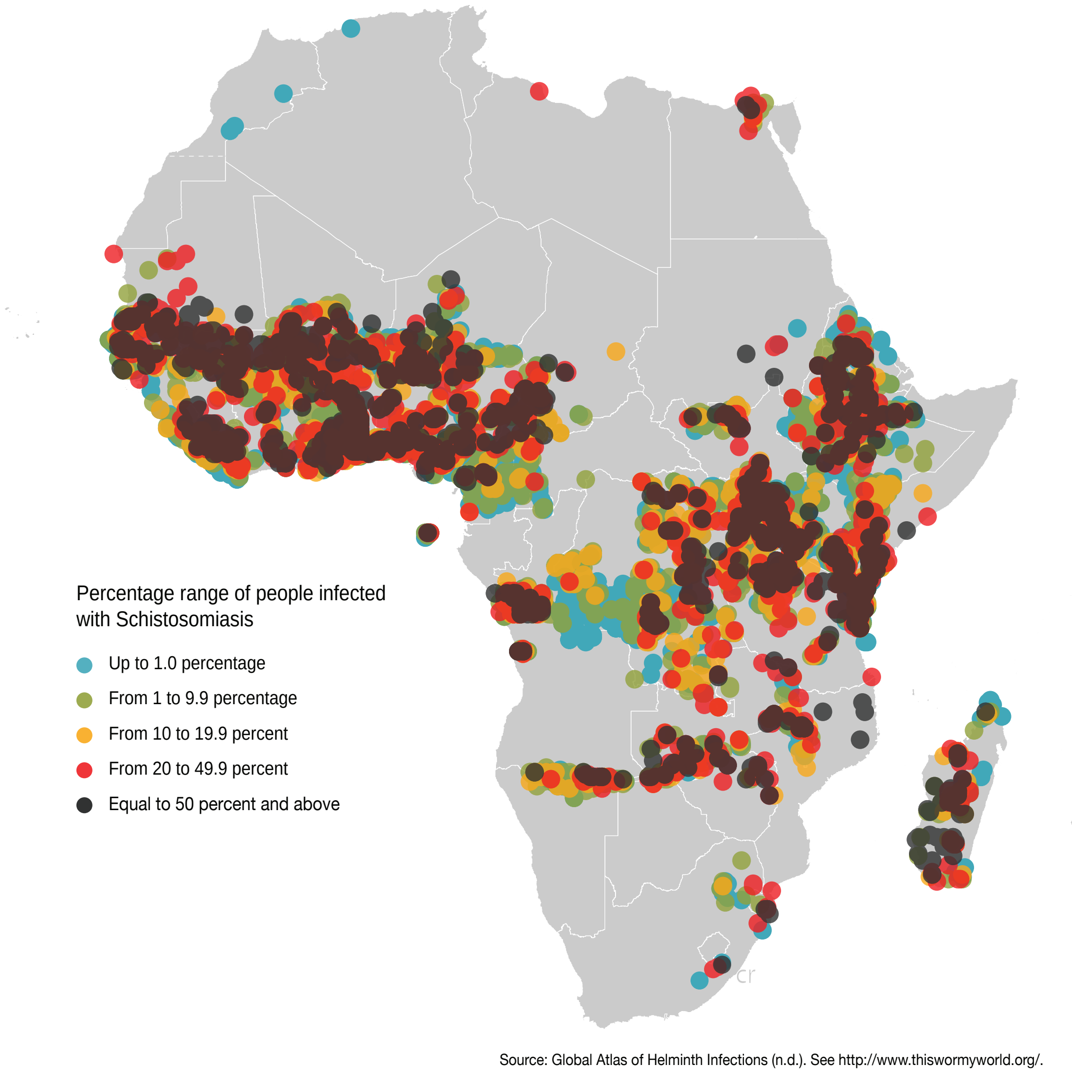


Figure 4.12. Schistosomiasis prevalence in Africa

Percentage range of people infected with soil transmitted helminths

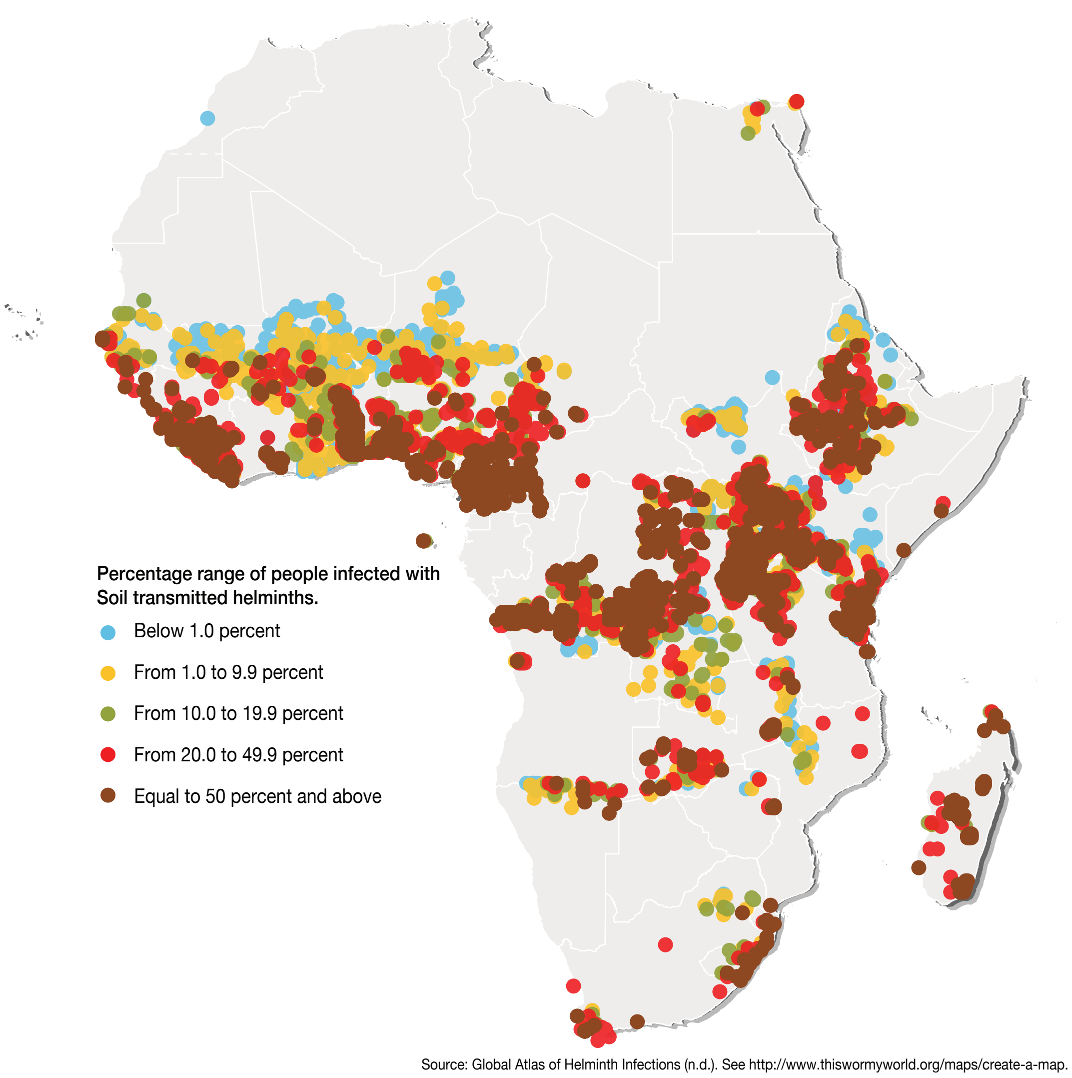


Figure 4.13. Ratio of people infected with soil transmitted helminths (STHs)

Schistosomiasis, also referred to as 'bilharzia' and 'snail fever', affects more than 200 million people, the majority of whom live in sub-Saharan Africa as Figure 4.12 shows (Lai et al. 2015). Infection in humans is caused by contact with water that is infested with trematode flukes carried by freshwater snails. The larvae penetrate the skin of people who come into contact with infested water. The larvae then develop into adult worms in the body, colonizing the blood vessels, where they effectively invade the immune system. They can release hundreds of thousands of eggs a day, some of which are excreted in faeces or urine, while others are trapped in nearby tissues (Colley et al. 2014). The trapped eggs produce an immune response, causing chronic diseases such as anaemia, stunted growth, impaired cognition and heart, liver, urinary and gastrointestinal complications.

Bilharzia is more prevalent among children

Soil transmitted helminths (STHs) are parasites that live in soil. Infection is caused by the ingestion of the parasitic eggs from four main species of roundworm, whipworm and hookworm (Tchuenté 2011). Infected individuals excrete parasite eggs in their faeces. In areas where open defecation occurs, pit latrines overflow and children's faeces is disposed, the soil and water become contaminated with faeces containing worm eggs.

It is estimated that more than 1.5 billion people are infected with STHs worldwide, with the greatest number of infections in sub-Saharan Africa in areas shown in Figure 4.13 (WHO 2019d). Heavy infestations can cause diarrhoea and abdominal pain, malnutrition, general malaise and weakness, as well as impaired growth and physical development in children (WHO 2019d). Control of STHs includes periodic treatment of at-risk populations with deworming medicines. The global target is to eliminate illness due to STHs in children by 2020 and this requires treatment of least 75 per cent of the children in endemic areas, estimated at 836 million in 2016 (WHO 2019d).

Box 4.5. WASH and disease

Waterborne diseases are intestinal diseases that spread through faecal contamination of drinking water. Examples include typhoid, giardiasis, cholera and rotavirus. The symptoms of intestinal diseases are typically watery diarrhoea, which when severe and not properly treated, can rapidly lead to dehydration and death.

Rotavirus *– the leading cause of hospitalization and death of children in Africa (ROTA Council 2016).*

Water access-related diseases are sometimes called 'water-washed diseases' and are related to availability and use of water. These diseases can be prevented if people have adequate supplies of clean water available for personal hygiene, such as hand and face washing (White, Bradley and White 1972). Water access-related diseases can be divided into two groups – faecal-oral intestinal diseases such as Shigella and superficial skin and eye infections such as trachoma.

Trachoma *– almost 83 million people in Africa were treated with antibiotics for trachoma in 2016 (WHO 2018a).*

Water-based diseases are those where the disease-causing organism spends part of its life cycle in water. Examples include parasitic worm (helminth) infections like schistosomiasis and bacterial infections like leptospirosis. Infection occurs when people are exposed to water infested with the disease-causing organisms, often during water collection or bathing.

Schistosomiasis *– it is estimated that nearly 200 million people in Africa require treatment (WHO 2019a).*

Water-related vector diseases are those caused by biting insects that breed in water, such as mosquitos and black flies. Examples include malaria and onchocerciasis ('river blindness').

Onchocerciasis *('river blindness') – more than 99 per cent of the estimated 20 million people infected globally live in 31 African countries (2019b).*

Source: Adapted from White, Bradley and White 1972.

Africa needs to invest more in hand washing facilities

Box 4.6. Antimicrobial resistance: A growing problem facing the treatment of WASH-related diseases

Many WASH-related diseases are treated with antibiotics. However, there is growing antimicrobial resistance (AMR) to the drugs used to control infectious outbreaks (UNICEF and WHO 2017; Serdeczny et al. 2017). Recent studies have highlighted the problem in antibiotics commonly prescribed in Africa, which tend to be older, first-line antibiotics (Tadesse et al. 2017). For example, *E. coli* infection circulating in children in Sub-Saharan Africa has been found to be multidrug-resistant (Ingle et al. 2017).

The choice of antibiotics is often quite limited, and decisions are not based on knowledge of bacterial susceptibility, but rather on cost and availability (Bernabé et al. 2017). Information on the local and regional antimicrobial resistance of specific drugs is important when choosing effective treatment options, but this information is generally not collected as it is an expensive and time-consuming task (Ampaire et al. 2016). The appropriate drugs may also be unavailable. The use of ineffective antimicrobial resistant drugs, coupled with poor infection-control practices can spread community and/or hospital-acquired drug-resistant pathogens, making disease control even more difficult.

Due to the high incidence of infections in both humans and livestock, and the common use of antibiotics in treatment, excreted antibiotics can find their way into the aquatic environment. Although information is sparse, elevated concentrations of commonly used antibiotics have been measured in potable water, treated wastewater, groundwater and surface water in a number of locations in Africa (Faleye et al. 2018). The increased concentrations of antibiotics circulating through the environment fuel the increase in drug-resistant pathogens – a global trend not confined to Africa

The damage due to cyclone Idai was felt beyond Mozambique. According to Chatiza (2019), when cyclone Idai struck Zimbabwe in March 2019, it affected about 270,000 people, causing 340 deaths and displacing 51,000 others. Infrastructure such as roads and bridges was damaged in the country's Chimanimani and Chipinge areas.

A network of about 1,500 km of roads was made unusable. Lives were affected as 140 schools were either damaged or made inaccessible. Homes were lost, while health facilities such as clinics were also damaged. As much as homes were damaged, toilets and deep wells for clean water were also damaged, thus reversing gains made in the rural areas towards improved sanitation and safe drinking water services. Water sources were contaminated as a result of the floods and overflow of toilets and sewerage systems. The affected 270,000 people were exposed to water-borne and water-based diseases, including diarrhea.

4.7 Conclusion: Stopping the Spread of Disease

Safe toilets and access to clean water are a human right, a right that must be extended to everyone if we are to achieve the SDGs. However, stopping the spread of infectious disease involves more than just access to a toilet or a bar of soap. Maintaining hygiene in areas without access to clean water is difficult and time-consuming. Governments need to develop effective strategies that include targeted investment, awareness-raising and improved monitoring and reporting. Hospitals, schools, families and farmers all need to understand and be involved in the effort to effectively separate people from disease-carrying human and animal waste. Table 4.2 shows some interventions to ensure proper sanitation for good health.

Table 4.2. Suggested interventions for proper sanitation for good health

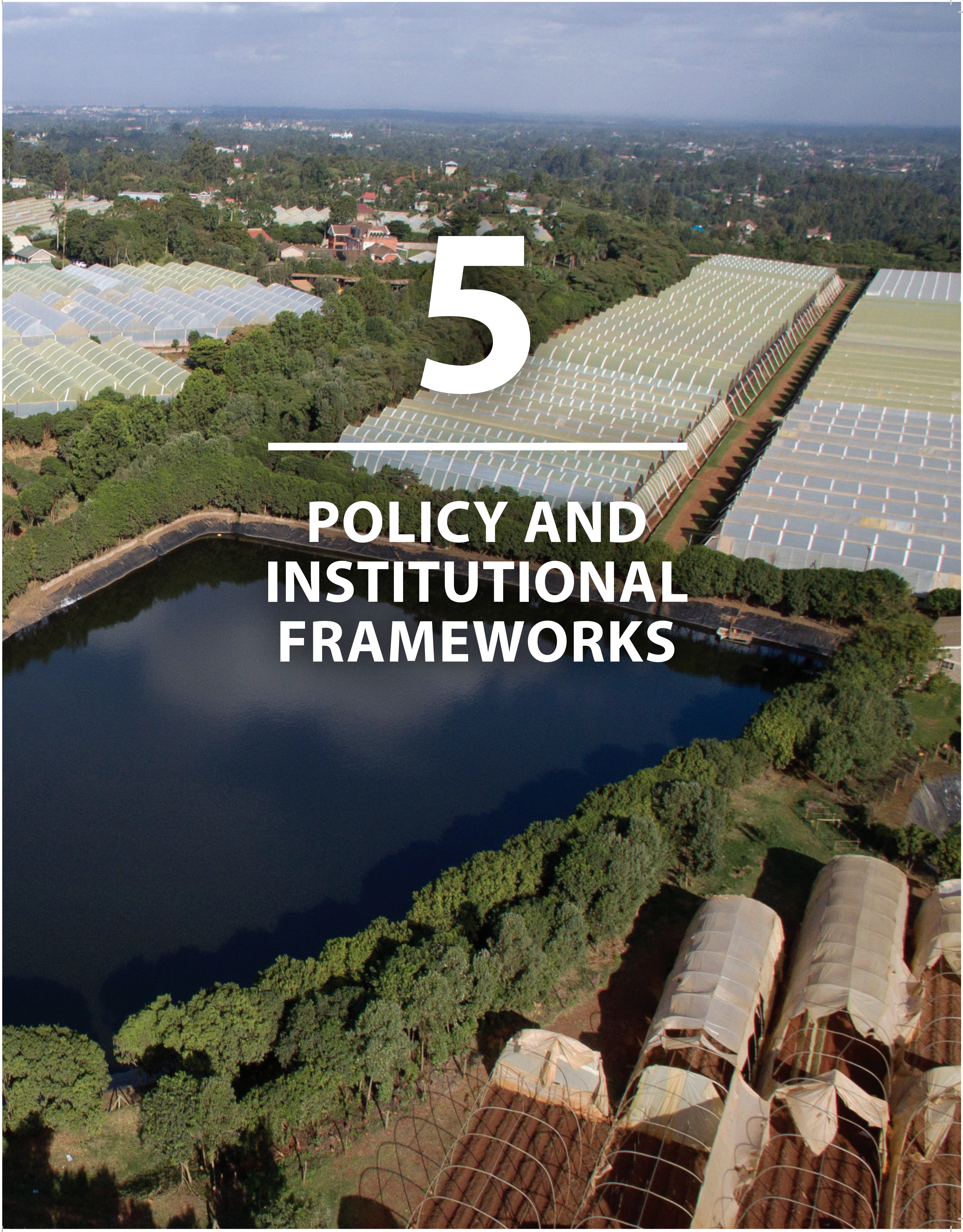
Intervention	Actions
1. Behavioural change, communication and social media	• Provide hygiene education for school children, mothers with babies and the general community; • Provide education on food and water storage and handling; • Provide education for farmers on best practices for wastewater usage; • Increase community health outreach

2. Remove faecal pathogens from hands, food and surfaces	• Wash hands with soap:
	  • After going to the toilet
	  • Before preparing or eating food
	  • After cleaning and changing babies;
	• Wash food and cook it to kill pathogens;
	• Wash raw food (such as lettuce grown with wastewater) with disinfectant

3. Safe drinking water	• Best option is an improved source located on-site; • Store water in narrow-mouthed containers with lids or taps; • Avoid touching the opening of the containers; • Boil or disinfect water before use; • Disinfect storage containers regularly
4. Clean toilets	• Best option is a sanitary single-household facility; • Ensure dry-pit toilets do not leak into groundwater and have handwashing facilities; • Ensure wet-pit toilets do not overflow or leak into groundwater and have handwashing facilities; • Regularly clean the toilet floor; • Ensure that insects cannot access the pit – i.e. place a cover on the toilet
5. Safe food irrigated with wastewater	• Limit contamination of produce; • Choose appropriate crops, irrigation methods and post-harvest treatment
6. Treatment of infections	• Use appropriate antibiotics and other drugs; • Make practitioners aware of antimicrobial resistance
7. Government policies that support WASH	• Develop improved sanitation services and wastewater treatment; • Improve healthcare and education
8. Strong legislation	• Work on legislation regarding prescription drug use, farming practices, commercial food handling
9. Infrastructure development	• Introduce piped water to homes, sewage treatment systems, safe water reuse, healthcare services

5

POLICY AND INSTITUTIONAL FRAMEWORKS



5.1 Introduction

The environmental, health and economic benefits of safe drinking water and sanitation in Africa are clear and well documented. Unpolluted ecosystems are better able to deliver their much-needed services of providing freshwater, food and genetic resources; regulating climate and natural hazards; providing a habitat for various species; and providing spiritual enrichment, recreation and aesthetic values. The availability of clean water and basic toilets, coupled with good hygiene practices, drastically reduces mortality rates in children under the age of five, who are at high risk of death from diarrhoeal diseases resulting from poor sanitation, poor hygiene practices or unsafe drinking water. Improved health in both children and adults translates to reduced direct and indirect health costs, which in turn reduces the financial burden on health. Less time spent on collecting water and looking for sanitation facilities allows more time to be spent on other productive activities – a gain mostly experienced by women and children. Clean water resources reduce treatment costs of water for domestic, agricultural and industrial processes, while improved water storage capacity provides more resilience to rainfall variability and provides more certainty and efficiency in productivity. Clean water resources also provide additional holiday destinations for tourism purposes, resulting in additional income for countries.

Access to adequate sanitation is a challenge for many in Africa

Providing access to safe drinking water and sanitation facilities remains a persistent challenge for the majority of countries, with a large proportion of the population on the African continent still not serviced. Nearly half of all people using unimproved sources of drinking water live in sub-Saharan Africa and 54 per cent of the population in 47 African countries still lack adequate sanitation facilities (African Ministers' Council on Water [AMCOW] 2014). The numerous efforts by continental bodies, regional associations, national governments, local communities and other stakeholders in the past two decades to address these limitations and increase coverage and quality of basic water and sanitation facilities in Africa have largely been outweighed by high rates of population growth, rapid urbanization (especially the unplanned informal settlements), desertification and increased industrialization, as well as drought, floods and other effects of climate change. Inadequate levels of funding, inappropriate technology and poor infrastructure and maintenance have also been identified as major limitations to achieving regional targets for water, sanitation and wastewater management.

It is clear that concerted efforts are required to tackle the root causes of inadequate access to safe and adequate water and sanitation services for all in Africa. Much more needs to be done to ensure that the many policy documents that have been developed and adopted and the laws that have been enacted are implemented and enforced. This is necessary in order to provide clean water and sanitation services to households and communities so that the health of people, water resources and ecosystems are no longer at risk and no longer a threat to the continent's economic development.

While policies against illegal dumping are in place in most countries, the practice is prevalent across Africa

5.2 Continental Policy and Institutional Responses

There are SDG targets to promote life on land and below water

Under Sustainable Development Goal (SDG) 6, governments are committed to targets for clean water and sanitation by 2030, including universal and equitable access to safe and affordable drinking water, sanitation and hygiene. Since SDG 6 is also linked with the other goals as Figure 5.1 shows, its success will contribute towards their success.

The fact that water, sanitation and hygiene (WASH) is the subject of dedicated targets within SDG 6 is testament to its fundamental role in public health and therefore in the future of sustainable development. The agreement of the SDG 6 target of universal access to water, sanitation and hygiene by 2030 requires a fundamental change in the way the sector has been managed. With the recognition that access to safe water and sanitation is a human right, collective fulfilment of the right to achieve the target requires well-resourced and capable institutions to deliver services, while also changing behaviour in appropriate and resilient ways. Delivering positive change in sector performance necessitates a system-wide approach that tackles all dimensions – policy, financing, institutions and other key building blocks – of the WASH sector as a whole (Aguaconsult et al. 2015). This will require a reform agenda based on a sound understanding of the political economy at relevant levels of decision-making, from village/community, city or district to national and global.

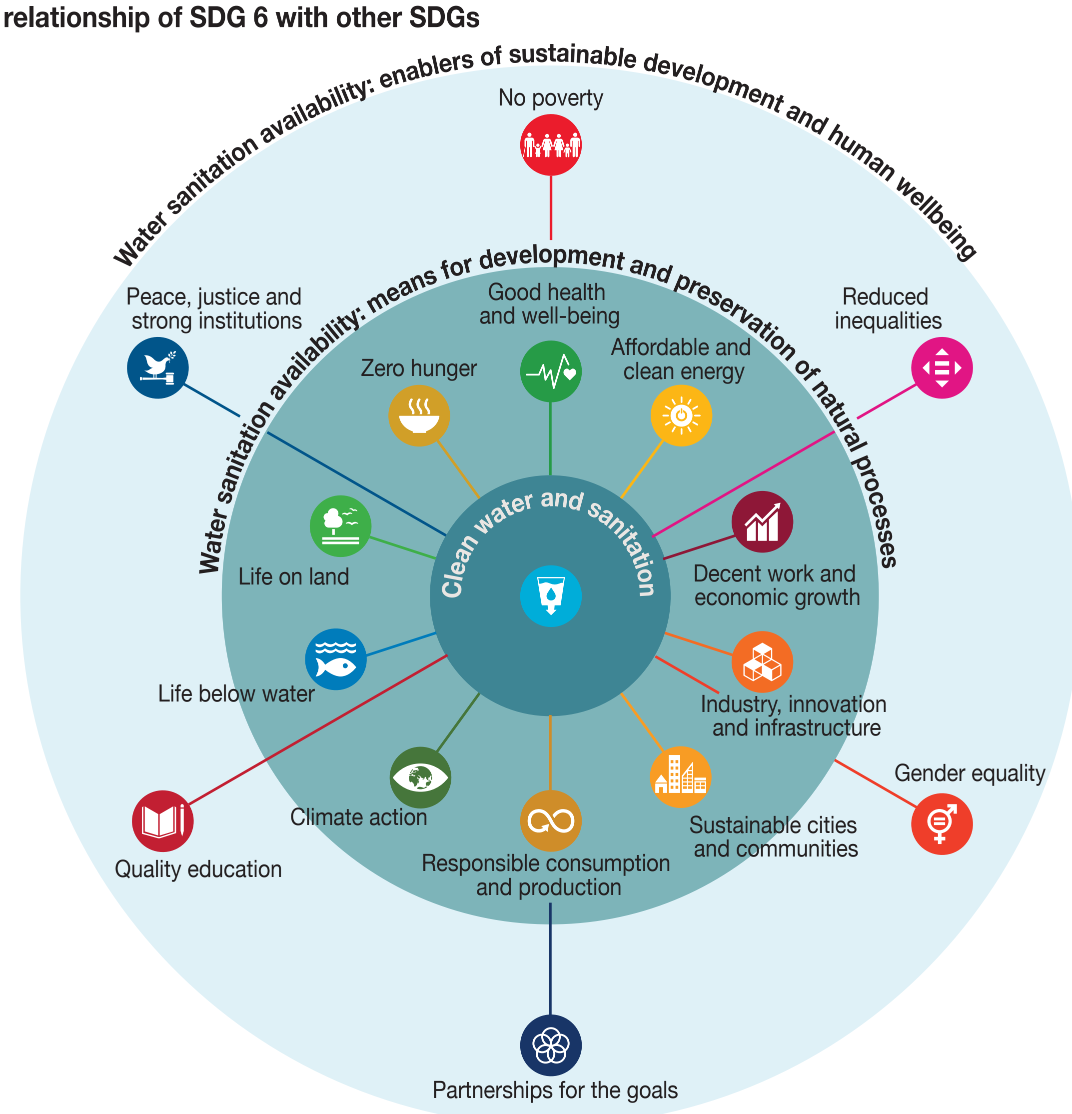
The African policy framework comprises a number of advanced declarations and resolutions to develop and use water resources in the region for socioeconomic advancement, regional integration and the environment (United Nations World Water Development Programme [WWDP] 2016). They include Agenda 2063 – The Africa We Want, the Africa Water Vision 2025 and its Framework of Action, and the N'gor Declaration on Water and Sanitation. These policy instruments have associated strategies and programmes such as the New Partnership for African Development Programme and the Programme for Infrastructure Development in Africa.

In addition, institutions created at all levels provide the necessary political engagement and further elaborate and implement the various policies and decisions of the African Union. Using their convening power, they provide an important networking platform and bring together African governments and other stakeholders to deliberate and develop common positions on issues and programmes to be implemented at national and local levels. These institutions also engage in awareness-raising and knowledge management and dissemination programmes within their areas of operation and review and monitor programmes at local, regional, sub-regional and national levels.

5.2.1 Agenda 2063

Africa's strategic framework for the socioeconomic transformation of the continent, Agenda 2063, provides a collective vision and road map for development, clearly emphasizing the central role of integrated economic, social and environmental aspects in continental aspirations. Specific mention of access to safe water supply and sanitation is made under Aspiration 1 – A prosperous Africa, based on inclusive growth and sustainable development. Water and sanitation are recognized among the "basic necessities for life" and indicators of performance in global quality of life measures (African Union Commission 2015). Agenda 2063 also calls for Africa's natural resources, environment and ecosystems to be healthy, valued and protected and specifically for Africa's water resources to be used equitably and sustainably for socioeconomic development, regional cooperation and the environment.

The relationship of SDG 6 with other SDGs



Source: United Nations Economic and Social Commission for Asia and the Pacific [UN ESCAP] (2017).

GRID-Arendal/Studio Atlantis

Figure 5.1. The relationship of SDG 6 with other SDGs

5.2.2 The Africa Water Vision 2025

The Africa Water Vision was developed as the continent's response and overall policy framework to address the key challenges facing the water sector. Echoing the call in Agenda 2063, the Vision aims to stimulate a change in approach towards equitable and sustainable use and management of water resources for poverty alleviation, socioeconomic development, regional cooperation and the environment. To this end, it provides very specific policy guidance to countries to develop and implement programmes aimed at strengthening governance of water resources; improving the wise use of water; meeting urgent water needs, including expanding safe water supply and sanitation services to meet basic human needs; and strengthening the financial base for the desired water future.

Box 5.1. Policy statements in the Africa Water Vision 2025

- Sustainable access to a safe and adequate water supply and sanitation to meet the basic needs of all
- Water inputs towards food and energy security are readily available
- Water for sustaining ecosystems and biodiversity is adequate in quantity and quality
- Water-resources institutions are reformed to create an enabling environment for effective and integrated management of water in national and transboundary water basins, including management at the lowest appropriate level
- Water basins serve as a basis for regional cooperation and development, and are treated as natural assets for all within such basins
- There is an adequate number of motivated and highly skilled water professionals
- There is an effective and financially sustainable system for data collection, assessment and dissemination for national and transboundary water basins
- There are effective and sustainable strategies for addressing natural and human-made problems affecting water resources, including climate variability and change
- Water is financed and priced to promote equity, efficiency, and sustainability
- There is political will, public awareness and commitment among all for sustainable management of water resources, including the mainstreaming of gender issues and youth concerns and the use of participatory approaches

Source: Africa Water Vision

5.2.3 African Ministers' Council on Water

Formed in 2002, the African Ministers' Council on Water (AMCOW) aims to promote cooperation, security, social and economic development and poverty eradication among Member States through effective management of the continent's water resources and the provision of water supply services (AMCOW n.d.). As the Specialized Committee for Water and Sanitation in the African Union (AU), AMCOW provides the sectoral leadership at continental level needed to tackle the water challenge in Africa and to this end has included sanitation as one of the strategic pillars in the AMCOW Strategy 2018–2030. The AMCOW is also mandated to develop and follow-up on an implementation strategy for achieving the vision and commitments expressed in the N'gor Declaration on Sanitation and Hygiene (N'gor Declaration).

A major initiative of AMCOW is the Africa Conference on Sanitation (AfricaSan) which has developed into a strong movement that blends political support, technical advancement and knowledge exchange to drive the momentum for improved sanitation in Africa. AfricaSan5, which was held in Cape Town, South Africa, in February 2019, focused on progress towards achieving the vision and commitments of the N'gor Declaration. The Conference noted the slow progress that has been made in achieving the N'gor Commitments and called on Heads of State of the AU "to declare an Africa-wide state of emergency on sanitation and hygiene" (AfricaSan 2019).

5.2.4 The N'gor Declaration on Sanitation and Hygiene

The N'gor vision and commitments, adopted by the fourth AfricaSan Conference in 2015, aim to accelerate the achievement of water and sanitation goals in Africa. The commitments are framed around issues such as inequalities in access and use, support to the sector at the highest political level, financing and human resource needs, waste management and government-led monitoring and evaluation of national initiatives. The building blocks necessary to achieve the commitments, and which form the framework within which implementation is evaluated, are the existence of an enabling environment and sanitation and hygiene service delivery targets, which countries set for themselves.

According to the 2019 AMCOW review, progress towards the commitments is slow, and countries will need to act quickly to speed up implementation if they are to meet SDG targets.

Enabling environment

Generally, countries have made significant efforts to establish leadership and coordination structures. However, this is not the case for the key commitments to eliminating inequality of access and use, improving waste management and establishing budgets for sanitation and hygiene. The worst performing of the commitments is that of eliminating untreated waste and encouraging its productive reuse. Overall, the enabling environment for sanitation and hygiene services needs to be strengthened.

Box 5.2. The N'gor Declaration on Sanitation and Hygiene – Commitments

- Focus on the poorest, most marginalised and unserved aimed at progressively eliminating inequalities in access and use and implement national and local strategies with an emphasis on equity and sustainability
- Mobilize support and resources at the highest political level for sanitation and hygiene to disproportionately prioritize sanitation and hygiene in national development plans
- Establish and track sanitation and hygiene budget lines that consistently increase annually to reach a minimum of 0.5 per cent of GDP by 2020
- Ensure strong leadership and coordination at all levels to build and sustain governance for sanitation and hygiene across sectors, especially water, health, nutrition, education, gender and the environment
- Develop and fund strategies to bridge the sanitation and hygiene human resource capacity gap at all levels
- Ensure inclusive, safely-managed sanitation services and functional hand-washing facilities in public institutions and spaces
- Progressively eliminate untreated waste, encouraging its productive use
- Enable and engage the private sector in developing innovative sanitation and hygiene products and services especially for the marginalised and unserved
- Establish government-led monitoring, reporting, evaluation, learning and review systems
- Enable continued active engagement with AMCOW's AfricaSan process

Country targets

Monitoring of country targets is generally weak, as more than half of the countries have made little progress in establishing the enabling environment to facilitate this. For instance, no country has made sufficient progress in establishing the enabling environment for eliminating untreated wastewater to report on targets.

5.3 National Initiatives

Policymaking and regulation are typically a function of government and there have been efforts made by national governments to develop policies and laws that specifically address access to water and sanitation. Aspects addressed at national level include public services regulation, water quality management, the quality of water and sanitation service provision, recognition and entitlements, allocation and availability, physical accessibility, non-discrimination and attention to marginalized and vulnerable groups, participation in and access to information, monitoring and complaints procedures and definition of the broad institutional framework for service delivery.

5.3.1 Institutional types and levels

One of the goals and targets of SDG 6 is to ensure sustainable access to WASH for everyone by 2030. Expediting the acceleration, scalability, universality, equity and sustainability of WASH service delivery underpinning SDG 6 entails a paradigm shift in our thinking and implementation processes. WASH services should be led by governments and offered as an all-inclusive, long-term, cross-sectoral partnership across the public, private and non-governmental organizations (Crocker et al. 2016). The WASH sector enabling environment comprises a set of related functions that help governments, public and private partners to collaborate on effective and sustainable WASH service delivery.

Rapid population growth, inadequate water supply and poor sanitation services have resulted in a strong emphasis on the construction of new facilities by national governments, development partners and NGOs. In some cases, this has been at the expense of properly and efficiently managing the current systems and installations. This results in both groundwater and surface water contamination from dry and wet sanitation systems. When water provision and sanitation facilities are developed, they are not always properly maintained. This is evidenced by the high percentage of dysfunctional hand pumps in rural areas and the high water losses in urban water reticulation systems (Gumbo 2004). Poorly managed facilities lead to declining service levels that in turn reduce the chances of cost recovery – resulting in service demand outpacing investment in service delivery (Chitonge 2014).

National level institutions

At the national level, government ministries such as those responsible for water, agriculture, environment, local government, energy and health may all have a mandate to deal with some aspects of water and sanitation issues. A clear definition of institutional roles and responsibilities and a consensus on which organization leads water and sanitation programmes is required. This will minimize

One of the targets of SDG 6 is to ensure sustainable access to water, sanitation and hygiene for everyone by 2030

Poor enforcement of laws is blamed for illegal dumping, especially in urban areas

duplication of efforts and, in some cases, inaction due to overlapping and conflicting mandates. It will also ensure proper coordination and harmonious supply of resources to priority areas. In some countries, such as Zimbabwe, a statutory instrument is gazetted at the formation of a new government outlining the clear roles and responsibilities of each Ministry. In addition, one Ministry is mandated to take a leading role on coordination of the WASH sector and to be accountable for the sector (Figure 5.2). This involves coordination of efforts by cooperating partners and NGOs. The coordination structure also extends to the local level.

Egypt's institutional framework for water supply and sanitation is centralized (Mumssen and Triche 2017). Key functions of policymaking, regulation, planning and investment are done at the national level by the Ministry of Housing, Utilities and Urban Communities. National works and also planning and implementation of capital investments are delegated to the National Organization for Potable Water and Sanitary Drainage and the Cairo Alexandria Potable Water Organization. Assets, billing and revenue collection are managed by the Holding Company for Water and Wastewater through its local subsidiaries, the water and sanitation companies. The Holding Company for Water and Wastewater is a public sector company providing 25 water and sanitation companies with administrative, technical and financial assistance to deliver water supply and sanitation services.

Some governments have delegated water supply and sanitation to government agencies or parastatals, which are created and governed by an act of parliament. Examples of this include the Directorate of Environmental Health and Sanitation under the Government of Sierra Leone and the Water and Sanitation Corporation of Rwanda. These are normally dominated by engineers and are strong on the supply side of delivering infrastructure, although criticisms have been made regarding their tendency to focus more on water supply than on sanitation infrastructure. Mobilizing communities to pay for water supply is easier than mobilizing sanitation services (Brikké and Bredero 2003).

Countries such as South Africa have very strong Departments of Water Affairs and regional water authorities. These again tend to be strong on water supply and water resources management. The sanitation function is often delegated to local municipalities and district authorities in rural areas. Other countries have urban housing development agencies such as the Botswana National Housing Corporation that deal with site services, of which sanitation is an integral part.

Institutions responsible for delivering such services can be public, private or cooperatively owned and managed entities, as well as entities that collaborate between these sectors. Service providers are responsible for establishing, maintaining and upgrading the water supply and sanitation systems, which typically involves collection, treatment, distribution, quality control, sewage treatment, disposal and reuse.

Local level institutions

Governance at local level is critical to translate national policies into action. An important component of this is achieving devolution of responsibility to the local level, where capacity to implement and manage service delivery might be weakest and support from national level institutions

Organogram of water resources management, water supply and sanitation in Zimbabwe

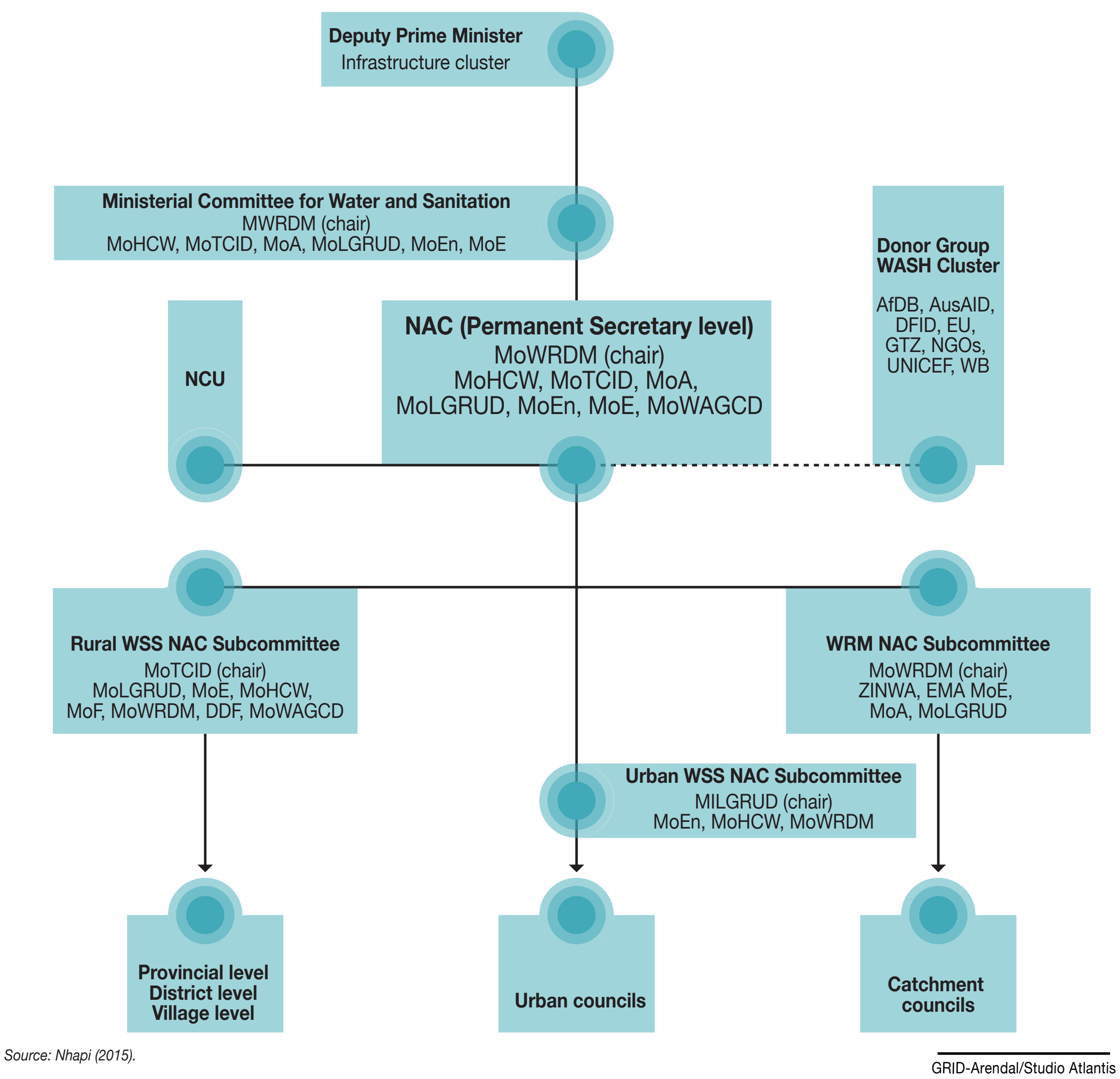


Figure 5.2. Organogram of water resources management, water supply and sanitation in Zimbabwe

> *The principle of subsidiarity depends on strong local leaders and leadership. In other words, institutional decentralization cannot happen without having people at the local level who are willing and show capacity at taking action in the context of water governance.*
>
> – Global Public Policy Network on Water Management

Non deterrent penalties result in the failure to properly manage waste

Box 5.3. South African service delivery standards for basic sanitation and for basic water supply services

Basic sanitation

The minimum standard for basic sanitation services is:

a) the provision of appropriate health and hygiene education; and

b) a toilet which is safe, reliable, environmentally sound, easy to keep clean, provides privacy and protection against the weather, well ventilated, keeps smells to a minimum and prevents the entry and exit of flies and other disease-carrying pests.

Basic water supply

The minimum standard for basic water supply services is:

a) the provision of appropriate education in respect of effective water use; and

b) a minimum quantity of potable water of 25 litres per person per day or 6 kilolitres per household per month –

i) at a minimum flow rate of not less than 10 litres per minute;

ii) within 200 metres of a household; and

iii) with an effectiveness such that no consumer is without a supply for more than seven full days in any year.

Regulatory bodies must provide a clear legal and policy framework so that community–managed water supply and sanitation is held to the same standards and legislation that applies to other kinds of service providers.

– Global Water Partnership

Box 5.4. Institutions must be accountable, efficient, responsive and sustainable

Accountability
In the process of carrying out its mandate, each institution must be able to explain and take responsibility for their actions. Clear obligations for each institution should be defined by the appropriate legislative and executive powers. Without genuine recognition and backing of their legal status, institutions cannot function properly.

Efficiency
Economic efficiency calls for serving more people with equity and minimum waste. Appropriate price regulations and standards for limiting the damage to the environment should be specified in that sense.

Responsive and sustainable
In order to be responsive and sustainable, policies must deliver what is needed on the basis of demand, clear objectives and evaluation of future impact and – where available – of past experiences.

Global Water Partnership (2004)

may be necessary to achieve sustainability. In Senegal, for instance, the Government created the Rural Wells Office, which is responsible for monitoring equipment and providing support to operators at local level (Jaglin et al. 2011). In Zimbabwe, the District Development Fund, in conjunction with the District Administrator, leads and resources the District Water Supply and Sanitation Committee and works closely with NGOs to facilitate sanitation projects. In sanitation, in particular, they train local technicians and public health extension workers on the construction of ventilated improved pit (VIP) latrines, school sanitation systems and hygiene services. For water supply, they train well diggers on deep well construction and protection, spring capture, borehole pump maintenance and repair, rope and washer pump installations, and other appropriate technologies. The District Water Supply and Sanitation Committee is also replicated at ward level in the form of the Ward Water Supply and Sanitation Committee, led by the ward councillor. This allows for the decentralization of sanitation issues to the local level.

Communities at the local level normally create a water user association (WUA) to manage water supply and sanitation services. These institutions can either exist independently or form part of a larger regional or national water user association. Strategic partnerships can also be formed with other entities such as government departments and NGOs that can provide useful assistance in establishing the water user associations (organizational, financial and others). In other countries, these are essentially cooperatives which can be registered and regulated by the ministry in charge of cooperatives. Cooperatives can report to the local council through a ward councillor or directly through the Department of Community Services.

Box 5.5. Supporting the development of the sanitation chain in Maputo, Mozambique

In Maputo, the capital of Mozambique, more than 95 per cent of the population relies on on-site sanitation systems (Rietveld et al. 2016), typically latrines (Water and Sanitation Program [WSP] 2014) that are often abandoned when full, with most of its content – faecal sludge – not being adequately treated (Bäuerl et al. 2015). This situation poses a serious threat to the environment and to urban dwellers alike (Marques Arsénio et al. 2018), with two different studies in the city concluding that children were found to be highly infected by enteropathogens and parasites (Rappelli et al. 2005; Fonseca et al. 2014) which underlines the poor environmental hygiene (Rappelli et al. 2005). This made other researchers look into the impact of well-managed on-site shared sanitation and population densities in urban contexts on the risk of enteric infections in children (Lofrano and Brown 2015), with yet another group associating the presence of a household toilet with lower risk of bacterial and protozoal enteric infections (Berendes et al. 2017).

To overcome this precarious situation, several projects have been implemented throughout the city, including capacity-building of local sanitation entrepreneurs and community-based organizations and support to modernize local government institutions and to improved management and regulation mechanisms for the sanitation sector in the city.

One of such projects is Water and Sanitation for the Urban Poor (WSUP)'s programme to support the construction of sanitation infrastructure, to develop faecal sludge management services and to promote sanitation at the community level (Drabble and Parente 2018).

Regarding sanitation infrastructure, a total of 50 communal sanitation blocks and 400 shared latrines were constructed between August 2014 and March 2016, covering the 11 wards of the Nlhamankulu Municipal District – one of the poorest and most densely populated in Maputo (WSP 2014) – and improving the living conditions of almost 9,000 people.

The main objective of the various partners with this project was to eradicate traditional latrines, which are used by around 10 per cent of the city's households (WSP 2014) and push for improved latrines – something that is also included in the municipal sanitation guidelines (Postura de Saneamento). Interestingly, the infrastructure built belongs to the municipality and is added to the municipal registration system, but the project "aimed to put the processes of toilet construction and maintenance and hygiene promotion and monitoring in the hands of communities" (Drabble and Parente 2018), following a regulation put in place by the municipality.

This means that despite not being enforced by the municipality, maintenance activities are advocated through the various authorities at the neighbourhood level. In particular, since all built infrastructure allows emptying, in accordance with the municipal sanitation guidelines, the families are reminded to empty their systems on a regular basis – once every two to three years – making use of the capacity existing at neighbourhood level following other project activities. Furthermore, the users that best manage their systems are also awarded a prize. Larger maintenance interventions can be supported by the municipality and/or donor funding. However, the poor condition of recently visited communal sanitation blocks, shared by large number of families (50+ people) calls into question the sustainability of the current management system in the long term, given the low capacity of the municipality to support maintenance works, and the reliance of NGOs on donations in project-based approaches that often lack funds for long-term maintenance. Anecdotal evidence shows that social conflicts have been on the rise due to improper maintenance of these shared facilities, for example, once households stop contributing to the maintenance (such as cleaning) as initially agreed.

Local level institutions are involved in all aspects of providing water supply and sanitation services – from formulating and designing schemes, to constructing the collection and treatment facilities, connecting homes to a sewer system and operating these systems. This model entails beneficiary ownership and therefore the maintenance and operations of facilities is typically managed with oversight of the respective communities themselves. Increasing the sense of ownership works not only to facilitate stakeholder engagement but also to help minimize project costs and increase programme efficiency

Apart from building and operating the actual water supply and sanitation networks, local level institutions can also provide assistance to social service programmes, for instance, with disseminating knowledge of national sanitation and hygiene strategies. In order to achieve this level of active coordination and collaboration, close contacts between these institutions and governments, especially at the local level, need to be maintained. For instance, in order to disseminate information and effect behavioural change, the Ministry of Rural and Urban Hydraulics of Chad entered into agreements with district community radio stations to air programmes on handwashing and community led total sanitation (CLTS) (Rheingans et al. 2006).

There is increased involvement of private players in the provision of drinking water

5.3.2 Institutional frameworks

Appropriate institutional arrangements are important to ensure social equity, economic efficiency and ecological sustainability in sanitation management, in line with the integrated water resources management (IWRM) philosophy (Savenije and Van der Zaag 2008). These three key elements of IWRM are interrelated and complementary. Institutional arrangements rely on a conducive enabling environment to be effective and sustainable, and the necessary management instruments cannot be fully attained without the appropriate system of institutions, especially stakeholder participation (Seppälä 2002). Unlike the traditional vision, institutional arrangements that are founded on IWRM principles work towards a more long-term goal while fulfilling their own respective institutional functions. In IWRM, institutions strive to orient their specific individual functions in ways that best serve the broader community objectives. They do not regard themselves as separate and/or dominant players but, rather, as components of a team.

Despite significant increases in resources spent on water supply and sanitation infrastructure investments to achieve SDG 6, water supply and sanitation service delivery in Africa has failed. Those who have access to water supply and sanitation services normally have to survive with poor service quality such as intermittent supplies (Saltiel 2016).

Peters (2011) defines an institutional framework as a set of formal organizational structures, rules and informal norms for service provision. A good institutional framework is a precondition for successful implementation of many other sanitation and water management intervention tools. An institutional framework for sanitation and water management consists of a range of organizations established to develop or manage water resources and to deliver water and sanitation services. A robust institutional framework is required for sustainable sanitation and water management.

Developing a sustainable institutional framework in water and sanitation management involves plainly indicating the mandates of service institutions for various functions of the sector (International Ecological Engineering Society [IEES] 2006). Institutional arrangements can be different for countries but should have instruments to support dialogue and coordination. A balance is required between providing a fully integrated approach in which specific issues may lose value due to the absence of required expertise or interest, and a sectoral approach in which different policies are pursued without adequate coordination (Global Water Partnership [GWP] 2008). Poor institutional frameworks are the root cause of numerous cases of poor service delivery and unsuccessful water and sanitation projects (WSP 2002). Such institutional weakness mainly results from unclear institutional mandates for planning and management, and limited capacity within institutions to coordinate and manage initiatives. The obvious outcome is deteriorating services, resulting in poor cost recovery and ultimately failed investments that cannot meet current or future demand (Scott et al. 2003).

Appropriate management models for sanitation are required to ensure that service delivery is sustainable beyond the implementation of infrastructure projects (Moriarty et al. 2013). In general, the capacity to provide sanitation services efficiently and effectively is critical for the long-term sustainability of service provision. Accelerated delivery of service is mostly constrained by capacity problems at provincial and municipality levels (Koma 2010). A good institutional framework for sustainable water supply and sanitation at the national level requires a number of organizations and actors to be established, as shown in Table 5.1.

Table 5.1. Essential organizations and actors at national level to ensure sustainable sanitation and water management

Organizations and actors	Form or role	Examples from Africa
Service providers	These include government departments, municipal councils, public corporations, private sector companies, community-based organizations, farmers' groups and others.	NAMWater in Namibia; Zimbabwe National Water Authority; National Water and Sewerage Corporation in Uganda; Johannesburg Water in South Africa Egypt's Water Supply and Sanitation Sector
Regulatory and enforcement bodies	These establish roles and ensure effective application of tools required for sustainable sanitation and water management.	National Water Supply and Sanitation Council for water supply and sanitation and Water Resources Management Authority for water management in Zambia; Rwanda Utility Regulatory Authority
The private sector	These play a crucial role in financing sustainable sanitation and water management and they include commercial banks and other financial institutions, financing both public- and private-sector service providers.	Development Bank of Southern Africa; Infrastructure Development Bank of Zimbabwe Private emptiers and transporters e.g. in Ghana, Benin, Senegal, Uganda Sanivation, Kenya Fortifer Production Plant (Tema, Ghana) Safi Sana Plant (Ashgiman, Ghana)
Local authorities	These play a key role in overseeing the execution of sanitation and water management activities within their boundaries, and local and regional watersheds. They regulate, provide services, and can raise funds.	Durban Wastewater Recycle Project Decentralised service delivery across Africa, e.g. Ethiopia, Burkina Faso, Benin, Mali, Tunisia and Uganda
Civil society institutions Non-governmental organizations Community-based Organizations	They play an advocacy role in the formulation and communication of sanitation and water management policies. They are concerned with nature and environmental protection, development and testing of new models and tools for sanitation and water management. They raise awareness and mobilize local communities.	Plan International; WaterAid; World Vision; SuSanA; Institute of Water and Sanitation Development, Zimbabwe; National Community Water and Sanitation Training Institute, South Africa; Water Trusts in Zambia

Source: Modified from Peters (2011) and Gupta and Pahl-Wostl (2013).

5.4 Sanitation Governance

5.4.1 Context of good sanitation governance

The current sanitation crisis in developing countries is believed to be mainly a crisis of governance, water scarcity and water pollution (Rogers and Hall 2003). Sanitation governance is therefore defined as a range of political, economic, social and administrative institutions required to manage and develop sanitation sustainably (Tropp 2007). Governance goes beyond narrow political and administrative terms. Good governance requires that all institutional actors (local communities, organizations and private entities) are actively engaged in managing sanitation work in harmony. Poor governance worsens social and political risks and institutional disasters and also reduces capacity to efficiently deliver. According to GWP (2018) good sanitation governance requires a flawless legal framework, comprehensive water policies, practical and enforceable regulations, functional institutions, smooth execution, stakeholder-driven systems of accountability and very strong interactions between these entities. In practice, sanitation problems could emanate from outside of the WASH sector, therefore good governance in general – rather than simply good sanitation governance – is required (GWP 2018). This means that effective sanitation governance is likely to exist in a general environment characterized by good governance. GWP (2018) identifies several key approaches and principles that are important foundations to establishing institutional arrangements that support good water governance (Box 5.3).

Rogers and Hall (2003) emphasizes the need for institutions to be efficient, responsive, accountable and sustainable in operating and performing their respective mandates. Accountability and transparency are key to ensure that each institution can explain and take full responsibility for actions taken. Obligations for each institution should be clearly defined by the appointing authority as they cannot function properly in the absence of genuine recognition and backing of their legal status. Economic efficiency requires serving more people with equity and minimal waste. Proper and appropriate pricing standards and regulations for limiting environmental damage should be specified to achieve this. In order to be responsive and sustainable, sector policies must also deliver what is required on the basis of demand, clear objectives and evaluation of future impact and past experience.

The governance of urban wastewater treatment works goes beyond the daily maintenance and upkeep of such systems (Meissner 2015). The governance includes all interested and impacted stakeholders, even beyond those in the immediate vicinity of the plant. Individuals and communities located downstream from such infrastructure and scientists could also become part of governance, by default or voluntarily. There exists a wide range of stakeholders involved in the governance of wastewater infrastructure. There is therefore a need to understand and appreciate how and to what extent the stakeholders influence governance. It will also be important to study the consequences of their actions as they directly or indirectly govern wastewater infrastructure (Nguyen, Skitmore and Wong Kwok 2009).

5.4.2 Contextual factors in sanitation governance

The main worldwide wastewater problems include the lack of functional wastewater treatment facilities and improper management of the existing ones. The implementation of wastewater treatment policies faces varying challenges given the various different contexts (Flores et al. 2017). Context-sensitive approaches are therefore required from a governance perspective. According to Flores et al. (2017), the governance context could constrain the implementation of wastewater treatment policies. Future reforms should thus consider the top-down nature of the policy implementation processes.

About 70 per cent of wastewater in high-income countries is normally treated. This is in stark contrast to an average 28 per cent treated in lower-middle-income countries (United Nations World Water Assessment Programme [UNWWAP] 2017). This poor performance has negative consequences on human health and the environment and has high cost implications. One response to this problem is the construction of technically effective but low-cost wastewater treatment plants (WWTPs). Flores et al. (2017) analysed the governance context of WWTPs in central Mexico by employing the Contextual Interaction Theory and the Governance Assessment Tool. The main conclusions were that the existing context generally restricts WWTP policy implementation and that integrated water resources management implementation and decentralization are only symbolic. The most restrictive instance was found to be where the participation of the state government was particularly limited. As such, strengthening the role of the government and improving mechanisms that currently limit the impact of political gamesmanship could be instrumental in increasing the support offered by the governance context (Flores et al. 2017).

Local contextual factors determine the appropriateness of different institutional models (Table 5.2). The ultimate institutional matrix in any country therefore depends on national priorities, experience and needs. An appropriate institutional framework for sustainable sanitation may include organizations at international, regional, national and local levels; with the political and legal complexity decreasing with each level. Decentralization could be a challenge in some countries due to a lack of local structures acceptable to the central government (Massoud, Tarhini and Nasr 2009). If decentralization is not possible, an institutional framework at local level is not applicable.

Box 5.6. Key approaches and principles for good water governance

- Institutions should be transparent and accountable on policy decision-making and finances
- Systems of communication and inclusiveness should play an active part, as they ensure that the maintenance of stakeholder engagement complements these transparency mechanisms
- WASH issues are dynamic and complex with time, so policies should also evolve to maintain interconnectedness between different actors and various stakeholders
- Various systems in sanitation governance should work towards ethical and equitable solutions, fairness, and gender equality.

Access to water is a challenge, especially in arid regions

Table 5.2. An analysis of the scope, advantages and disadvantages, and examples of different institutional structures for sanitation provision in Africa

Service provision model and description	Strengths and weaknesses	Examples
1. Municipal service provision The provision of water supply and sanitation typically carried out within a dedicated municipal department, or through a separate water board run by the municipality or group of municipalities	• Offers potential of exploiting significant economies of scale, especially in billing and accounting • Can coordinate activities among various city departments • Faces numerous legal, political, financial and institutional constraints, making the provision of high-quality service challenging • Political interference in human resources management may divert the attention away from poor neighbourhoods in preference to those yielding more political influence • The pressure to keep service costs low, with reduced transfers for public services, potentially leaves the municipality with barely sufficient funds to maintain the WASH infrastructure and much less funds for extending services to unserved areas	District assemblies, Ghana; Urban local governments, Zimbabwe; County governments, Kenya
2. Small-scale independent providers These are normally self-employed entrepreneurs who provide WASH services to a portion of the municipal population. They include both simple services, such as delivering water in jerricans on carts and bicycles, and more sophisticated services, such as emptying septic tanks with suction tanks.	• They invest using their own resources which gives them a strong incentive to provide reliable, responsive services • They play an important role in unreticulated low-income neighbourhoods and in smaller towns • Their price of water is typically much higher than municipal networks – even in competitive markets • Small-scale independent providers are generally not formally registered companies, so they do not pay taxes and are difficult to regulate • Small-scale independent providers such as water vendors and sweepers could be the largest provider of services to the poor, but it is often difficult to protect them	Private operators who supply water to small communities and poor districts in Burkina Faso, Mali, Mauritania and Senegal; Private operators also collect and dispose of faecal sludge in countries like Ghana, Kenya and Senegal
3. Non-governmental organizations (NGOs) and community-based organizations (CBOs) They may be managing communal water facilities or toilets. They sometimes partner with the municipalities to provide services such as education, the management of public water points or toilets, or community development.	• They are important partners in bringing improved water supply and sanitation services to poor neighbourhoods • They tend to be better known and respected by the poor than the local municipalities • Most have limited resources and a narrow focus, so their impact tends to be small in relation to the scale of the problems of inadequate service	Community Water Alliance, Dialogue on (Water and) Shelter in Malawi, Zambia and Zimbabwe
4. Private sector participation These range from service contracts for single functions such as billing and revenue collections to concessions that perform full operations, maintenance and expansion of the infrastructure network. Private companies may have citywide mandates for particular functions or may have mandates for specific geographic areas such as public latrine management in a central business district.	• Private companies normally have reasonable access to capital compared to public agencies • They also operate along commercial lines with an emphasis on cost-reduction, giving them an incentive to source technical and institutional innovations to ensure cost effectiveness • Private companies' focus on commercial principles could be detrimental to poor households unless they are given incentives to do so (for example, regulation or subsidies) • Private operators are less interested in serving poor neighbourhoods where the potential for revenues is regarded to be low	Private utilities and private sector participation
5. Partnerships Varieties include a municipality collaborating with small-scale independent providers, civic organizations or private companies for water supply or sanitation services. The municipality normally retains the primary responsibility of managing the piped network and uses partnerships to extend services or to improve the quality of specific functions such as health education or billing.	• Partnerships could bring alternative technologies, credibility among poor communities (NGOs and CBOs), access to lines of credit (private companies), or other comparative advantages • Partnerships have the potential to benefit poor consumers. Typically, partnerships with small-scale independent providers or civic organizations may assist municipalities to improve WASH services for neighbourhoods that cannot be supplied by a reticulated network	Abidjan; Cote d'Ivoire
6. Individual Self-provision varies from paying a vendor to deliver water to a house or paying for the use of a toilet facility to constructing a private borehole or latrine. Individuals who invest in WASH services should source their own financial resources, arrange for any required private sector services and maintain their own infrastructure.	• Self-provision delivers better services and is a viable alternative to inadequate service provided by the municipality • The cumulative effect of numerous households abstracting groundwater, pumping supplementary water from municipal pipes and illegal connections to the network could be quite devastating for service delivery management at the municipal level • There are no economies of scale for individual service provision	Ghana; Nigeria; Zimbabwe This is happening almost throughout Africa, with varying coverage of the stages of the service chain

Table 5.2. An analysis of the scope, advantages and disadvantages, and examples of different institutional structures for sanitation provision in Africa *(continued)*

Service provision model and description	Strengths and weaknesses	Examples
7. Regulator WASH services are monopolistic by nature, which makes competition prohibitively costly. A regulator provides incentives for efficiency improvements that a service provider faces in a competitive market. A regulator is involved in decisions about service pricing, service quality and network extension.	• Price regulation helps to ensure that services remain affordable, while regulations related to coverage expansion and service quality could help poor households gain access to water and sewer networks • Effective regulation requires the regulator to be fairly independent of the service provider and of the political wing • In some countries there are no regulators and city councils, or state legislatures have authority over service prices and standards	Rwanda; Uganda; Zambia

5.4.3 Socioeconomics and political context

The question of social acceptability of reusing treated wastewater and faecal sludge in agriculture relates to how receptive farmers and consumers will be to the process and the resulting product quality (Keraita and Drechsel 2015). Interest and technical capacity to reuse water has grown in response to increasing water security concerns. There are more than 3,300 water recycling projects for non-potable end uses in the world (Rodriguez et al. 2009), but wastewater reuse remains limited to regions suffering water scarcity. The main obstacles to wider uptake are acceptance problems (especially regarding health), institutional and political issues and economic concerns (Moss et al. 2016). The distribution of benefits and the burden of resource use is determined by policy actions that are strongly linked with what is possible at different levels of economic development (Fernanda and Inés 2017). Water reuse for agriculture has been practised for thousands of years (World Water Assessment Programme 2017). While the understanding of – and concern for – the safety of reusing wastewater is growing, its practice is important in addressing water scarcity and continuously increasing water demand. The most intensive and increasing reuse seems to be occurring in water-scarce countries in north Africa. According to Sato et al. (2013), over half of the treated wastewater in these areas is being used for irrigation. Several countries in Africa have proactive policies and monitor water scarcity and reuse (Adewumi et al. 2010).

While the earliest and most common use of recycled water is agriculture, the range of areas for reuse widens with economic diversification. Possible areas of intervention are industrial and commercial use, urban landscape irrigation, recharging groundwater, environment and recreation, energy production and advanced treatment for potable use (Angelakis and Gikas 2014). The major barrier to change in urban water management relates to the characteristics of existing urban water management technologies – centralized, large-scale, capital-intensive and durable (Domènech 2011). These barriers are compounded by governance factors arising from existing social and political institutions and dominant values and beliefs. Although significant progress has been made, it seems the influence of governance on the adoption of technological innovations in urban water management in Africa, as well as technical or economic factors, are still not well understood.

In Africa, the public acceptance of sanitation technologies, from toilets to reuse and disposal, are shaped or affected by the socio-cultural and religious dynamics of the people or communities concerned. For instance, the use and reuse of wastewater or faecal sludge for agricultural purposes is strongly denied in most parts of Africa, whereas in other regions such as Asia, the practice is well recognized as economic and ecological (Helmer, Hespanhol and the World Health Organization [WHO] 1997). In Islamic communities, the reuse of wastewater is acceptable if, for example, the wastewater undergoes some form of purification or dilution procedure prior to reuse. However, due to the wide variety of religious and cultural beliefs, the acceptance of a practice or technology may not be the same across the board and differs depending on the community and its beliefs. In Africa, every sanitation project must give serious consideration to socio-cultural and religious dimensions to ensure that the solutions provided are relevant, well-integrated and in accordance with these dimensions (Jiménez Fernandez de Palencia et al. 2014).

The infrastructure for safe drinking water is often lacking in many African countries

5.4.4 Institutional roles and coordination

The current global, regional and industrial challenges resulted from many systems at different levels. There are global systems that affect the environment and natural resource security, and economic systems that lead to inequality and poverty. The regional systems could affect the fortunes of countries, while the industrial systems could determine the effectiveness of supply and demand. The inability to correctly prioritize and invest in localized disaster resilience hampers development gains, worsens poverty and entraps susceptible communities in a brutal cycle of exposure, poverty and risk. Strong local leadership and an effective enabling environment are therefore key to overcome these challenges and ensure sustainable sanitation services in Africa.

Based on Rogers and Hall (2003) and Organisation for Economic Co-operation and Development [OECD] (2015), Table 5.3 identifies four main institutional functions that are essential to achieving strong institutional arrangements and are thereby also deemed conducive to good sanitation governance.

Effective coordination, clear mandates and responsibilities for all actors are vital to achieve a good functioning institutional framework (Rogers and Hall 2003). Institutions and actors should therefore work transparently and in consultation with each other. It is sometimes very important to build partnerships based on basic policies accepted by all parties (Peters n.d.). According to the Department of Water Affairs and Forestry (2003), a good institutional framework should be accountable, transparent, stable and based on the rule of law. In addition, it should respect basic human needs and ecosystems protection, promote local empowerment and adopt good cost recovery approaches. For new local institutional frameworks, it is recommended to build on and strengthen the existing systems instead of starting from scratch (IEES 2006). The promotion of extensive institutional reform could be appropriate in some cases and could include lending support to a range of different sustainable initiatives in the sanitation sector (Table 5.4).

Table 5.3. Four main institutional functions for good sanitation governance and examples in Africa

Key institutional function	Responsible areas	Examples where applied in Africa
Sector regulation and enforcement	Standards compliance, equity and quality of service, competition, environmental protection, tariffs and service sustainability	National Water Supply and Sanitation Council in Zambia; Rwanda Utility Regulatory Authority in Rwanda
Service provision	Provision of public, private and community-based water supply and sanitation services	Water and sanitation utilities in Ghana, Kenya, Morocco, Namibia, Rwanda, Uganda and Zambia; Urban and rural local authorities in Egypt, Nigeria and South Africa; Housing corporations and cooperatives in Botswana and Zimbabwe
Regional, national and local coordination, facilitation, monitoring and reporting	Sector coordination, transboundary water management, national agencies, civil society organizations, river basin organizations and impact assessment committees	Southern African Development Community (SADC) water sector coordination unit; Nile Basin Initiative (NBI); Zambezi Watercourse Commission (ZAMCOM);
Research and capacity-development	Sector capacity-development of institutions, professionals, technicians, etc Research and development of sanitation technologies	Regional level, such as WaterNet and Nile Basin Capacity Building Network and regional SADC Groundwater Management Institute; Inter-University Council of East Africa

Table 5.4. Institutional reforms for sustainable sanitation and water management

Institutional options	Reform process description and rationale	Examples and references
Organizational restructuring through bundling or unbundling of functions	• The allocation and nature of functions, processes, activities, roles and responsibilities within an organization should be revamped for efficient management. • The roles and responsibilities at different levels of government, community-based organizations and the private sector should be clearly defined, recognized and established and the necessary support provided. • Fragmentation and overlapping mandates between different organizations and stakeholders should be avoided. • The roles of regulation and operation should be clearly separated and preferably executed by separate institutions.	Department of Water Affairs and Forestry 2003 Many water sectors in Africa have been undergoing restructuring and reforms – Kenya, Rwanda, Uganda, Morocco, Burkina Faso, etc.
Strengthening regulatory and enforcement bodies	• There must be a sound body monitoring and enforcing laws, rules, structures, responsibilities and partnership agreements.	National Water Supply and Sanitation Council in Zambia; Zambia Water Partnership
Decentralization	• Decentralization brings government closer to local communities. It is also an encouraging factor for better services and use of local capacity.	International Ecological Engineering Society 2006 Many countries in Africa have decentralised services delivery – Ethiopia, Uganda, Burkina Faso, Mali, Benin, Tunisia)
Improving cost recovery	• Cost recovery is key in generating funds for maintaining and extending services and meeting existing and future demands.	Zambia Water Partnership/Ministry of Energy and Water Development 2008
Building Public-private Partnerships (PPPs)	• Governments could benefit from private-sector expertise in PPPs such as in the preparation of guidelines, technical assistance, planning, design and contract supervision, construction, preparation of communications materials, training and capacity-building, materials supplies, financing, among others.	
Privatizing some parts of the water and sanitation sector	• The introduction of private-sector incentives and management skills and efficiency to deal with service provision challenges can catalyse change.	Zambia Water Partnership/Ministry of Energy and Water Development 2008 Private emptiers and transporters associations e.g. in Ghana, Uganda, Benin, Senegal.
Nationalizing some parts of the water and sanitation sector	• It is sometimes better to transfer some responsibilities to the local or national government to protect the poor and vulnerable and make the sector work efficiently and at reduced cost.	Zimbabwe National Water Authority
Human resources upgrading	• This is required to give support to improved capacity in all the above-mentioned aspects.	

Proper waste management is difficult in overcrowded places such as informal settlements

5.4.5 Regulation of the sanitation sector

The fragmented, complex and disconnected nature of arrangements within and between sanitation infrastructure provision and service delivery sectors, along with increasing interdependence between sectors, is reshaping business models of infrastructure-based services, prompting the emergence of new approaches to regulation and governance. The sanitation cityscape conceptual framework separates the urban sanitation system into three components (Scott 2019) as shown in Figure 5.3:

- The living environment (i.e. the household and surrounding area and the peri-domestic area)
- The service delivery environment (i.e. the service delivery chain)
- The enabling environment

Some sub-Saharan African countries are under continuous stress due to the incidences of waterborne disease and water pollution. This situation is mainly the result of poor design, performance and maintenance of the dominantly used on-site sanitation systems such as septic tanks and cesspools. In addition, faecal sludge, which has to be emptied from these on-site sanitation systems, is not properly managed. There are hardly any rules and regulations on faecal sludge management for utilities.

The role of a utility regulator is defined by the scope of its coverage, its role in relation to ministries, and its role in relation to other regulatory entities such as the competition agency or agencies which deal with the environment, energy, telecommunications, or other sectors

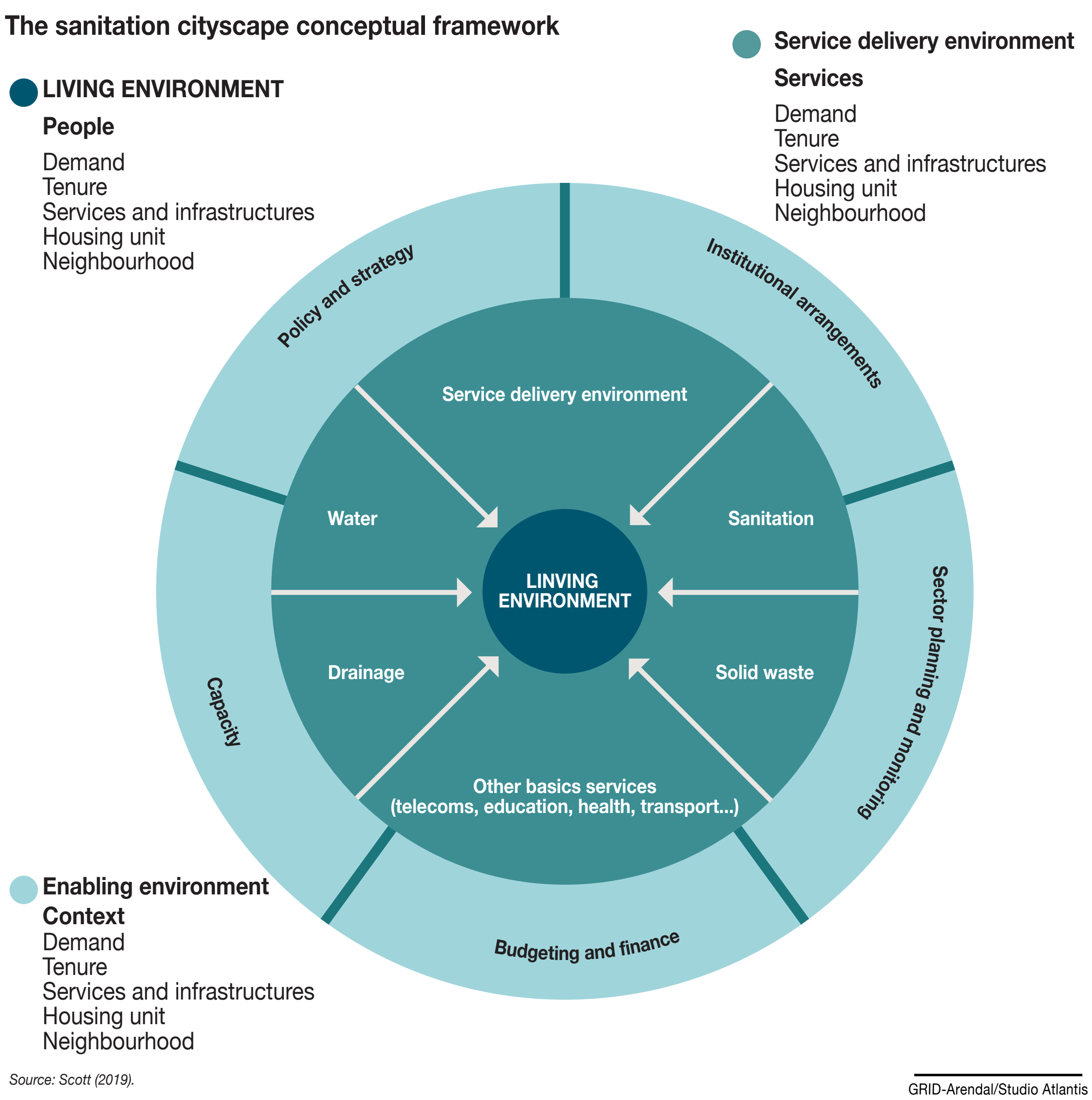


Figure 5.3. The sanitation cityscape conceptual framework

(Smith 1997). Some countries use multi-industry agencies covering everything from power and water to transport (for example, Rwanda). Multi-industry agencies allow scarce expertise to be pooled and greatly reduce the risk of industry and political capture. They also decrease the risk of inconsistency in regulatory approaches across sectors and help to deal with the blurring of sector boundaries as utilities enter one another's markets (Smith 2000). Some governments may be reluctant to relinquish political control over regulatory decisions and some may question whether independent agencies are feasible in all country settings. Ideally, the regulatory agencies should have closer relationships with regulated firms, consumers and politicians and they should also have the funding and expertise to sustain such independence. The funding for a regulator is normally provided by the regulated parties through various fees and levies. This provides for independence from government influence.

The design of a regulator's decision-making structure covers issues relating to the number of decision makers, the basis for selection, the role of stakeholders and the regulatory and appeals processes. The correct selection of the regulator is critical, more so for countries that have not yet established a reputation for competence and reliability. For regulators to be independent, the selected board members should possess the personal qualities necessary to exercise independent judgement and to resist undue pressures. An appeals process should be set up to ensure that the regulator does not stray from its mandate and that it remains accountable.

Decision-making within a stand-alone regulator is carried out by a board, which normally has between five and nine members appointed for their skills and experience in the water sector. The main functions of a regulator can typically be summarized under the following headings:

- Technical regulation (performance monitoring, benchmarking, dam safety, registration of qualified dam engineers and drilling firms)
- Economic regulation (licencing of water service providers, tariff approvals for water supply and sanitation, tariff approvals for raw water, outreach on economic regulation)
- Consumer relations (water watch groups, complaints handling, public relations, capacity-building of water service authorities and water service providers)
- Rural WASH (monitoring, benchmarking, technology approval, information dissemination)
- Day-to-day administration of the regulator (day-to-day operations, accounting, human resources management)

The main sources of funding for the regulator are licence application fees and annual licence fees. These are paid by the water service providers from revenues collected from their customers. Increasingly, some new and innovative ways of financing infrastructure for sanitation are being explored, as shown in Box 5.7. Regulators are also centres of knowledge and excellence in the water sector. An important general function in this regard is to provide advice to government and parastatals and capacity-building to water service authorities and providers.

Deregulation and new technology, including the advent of smart markets, have provided new opportunities for competition in power, water, transport and telecommunications. Options for competition include competition for the market (franchising), competition in the market (open access, pooling and timetabling), and competition among networks (Smith 1997). How network competition is introduced and how effectively and easily it is implemented will vary from one network industry to another. The more complex the network and the lower the sunk costs, the greater the value of introducing competition from other networks. The faster the rate of technical change, the greater the dynamic benefits from competition. And the lower the regulatory capacity, the more efficient it will be to opt for competition (Kahn 1988).

Egypt has established a specific water sector regulator solely dedicated to monitoring service provision. Challenges reported in this set up include overlapping responsibilities, lack of clarity and the need to strengthen the regulator's role (Mumssen and Triche 2017). The country has made concrete efforts since 2015 to establish the required institutional arrangements to enhance overall sector performance. These include establishing

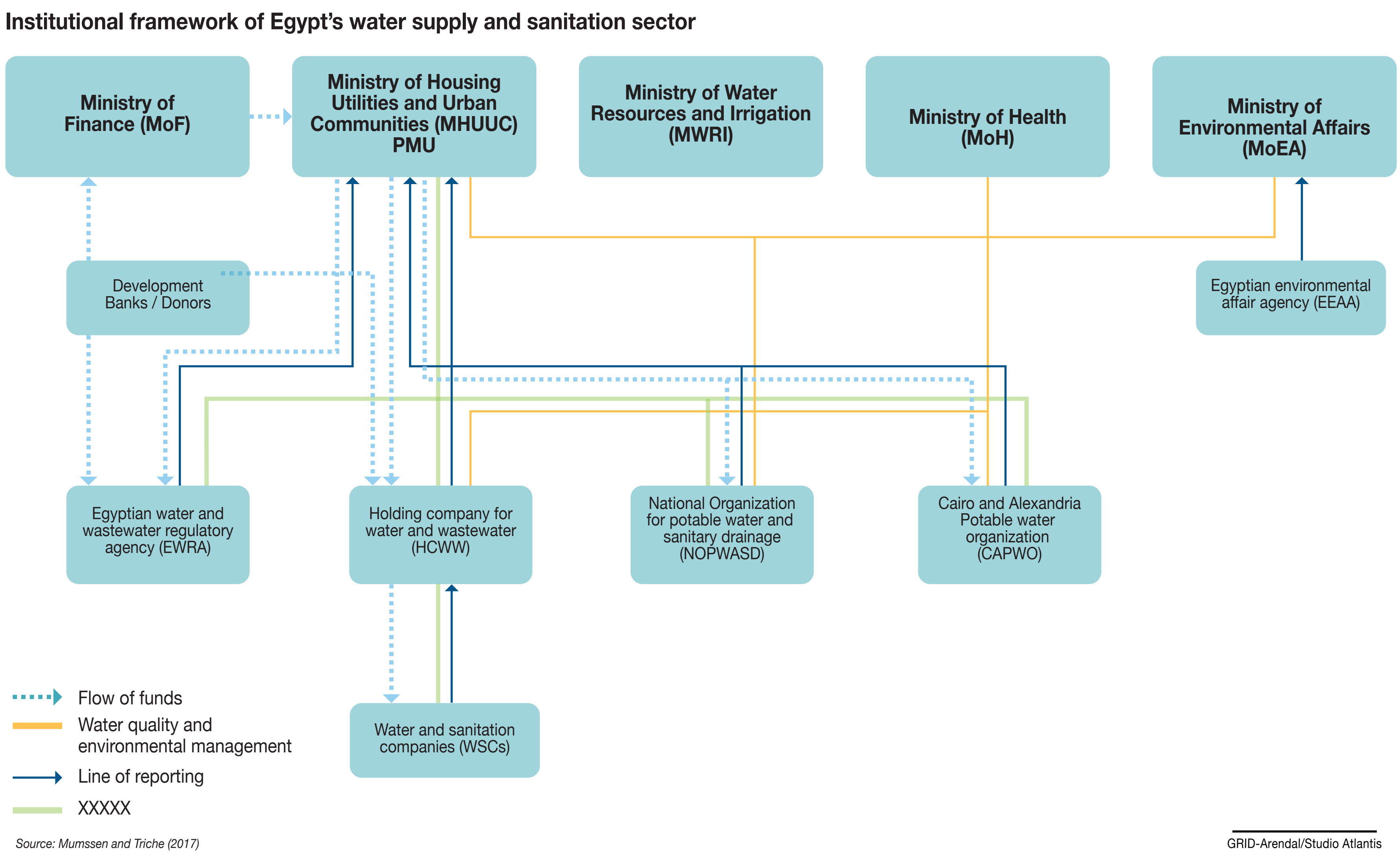


Figure 5.4. Institutional framework of Egypt's water supply and sanitation sector

Box 5.7. Innovative financing mechanisms for urban sanitation infrastructure – The case of Maputo, Mozambique

One project aimed at improving the sanitation services and infrastructure in the city of Maputo involves the financing of domestic sanitation systems through a revolving fund established with the support of local community-based organizations and the Municipality of Maputo, with funding from international NGOs.

A lump sum is initially provided to the participating communities and these are then responsible for managing the fund and providing interest-free loans. The loans are made available to families with a minimum monthly income of MZN 4,000 (US$ 70) and are repaid in monthly instalments of MZN 1,250 (US$ 21). As a comparison, the monthly expenditure of more than 60 per cent of families dependent on on-site sanitation in the city of Maputo is below MZN 6,000 (US$ 100), with almost 35 per cent spending less than MZN 3,000 (US$ 50) (WSP 2014). The project was initially devised to support the construction of improved latrines (MZN 5,000 or US$ 84) but upon request from the families, was later expanded to allow for the first phase of construction of a septic tank and a leach pit at a cost of MZN 22,000 (US$ 368). Infrastructure management, including faecal sludge removal, is the responsibility of the family, that can make use of the capacity existing at neighbourhood level. Regarding water availability – a prerequisite for the operation of septic tanks – the high coverage of domestic connections at household level, with the large public operator reaching almost 60 per cent of the city's households (CRA 2016), shows that water is not a limiting factor for Maputo.

The families in need are identified by the neighbourhood institutions in a process that takes into consideration the size and the condition of the existing infrastructure and the capacity to pay back the loan. Upon being authorized to receive the loan, the family is responsible for the transportation of the material, for doing the digging and for clearing and cleaning the premises, which includes removing old faecal matter and/or buried structures, for example, old latrine linings. The construction then takes around five days.

Since these are interest-free loans, the community-based organizations' profits come from the margins associated with the economies of scale, such as from simultaneously building more septic tanks and making the exercise cheaper in the process. Some community-based organizations ask for personal goods such as televisions and freezers as collateral for the loans, with the amount of collateral demand depending on the sum that is loaned. Not all community-based organizations follow this approach due to legal concerns. Irrespective of this, when families cannot pay the loans, the community-based organization initially contacts the Neighbourhood Secretary who tries to solve the situation and if this does not work, the case then goes to the Neighbourhood Tribunal.

One of the local community-based organizations responsible for implementing the revolving fund in Maputo is Associação Comunitária de Ajuda e Desenvolvimento do Bairro Chamanculo (ACADEC). ACADEC is responsible for community education regarding sanitation and use and management of sanitary facilities. ACADEC has built 17 septic tanks since 2017, 10 of which were built in 2017 in Chamanculo, one of the poorest and more densely populated neighbourhoods in Maputo. The loan repayment rate is 100 per cent. In the same neighbourhood, for areas where several families were already sharing sanitation infrastructure – typically latrines – and where due to available space constraints private facilities cannot be built, shared infrastructure is favoured.

According to ACADEC, a major limitation of the revolving fund is that many families cannot afford the investment, either because they do not have the capacity to pay or because sanitation is not a priority for the family. The health impact of these projects is yet to be scientifically quantified (Lofrano and Brown 2015) but anecdotal evidence from household interviews seems to indicate that the number of cases of diarrhoea is falling. The households that were interviewed were very positive about the project, as it "gave them the opportunity to build sanitation infrastructure that they would not have been able to afford".

Finally, given that septic tanks require physical space that is often not available in densely populated areas such as Chamanculo and the costs involved with the construction, operation and maintenance of septic tanks, it can be concluded that only a small fraction of the population can be reached with similar projects. To reach more of the population, subsidization schemes would be necessary.

a dedicated management team in the Ministry of Housing, Utilities and Urban Communities (Figure 5.4), and tariff reforms to improve financial sustainability. A new Water Law clearly spells out mandates and strengthens the regulator and the regulatory framework. A capacity-development programme for the regulator was also developed.

5.4.6 Gender and stakeholder involvement

Women have primary responsibilities in the management of household water supply, sanitation and health in most societies in Africa. Unfortunately, efforts to improve the management of water supply and sanitation systems and extending access often overlook this crucial role played by women. WHO/UNICEF (2019) figures show that about 521 million people in sub-Saharan Africa have no access to improved sanitation. Poor water and sanitation, as well as unsafe hygiene practices, are the main causes of diarrhoea and one of the main child killers in the region. Each year, more than 250,000 children under the age of five die from diarrhoeal diseases in Africa (WHO/UNICEF 2018). Without adequate sanitation, safe drinking water and hygiene facilities at home and in places of work and schools, it is disproportionately difficult for women and girls to lead safe, productive and healthy lives (UN-Water 2019). For girls and women, performing these roles often precludes any other activity or participation in education. Their marginalization is worsened by the indignity and insecurity of having nowhere private to go to the toilet. Addressing the needs of females in relation to water, sanitation and hygiene is a key driver in achieving gender equity and unlocking the potential of half of the global society.

In many countries, the presence or absence of improved sanitation facilities has a disproportionate effect on the lives of women and girls for two main reasons (Saleem et al. 2019). Women and girls are more vulnerable to abuse and attack while walking to and using a toilet or open defecation site. Women also have specific hygiene requirements during menstruation, pregnancy and child-rearing. At a local level, gender-sensitive approaches help to improve the suitability, sustainability and reach of sanitation services by both focusing on and involving women in the facilities' design, implementation and management. Embedding gender equity into WASH policy at all levels is crucial to achieving water and sanitation for all, which in turn will greatly help to advance many other parts of the SDG agenda, especially education and work.

The above highlight the need for gender tools and policies in water supply and sanitation. A guide can be derived from organizations such as Plan International Australia which has prepared the Gender and WASH Monitoring Tool of 2014. In Africa, Kenya launched the National Gender and Development Policy in 2001, embarked on national training programmes and launched the Gender Data Sheet in 2011. Water sector indicators captured included the distance travelled to reach the nearest water point (one way). A Gender Toolkit was developed and piloted for water service providers in Athi, Lake Victoria North and Coast water service boards. The toolkit guides water service providers in all its areas and activities such as developing new services, operations and policies.

The pace at which Africa is investing in water, sanitation and hygiene is not fast enough to match the growing population

The involvement of all stakeholders in water and sanitation provision and governance is very important for sustainability. This normally starts at a much lower level such as water point committees and water user associations and extends up to sub-catchment and catchment levels. However, most of these structures focus more on water supply than sanitation. However, countries such as Zimbabwe have ward and district water supply and sanitation committees, where sanitation plays a prominent role. Civil society advocacy groups are more visible in urban areas and these lobby for equity and accountability on behalf of residents. These can be in the form of resident associations or community water alliance chapters. Examples include Burkina Faso, Cameroon, Ghana and Zambia. Other key interest groups include industrialists and NGOs, CBOs, the disabled, academia and cooperating partners.

In its new policy, Ghana incorporated the relevant stakeholders who need to be involved in the sanitation sector. There has been considerable involvement of the private sector in the provision of sanitation services, which through public-private partnerships has brought change to sanitation service provision in Ghana. The country has also recognized community partnerships in order to help solve problems in the sanitation sector (Amoah 2009).

5.4.7 Legal and policy provisions

Sanitation policies and the right to sanitation
AMCOW has been piloting the development of sanitation and hygiene policies. With its assistance, Zimbabwe developed and launched its National Sanitation and Hygiene Strategy 2011–2015 in September 2011. A successor to this policy was also developed, abandoning the traditional technology-based supply approaches and adopting a demand-driven approach centred on behaviour change and services responsive to community and consumer demand. Sanitation issues are also embedded in other policy documents such as the 2013 National Water Policy and the Public Health Act (Chapter 15:09). Zimbabwe has a budget plan for financing of sanitation and hygiene projects but struggles to implement it because of economic challenges. The investment by Government in water resources, water supply and sanitation infrastructure as a percentage of total budget expenditure in recent years has averaged 2.1 percent, well below the Sanitation and Water for All commitment of 7 percent per year (UNICEF 2019). The WASH infrastructure investments as a percentage of GDP has averaged 0.5 percent between 2010 and 2018 (United Nations Children Fund (UNICEF) 2019).

According to the Bawa (2019), 10 countries in the West Africa region had a national sanitation policy, while another six were still in progress. After the eThekwini Municipality Agreement, the region was seen to respond positively to coming up with sanitation policies, plans and strategies. Most countries in the Central Africa region were in the process of developing and implementing sanitation policies and national sanitation plans, with the Central African Republic and the Democratic Republic of the Congo both having already prioritized the development of a national sanitation policy (WSP 2011). In East Africa, most countries in the region either had a sanitation policy or were developing one in 2008.

The Human Right to Water and Sanitation was recognized by the United Nations General Assembly on 28 July 2010. In South Africa, the right to water is protected by the Constitution and is implemented by ordinary statutes. However, the right to adequate sanitation is rarely mentioned and is undermined by the right to water. In the absence of an international body to enforce it, the Human Right to Water and Sanitation relies upon the activity of national courts.

Sanitation service standards

African countries have defined their sanitation service standards differently for both urban and rural areas. The focus in rural areas has mainly been on on-site sanitation technologies that countries find acceptable. Figures show that most rural areas are served by pit latrines, in line with Millennium Development Goal (MDG) targets and specifications (Munamati, Nhapi and Misi 2015). However, other unimproved technologies tend to dominate rural Africa, resulting in poor performance in rural sanitation (WHO/UNICEF 2018). In urban areas, the non-waterborne systems still dominate the sector (Munamati, Nhapi and Misi 2015). However, in countries such as South Africa and Zimbabwe, the insistence has been on more advanced technologies such as the VIP latrines in rural areas and flushing toilets in urban areas. The countries which insisted on high standards did not do well in the MDG era, although South Africa had better resources.

In urban areas, service standards have been developed at various levels – by governments, urban councils, utilities or utility partnerships. The Africa Water Utility Partnership has been less visible on the continent over the years but had the following services covered through their service standards:

- Household latrines - with on-site pit or septic tank disposal
- Household toilets - with off-site conventional sewer systems
- With off-site small-bore (small pipe) sewerage (solid-free)
- With off-site condominial (shallow) sewerage
- Shared household latrines - on- or off-site disposal
- Public latrines/toilets - on- or off-site disposal
- Emptying services - for pits or septic tanks

The performance of a water and sanitation utility is indicated by service equity or access, efficiency and sustainability. The following are also some of the performance indicators that have been used by African countries that are on the International Benchmarking Network:

- Coverage of toilets
- Coverage of sewerage network services
- Efficiency of collection of sewage
- Adequacy of capacity for treatment of sewage
- Quality of sewage treatment
- Extent of recycling or reuse of sewage
- Efficiency of satisfactory response/reaction to customer complaints
- Efficiency of cost recovery in sewage management
- Efficiency of collection of sewage charges
- Maintenance coverage ratio

Infomal settlements often lack adequate sanitation

Effluent disposal standards

Human waste must be properly collected, treated and disposed of in order to protect public health and the environment. The level of wastewater treatment required depends on the method of disposal which can be broadly classified into two categories: surface water discharge and land application. Sewage disposal to surface waterbodies such as rivers, lakes, estuaries and oceans is the most common approach in the world (Tchobanoglous et al. 2003). In land application systems, wastewater is applied on land and naturally drains to groundwater or surface waters. Two types of effluent standards for municipalities are generally set by regulatory agencies: technology-based standards or effluent discharge standards used in some countries; and water quality-based limits, or in-stream or environmental standards in some countries. A technology-based standard is simply a minimum level of technology and pollution-control performance that must be achieved by municipal wastewater treatment plants. A water quality-based limit is based on the water quality standards applicable to receiving water and are more stringent than technology-based standards (see Table 5.5 on typical effluent standards). This limit may be necessary to protect a waterbody's designated uses, such as contact recreation and aquatic life, by which the discharged effluents are then regulated to avoid exceeding the self-purification capacity of the receiving water bodies. A look at some of the regulations in Africa shows inconsistencies in what is covered. This may be due to the individual priorities of the different countries.

In Kenya, the National Environment Management Authority (NEMA) has standards for effluent or wastewater before it is discharged into water or land. The maximum permissible levels are provided in the National Environment Standards for discharge of effluent into water or on land under the regulations SI No. 5/1999. The Nigerian standards are based on types of activities.

Table 5.5. Typical Effluent Disposal Standards used in Selected African Countries

Parameter	Kenya	Tunisia	Nigeria	Zimbabwe
Ammonia (N), mg/l	10			≤0.5
Nitrite-nitrogen, mg/l	20			≤3
Nitrogen Total (N), mg/l	10			≤10
Boron (B), mg/l				≤0.5
BOD5, mg/l	50	30	20	≤30
COD, mg/l	100	90		≤60
Conductivity (μS/cm)	7,000			≤1,000
DO, % saturation				≥60
FC (#/100 ml)			400	≤1,000
Helminth eggs (#/100 ml)				≤1,000
Iron (Fe), mg/l	10		20	≤1
Lead (Pb), mg/l	0.1		1.0	≤0.05
Oxygen absorbed, mg/l				≤10
pH (pH units)	6.0-8.0	6.5-8.5	6.0-9.0	6.0 – 9.0
Total-PO_4- (P), mg/l	10		5	≤0.5
Potassium (K), mg/l				
TDS, mg/l	1,200			≤500
Temperature deg. C	20-35			≤35
Total heavy metals, mg/l			3.0	≤2.0
TSS, mg/l		30	30	≤25
Turbidity (NTU)	300			≤5

Sources: Government of Kenya (1999), Institut National de la Normalisation et de la Propriété Industrielle [INNORPI], (n.d.), Government of Nigeria (1991) and Government of Zimbabwe (2007).

5.5 Conclusions and recommendations

Most countries in Africa need to strengthen their WASH enabling environments by establishing resilient institutional frameworks, transparent governance systems and their associated instruments. In particular, the coordination of the sanitation sector needs to be strengthened so that sanitation receives equal attention to water supply.

A number of countries are yet to establish sanitation and hygiene strategies to guide their sanitation sectors. These are required to define the technologies and approaches most suitable to the sector and to ensure the participation of all stakeholders. Besides the water and sanitation policies and strategies, specific programmes should focus on gender issues and sanitation for vulnerable groups, including the disabled.

A small fraction of wastewater from African cities is receiving treatment, leading to the pollution of downstream water bodies. Suitable effluent disposal standards should be adhered to by each country to ensure environmental sustainability.

The sanitation sector needs to be efficiently regulated. There are still quite a number of countries where regulation is spread across different ministries and government agencies.

A polluted stream in Nairobi

6

CIRCULAR ECONOMY

6.1 Introduction

Circular economy approaches to sanitation services in Africa focus mainly on wastewater management. Their goal is to not only enhance sanitation services' delivery across the continent, but also to create an environment for healthy living. The main objective of the circular economic model is to eliminate waste "systematically, throughout the life cycles and uses of products and their components" (Zils 2014). The principle of circular economy is zero-waste, based on three rules:

- All durables, which are products with a long or infinite lifespan, must retain their value and be reused but never discarded or downcycled (broken down into parts and repurposed into new products of lesser value)
- All consumables, which are products with a short lifespan, should be used as often as possible before safely returning to the biosphere
- Natural resources may only be used to the extent that they can be regenerated (Stuchtey 2015)

Six types of circular economy are common to Africa, including treated water reuse for agriculture, reclaimed sewer wastewater for potable use, treated wastewater for aquaculture, recycled wastewater for agriculture, untreated wastewater for irrigation, and non-sewer wastewater recycling for agriculture and energy. Household wastewater stream caters for less than 20 per cent of the people of Africa, and there are examples of circular economy around (or with) faecal sludge and solid wastes. While there are multiple benefits of circular economy application to wastewater management in different contexts, there are also constraints such as financial, institutional, technical, social and health aspects that need to be addressed.

In Africa, a proportion of consumed water along with excreta from toilets ends up as wastewater in sewers or on-site sanitation systems (OSS) such as septic tanks or wet pits. While, to a variable extent, sewers are often developed in large urban centres, sanitation coverage with on-site sanitation systems in Africa remains one of the highest in the world. Figure 6.1 presents a typical sanitation service chain as applicable to many African countries.

Both sewer-based wastewater and non-sewer based wastewater (also called 'faecal sludge') require treatment. However, many cities in Africa still struggle to provide adequate collection and treatment systems for these materials (Andersson, Dickin and Rosemarin 2016). Main constraints along the sanitation value chain include: poor institutional arrangements for collection, high capital costs for treatment facilities, high operation costs, poor maintenance, vandalism and lack of capital. Conventional treatment follows a linear approach from collection to disposal, whereas recent emphasis has been placed on a circular economy approach in wastewater management.

6.1.1 Linear and circular approaches to wastewater management

In the past few decades, actions taken to mitigate the impacts of human activities on the Earth's ecosystems have followed the linear economy approach to resource management. With such an approach, it has been estimated that the human demand on the Earth's ecosystems will exceed what nature can regenerate by about 75 per cent by 2020 (Global Footprint Network 2019).

Conceptually, a circular economy approach implies that resources are used for as long as possible by extracting the maximum value of the resource while in use and recovering and regenerating products and materials at the end of each service life. It is an "economy that preserves the value added in products for as long as possible and virtually eliminates waste. The resources are retained when a product has reached the end of its life, so that they remain in productive use and create further value" (European Commission 2010). This is in contrast with the linear economy approach, where waste products are managed as materials that have reached the end of their lifecycle. The linear approach is premeditated on taking, making, using and disposing of resources and is extractive, often leading to waste of resources, environmental pollution and overall system inefficiency.

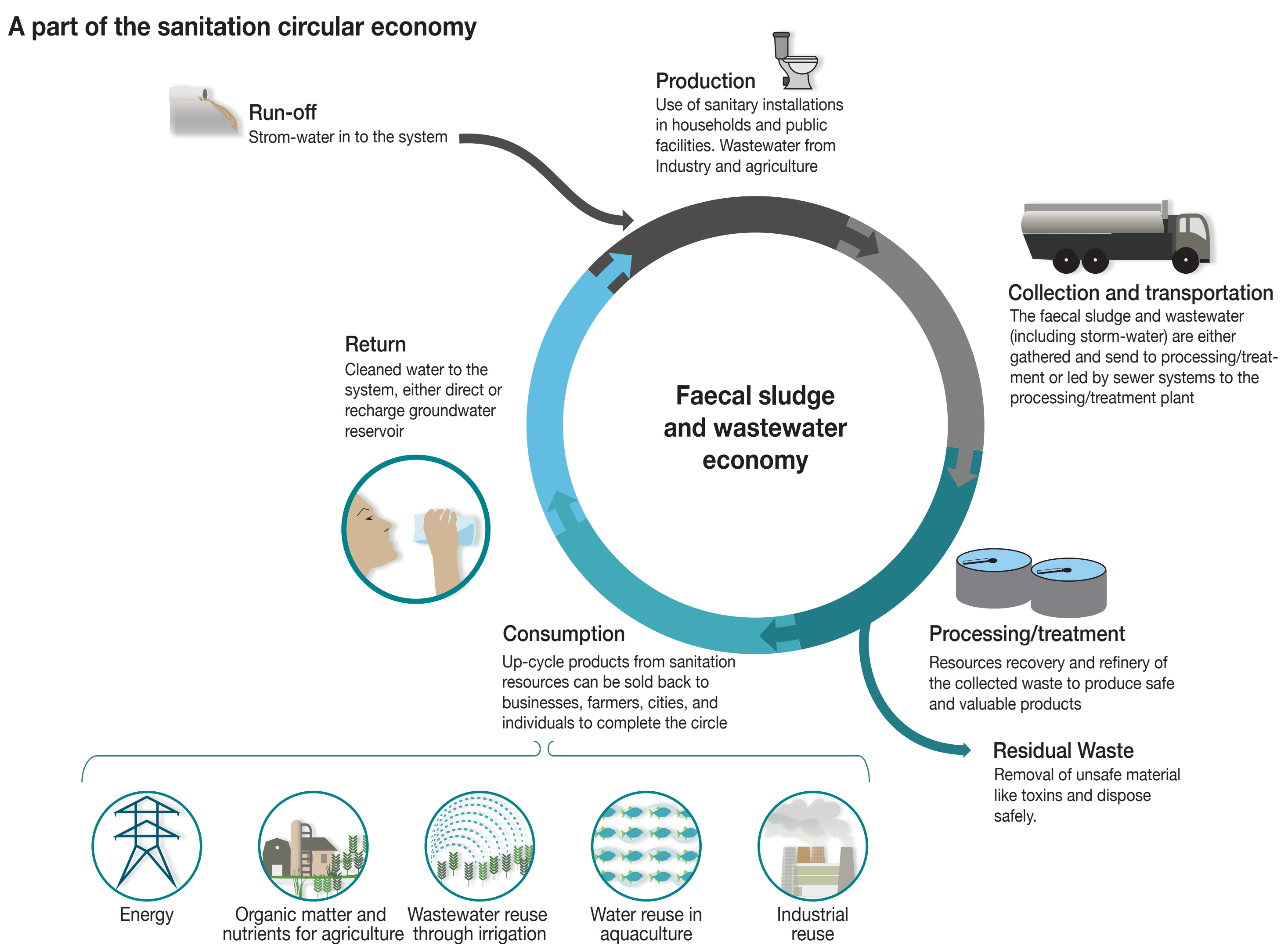


Figure 6.1. A typical example of the sanitation service chain with variation for urban and rural areas

The practice at the centre of the circular economy approach in sanitation is not new. In particular, closed loop systems linking food waste and food production have been practised for generations in many rural societies. Since 1966, there have been renewed interests and numerous publications on the importance of the circular economy approach in resource management. From Kenneth Boulding's The Economics of the Coming Spaceship Earth, published in 1966, to the European Commission's circular economy action plan of 2015, many different schools of thought condemn the linear economy approach of take, make, use and dispose, instead envisioning waste as a resource to be reused.

The circular economy is a preferred alternative to the linear wastewater and solid waste management approach of "store/collect, transport, treat, dispose". It aims at deriving value from waste streams, applying a business perspective and shifting the focus from coverage to creating value and improving resource efficiency. It implies closing cycles by turning 'waste' resources produced by the community into valuable inputs for another use, as shown in Figure 6.2. It involves not only flows of water, nutrients, materials and energy but also flows of value (such as revenues or societal benefits) and information streams, as well as cost recovery and resource efficiency. It entails adopting a holistic perspective, considering different waste streams, contexts and technologies. Although it is implemented at the local level, it goes beyond the micro-organization level of production, linking to higher levels. It also involves a multi-stakeholder approach, requiring partnerships and cooperation across sectors and stakeholder groups.

It is estimated that 60 per cent of the urban population in Africa is living in settlements where sanitation services are poor, inadequate, and unreliable (Wang et al. 2013). In a conventional sanitation delivery approach, wastewater and faecal sludge are viewed as materials that have reached the end of their lifecycle. With this approach, the annual economic loss due to poor sanitation is equivalent to between 1 and 2.5 per cent of GDP for each of the 18 Sub-Saharan African countries considered in a study (Water and Sanitation Program [WSP] 2012). By implementing the circular economy approach, these undesirable materials may be converted into goods offering multiple benefits, leading to improvement of sanitation (Drechsel et al. 2018a) and some cost recovery.

In general, the circular economy approach builds on three main principles (Ellen MacArthur Foundation 2017), namely:

- Preserving and enhancing natural capital by controlling finite stocks and balancing renewable resource flows
- Optimizing resource yields by circulating products and materials in use at the highest utility
- Fostering system effectiveness by revealing and designing out negative externalities

Prior to the emergence of the concept of circular economy, ecological sanitation ('ecosan') was in vogue. Ecosan perfectly encapsulates the idea of closing the loop, as it aims to meet socioeconomic requirements, prevent pollution of surface and groundwater, sanitize urine and faeces, recover nutrients for food production, and save water, energy and resources in a given local context (Hu et al. 2016). In the last three decades, multiple types of ecosan systems have been advanced with different user interfaces, collection and storage, treatment processes and reuse or recycling of water and nutrients for waste materials. Recycling has also been commonly practised throughout most of human history, although not to reduce waste. Its practice was historically as a result of a lack of adequate resources or the difficulty of acquiring new resources. This contrasts with the reason for the practice in the modern world, where recycling is carried out for environmental reasons and for the future.

A typical example of the sanitation service chain with variation for urban and rural areas

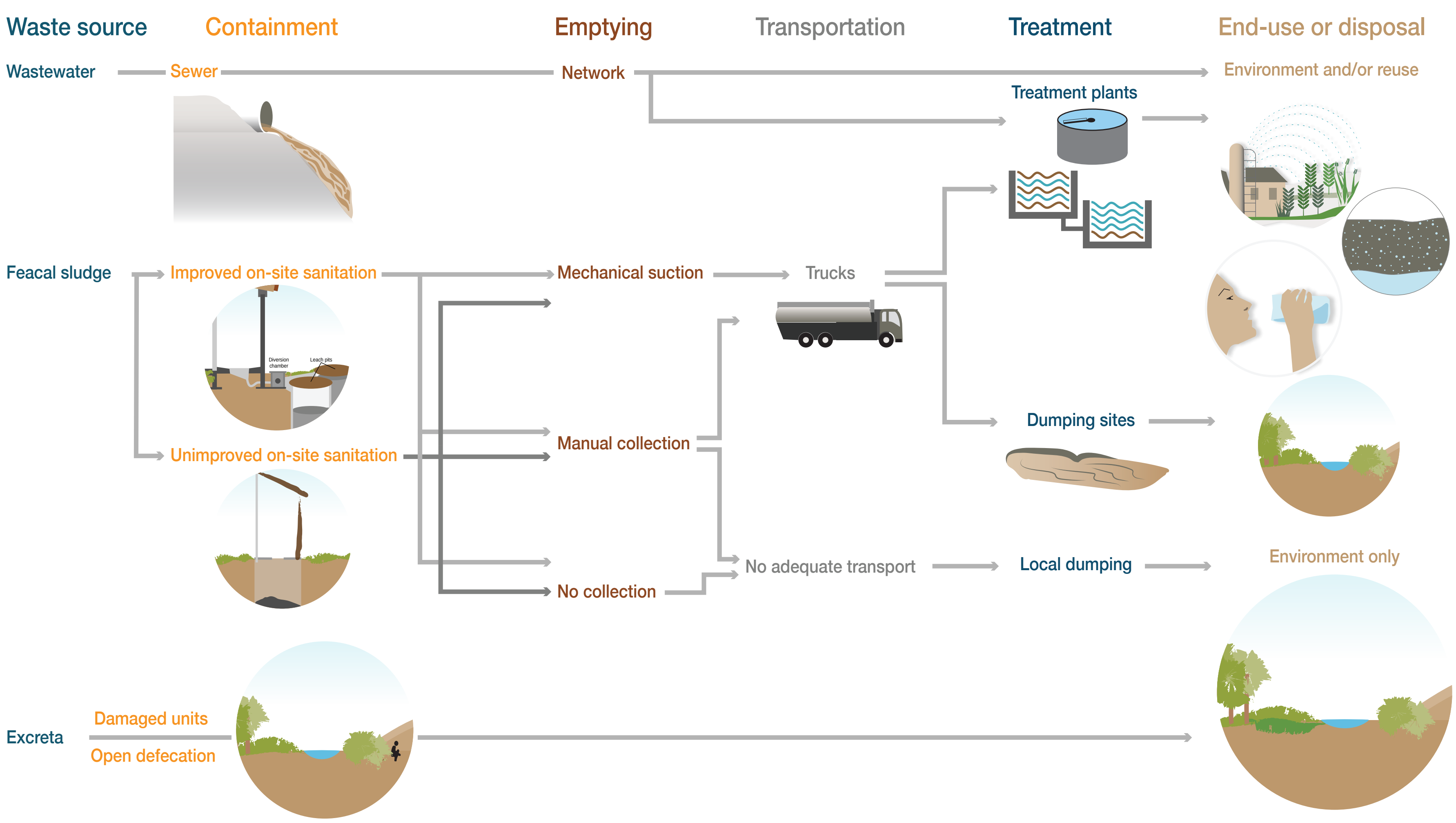


Figure 6.2. Outline of a circular economy

6.2 Driving Factors for the Application of the Circular Economy Approach in Wastewater Management

The circular economy approach in wastewater management is applied through the diverse wastewater reuse or recycling options that are being practised all over the continent. Some of the factors that drive this practice are outlined in Figure 6.3.

6.2.1 Competition for resources

6.2.1.1 Water scarcity

Water scarcity is defined by water availability below 1,000 cubic metres per capita per year which may result from the physical absence of water or from economic factors which constrain access to available water. Physical water scarcity is common in the arid countries of northern and southern Africa (such as Egypt, Morocco and Namibia), while several other sub-Saharan African countries face economic scarcity (see Figure 6.4). Moreover, local scarcity may be due to locally specific factors. This is the case in and around many large towns where the huge population densities lead to increasing water demand for drinking and for agricultural and industrial use, putting undue pressure on available water resources and thereby generating temporal scarcity. For rapidly expanding cities in Africa, supply of safe drinking water will be a major challenge in the future. In such cases, reclamation of wastewater could contribute to increasing water availability.

6.2.1.2 Resource diversification

Compost or biogas from wastewater treatment plants are by-products with possible market value. The biogas is a source of energy which could be used on-site to reduce electricity demand for treatment processes. The compost can be used as a soil conditioner or fertilizer (nitrogen content: 1.7–5.6 per cent; 50 per cent of phosphorus in wastewater ends up in the biosolids). Despite policy support, fertilizer application rates across sub-Saharan Africa are still very low (around 8–32 kg/hectare for different sub-Saharan countries). In particular, phosphorus has been seen as a limited resource which may be depleted soon unless, for example, recycling measures are adopted. Nutrient reuse via wastewater could help reduce the leaching of mineral fertilizer (Sustainable Water Integrated Management [SWIM] Programme 2013). Access to energy is also a critical issue in many countries.

6.2.1.3 Climate variability/change

Scientists estimate that climate change will cause several impacts that can exacerbate water scarcity:

- Temperature increase will translate into higher evaporation rates for water
- Change in water availability, especially in countries that are already dry, which will become dryer (particularly in Africa)
- Sea level rise, which will increase the amounts of land lost in coastal areas and cause an increase in intensity of storms, resulting in floods (Loutfy 2011; Jimenez 2008)

As part of the mitigation strategies, adoption of new water infrastructure and water demand management solutions must be implemented. In this regard, reuse of wastewater is a water-saving measure, since it reduces the demand for freshwater sources. Wastewater reuse may also constitute a low-cost measure for mitigating impacts of short-term droughts (Van der Merwe et al. 2008; Drechsel et al 2018b).

6.2.2 Cost savings

6.2.2.1 Low-cost treatment of wastewater

Although the use of untreated wastewater in Africa could be unintentional, for example, when sewers or wastewater treatment plants (WWTPs) become dysfunctional, deliberate use of untreated wastewater for irrigation is increasing in many African cities. Capture and reuse of wastewater can be considered as a simple way of treating wastewater with minimal financial and technical input. It reduces risks of contamination of remaining water sources (Jimenez 2008) as retention of nutrients in treated wastewater results in lower risks of eutrophication of water bodies (Candela et al. 2007) while the nutrients available for agriculture constitute savings for farmers (Thebo et al. 2017; SWIM Programme 2013). Wastewater reuse may generate revenue, which can reduce treatment cost. In particular, soil aquifer treatment processes associated with the reuse of agricultural wastewater could yield similar or improved water quality compared to conventional wastewater treatment plants, such as activated sludge.

6.2.2.2 Sales of products from treatment plants

Water treatment and reuse can help sustain the operations and maintenance of treatment plants through the sale of by-products (such as compost, biogas, briquettes, electricity) from the plants. This depends on the marketability of the products and the local contexts. For example, electricity sales to the public may be constrained by imposed tariffs, while biogas and briquette sales may be

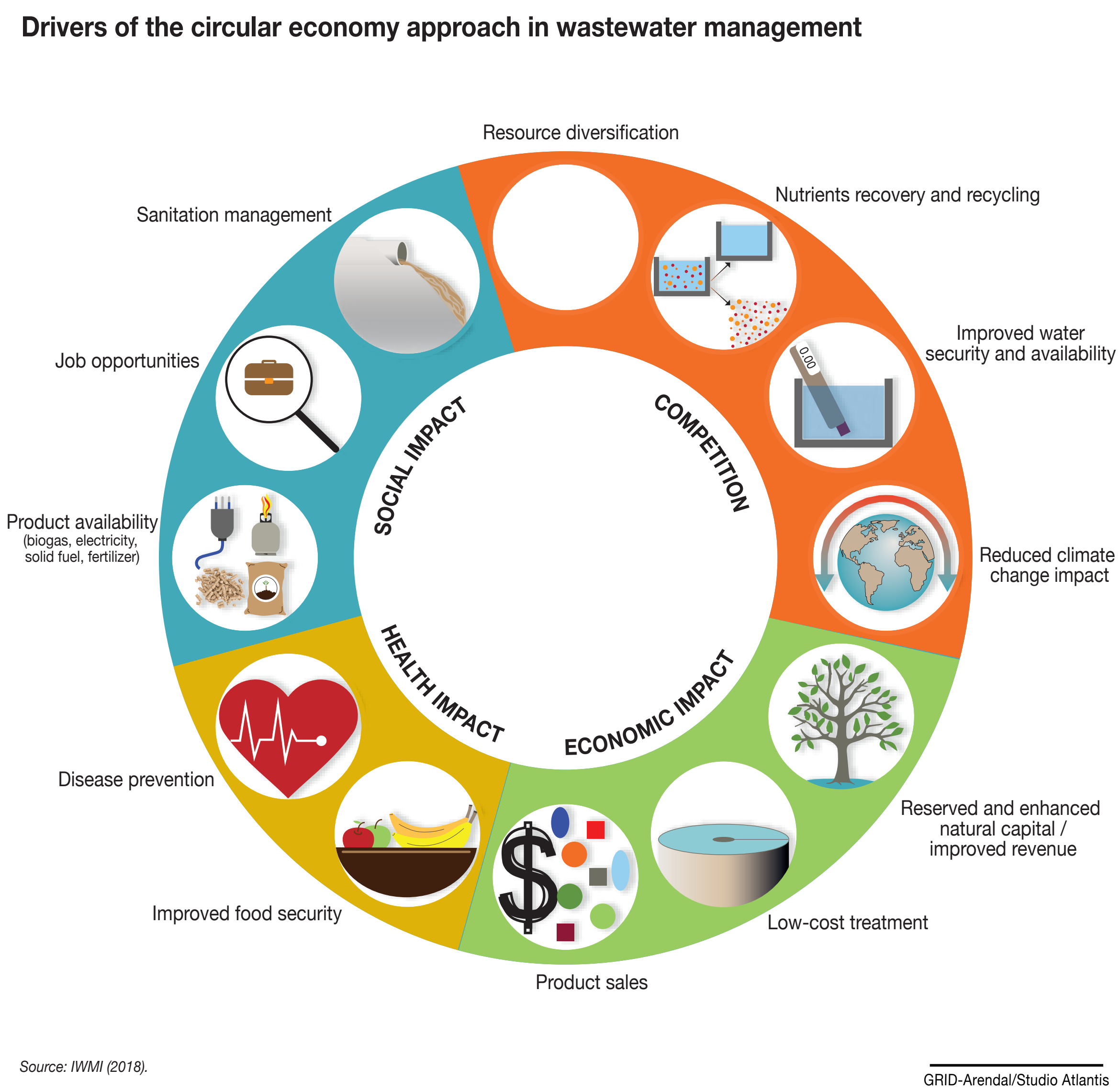


Figure 6.3. Drivers of the circular economy approach in wastewater management

Reuse of wastewster in agriculture

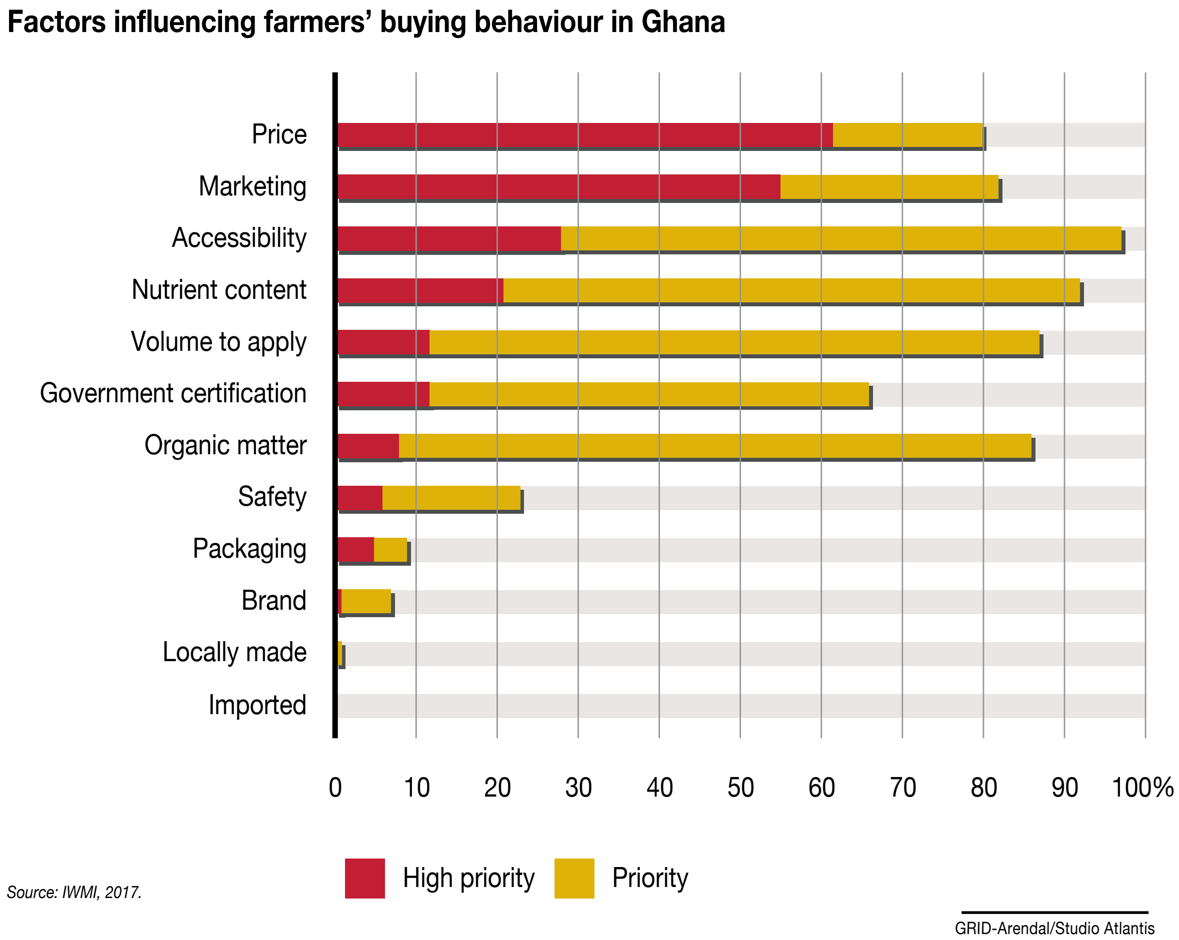


Figure 6.4. Factors influencing farmers' buying behaviour in Ghana (per cent)

constrained by the location of the plant. To benefit from compost sales, suitable credit options must apply, as indicated by buying behaviour reported in Ghana (see Figure 6.4).

6.2.2.3 Job opportunities and improved livelihoods

In the agricultural sector, wastewater is viewed as a reliable source of water and nutrients, especially when it is available near farmlands (Hanjra et al. 2018). Although the nutrients constitute a threat to the environment when wastewater is discharged into water bodies, they represent an opportunity for the agricultural sector through reducing the amount of inorganic fertilizers used (Thebo et al. 2017; SWIM Programme 2013; Jimenez 2008). Not only does this represent important cost savings for farmers, it also closes the loop for nutrients that are essential for sustainability (Hanjra et al. 2018). Treated wastewater can also be used productively in many sectors, for aquaculture production, extended farming, and more. It therefore provides a great opportunity to improve livelihoods in both rural and urban areas.

6.3 Circular Economy Approaches in Wastewater Management

There are six types of applications of the circular economy approach in wastewater management in Africa. A generic schematic of the circular economy approach (CEA) in wastewater management is presented in Figure 6.5.

6.3.1 CEA 1: Treated wastewater reuse for irrigation

This CEA treats sewer wastewater (from domestic and possibly industrial sources) to meet quality standards, allowing the treated wastewater to be safely used for irrigation, taking advantage of the available nutrients. It is the most common CEA in Africa. In some cases, sewage sludge is recycled on-site, for example, for biogas production (which reduces the demand for energy of the wastewater treatment plant processes by 37–68 per cent), composting or incineration (Drechsel and Hanjra 2018-14; Weissenbacher et al. 2013).

The wastewater treatment and reuse components could be managed by the same parties. Alternatively, responsibilities for wastewater transport, treatment and reuse could be shared between different stakeholders, be they public or private.

Main resources:
Treated water for agriculture and sludge

Treatment technology:
Conventional wastewater treatment processes, such as waste stabilization ponds or activated sludge, and advanced technologies such as membranes

Typical geography:
Peri-urban, rural

The business model of CEA 1 is presented in Figure 6.6.

6.3.1.1 Case examples

Egypt has a long tradition of treated wastewater reuse dating as far back as 1911 (Loutfy 2011). Reuse of treated wastewater in irrigation is encouraged to bridge the gap between available water and demand, given the pressing water scarcity in the country, which relies on the transboundary River Nile for 97 per cent of its freshwater supply (Abdel-Shafy and Mohamed-Mansour 2013). In Egypt, as in many other African countries, two main routes for wastewater reuse coexist: direct use of treated wastewater to irrigate and cultivate the desert around urban centres (for example, in border governorates and in Upper Egypt), or indirect use by draining wastewater (treated or not) into agricultural land (for example, in the Delta governorates) (SWIM Programme 2013).

Morocco uses treated wastewater in many ways, ranging from conventional irrigation practices to landscaping, groundwater recharge and industrial use. About 25 per cent of the wastewater generated undergoes treatment in Morocco, and about 45 per cent of the treated wastewater is recycled (SWIM Programme 2013). The country's largest reuse project is in Marrakech, where reclaimed water from the municipal wastewater treatment

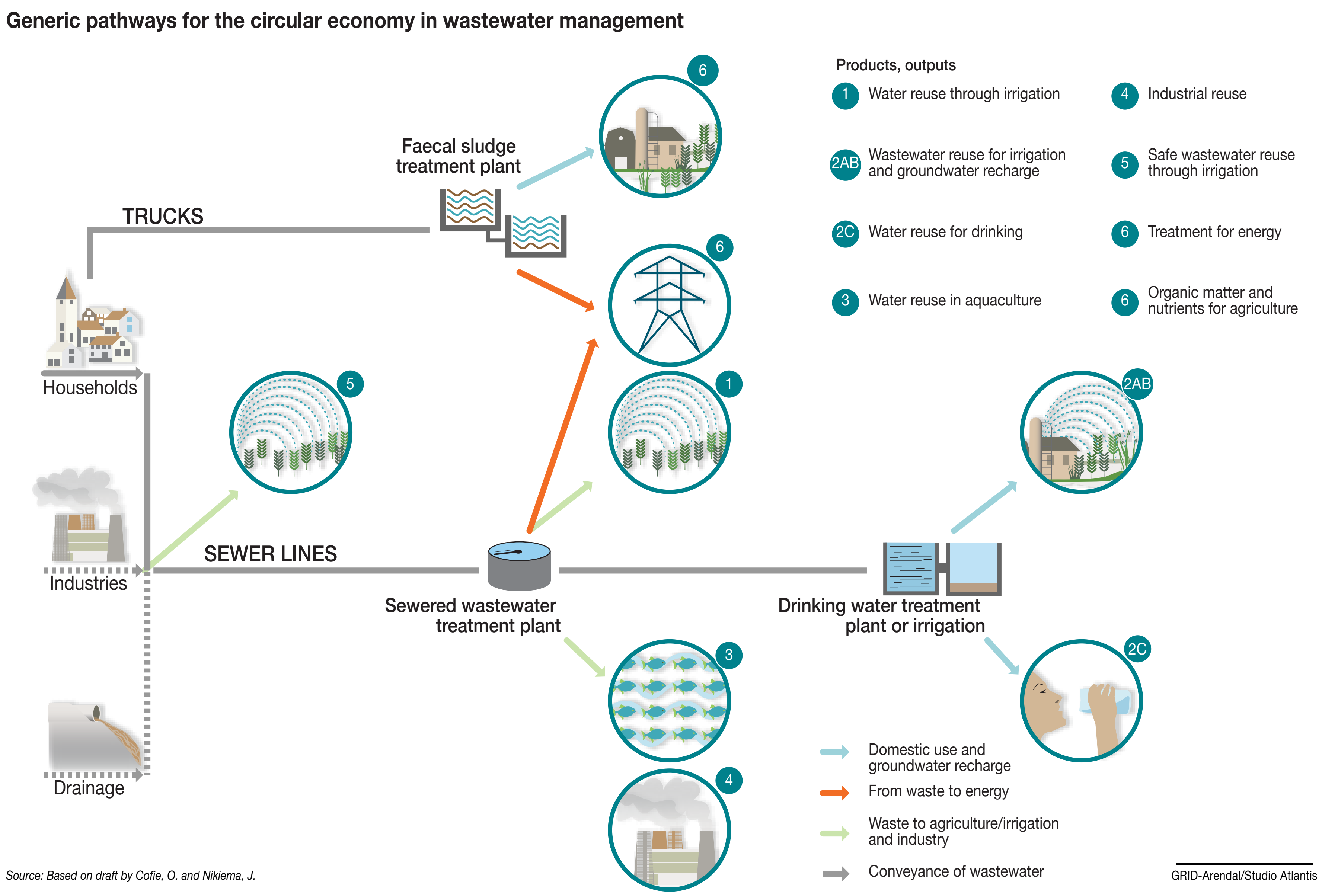


Figure 6.5. Generic pathways for the circular economy in wastewater management

Table 6.1. Wastewater treatment technologies and type of reuse

City	Treatment capacity (Mm3/year)	Treatment process	Treated wastewater reuse
Marrakech	33.1	Activated sludge + sludge digesters + tertiary treatment	Irrigation of 18 golf courses (>1,200 ha) and landscaping
Agadir	18.2	Infiltration + sand filtration	
Ben Slimane	2.0	Aerated waste stabilization ponds + quick sand filtration and ultraviolet disinfection with chlorination	
Biougra	0.5	Waste stabilization ponds + infiltration	Groundwater recharge
Tiznit[a] and Oujda[b]	16.4	Waste stabilization ponds	Agricultural crop production[c]
Khouribga, Ben Guerir and Youssoufia	11.2	Activated sludge	Industrial (phosphate extraction)

Source: Danso et al. 2018-14; Jaouhar, Bourziza and Soudi (2018); SWIM Programme (2013)

a Crops grown in Tiznit include cereals (25 per cent), forage and vegetables (25 per cent) and fruit (olive) trees (50 per cent) (SWIM Programme 2013).
b In Oujda, treated water is used by 245 farmers to grow olive trees and fodder on 1 500 ha of land (Jaouhar, Bourziza and Soudi 2018).
c Treated water is used for unrestricted irrigation.

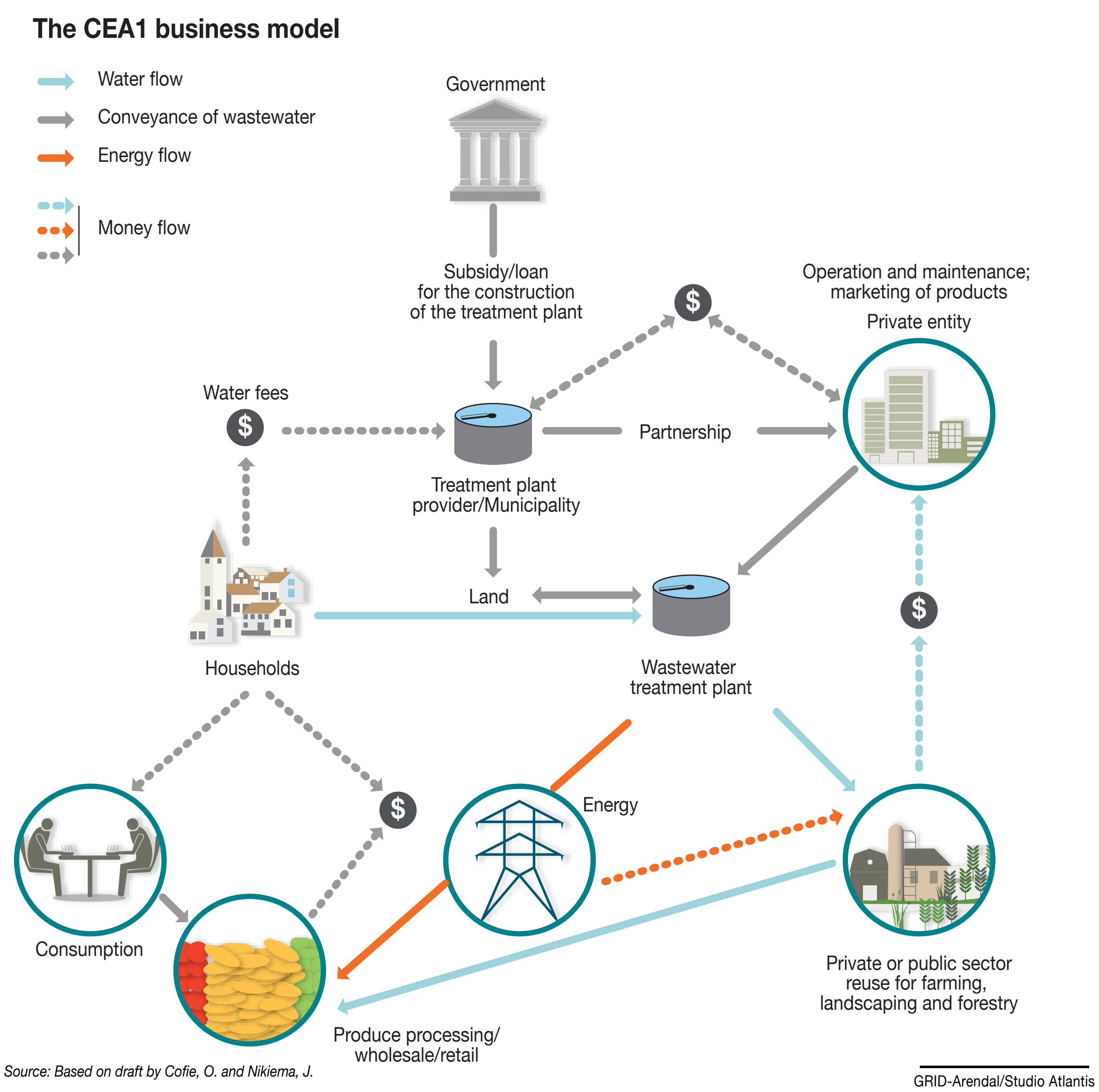


Figure 6.6. The CEA1 business model

plant with a capacity of 33 cubic megametres per year is reused, primarily to irrigate golf courses (see Table 6.1). A partnership between public and private entities has yielded positive outcomes, creating room to source part of the capital cost for wastewater treatment plants from private entities that reuse the wastewater. The same type of co-financing arrangement is replicated in other cities in Morocco. In irrigation models targeting agriculture and involving farmers, challenges such as low cost-recovery due to low willingness to pay for treated wastewater, as well as concerns regarding the quality of treated water (for example, wastewater in Morocco has been reported to have high salinity, with electrolytic conductivity of between 1.8 and 5.5 dS/m) constitute a limitation to large-scale adoption of treated wastewater reuse (SWIM Programme 2013).

Table 6.2 presents the status of treated wastewater use in selected African countries, namely Algeria, Egypt, Morocco and Senegal, as of 2018.

6.3.1.2 Sources of revenue

Treated wastewater is either free or available for a fee. If it is free, cost recovery for the reuse components will largely be impacted by the wastewater treatment plants' operation and maintenance costs, which must be reduced to be kept to a minimum. For example, in Egypt, land is leased to farmers to promote reuse of treated wastewater on allocated land (Drechsel and Hanjra 2018-14). If a large amount of wastewater is treated, sufficient volume of sewage sludge is produced. It can further be treated for biogas generation and compost or dry sludge production, adding to the sources of revenues. Another possible revenue stream could be carbon sequestration in forest plantations or orchards.

Although the reuse of treated water for irrigation does not always provide significant financial returns, it has some environmental benefits and also serves to meet demand under competing needs for freshwater resources, as presented in Appendix 6.1 (Tables 6.12 to 6.16).

Box 6.1. Sources of revenue, conventional and non-conventional

Conventional sources of revenue:
- Household sanitation fees
- Government subsidies
- Treated wastewater use charges

Non-conventional sources of revenue:
- Sales of forest/tree-crop products
- Sludge recycling
- Land charges
- Carbon credits

Sources: Drechsel and Hanjra (2018-14); Danso et al. (2018-14).

Table 6.2. Status of treated wastewater (TW) reuse in selected African countries as of 2018

	Algeria	Morocco	Senegal	Egypt
Number of treatment plants in the country	188 (including 8 with tertiary treatment and 17 applying wastewater reuse [WR])	121 (66 per cent WSP, 14 per cent activated sludge)	14 wastewater treatment plants (WWTPs) and 14 faecal sludge treatment plants	358 (as of 2013) (11 per cent WSP, 75 per cent activated sludge)
Volumes treated	123 Mm3/year	314 Mm3/year	7 Mm3/year (in 2012)	3,000–3,650 Mm3/year
Per cent reused directly	7 per cent	15 per cent of wastewater generation or 45 per cent of treated fractions	0.50 Mm3/year in Thiès; 0.46 Mm3/year in Dakar	19–23
Irrigated surface – Actual (potential)	11,062 ha (target to reach by 2030: 100,000 ha)	2,000 ha for agriculture	60 ha	4,478 ha (public forestry only) (potential is up to 37,000 for public-sector initiatives)
Implementing institution(s)	National Sanitation Utility	National Water and Electricity Utility; Ministry of Energy, Mining, Water and Environment; Municipalities	National Sanitation Utility	Holding Company for Water and Waste Water and its affiliates: Ministry of Water and Wastewater Utilities and Ministry of Agriculture and Land Reclamation
Guiding regulations	• Law 05-12 (2005) permits treated water use in irrigation • Decree 07-149 (20/05/2007) defines conditions for treated water use in irrigation; supported by the Ministerial Decree of 02/01/2012 • Algerian Standard 17683 defines specifications of physical, chemical and microbial quality of treated wastewater (TW)	• Decree 2-97-875 defining conditions of TW use • Ministerial Decree in 2002 on standards on TW quality (physical, chemical and microbial) for irrigation • Restrictions on irrigation systems for different water qualities and crops	• Article R30 sets conditions of reuse of water • Standard inspired by World Health Organization (WHO) guidelines	• Egyptian Code (Ministerial Decree No. 171/2005) defines conditions of TW use in agriculture (for example, it prohibits the use of raw wastewater) • Law 48/1982 defines TW quality for discharge and imposes limits on agricultural uses of TW
Financing of WWTPs (operation and maintenance)	Public sector	Public and private (mostly golf courses) sectors	Public sector	Public sector
Challenges with TW use	• Disconnect between plans of TW producers and users; unclear roles and responsibilities for many actors; non-alignment of treatment standards with reuse standards (i.e. financing of additional resources required for TW safe use) • Limited awareness of safety measures, standards and best use practices; incomplete or constraining regulations on TW use beyond WHO standards • Competition with conventional water; insufficient TW availability during summer due to lack of adequate storage facilities • Cost of O&M of WWTPs and irrigation systems (insufficient cost recovery); management of treatment plant by-products; low willingness to pay for TW (prices must be subsidized) • Poor/inadequate TW quality (for example, odour in the water); limited monitoring of TW quality due to high costs required or lack of capacity • Low willingness to pay for TW versus high O&M costs of networks • Inadequate/insufficient water quality (salinity, pathogens) potentially leading to reduced soil fertility • Poor linkage between treatment and reuse • Land availability for irrigation; inadequate localization of the WWTPs (away from farming areas)			
Use of TW	• Tree irrigation • Agriculture	• Mainly: Irrigation of green parks and golf courses • Agriculture (farmers' fee: 0.056 USD/m^3, half the price for agricultural water) • Industrial use (transport of phosphates) • Groundwater recharge	• Agriculture (water reuse tariffs set at €0.076/m3)	• Tree irrigation • Landscaping • Indirect reuse is very prominent
References	Hartani 2018	Danso et al. 2018-14; Jaouhar, Bourziza and Soudi 2018; SWIM Programme 2013	Niang 2018; Waterbiotech 2012	Moussa 2012; Drechsel and Hanjra 2018-14; SWIM Programme 2013

6.3.2. CEA 2: Reclaimed sewered wastewater for direct and indirect potable use

In this CEA, sewered wastewater is treated to meet quality standards for drinking. There are three possible pathways to convert wastewater into drinking water, as shown in Figure 6.7.

Main resources:
Treated water for drinking or storage

Treatment technology:
- Advanced wastewater treatment processes (for example, membrane filtration) for direct reuse as potable water
- Conventional wastewater treatment processes for indirect reuse through groundwater recharge
- Untreated wastewater use in agriculture with indirect groundwater recharge

Typical geography:
Peri-urban, rural

Rivers flowing through towns are at a great risk of pollution

6.3.2.1 Case examples

Reclaimed sewered wastewater for direct and indirect potable use has not yet been extensively explored in Africa. Examples of groundwater recharge initiatives are reported in Morocco (Jaouhar, Bourziza and Soudi 2018) and are being explored in other parts of Africa such as Egypt (El Arabi 2012), albeit with several challenges in demonstrating positive impacts. Box 6.2 presents a brief overview of the most promising example reported of this case, in Windhoek, a city with about 350,000 inhabitants located in Namibia, which is the most arid country in sub-Saharan Africa. Annual rainfall is 370-450mm and there are no perennial rivers in the country (van der Merwe 2008; Lahnsteiner and Lempert 2007). For many decades before the 1960s, Windhoek relied solely on groundwater for drinking. Later on, dams were constructed but the water supply was insufficient, especially during extended periods of drought (Biggs and Williams 2001). The first plant to process domestic wastewater for drinking purposes was constructed in 1968 and subsequently replaced in 2002 with a new system.

In Windhoek, operational barriers are essential aspects of the treatment processes (van der Merwe 2009). The following non-treatment barriers are also being used for the city water management:
- Strict control of wastewater release into sewers for treatment and drinking, including diversion of all industrial effluents to other treatment plants
- Strict control of raw and treated wastewater, to ensure early detection and correction of any public health issue
- Implementation of good solid waste management practices (van der Merwe 2009)

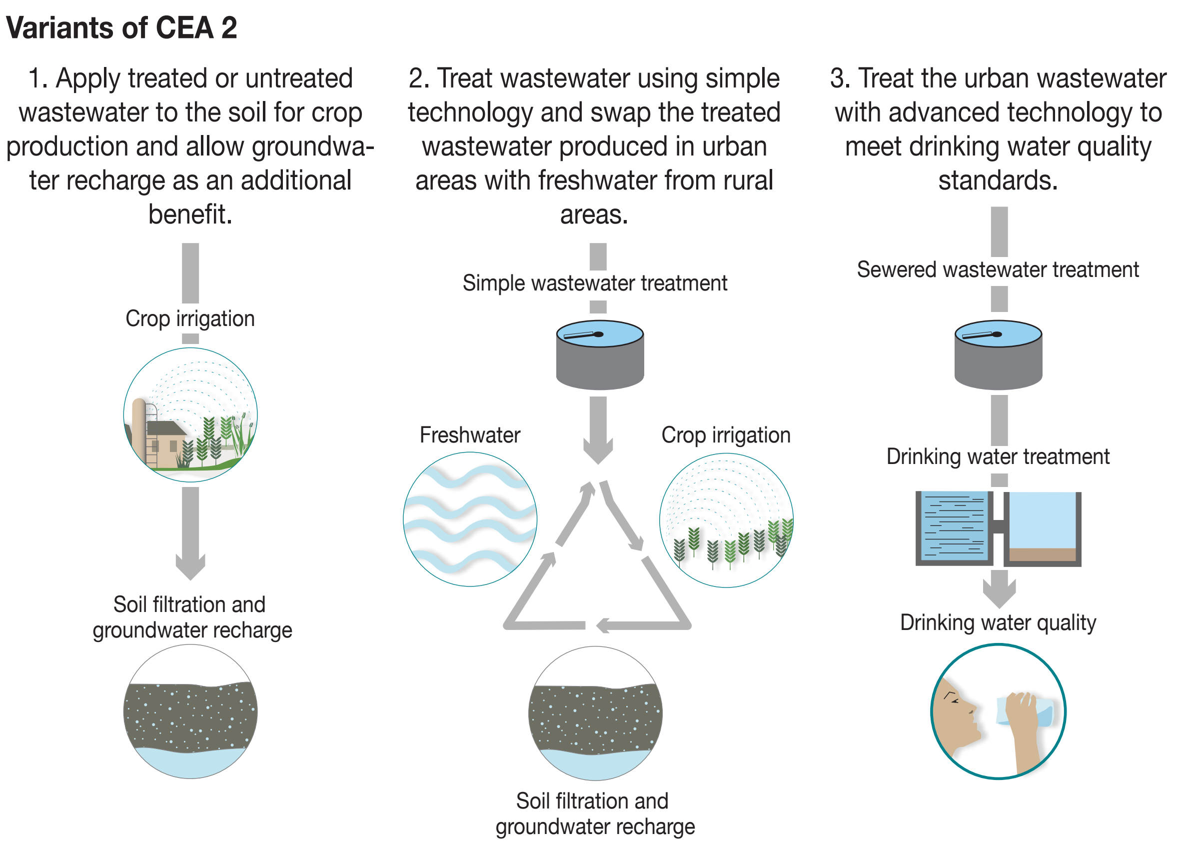


Figure 6.7. Variants of CEA 2

Box 6.2. CEA 2: Existing plant in Namibia

Volumes of wastewater treated:
9.1 Mm^3/year in one plant

Implementing institution(s):
Windhoek Goreangab Operating Company

Guiding regulations:
Quality compliance guidelines are stipulated under the Private Management Agreement

Financing of wastewater treatment plants operations and maintenance:
Public

Use of treated water:
- Only a maximum of 35 per cent of treated wastewater blended with conventional drinking water sources can be supplied to residents;
- Surplus treated wastewater is used for aquifer recharge and irrigation

Since these (treatment and non-treatment) risk-mitigation measures have been put in place, no health problems have been encountered in the city (Onyango, Leslie and Wood 2014; Lahnsteiner and Lempert 2007). To improve acceptance of wastewater reclamation, several awareness campaigns are organized with the media and in schools (Onyango, Leslie and Wood 2014). There are also policy measures for water conservation such as water-efficient equipment and strict rules for gardens and swimming pool water management (Lahnsteiner and Lempert 2007).

The business model of this CEA is presented in Figure 6.8.

6.3.2.2 Sources of revenue

Sources of revenue include household sanitation fees for wastewater discharged into sewers and government subsidies (van der Merwe 2009), as well as drinking water charges and groundwater abstraction fees (Drechsel and Hanjra 2018c; Van der Merwe 2009; Jimenez 2008; Danso et al. 2018-17). In Windhoek, financial savings from wastewater reclamation are between US$2.16/m^3 (if a nearby groundwater supply has been adopted) and US$25.81/m^3 (if the drinking water was sourced from the closest surface-water source) (Van der Merwe et al. 2008). However, to obtain drinking-quality water, the operation and maintenance costs per cubic metre are double those of treating wastewater for irrigation (i.e. US$1.05 against US$ 0.52).

The main advantages of reclaimed sewered wastewater for direct and indirect potable use are the high social impacts. For farmers, increased water availability and nutrients means higher yields and better livelihoods, while for citizens, sufficiently available drinking water is essential for a good quality of life.

Reuse of wastewater to water lawns

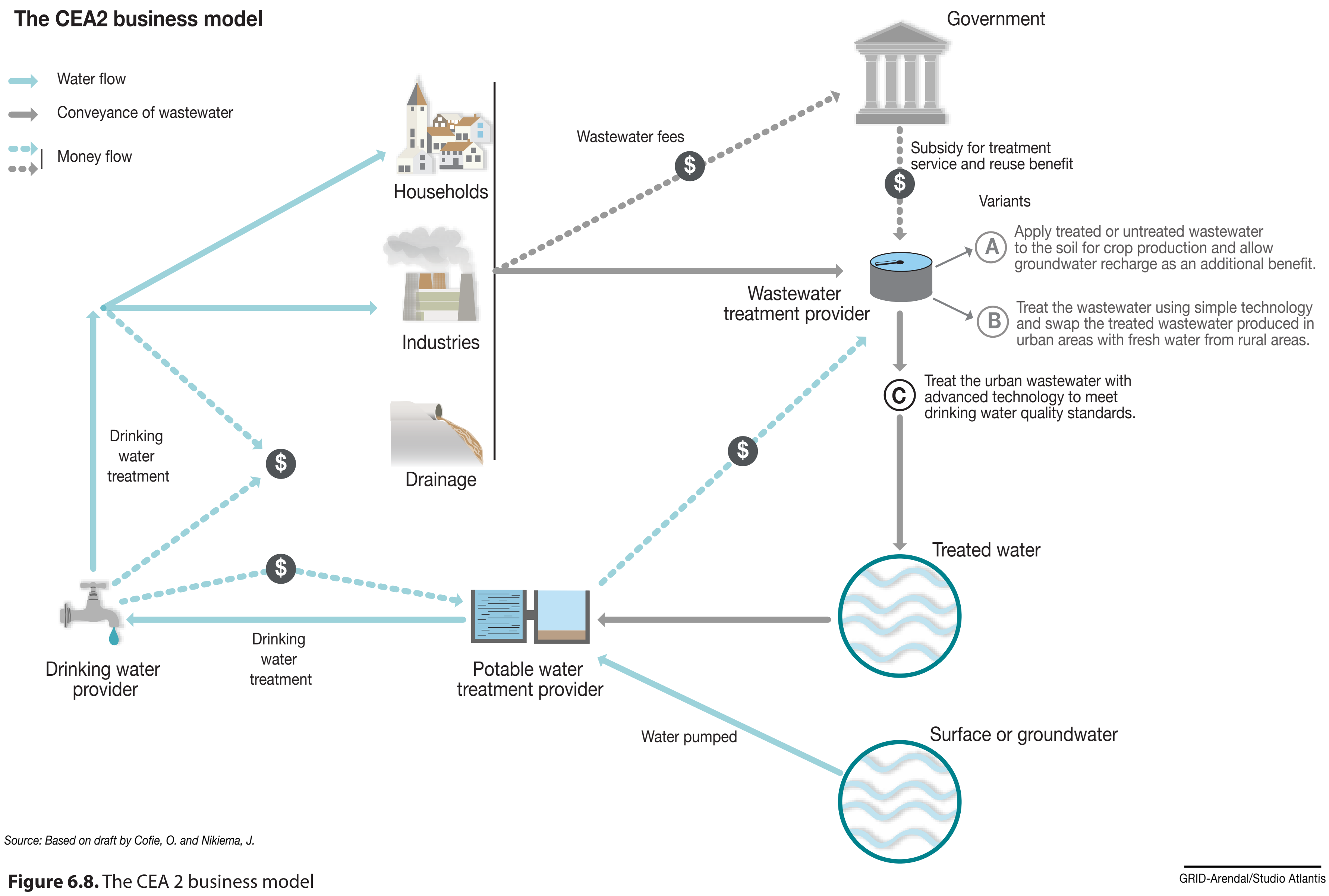


Figure 6.8. The CEA 2 business model

6.3.3. CEA 3: Treated wastewater for aquaculture

In this CEA, sewered wastewater is treated to quality standards suitable for fish, fingerling and livestock feed production.

6.3.3.1. Case examples

Table 6.3 presents the status of treated wastewater reuse for aquaculture in selected countries. Waste stabilization ponds are transformed into fish ponds for fish species that can survive under such conditions (Drechsel and Hanjra 2018a; Drechsel and Hanjra 2018b). Studies (IWMI 2018) show that pathogens may accumulate on the skin and in the gut of the fish, so it is important that fish ready for harvesting spend the days prior to the harvest in clean water. Post-harvest processing techniques such as smoking should be carried out on the fish harvested from wastewater ponds. The preferred fish-processing method depends on the local context and market demand. Rearing of broodstock for fingerling production helps to minimize the negative perception of using wastewater for aquaculture. Since the use of treated wastewater for aquaculture is not consumptive, it can still be used for other activities, such as irrigation of crops or fruit trees (Drechsel and Hanjra 2018d).

6.3.3.2. Sources of revenue

Conventional revenue sources (Box 6.3) include household sanitation fees for wastewater discharged into sewers, either collected as part of the water bill or separately, and government subsidies reflecting the treatment service benefits for society and nature. Another key revenue source comes from fish and fish feed sales. In some cases, fingerlings are also produced and sold.

Main resources:
Treated water for aquaculture

Treatment technology:
Pond stabilization systems or any process involving the use of ponds or enabling the construction of fish ponds

Typical geography:
Urban, peri-urban

Table 6.3. Status of wastewater treatment and reuse for aquaculture in Ghana and Bangladesh

Country and wastewater treated	Main wastewater treatment pond processes in the country	Products
Ghana 225 m³/d	Waste stabilization ponds (1 ha)	• 40 tons of African catfish • Fingerlings • Broodstock
Bangladesh 300 m³/d	Waste stabilization ponds (1ha) + duckweed canals (0.6 ha)	• 6.5–15 tonnes carp • Fish feed • Fruit

Source: Amoah et al. (2018); Drechsel et al. (2018)

Box 6.3. Sources of revenue, conventional and non-conventional

Conventional sources of revenue:
- Household sanitation fees
- Government subsidies
- Fish sales
- Fish feed and fingerling sales

Non-conventional sources of revenue:
- Sludge recycling
- Reuse of treated wastewater for irrigation
- Carbon credits

Figure 6.9 presents the typical financial flow from a recently implemented model in Kumasi, Ghana. The main sources of revenue are from sales of African catfish, which exceed the operation and maintenance costs of the wastewater treatment plant.

Treated wastewater can also be reused on-site to irrigate crops and fruit trees or for several other purposes. The volumes of sludge in small plants may not be attractive enough to engage in sludge recycling and commercialization. Also, carbon credits may be considered if the scale of implementation of this CEA and related savings are sufficient.

The main benefit of using treated wastewater for aquaculture is the high profitability potential of fish farming and the low operation and maintenance costs of the treatment plant. The environmental impact of treated wastewater for aquaculture is moderate compared with other CEAs, as the addition of fish feed to treating ponds may increase the nutrient content of the treated wastewater.

6.3.4. CEA 4: Recycling of wastewater for industrial use

Recycling wastewater for industrial use is critical in regions affected by high water stress. In Durban, South Africa, a private company treats the city's wastewater for local industries to reuse.

Main resources:
Wastewater

Treatment technology:
Multiprocess treatment of municipal waste-water with activated sludge and ozonation

Typical geography:
Urban, peri-urban

6.3.4.1. Case example

Durban is the third biggest city in South Africa, a water-scarce country. During the 1990s, Durban faced constraints in its sewage capacity and management. The existing infrastructure could not cope with the city's growing population and economic development. The municipality therefore had to invest in new infrastructure to increase wastewater collection in order to avoid negative impacts on its citizens and the environment. Durban's first option was to invest in a new marine outfall pipeline to discharge the treated wastewater

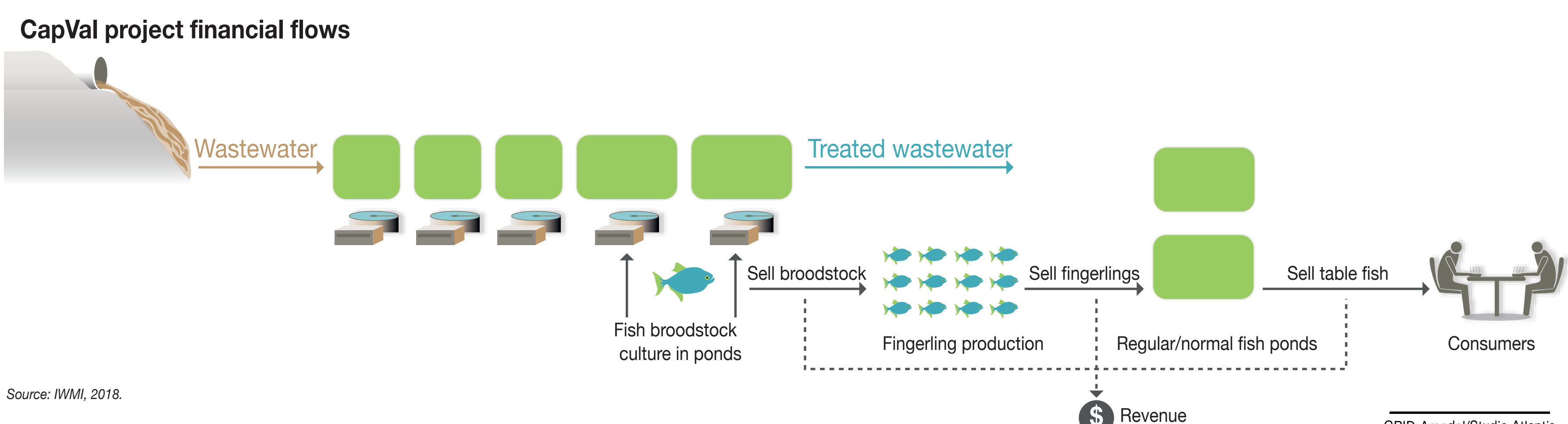


Figure 6.9. CapVal project financial flows

into the Indian Ocean. The costs of this infrastructure were very high, leading the city to consider alternative solutions to prevent large increases in the costs of wastewater disposal in the area. Through a public-private partnership, the municipality successfully implemented a wastewater recycling project for industrial purposes. This project is an example of sustainable wastewater management that also has multiple environmental, economic and social benefits for the region. In addition, the project is the first of its type in South Africa and is an example of a solution that does not dispose of wastewater, but considers it an asset.

Instead of increasing the capacity of the existing marine outfall pipeline in the city's Southern Wastewater Treatment Works to discharge primary treated wastewater into the ocean, Durban explored the possibility to further treat it for industrial reuse. A paper company and an oil refinery expressed interest in receiving the treated wastewater. The aim of the project was to treat around 48,000 m^3 per day (approximately 10 per cent of the city's municipal wastewater) and achieve an acceptable quality for industrial reuse, with 85 per cent of the treated wastewater going to the paper company and 15 per cent to the oil refinery. In order to be able to supply recycled water to these two industrial users, the municipal water utility (eThekwini Water Services) needed to upgrade the existing activated sludge process, build a new tertiary wastewater treatment plant, refurbish the high-level storage tank and install a reclaimed water reticulation system. One of the project's complexities was that the paper company required high-quality water, given that it is used to produce fine paper (World Bank Group 2018).

6.3.4.2. Sources of revenue

The revenue from the sale of the treated wastewater for industrial use covers almost all operation and maintenance costs of the treatment plant as shown in Figure 6.10. After an international biding phase, Durban Water Recycling, a consortium of private companies led by Veolia (formerly Vivendi Water) was chosen to finance, design, construct and operate the tertiary wastewater treatment plant at Southern Wastewater Treatment Works under a 20-year concession contract. Durban Water Recycling funded the entire project and also undertook the risk of meeting the two industrial users' water quality needs, meaning the municipal utility did not incur any extra costs for taxpayers.

Figure 6.11 presents a stakeholder diagram for the Durban wastewater recycling project. The total investment in the project was R72 million (US$4.858 million). Equity from Durban Water Recycling company was 19 per cent of the investment cost. After signing a 20-year concession contract with the eThekwini Water Services (municipal utility), the Durban Water Recycling consortium approached the Development Bank of Southern Africa and the Rand Merchant Bank for loans of R34 million ($2.295 million) and R24 million ($1.62 million).

The guaranteed demand for treated wastewater from the two industrial users made the project economically attractive. The Durban Water

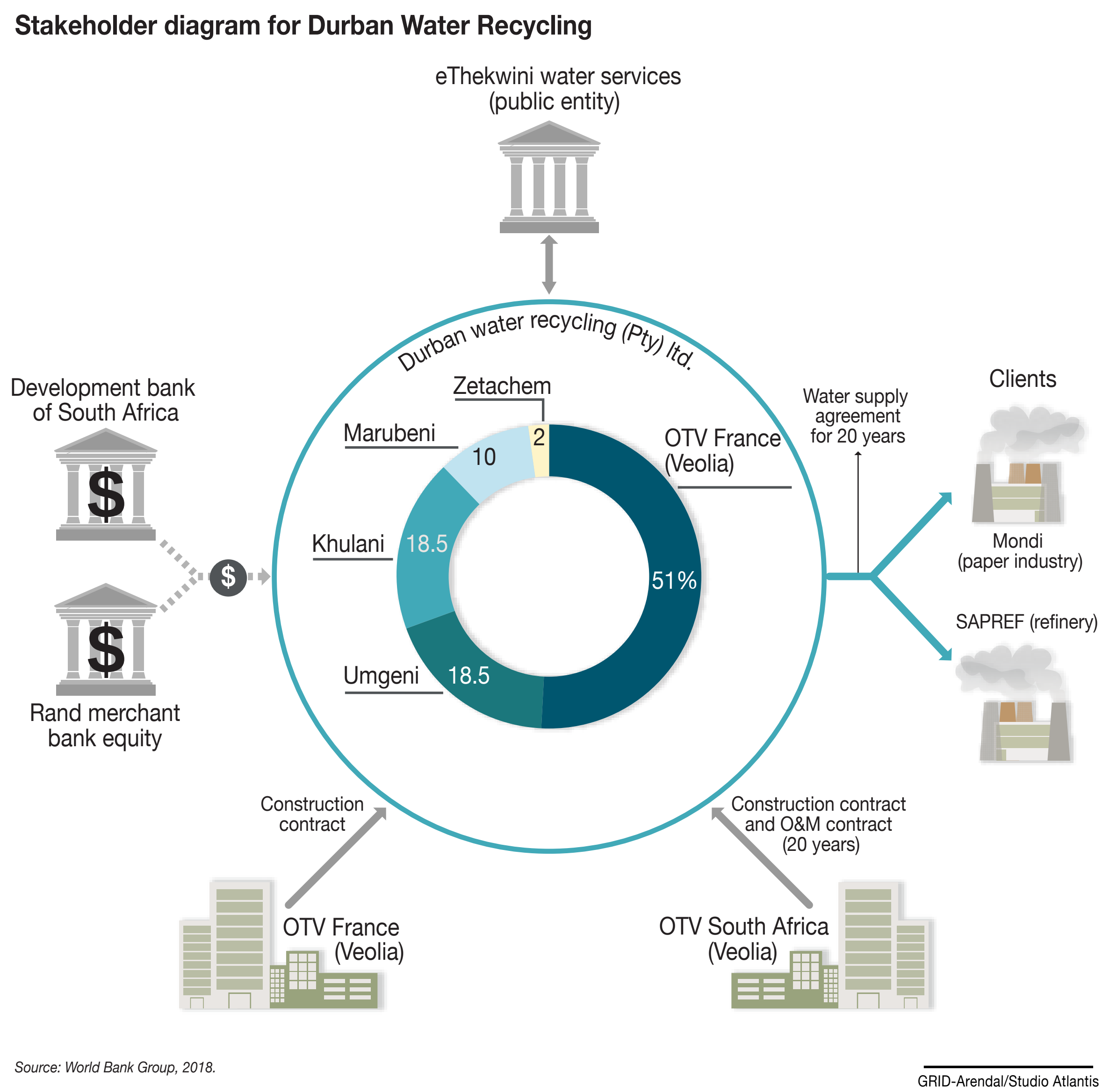


Figure 6.11. Stakeholder diagram for Durban Water Recycling

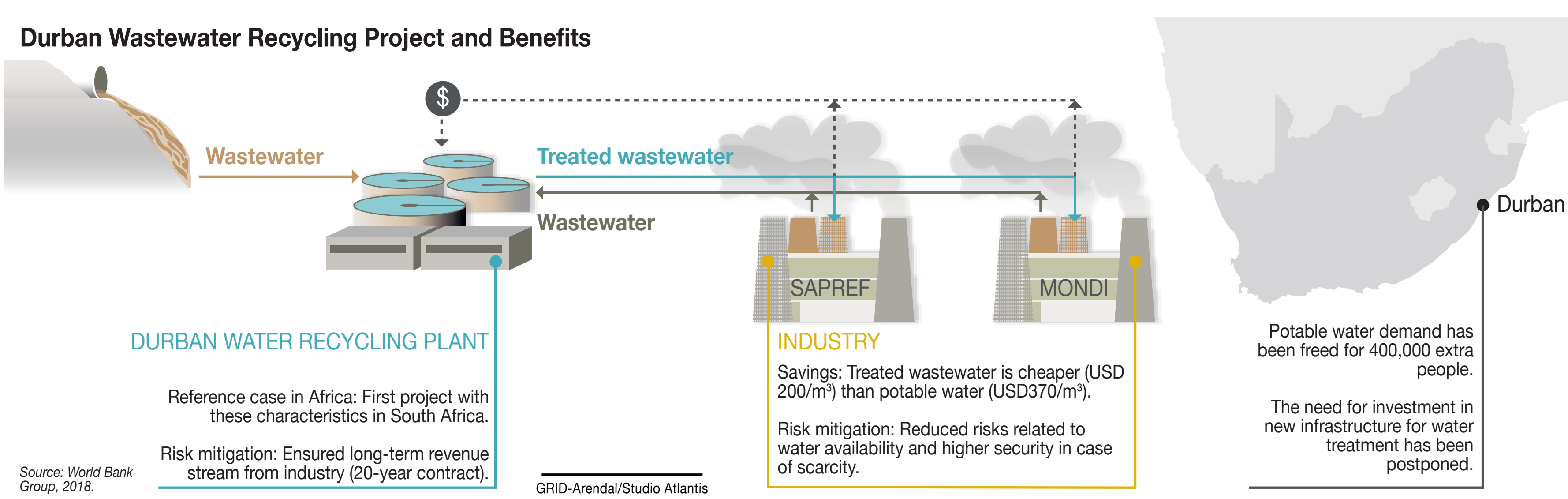


Figure 6.10. Durban wastewater recycling project and benefits

Recycling consortium pays fees to the municipal utility, including an annual management fee, a land-leasing fee and a levy per cubic metre to reflect the cross-subsidization income from the industrial users. The sales price of treated wastewater is now cheaper than potable water, at R28/m³ ($1.89/m³) compared with R54/m³ ($3.65/m³).

The model of recycling wastewater for industrial use is an example of a successful and innovative public-private partnership agreement that improves the sustainability of wastewater management, minimizes environmental impacts and generates multiple benefits for the community. The city of Durban was able to convert a challenging situation into an opportunity, leveraging local conditions and innovative thinking into a win-win solution for all stakeholders. Though the wastewater treatment technologies implemented for the project are quite standard, the innovative combination of the different steps makes the project unique, as the treatment technology has been customized to ensure that the recycled water meets the quality standard of the industrial clients.

Untreated wastewater for irrigation

6.3.5. CEA 5: Safe use of untreated wastewater for irrigation

Untreated wastewater is used for crop irrigation, usually in an uncontrolled and unregulated manner. This practice can be made safe by setting up risk barriers at different critical points, including appropriate strategies to enhance public risk awareness and improve safety (Drechsel 2018). Countries such as Mauritius or Tunisia have shifted away from reusing wastewater in an informal or indirect manner towards more formal and safer practices.

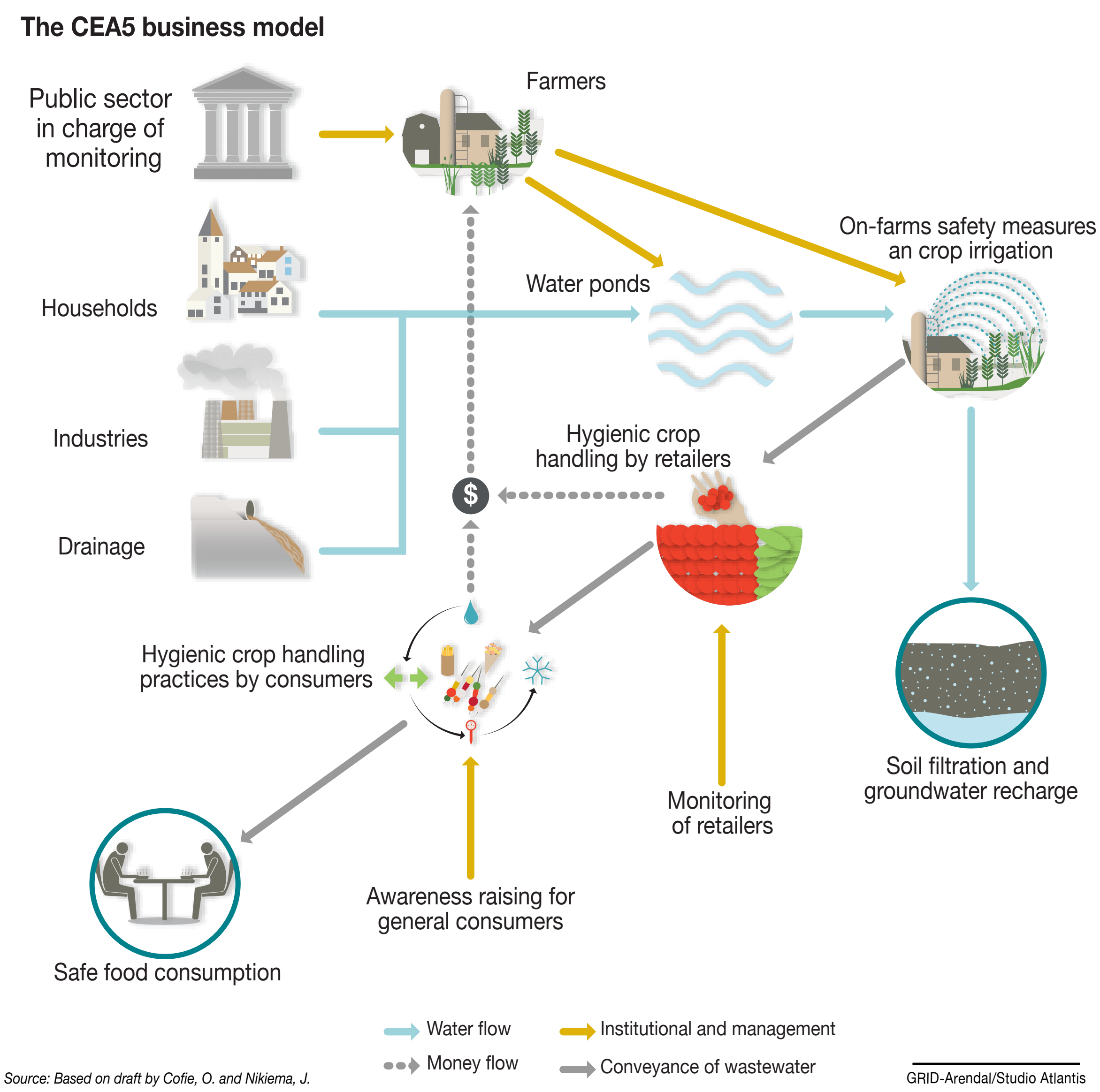


Figure 6.12. CEA 5 business model

Main resources:
Untreated wastewater for irrigation

Treatment technology:
On-farm safe irrigation practices combined with hygienic handling practices and safety awareness

Typical geography:
Urban, peri-urban

The business model of CEA 5 is presented in Figure 6.12.

6.3.5.1. Case examples

In general, only 10 per cent of the wastewater generated in the world receives some form of treatment (Thebo et al. 2017). Africa has particularly low coverage of wastewater treatment. The use of untreated, partially treated or diluted wastewater occurs downstream of urban areas in four out of five cities in the developing world and is usually driven by farmers' lack of alternative water sources and/or search for nutrients (Thebo et al. 2017). This often informal reuse of wastewater benefits farmers and the local economies and contributes to increasing the food supply. To mitigate associated risks and protect public health, it is important to apply the multiple-barrier approach as recommended by the World Health Organization (WHO) in 2006 (see Figure 6.13).

Many low-cost technologies and practices can significantly reduce health risks on- and off-farm. As part of on-farm measures, use of ponds (Figure

Washing vegetables with clean water can help reduce the germs and contaminants on food

Table 6.4. Examples of incentives to encourage farmers and consumers to adopt safety measures in the use of untreated wastewater for irrigation

Incentive	Description
Tenure security	Many farmers who use wastewater in peri-urban areas are challenged with land tenure security. This could therefore be used as an incentive for adopting good on-farm practices.
Credit on condition	Low-interest credit could be provided to farmers applying safe irrigation methods. In this case, there is need for monitoring farmers' compliance with their contractual obligations.
Fear of exposure	Media exposure (e.g. naming and shaming) can be a powerful alternative to steer compliance. Urban farmers and food restaurants often fear media exposure which could trigger eviction from the land or business closure.
Social values	Social marketing can encourage households to adopt safety measures. Possible triggers and drivers for change need to be identified for key target groups.

Source: Drechsel (2018)

6.14), weirs and reservoirs (Figure 6.15), changes in irrigation methods, timing, and adequate selection of crops grown are commonly suggested risk-mitigation measures. Figure 6.16 shows the pathogen concentration as a function of the water retention time in a pond, though these solutions may not always be financially attractive for farmers (Drechsel 2018). Table 6.4 shows the benefits of adopting safety measures when using untreated wastewater.

Implementing good post-harvest handling practices, such as washing by traders and processors (restaurants or households), can further improve the quality of farm produce. Experiences in Ghana showed that the cumulative effect of the multiple-barrier approach can completely address the health risks associated with using poor quality water for irrigation (Figure 6.17).

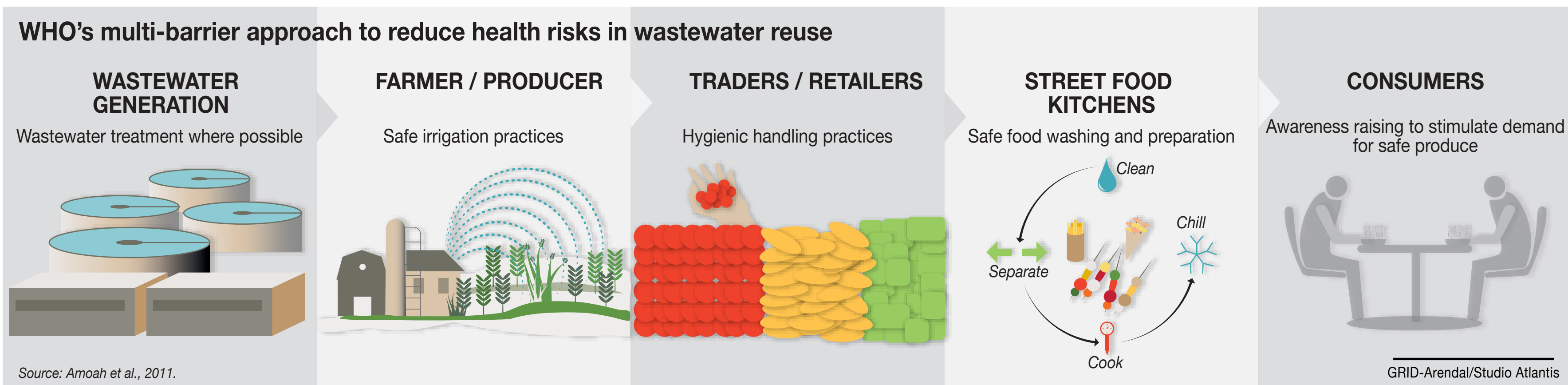


Figure 6.13. WHO's multi-barrier approach to reduce health risks in wastewater reuse

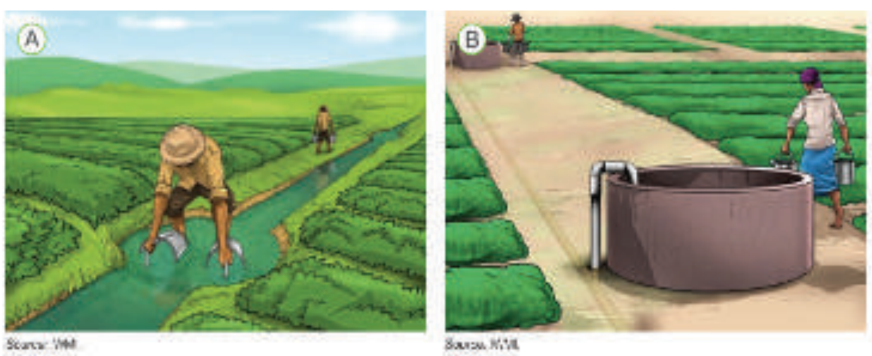


Figure 6.14. Common on-farm ponds use in West Africa

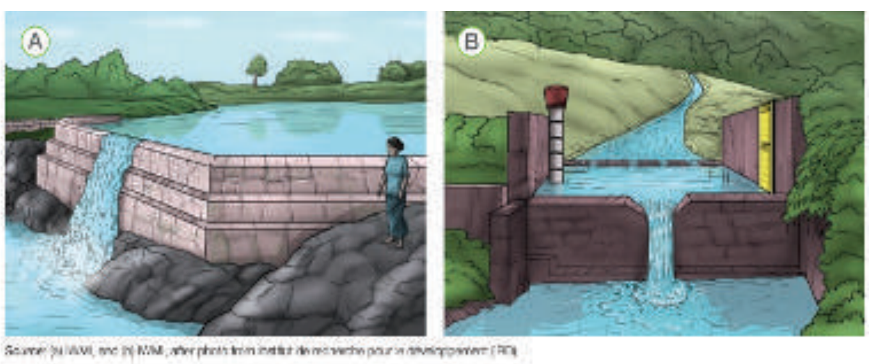


Figure 6.15. Use of weirs and reservoirs

Safe use of wastewater is a challenge for poor farmers

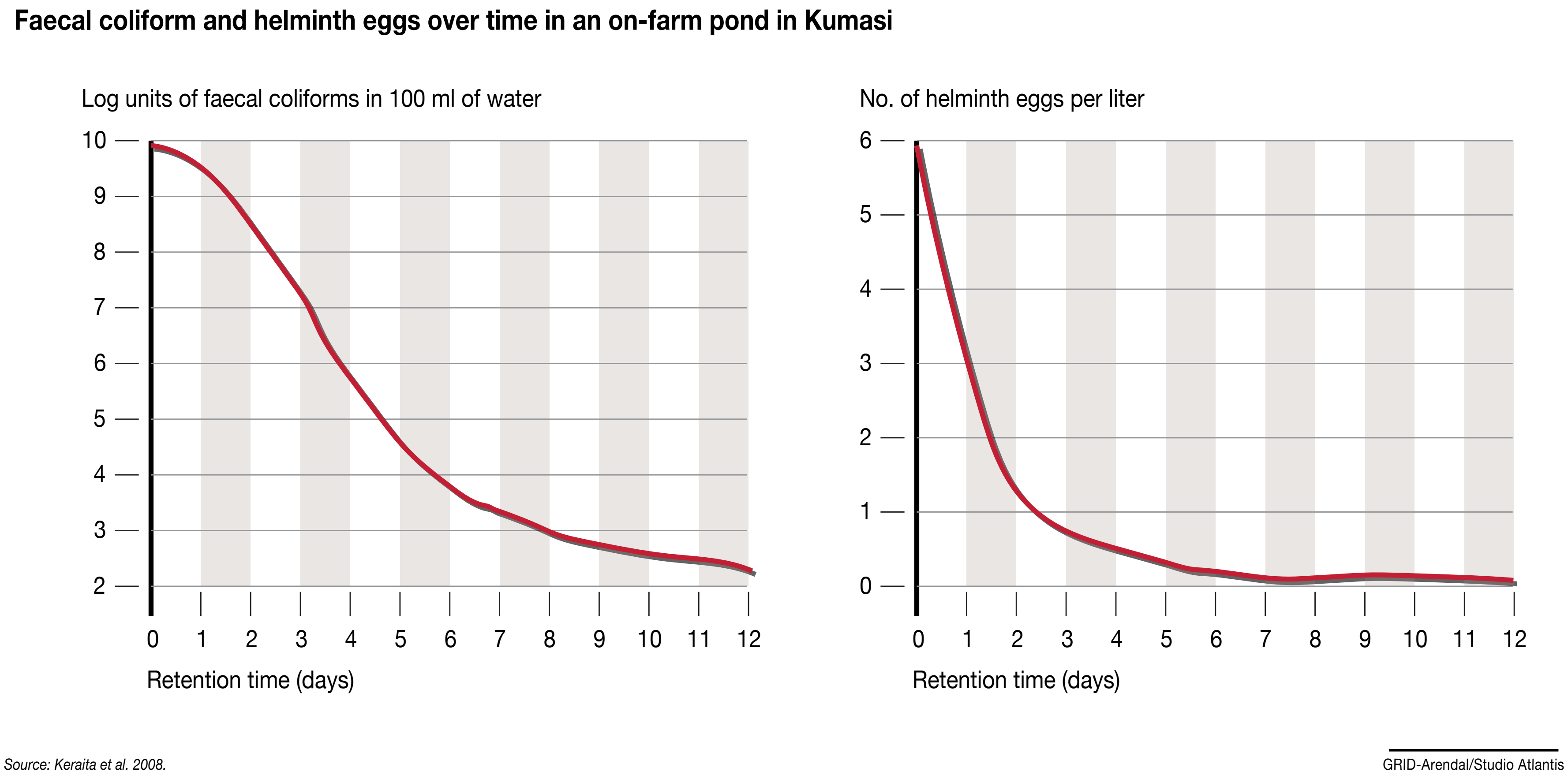


Figure 6.16. Faecal coliform and helminth eggs over time in an on-farm pond in Kumasi

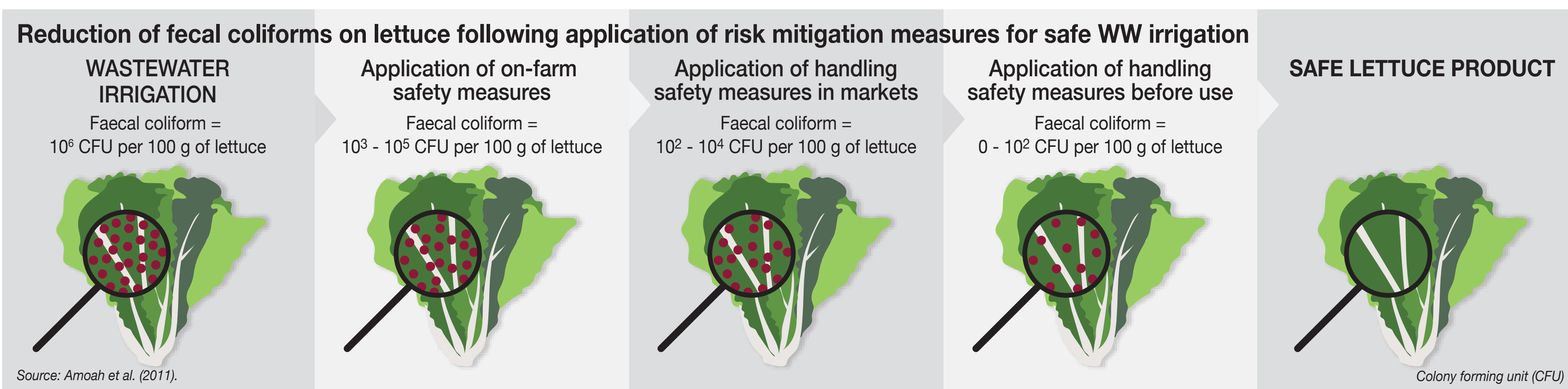


Figure 6.17. Reduction of faecal coliforms on lettuce following application of risk-mitigation measures for safe wastewater irrigation

Small-scale irrigation

6.3.5.2. Sources of revenue

The main advantage of using untreated water for irrigation is increased food production. Studies confirm that for every dollar spent on risk reduction from 'farm to fork' will return US$5 in consumer health care savings (Drechsel 2018). The social nature of these costs justifies the relevance of public investments in incentives to promote safe reuse of wastewater and minimize risks along the entire crop value chain. However, risk awareness and the incidence of costs and benefits do not fall evenly across stakeholders along the value chain, which creates difficulties in terms of financing the implementation of this approach.

Overall environmental impacts are minimal due to the use of untreated wastewater for irrigation. It also reduces expenditure on public health while supporting the informal irrigation sector (often dominated by rural migrants or minority groups).

Table 6.5. Mechanisms for financing the needed changes

Driver of change	Means of achievement	Measures adopted for improved safety	Examples
Corporate social responsibility	Support of wastewater treatment	Conventional wastewater treatment plant	Industrial companies such as Nestlé invest in wastewater treatment plants to treat their wastewater in areas where there are no such facilities. Wastewater therefore becomes available for irrigation.
	Support of farm-based interventions	Drip irrigation used on-farm	In Botswana or South Africa, some supermarkets or wholesale companies opt for compliance with a 'responsible sourcing policy' to meet international quality and sustainability standards. These companies source their crops from farmers applying safe on-farm irrigation practices.
	Support of post-harvest interventions	Awareness-raising campaigns	As part of its consumer service programme, Nestlé initiated the establishment of trader associations, such as the Maggi™ Fast Food (Seller) Association (MAFFAG), in Ghana, which is now the strongest association in the country's street food sector. MAFFAG regularly provides training in food preparation, cooking, environmental hygiene and food safety across the country. Their training programmes are able to address food safety issues throughout the sector.
Quality assurance	Branding certificate	Branding	A recognized certification body could help in attesting compliance with food safety standards. This could increase customers' willingness to pay a premium for better quality products.
Farmer innovations		Investments to secure water	The Water Resources Users Association is a commercial farmers group in Ghana that produces crops for the local market. With a private-sector non-governmental organization (NGO), the group co-invested in a pond and canal system, which supports natural water remediation and can easily be combined with further safety enhancing features.

Source: Drechsel (2018)

6.3.6. CEA 6: Non-sewered sanitation recycling for agriculture or energy

In many African urban and rural areas, people rely on on-site sanitation installations, such as pit latrines and septic tanks, to capture human excreta either at the household level or through shared facilities. Occasionally, these on-site sanitation installations must be emptied with the collected waste (faecal sludge) sent for treatment. Unfortunately, a high proportion of the faecal sludge is released into the environment untreated or only partially treated, which contaminates coastal areas, waterways and land. Faecal-borne pathogens are also released, which can affect food supplies. However faecal sludge has some benefits, such as, for example, its nutrient content, which can be used in agriculture, as well as its carbon, which can be used for soil remediation or converted into energy. The use of non-sewered wastewater recycling for agriculture or energy generation allows compost or energy to be produced from faecal sludge.

6.3.6.1. Case examples

The Fortifer production plant in Tema and the Safi Sana production plant in Ashiaman, Ghana, are examples of non-sewered wastewater that is recycled for agriculture or energy. Both examples involve a public-private partnership arrangement. Jekora Ventures converts faecal sludge into compost fertilizer called Fortifer. The production process (Figure 6.18), which was developed by IWMI, does not demand sophisticated technology. Rather, sufficient space is needed for faecal sludge drying beds and heap composting. Electricity supply is only needed for the post-processing of the compost, if desired. The compost obtained at this plant contains both nutrients and organic matter, which are essential for plant growth and soil health. The compost can be processed further through pelletization and/or enrichment, which increases its quality and market value.

Bulk water delivery

Under the public-private partnership arrangement, Jekora Ventures agreed the following implementation conditions with the Tema Metropolitan assembly:

- the private entity bears the operation and maintenance costs
- the public sector and other donors are to finance the capital cost
- profits from the plant operation are to be shared as follows:
  - municipality/private entity: 20 per cent/80 per cent after breakeven and until the private entity recovers the working capital investment
  - municipality/private entity: 50 per cent/50 per cent thereafter
- profits generated by the municipality will finance community sanitation projects (see Figure 6.19 for the business financial flows).

As regards the second company, Safi Sana, faecal and organic waste are collected from urban slums and treated in a biodigester to create compost fertilizer called Asase Gyefo, irrigation water and biogas, which is generated into electricity that feeds into the national electricity grid. The sale of these products can cover operational costs, thus making the company independent of government subsidies support. Irrigation water and a percentage of the compost fertilizer are used in a greenhouse for seedling and herb production (where compost is used as a substrate). Safi Sana provides employment for the local community, improves quality of life through better hygiene at central toilets and better waste management and improves local food security through high-yielding compost. Fortifer and Asase Gyefo have been tested for other contaminants, in particular heavy metals.

Sanivation, a social enterprise, is another case example. The enterprise operates container-based sanitation services in the Kenyan town of Naivasha since 2012. Naivasha has a population of almost 200,000 people and is located about 90 km north-west of Nairobi, the capital city of Kenya. The container-based toilets provided by Sanivation are urine diversion dry toilets (UDDTs) in which the urine and faeces are collected in separate containers at the site where the toilets are located. As of late 2018, around 130 container toilets had been installed in the areas served by Sanivation. Twice a week, the excreta is collected by Sanivation from all their clients and transported to a factory where the faeces are sterilized through thermal treatment, mixed with other local biomass materials and then compressed into briquettes while the urine is drained into a soak pit. As of April 2019, Sanivation had sold over 1,000 tonnes of briquettes to a variety of clients including households, restaurants, supermarkets and poultry farms, all of whom use the briquettes as solid fuel for cooking and heating.

In late 2018, Sanivation in partnership with the Naivasha Water and Sanitation Company, a local utility, established another factory that produces solid fuel from faecal sludge in the form of super logs. The super logs are made from a mixture of faecal sludge and other biomass types like saw dust, with the faecal sludge acting as a binder. Just like briquettes, the super logs will also be used for energy although they are suited for industrial and commercial applications due to their bigger size in comparison with briquettes.

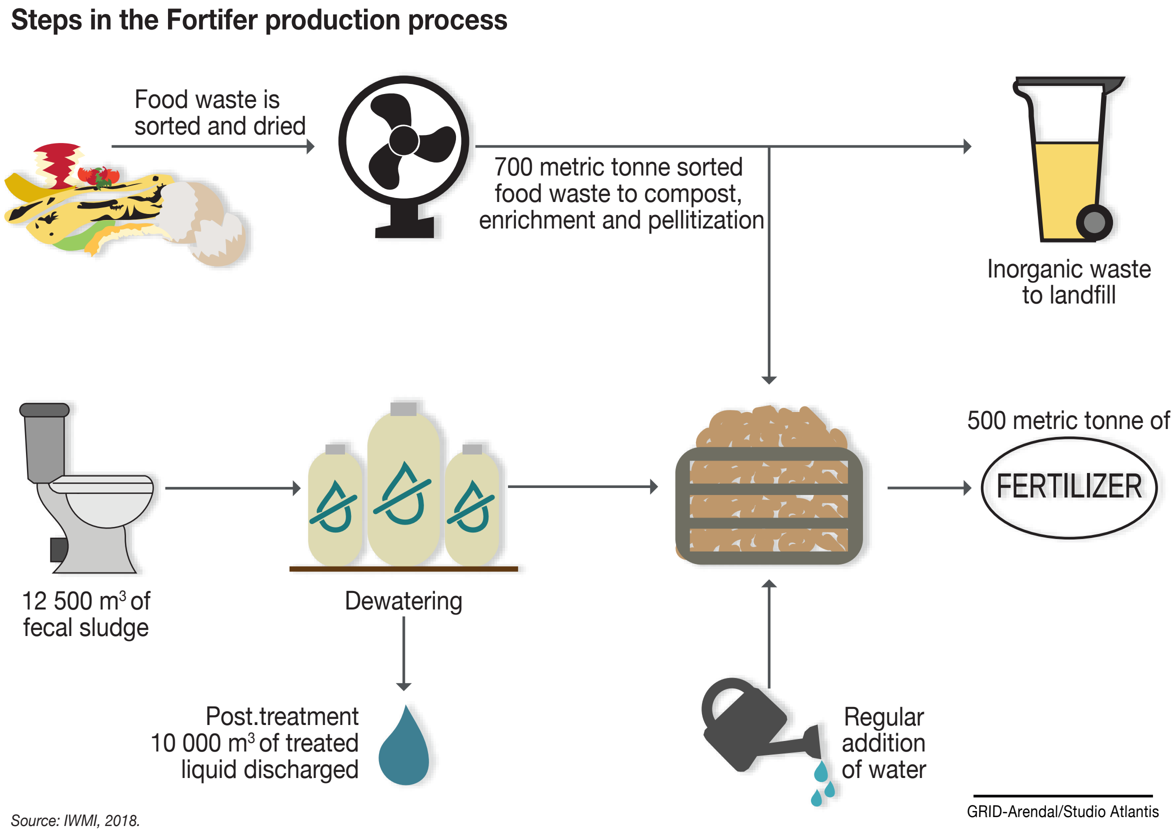


Figure 6.18. Steps in the Fortifer production process

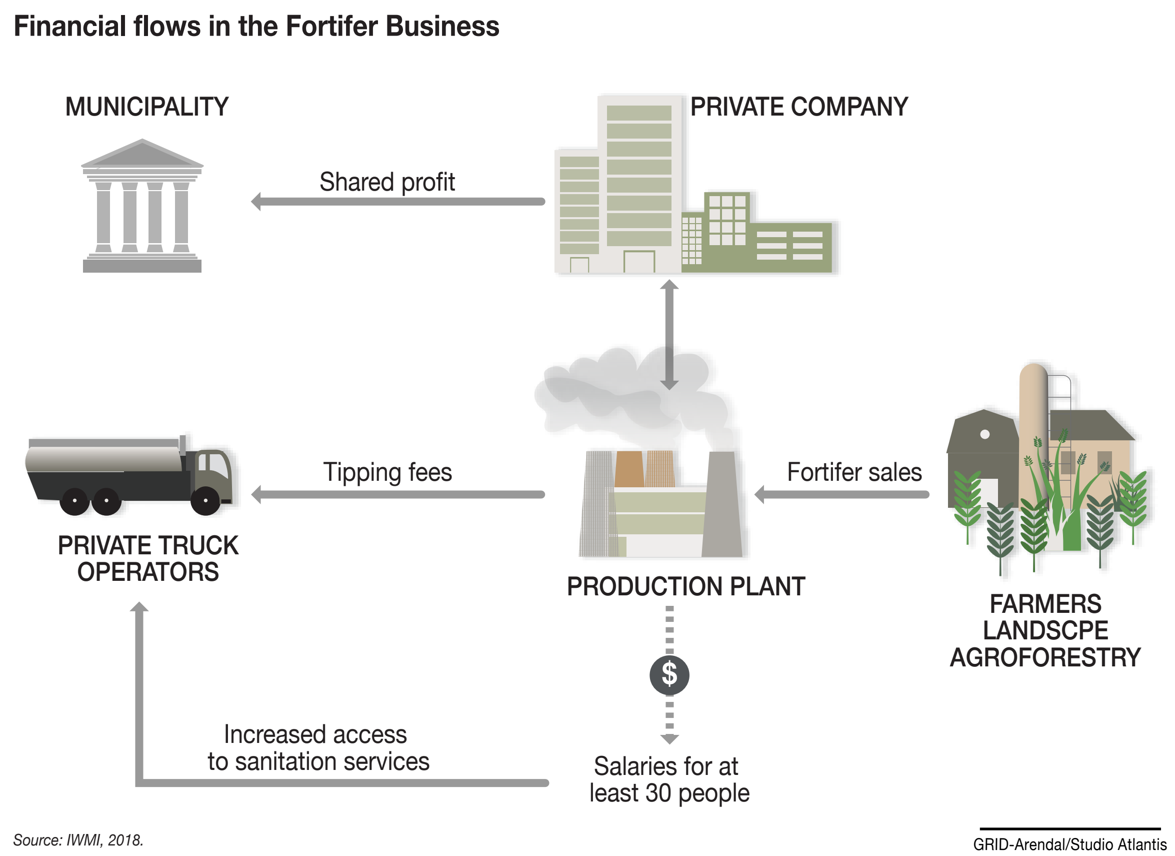


Figure 6.19. Financial flows in the Fortifer business

6.3.6.2. Sources of revenue

The key sources of revenue for non-sewered wastewater recycled for agriculture or energy as presented in Box 6.4 and include conventional sources such as tipping fees, which are paid by the sludge collecting/desludging body at the treatment plant gate and taken from charges paid by households that demand emptying of their on-site sanitation systems. The CEA also depends on the sale of its key recycling products, i.e. compost, electricity or biogas. When compost is produced, it may be sold to farmers or used in-house to produce seedlings or enhance agricultural productivity of company farms. In the latter case, the compost becomes an indirect source of revenue to the CEAs.

Other revenue sources may include governmental subsidies reflecting the treatment service benefits for society and nature, paid as part of an off-take agreement for the compost (applied on municipal parks and landscapes) and energy (based on tariffs for feeding the national electricity grid) or as a subsidy for the treatment process.

Box 6.4. Sources of revenue, conventional and non-conventional

Conventional sources of revenue:
- Tipping fees
- Sales of compost/electricity/biogas/dry fuel
- Savings from solid waste management
- Sales of seedlings or crops

Non-conventional sources of revenue:
- Governmental subsidies
- Carbon credits

6.4 Constraints to the application of a circular economy approach in wastewater management in Africa

Although the aforementioned circular economy concepts sound attractive and promising in many ways, there are important challenges that have, through the years, negatively affected the successful adoption of these solutions. Table 6.6 presents key essential elements required for sustainable CEAs in terms of financial, institutional, environmental, technical, and social and health aspects. One of the key factors it highlights is to set adequate financing and cost recovery mechanisms to sustain the CEA. Although the environment often benefits from the implementation of circular economy concepts, it is important to manage public health risks in a rigorous way, which demands three sets of interventions:

- policy, regulation and institutional initiatives, such as defining guidelines for practices (e.g. water quality standards, crop restrictions, if any, and immunization requirements for farm workers);
- engineering solutions (for treatment of water, irrigation and more);
- suitable end-user practices (crop selection, product use and application rates, harvesting measures, etc.) (Lazarova et al. 2013).

Use of wastewater on root crops is often discouraged

All CEAs must build on stakeholders' needs and preferences to promote acceptance and buy-in in the long term. When necessary, the public sector needs to create a conducive policy environment, which will help attract and retain the private sector. This is especially critical given that uncertainties concerning the impacts of treated wastewater or wastewater use may be difficult to evaluate in the shorter term.

Table 6.6. Financial, institutional, environmental, technical, social and health requirements for sustainable CEAs in wastewater

Requirements	Essential factors
Financial	• Existence of financing opportunities for public-private partnership ventures. • Adequate or sufficient market opportunities for public-private partnership products. • Securing of financial viability for reuse, reduce and recovery projects
Institutional	• Existence of mechanisms for monitoring and managing plants. • Setting of procedures for managing conflicts between stakeholders. • Strong and capable players/stakeholders. • Favourable policy environment for products and processes. • Adequate/smart and timely protocols. • Political acceptance of reuse, reduce and recovery products and solutions.
Environmental	• Clear protocols with standards and benchmarks. • Existence of a water law, regulating bodies and guidelines, and/or criteria for treated wastewater use or management of by-products (crop selection, irrigation and soil-based practices). • Proper enforcement of by-laws, etc. • Responsible environmental management
Technical	• Capacity to access the wastewater or faecal sludge through adequate collection infrastructure. • Capacity to operate and maintain treatment and recycling systems. • Technology availability. • Capacity to adapt to environmental and health standards. • Innovative and cost-effective technologies. • Access to land for the construction of treatment plants at a convenient location. • Quality of treated water and by-products guaranteed continuously
Social and health	• Food safety guaranteed. • Proper management of public perception. • Treated water quality guaranteed. • Low/no pathogens in human excreta, i.e. worm eggs, protozoa, bacteria and viruses. • Co-treatment of industrial and domestic wastewater (which leads to changes in pH levels or the inflow of high levels of heavy metals, salts or various other synthetic and recalcitrant compounds) avoided. • Potential impacts from emerging pollutants, such as pharmaceutical and personal care products (e.g. painkillers, antibiotics, contraceptives) or other contaminants, understood and mitigated. • Enhanced public/social awareness of health risks associated with treated wastewater or wastewater use

Sources: Loutfy, 2011; Lazarova, et al., 2013; IWMI, 2017.

6.5 Conclusion

Due to urbanization and population growth, there is growing pressure on freshwater reserves in cities. Available water is used for multiple purposes and substantial wastewater is generated. Many wastewater treatment projects depend on subsidies and barely survive over time. In Africa, viable wastewater-based resource recovery initiatives are emerging. These initiatives are founded on public-private partnerships that leverage private capital to finance large treatment infrastructure or cover the costs of operating and maintaining the plants. In this way, the focus is being shifted from 'treatment for disposal' to 'treatment for safe reuse', which is not only yielding valuable resources such as water, food and energy, but also improving livelihoods and the environment.

Considering that wastewater has been reused in irrigation for over a century, other reuse solutions have great prospects for the continent, including treated wastewater for drinking, aquaculture and energy, as well as sludge recycling for soil management. Reuse of untreated wastewater is still common and mostly uncontrolled. New solutions that are yet to be tested at scale could help Africa mitigate possible health risks that may result from such practices.

An advantage of the circular economy approach is that it helps increase the volumes of wastewater treated. The impacts are then multiplied, since water is central to life and therefore simultaneously impacts several SDGs and their targets. In fact, the SDGs – enshrined in the United Nations 2030 Agenda – are a testament to the key role that sustainable environmental management plays in terms of economic growth and human well-being. Current experiences attest to the fact that the various wastewater-based circular economy approaches could contribute to achieving SDG 2 (Zero hunger) and SDG 6 (Clean water and sanitation) and should constitute a key component of climate change mitigation strategies (SDG 13) in many countries. The circular economy for sanitation can help increase revenue from additional product streams, increase efficiency through the circular provision of equipment and facilities, and build shared best practices to monetize some of the externalities.

Plastic is increasingly becoming a major component of waste

7

COUNTRY PROFILES

7.1 Introduction

The country profiles in this chapter provide information about the water and sanitation sector in the 54 countries of Africa.

Each country profile examines four main areas: water resources, wastewater management, water and sanitation provision, and legal and institutional frameworks. The data are displayed graphically to provide readers with easily understandable snapshots of the water and sanitation situation. Each profile also includes a country map for locational context and a graphic to show water use of the three major consumptive use sectors (agriculture, municipal and industry).

The profiles benchmark the process of tracking country status and progress towards meeting Sustainable Development Goal (SDG) 6: Ensure availability and sustainable management of water and sanitation for all. Such progress is partly informed by the countries' achievements of Millenium Development Goal 7.C on sustainable access to safe drinking water and basic sanitation. Water and sanitation ladders are also provided to help benchmark and monitor progress across the different indicators.

The last section of the profiles highlights the countries' legal, policy and institutional frameworks for water and sanitation. In some countries, significant change is ongoing, meaning that situations may have changed before the publication of this report.

Most countries in Africa failed to meet their target for sanitation under the Millennium Development Goals. There is hope that significant progress will be made under the Sustainable Development Goals

Researching the data in this chapter presented some challenges. In order to allow for consistent and comparable profiles, data were obtained from only a few select sources. The Africa Water Sector and Sanitation Monitoring and Reporting System established by the African Ministers' Council on Water (AMCOW) was a key information source for these profiles. However, while some countries had time-series data for many indicators, others had little or no data. Information on wastewater management was particularly hard to find and points to an information gap that urgently needs to be addressed for the continent. In addition, access to sanitation datasets related to SDGs' definitions is hardly available, and this presents an urgent monitoring and evaluation challenge that needs to be addressed

Africa is the second driest continent in the world after Australia

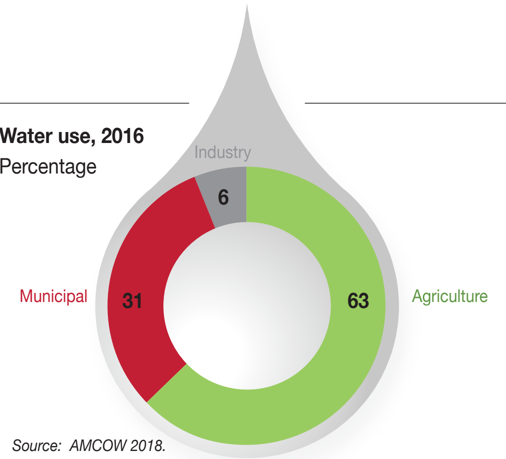
Algeria

Water resources

Algeria covers a total land area of 2,381,740 km^2, of which 87 per cent is desert, 9 per cent is semi-arid and 4 per cent is coastline or mountain ranges (Food and Agriculture Organization of the United Nations [FAO] 2016). Average rainfall is 56 mm/year and droughts are common (African Ministers' Council on Water [AMCOW] 2018). Surface run-off and groundwater recharge rates are low, and even during the rainy season, stream flow is not continuous, with internal rivers only flowing for 10–75 days a year (FAO 2016). Water availability is about 5,410 m^3/year per person and the pressure on groundwater resources is 188 per cent (AMCOW 2018).

Algeria is one of the most water-stressed countries in the world. The aqueduct water stress for all sectors measured in 2010 was 3.04 and is projected to increase to 4.17 by 2040 (Luo et al. 2015). A score of 4.17 indicates that there is extremely high competition among water users relative to available surface-water resources. Water stress comes as a result of water scarcity and may result in crop failure, food insecurity, water usage conflicts and a decline in service levels (AMCOW 2011).

Water use, 2016
Percentage



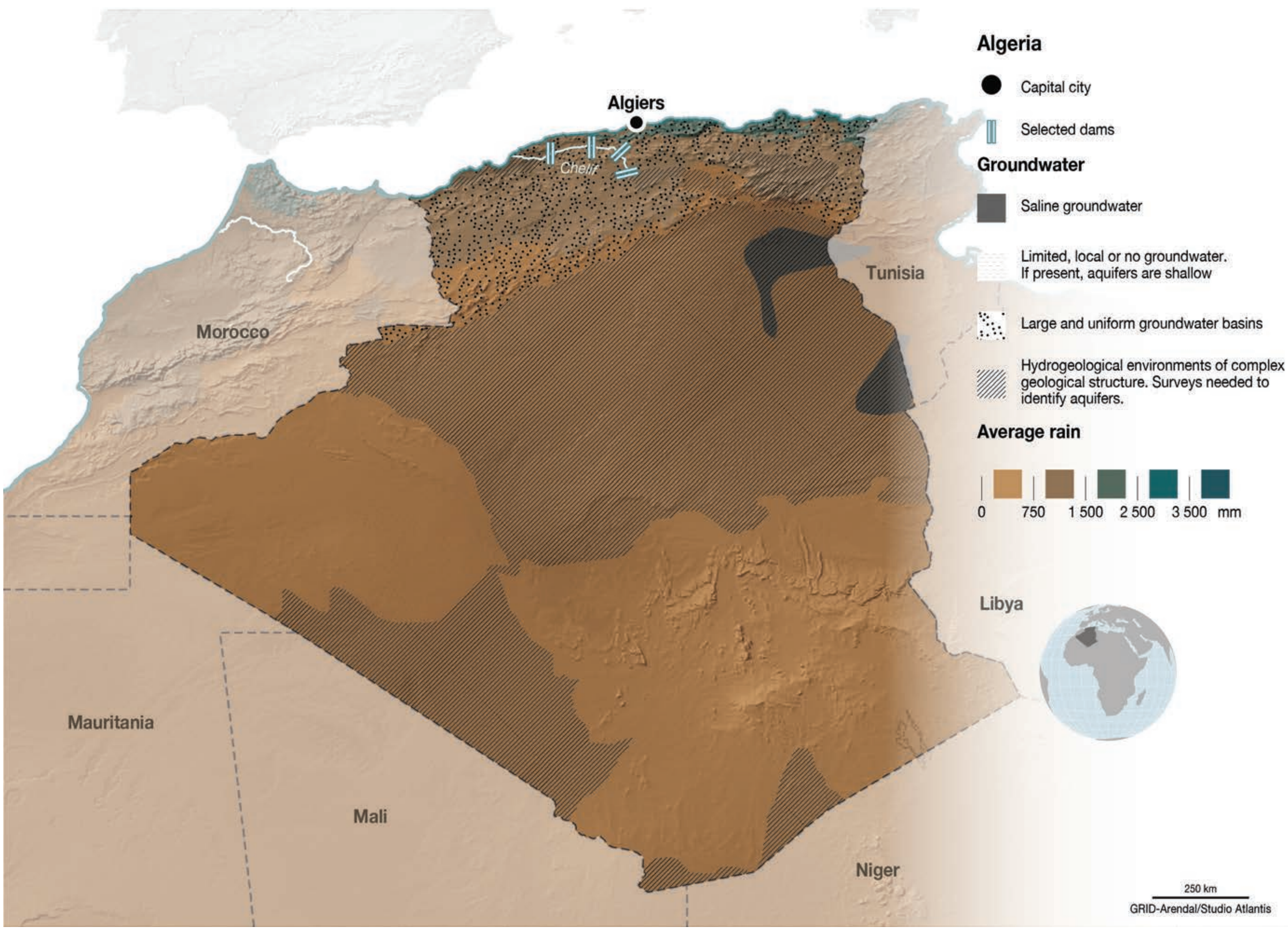
Source: AMCOW 2018.

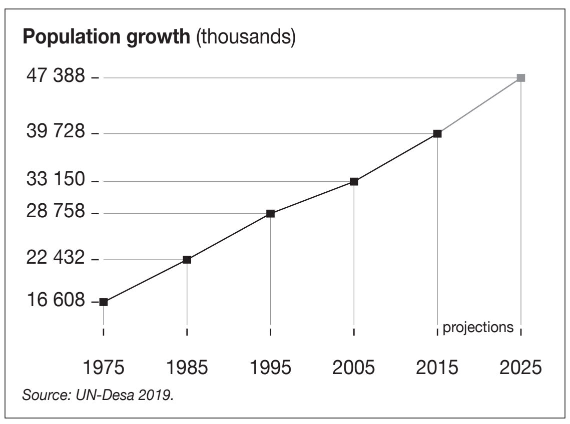
Water availability

	m^3/person and year
Total renewable freshwater	334
Total water withdrawal	322
Internal renewable water sources	329
of which are surface water	267
pressure on surface water	*76.9%*
of which are groundwater	61.9
pressure on groundwater	*188.0%*
Water stress	***96.0%***

Source: AMCOW 2018; FAO 2018.

Algiers

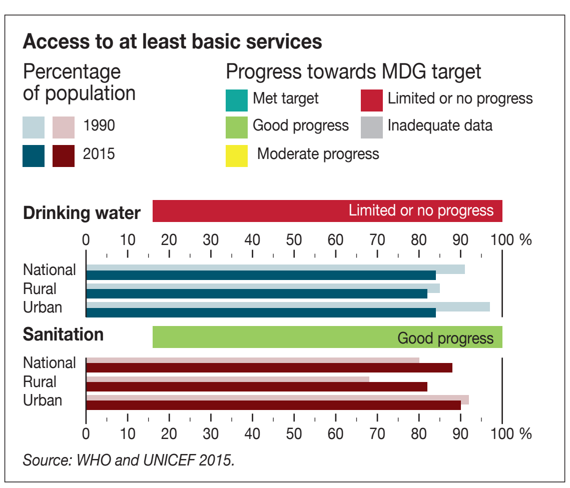




Wastewater management

There is a dearth of recent data regarding wastewater management. Available data show that 820 million m^3/year of municipal wastewater was produced in 2012 and that 324 million m^3/year was treated in the same year (FAO 2018). In 2012, there were 138 treatment plants, a significant increase from 44 in 2001, which operated with a capacity of 270 million m^3/year of treated wastewater (FAO 2018).

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	6.4	4.2	2.3	0.8
	Proportion of population using safely managed sanitation services (%)	21.2	20.5	19.9	19.1
	Proportion of population with basic handwashing facilities on premises (%)			83.1	83.5
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				17.7 (2018)
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/$m^3$)				14.1
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				96
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				48.0 (2017)

Source: United Nations Statistics Division (UNSD), 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water Resources • Hydrographic Basin Agencies (ABH) • National Agency for Water Resources (ANRH) • National Office for Irrigation and Drainage • National Office for Sanitation • National Dam and Inter-Basin Transfer Agency • Ministry of Land-use Planning and the Environment (MATE) • National Waste Agency (NDA) • National Conservatory of Environmental Training (CNFE) • Directorates of the 48 wilayas • Ministry of the Interior and Local Governments (MICL), with financial support for municipalities
Presence of a functional water regulator	• Water Utilities Regulatory Authority
Environment for private sector participation	• No public-private partnership unit • Regulatory Authority for Public Procurement and Services and the Ministry of Finance • Presidential Decree No. 15-247 of 2 Dhou Zl Hidja 1436 of 2015 covering public procurement regulations and delegation of public services. Public-private partnerships in the water sector to follow Water Law No. 05-12 of 2005 • Desalination plant in Djerba; contracts for the management of drinking water in Algiers, Oran and Constantine.
Legal, policy and strategy frameworks	
Current enabling policies	• The National Water Sector Development Programme 2006–2025 adopted in 2007 and integrated into the National Land-use Planning Scheme (SNAT) is the main water policy
Current enabling laws	• Water Law No. 05-12 of 2005 • Law No. 03-10 of 19/07/2003 on the protection of the environment and sustainable development

Source: FAO 2016.

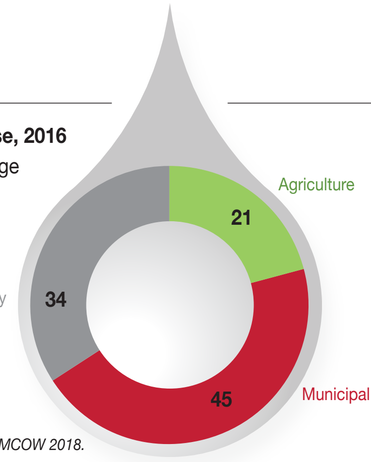
Angola

Water resources

On average Angola receives annual rainfall of 1,010 mm/year (AMCOW 2018). The north has two rainy seasons, while the arid south has one (FAO 2016). Water availability is 5,750 m³/year per person (AMCOW 2018).

The aqueduct water stress for all sectors measured in 2010 was 1.13 and is projected to increase to 1.21 by 2040 (Luo et al. 2015). A score of 1.21 indicates that there is low to medium competition among water users relative to available surface-water resources. Unlike most African countries, Angola's agricultural water withdrawals as a proportion of total water withdrawals is less than municipal or industrial usage. This could partly be attributed to the effects of neglect of the agricultural sector arising from the civil war between 1975 and 2002. By 2018, 50 per cent of the population was employed in the agriculture sector, whose value added contribution to gross domestic product (GDP) was 10 per cent in 2017, though this has been slowly increasing over the years (World Bank 2018). Rebuilding the agricultural sector is a priority for creating employment opportunities and increasing competitiveness.

Water use, 2016
Percentage

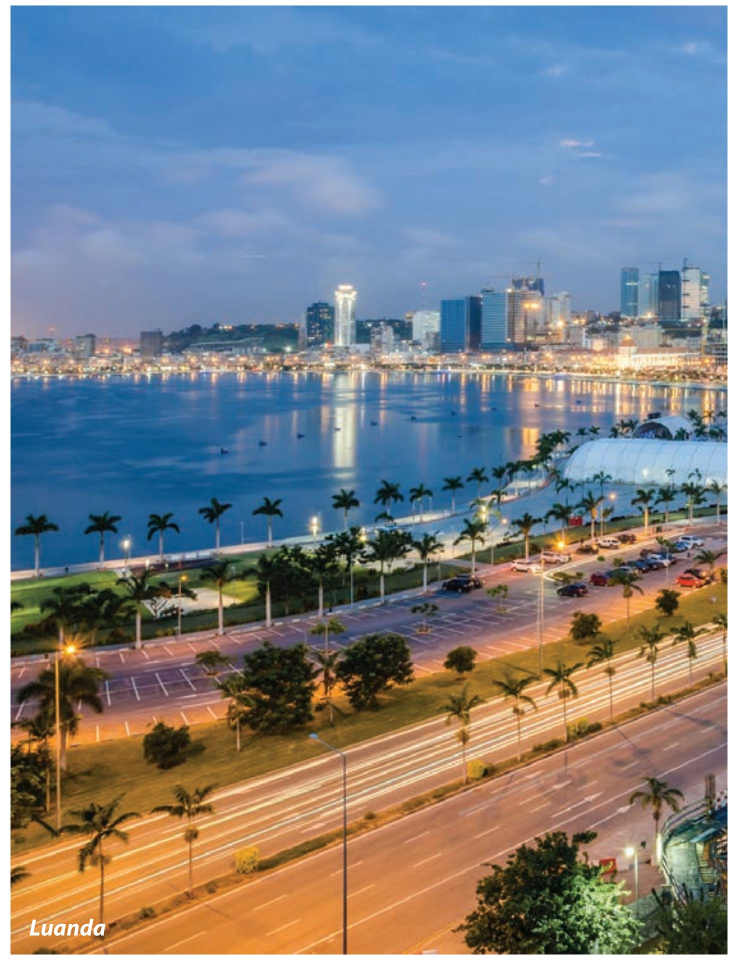


Source: AMCOW 2018.

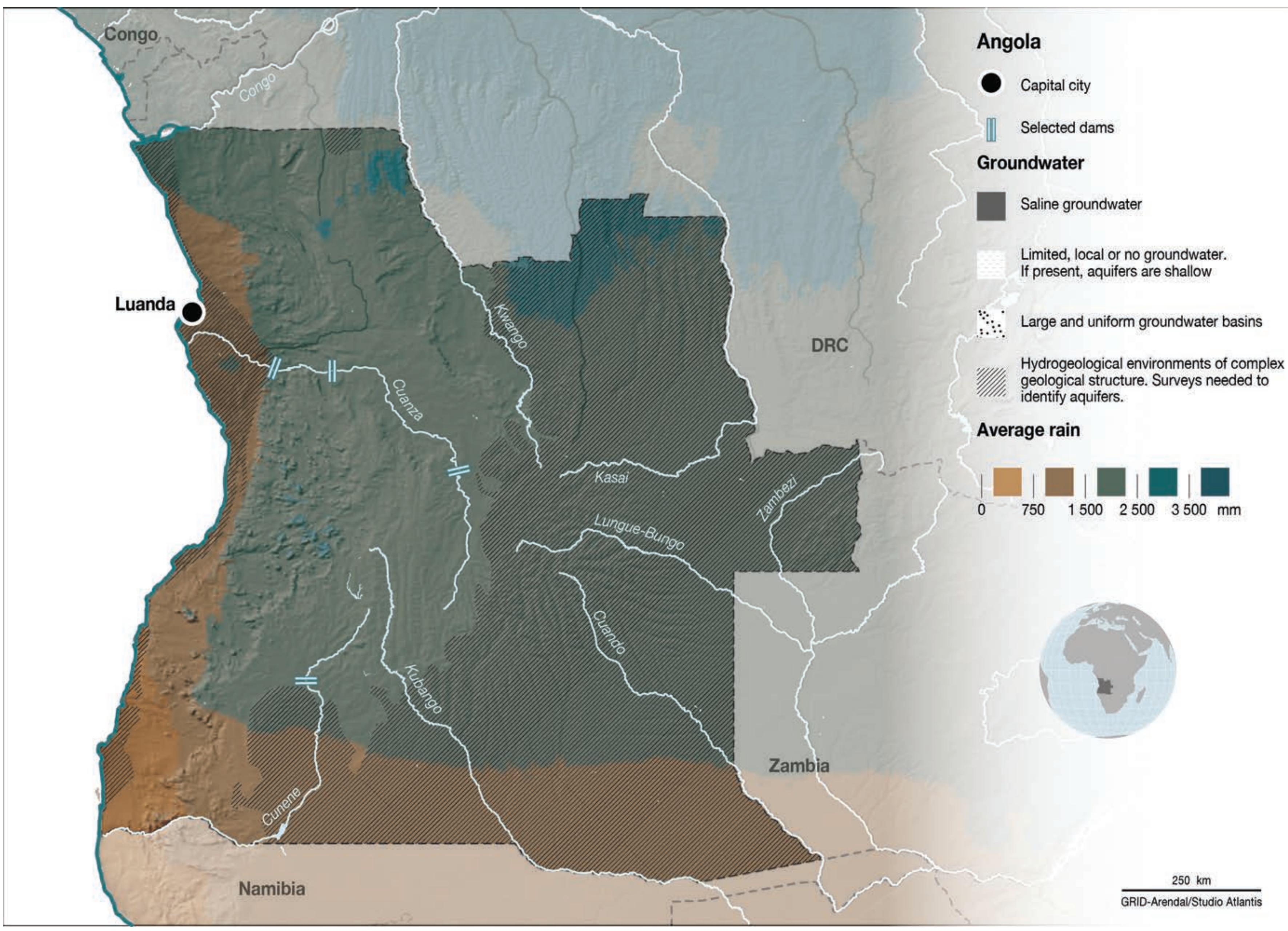
Water availability

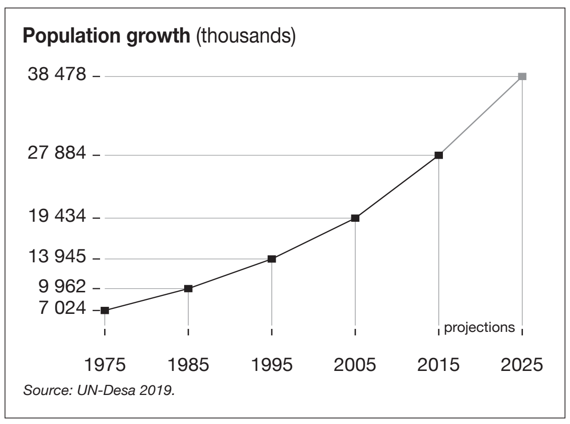
	m³/person and year
Total renewable freshwater	5 750
Total water withdrawal	27.7
Internal renewable water sources	5 740
of which are surface water	5 620
pressure on surface water	*no data available*
of which are groundwater	2 250
pressure on groundwater	*no data available*
Water stress	***0.40%***

Source: AMCOW 2018; FAO 2018.



Luanda

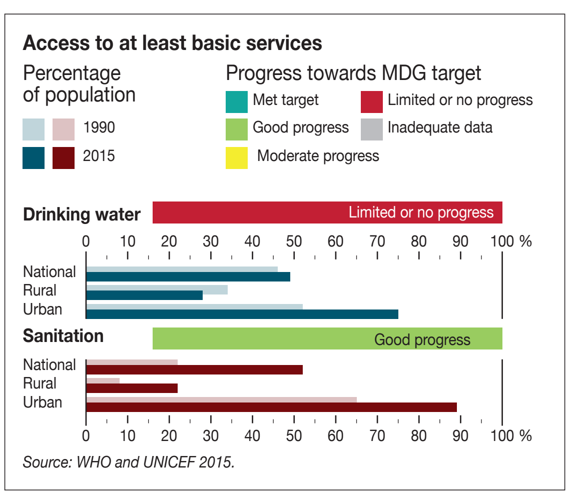




Wastewater management

There is a dearth of recent data regarding wastewater management. Available data show that the amount of wastewater produced was expected to reach 381 million m³/year in 2017, 80 per cent of which is discharged directly into water bodies without treatment (International Trade Administration [ITA] 2017).

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	51.3	45.3	39.1	32.8
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)			24.1 (2012)	24.6
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)	108.7 (2005)			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)	1.9 (2005)			0.4
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				37.0 (2017)

Source: UNSD, 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Energy and Water • National Directorate of Water Supply and Sanitation (DNAAS) • State Secretariat for Water (SEA) • National Water Resources Institute (INRH), 2010 • River Basin Management Cabinets
Presence of a functional water regulator	• Regulator Institute for Services of Electricity, Water Supply and Waste Water Sanitation (HIRSEA), 2016
Level of participation in transboundary water infrastructure and institutional arrangements	• Permanent Joint Technical Commission (PJTC) on the Cunene River, set up with Namibia • Permanent Okavango River Basin Water Commission (OKACOM), established in 1994 with Namibia and Botswana • Zambezi Watercourse Commission (ZAMCOM), set up in 2004 with Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe • Observer status in the International Commission of the Congo-Oubangui-Sangha Basin (CICOS)
Environment for private sector participation	• Law No. 2/11 on public-private partnerships of 14 January 2011 and the General Plan for Public-Private Partnerships.
Water pricing facility	• Tariff code for energy and drinking water
Legal, policy and strategy frameworks	
Current enabling policies	• National Water Plan 2017 • Agua por Todos [Water for All] • Presidential Decree No. 214/15 approving the National Strategic Plan for Territorial Management (PLANEAT) 2015–2025
Current enabling laws	• Law No. 6/02 of 21 June on water use • Law No. 5/87 approving the Sanitary Regulation of 1987 • Presidential Decree No. 83/14 approving the Regulation of Public Supply of Water and Water Disposal Sanitation of 2014 • Presidential Decree No. 82/14 approving the Regulation of General Use of Water Resources of 2014

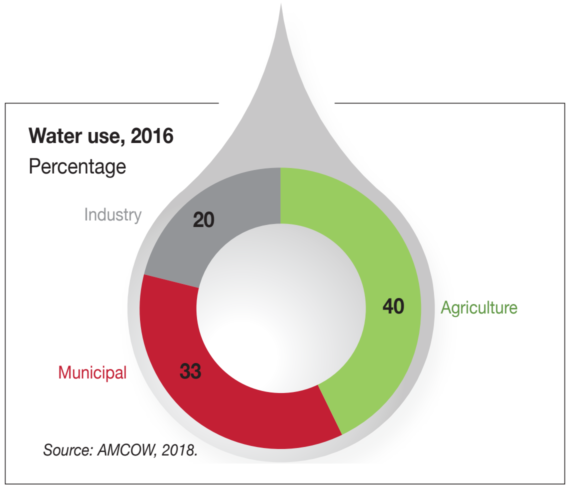
Sources: FAO, 2018; World Bank, 2018b.

Benin

Water resources

Benin has an annual rainfall of 1,039 mm that varies greatly depending on the area and time of year. Water availability is around 2,490 m³/year per person (AMCOW 2018).

The aqueduct water stress for all sectors measured in 2010 was 0.00 and is projected to increase to 0.01 by 2040 (Luo et al. 2015). A score of 0.01 indicates that there is low competition among water users relative to available surface-water resources.

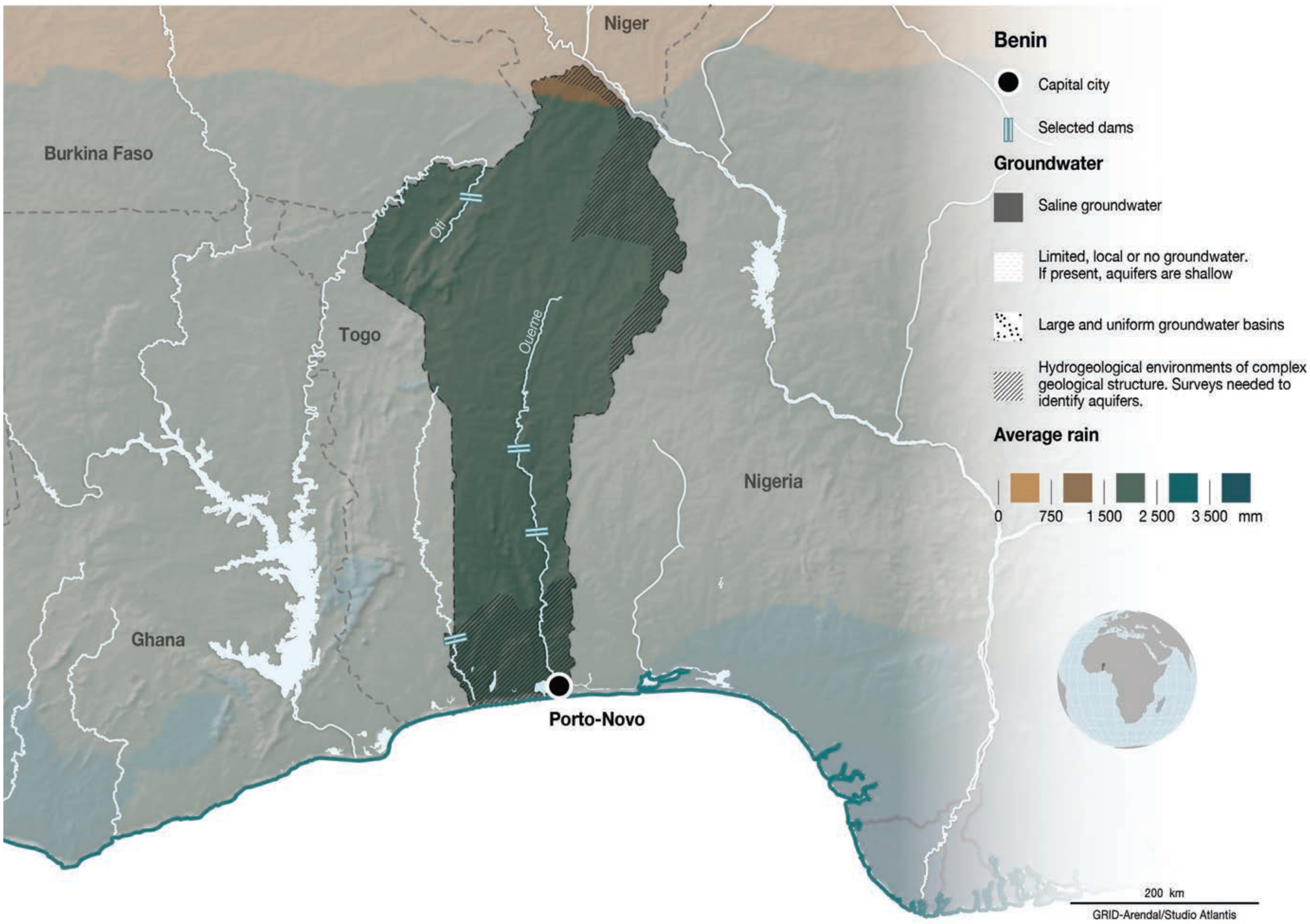


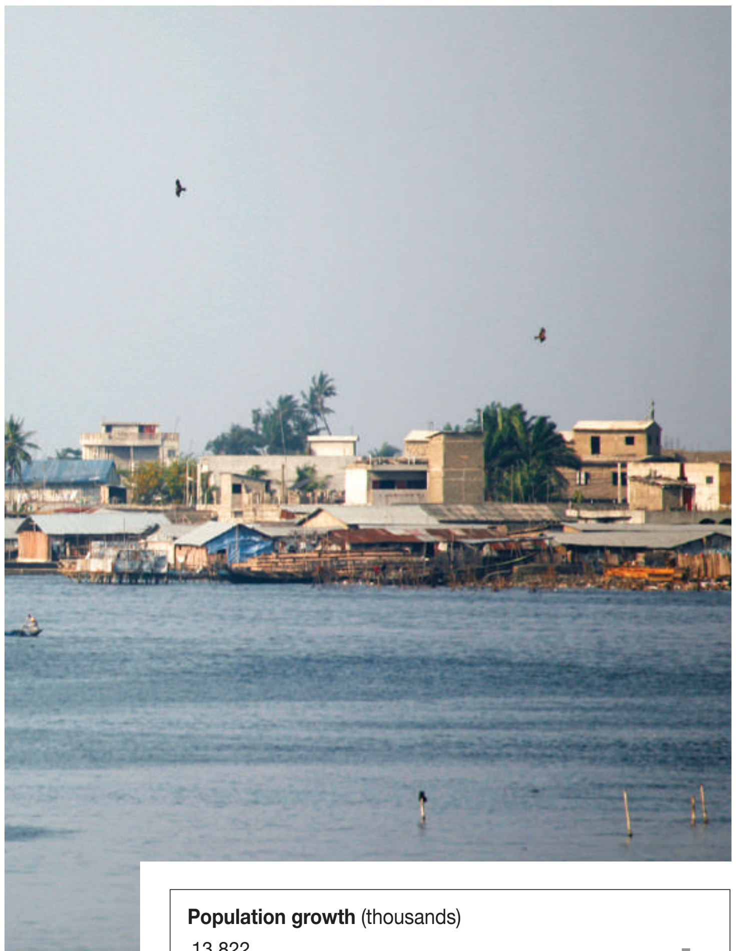
Water availability

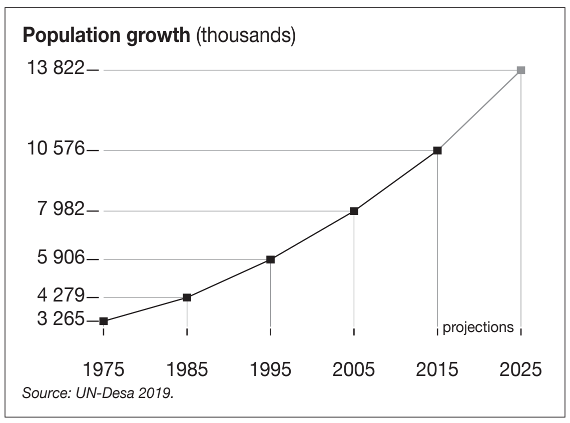
	m³/person and year
Total renewable freshwater	2 490
Total water withdrawal	14.2
Internal renewable water sources	1 410
of which are surface water	1 240
pressure on surface water	*0.31%*
of which are groundwater	170
pressure on groundwater	*4.44%*
Water stress	***0.60%***

Source: AMCOW 2018; FAO 2018 .

Porto-Novo



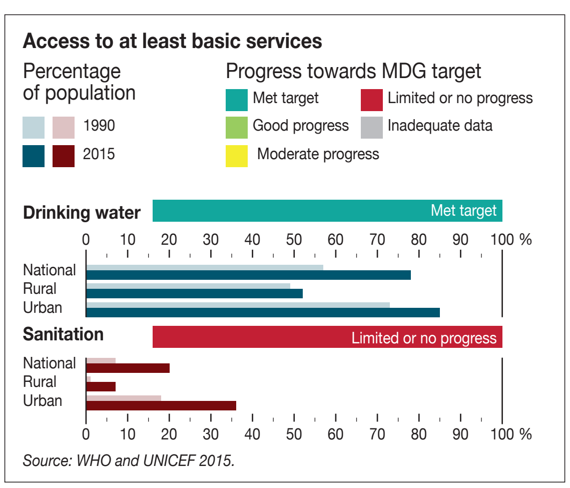




Wastewater management

There is a dearth of recent data regarding wastewater management. According to the World Bank (2018), by 2015 only 13.9 per cent of the population had at least a basic level of sanitation, which is an indicator of very poor waste management. In Cotonou, the capital city, wastewater is disposed of at the Industrial Society of Urban Equipment and Sanitation plant, which was designed to treat 180 m^3 of wastewater per day, but received 477 m^3 on average per day between 2008 and 2010, with 70 per cent of this coming from latrines (Hounkpe et al. 2014).

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	67.7	63.7	59.5	55.2
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)	1.0	3.7	6.8	10.1
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/$cm^3$)	24.8			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)	1.0			0.6
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				63.0 (2017)

Source: United Nations Statistics Division (UNSD), 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Energy and Water Engineering (MEE) • National Water Company of Benin (SONEB) • Directorate-General for Water, in charge of IWRM and rural and peri-urban water supply • National Agency for Drinking Water in Rural Areas (ANAEPMR) • Directorate for Hygiene and Basic Sanitation, Ministry of Health
Environment for private sector participation	• Law No. 2001-07 • Public-Private Partnership Support Unit (CAPPP) • National Directorate of Public Procurement Control (DNCMP) • Public Procurement Regulatory Authority (ARMP)
Legal, policy and strategy frameworks	
Current enabling policies	• National Sanitation Policy, 1995 • National Water Policy, 2008 • National Strategy for Rural Water Supply 2005–2015 • Strategy for Urban Water Supply 2006–2015 • National Sanitation Development Plan 2009–2018 • National Action Plan for Integrated Water Resources Management (PANGIRE), November 2011 • National Action Plan for Integrated Water Resources Management (PANGIRE) Operationalization Strategy (2016–2020)
Current enabling laws	• Law No. 2010-44 of 24 November 2010 on water management in the Republic of Benin • Decree No. 2007-310 relating to the conditions of the control of cold drinking water metres in the Republic of Benin of 2007 • Decree No. 2001-094 setting quality standards for drinking water of 2001 • Decree No. 2011-573 of 31 August 2011 establishing the master plan for the development and management of water

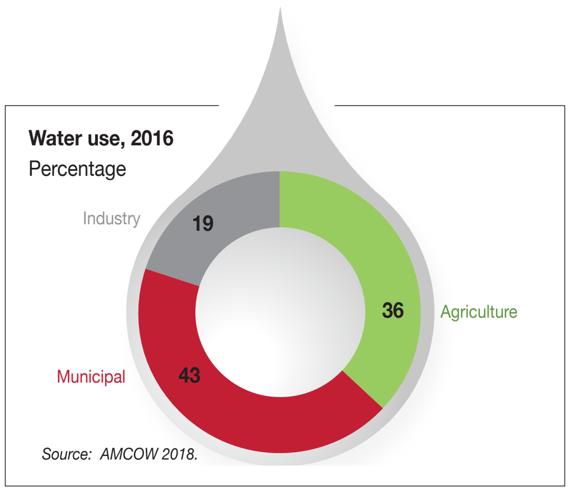
Sources: FAO, 2016; Policy and Operations Evaluation Department, 2011; United States Agency for International Development, 2010a.

Botswana

Water resources

Botswana is a semi-arid country with annual rainfall of 416 mm (AMCOW 2018). Drought is a recurring problem. Surface run-off and groundwater recharge rates are low and even during the rainy season, stream flow is not continuous, with internal rivers only flowing for 10–75 days a year (FAO 2016). Water availability is about 5,410 m^3/year per person (AMCOW 2018).

The country's aqueduct water stress for all sectors measured in 2010 was 1.48 and is projected to increase to 3.00 by 2040 (Luo et al. 2015). A score of 3.00 indicates that there is medium to high competition among water uses relative to available surface-water resources. Agricultural water usage is not as high as in some other African countries. The recurrent droughts have hindered the growth of the agricultural sector and its contribution to GDP has remained low, fluctuating between 1.8 and 2.7 per cent in the 2006–2017 period. Just over 25 per cent of the population is employed in this sector (World Bank 2018).

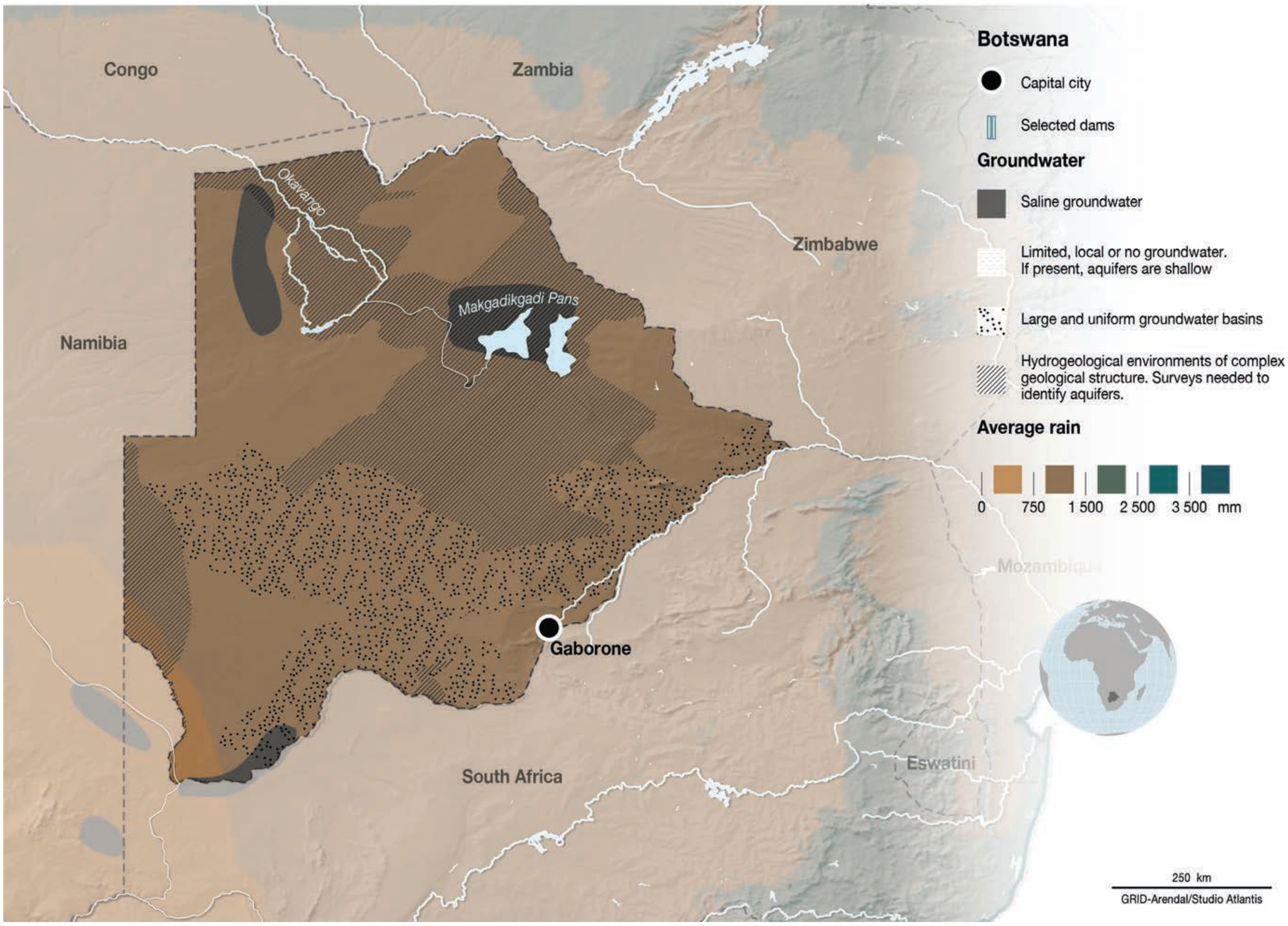


Water availability

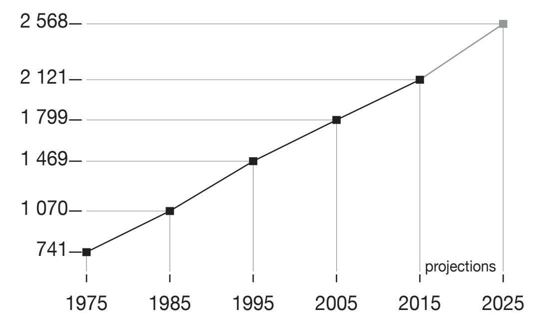
	m³/person and year
Total renewable freshwater	5 410
Total water withdrawal	89.3
Internal renewable water sources	1 060
of which are surface water	354
pressure on surface water	*8%*
of which are groundwater	751
pressure on groundwater	*7.65%*
Water stress	***1.7%***

Source: AMCOW 2018; FAO 2018 .


Gaborone



Population growth (thousands)



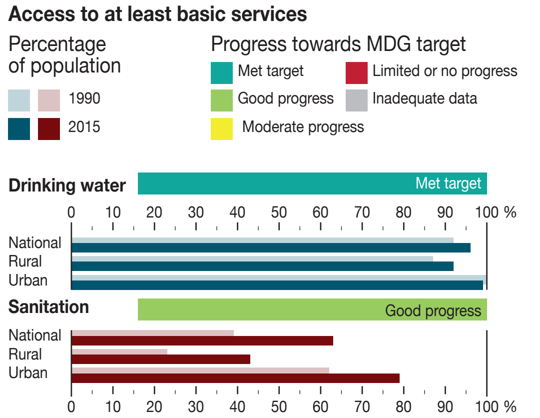
Source: UN-Desa 2019.

Wastewater management

There is a dearth of recent data regarding wastewater management. Available data show that the amount of municipal wastewater produced in 1990 was 0.011 (109/m³/year) and that 0.008 (109/m³/year) was treated in 1999 (FAO 2018).

Water and sanitation provision

Access to at least basic services



Source: WHO and UNICEF 2015.

Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	21.2	19.4	17.9	16.9
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				50 (2017)
	Proportion of groundwater bodies with good ambient water quality (%)				7.69 (2017)
Water-use efficiency	Water-use efficiency (US$/cm³)				74.3
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				1.7
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				41 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Minerals, Energy and Water Resources • Department of Water Affairs • Department of Waste Management and Pollution Control • Department of Geological Surveys • Water Utilities Corporation (WUC), responsible for water supply and wastewater treatment
Presence of a functional water regulator	• Botswana Energy and Water Regulatory Agency • Water Resources Board
Level of participation in transboundary water infrastructure and institutional arrangements	• OKACOM, established in 1994 following an agreement with Angola and Namibia • Limpopo River Basin Commission, 2003 • Zambezi Watercourse Commission, 2004 • Protocol on Shared Watercourses in the Southern African Development Community (SADC), 2000
Environment for private sector participation	• Public-Private Partnership Policy and Implementation Framework, 2009
Legal, policy and strategy frameworks	
Current enabling policies	• National Water Master Plan, 1991 • National Water Master Plan Review, 2006 • National Water Policy, 2012 • Integrated Water Resources Management and Water Efficiency Plan 2013–2030
Current enabling laws	• Water Utilities Corporation Act (Chapter 74:02), 1970 • Water Act, 1968 • Boreholes Act, 1956 • Waterworks Act, 1962 • Town Council (Public Sewers) Regulations • Mines and Minerals Act

Sources: Dikobe 2013; FAO 2016; WUC 2015.

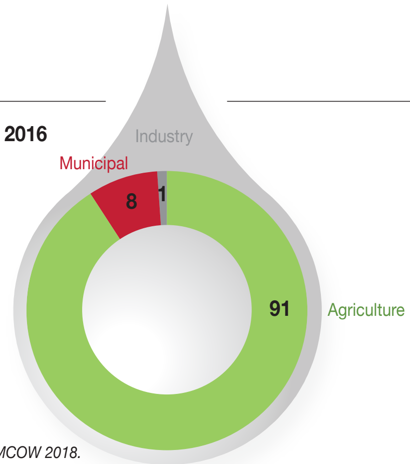
Burkina Faso

Water resources

Burkina Faso receives an annual rainfall of 899 mm (AMCOW 2018). The country has three climatic zones with rainfall increasing from north to south (FAO 2016). Water availability is about 899 m³/year per person (AMCOW 2018).

The aqueduct water stress for all sectors measured in 2010 was 0.00 and is projected to increase to 0.39 by 2040 (Luo et al. 2015). A score of 0.39 indicates that there is low competition among water users relative to available surface-water resources.

Water use, 2016
Percentage

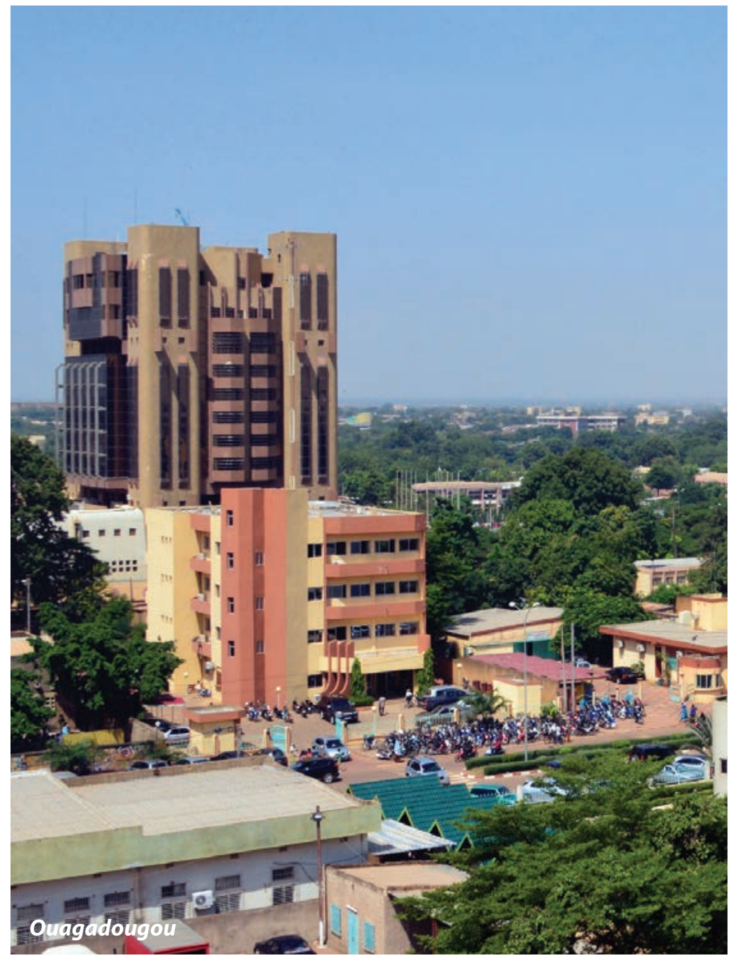


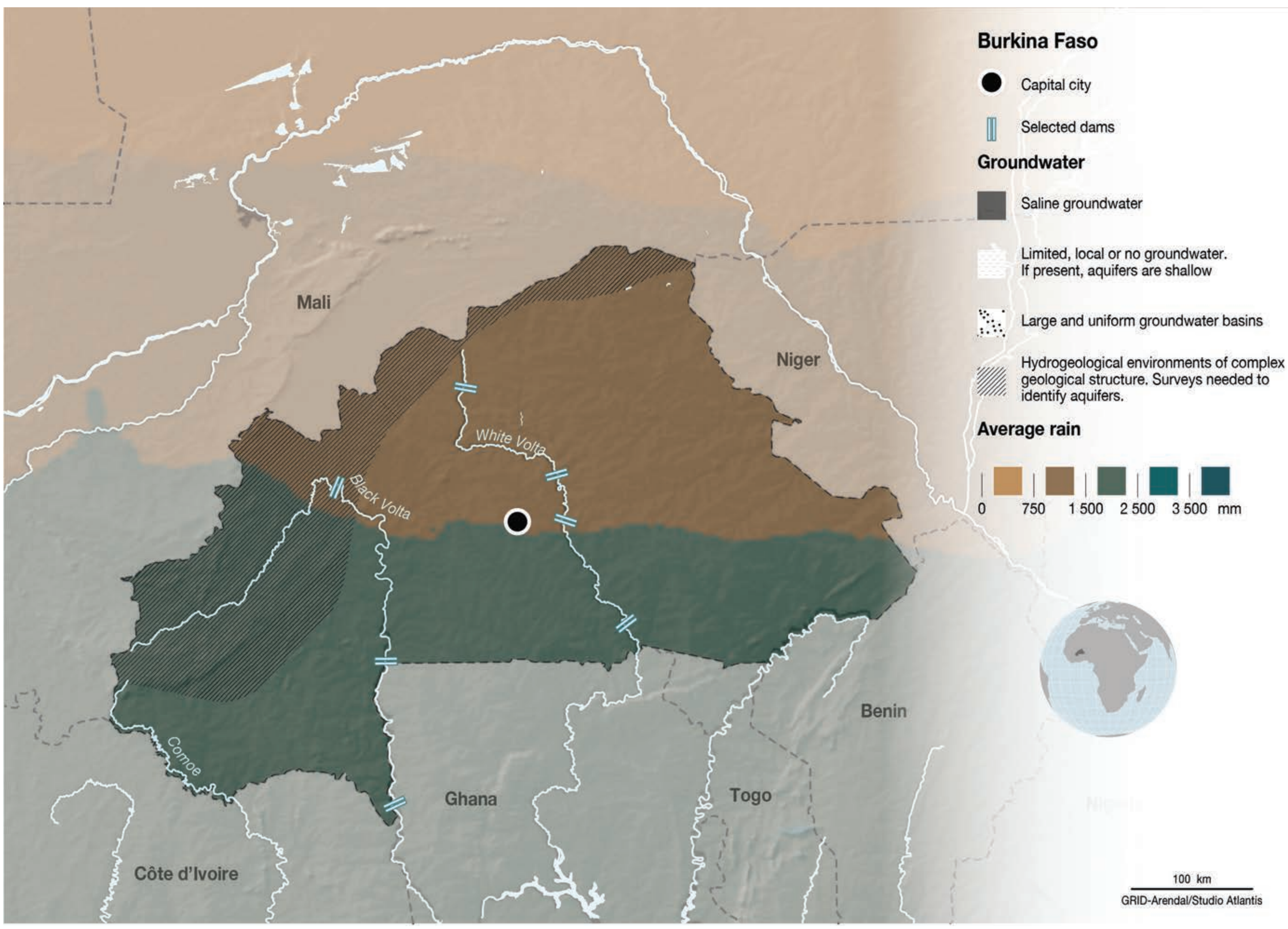
Source: AMCOW 2018.

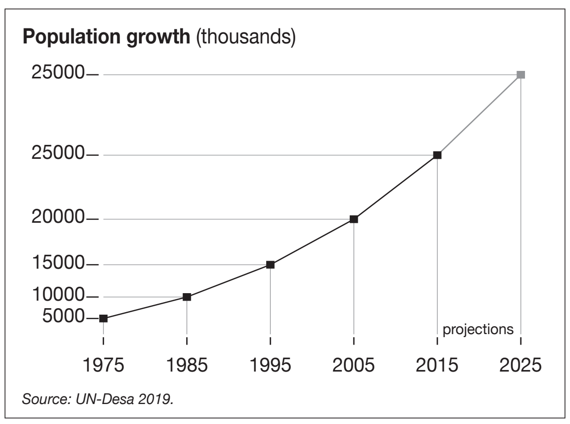
Water availability

	m³/person and year
Total renewable freshwater	476
Total water withdrawal	61.4
Internal renewable water sources	476
of which are surface water	476
pressure on surface water	*12.6%*
of which are groundwater	0
pressure on groundwater	*-*
Water stress	***12.90%***

Source: AMCOW 2018; FAO 2018 .



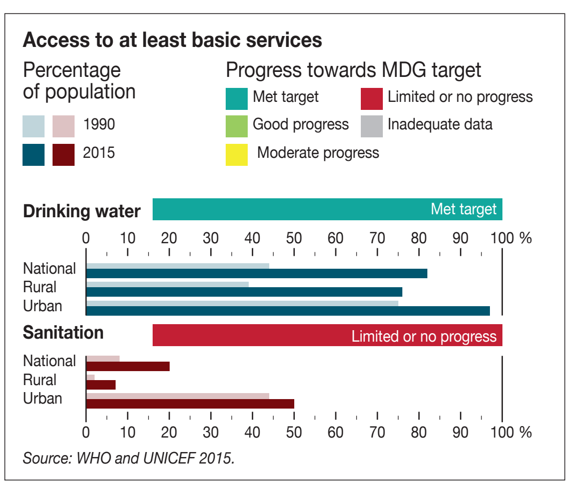




Wastewater management

There is a dearth of recent data regarding wastewater management. Available data show that 48.7 million m^3/year of municipal wastewater was produced in 2009 and the 2.4 million m^3/year was collected in 2011, with 1.4 million m^3/year treated in the same year (FAO 2018).

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	71.4	64.1	55.8	47.9
	Proportion of population using safely managed sanitation services (%)	5.3	7.7	10.2	11.6
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)			5.2 (2005)	
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)			7.8	12.9
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				63 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• General Directorate of Wastewater and Excreta Sanitation (DGAEUE), 2008 • General Directorate of Water Resources (DGRE) • National Office of Water and Sanitation (ONEA) • General Directorate responsible for water and sanitation under the Ministry of Agriculture, Water and Fisheries (MAHRH) • Five water agencies for decentralized water management
Presence of a functional water regulator	• MAHRH, Ministry of Health and Ministry of the Environment, Green Economy and Climate Change
Environment for private sector participation	• Law No. 020-2013/NA of 23 May 2013 on the legal regime of public-private partnerships in Burkina Faso
Water pricing facility	• Law No. 058-2009/AN on financial contributions for water, 2009 • Law No. 058-2009/AN of 15 December 2009 establishing a parafiscal tax for the benefit of water agencies
Legal, policy and strategy frameworks	
Current enabling policies	• Action Plan for Integrated Water Resources Management (PAGIRE) • National Sanitation Policy and Strategy, 2007 • National Water Policy, 2009 • Implementation Strategy for the treatment of wastewater and excreta in rural areas, 2009
Current enabling laws	• Law No. 023/94/ADP on the Public Health Code, 1994 • Law No. 005/97/ADP on the Environment Code, 1997 • Law No. 002-2001/AN on water management guidance, 2001 • Decree No. 2007-4233/PRES/PM/MAHRH/MEF/MECV/MATD/MS/SECU/MJ/MRA/MCE on the definition, organization, powers and functioning of the water police, 2008

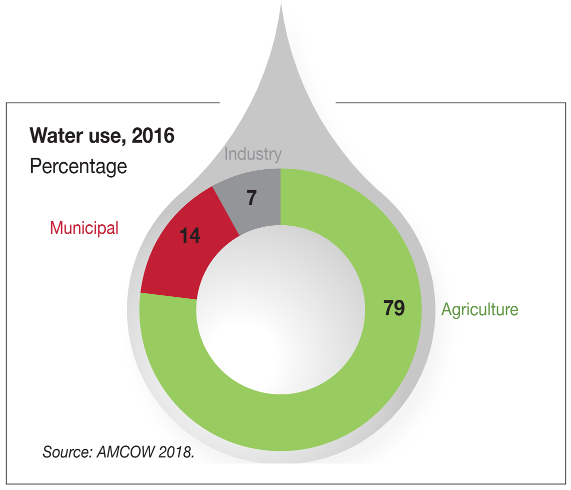
Sources: FAO 2016; World Bank 2018b; Water and Sanitation Program (WSP) 2011a.

Burundi

Water resources

All of Burundi's water comes from precipitation and feeds a dense network of water bodies (FAO 2016). Average rainfall is 1,274 mm/year and water availability is 1,274 m³/year per person (AMCOW 2018).

The aqueduct water stress for all sectors measured in 2010 was 0.00 and is projected to increase to 0.30 by 2040 (Luo et al. 2015). The score of 0.30 indicates that there is low competition among water users relative to available surface-water resources.

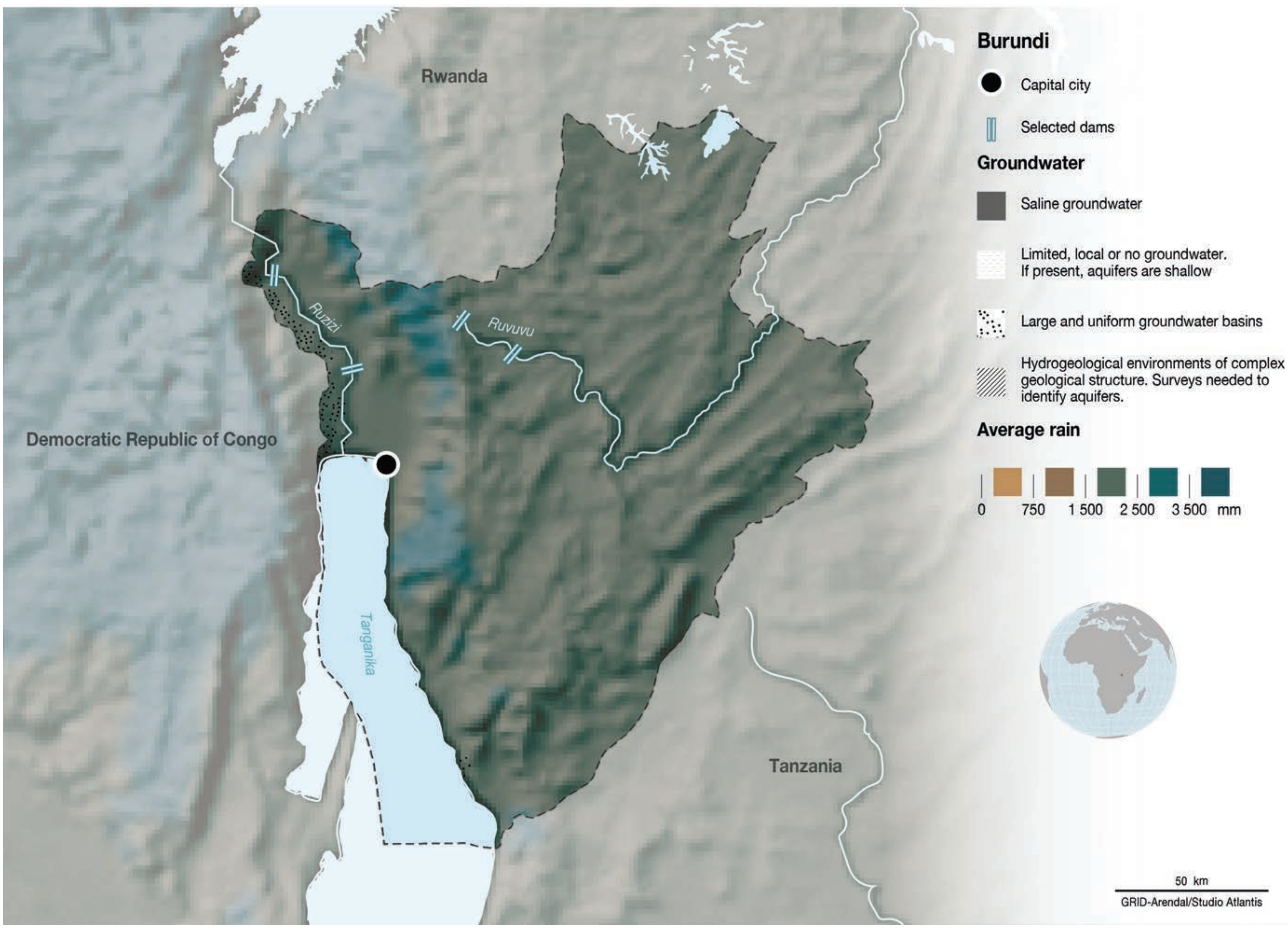


Water availability

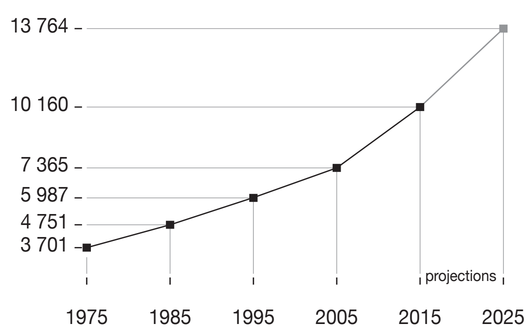
	m³/person and year
Total renewable freshwater	5 750
Total water withdrawal	27.7
Internal renewable water sources	5 740
of which are surface water	5 620
pressure on surface water	*no data available*
of which are groundwater	2 250
pressure on groundwater	*no data available*
Water stress	***0.50%***

Source: AMCOW 2018; FAO 2018 .

A market in Bujumbura



Population growth (thousands)



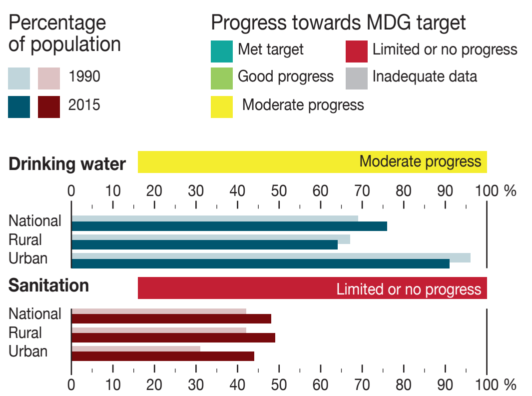
Source: UN-Desa 2019.

Wastewater management

While there is a dearth of recent data regarding wastewater management, information indicates that sewerage and wastewater treatment services are grossly inadequate. For instance, it is estimated that service provision in the capital, Bujumbura, only covers 40 per cent of the city's needs and that around 90 per cent of the population in most peri-urban areas does not have sanitation facilities (Fortune of Africa n.d.). Most wastewater generated in Bujumbara is disposed of in storm drains that channel it untreated into Lake Tanganyika. Several other cities do not have sewerage systems or wastewater treatment facilities (Fortune of Africa n.d.).

Water and sanitation provision

Access to at least basic services



Source: WHO and UNICEF 2015.

Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	2.4	2.7	2.9	3.1
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		5.9 (2006)	6.1	6.3 (2014)
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)	4.3			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.5
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				32.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water, Energy and Mines (MWEM) • Directorate-General for Water and Energy (DGEE) • Directorate of Water Resources (DRH) • Directorate-General of Rural Water and Electricity (DGHER) • Municipal Engineering Services (SETEMU) – sewerage and wastewater treatment services in urban areas
Presence of a functional water regulator	• Agency for Control and Regulation of Water and Electricity (ACR)
Environment for private sector participation	• Law No. 1/14 of 27 April 2015 on the General Scheme for Public-Private Partnership Contracts
Water pricing facility	• Water tariff policy for rural and urban areas
Legal, policy and strategy frameworks	
Current enabling policies	• Burundi National Sanitation Policy and Operational Strategy for Burundi Vision 2025 • National Water Master Plan (PDNE)
Current enabling laws	• Decree No. 100/189 of 25 August 2014 on the determination and establishment of protection areas for water intended for human consumption • Law No. 1/02 of March 26, 2012 on the Water Code in Burundi

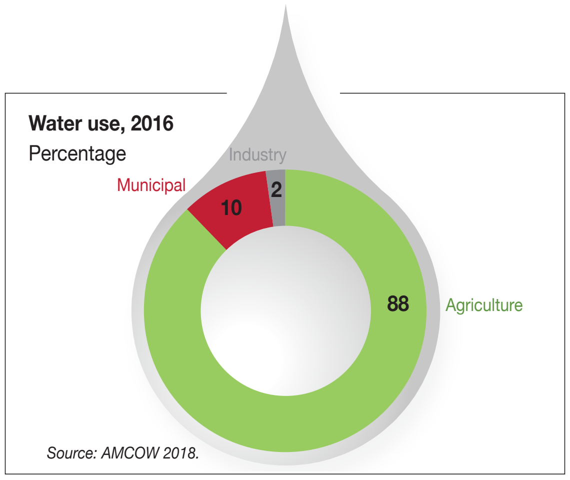
Sources: FAO 2016; World Bank 2018b.

Cabo Verde

Water resources

The island of Cabo Verde has annual rainfall of 228 mm, and water availability of about 38.4 m^3/year per person (AMCOW 2018). Desalination is a major but expensive process of providing clean water due to the use of imported fuel to power electric generators. There were no data on the water stress index for the country designed by Luo, Young and Reig (2015).

Although agriculture contributed just 6 per cent to GDP and employed 67 per cent of the population in 2017, water usage in the sector is extremely high (World Bank 2018). The Government has made agriculture a significant sector in the transformation of the economy. The expansion of arable land, including water for agriculture, is a crucial part of its strategy.

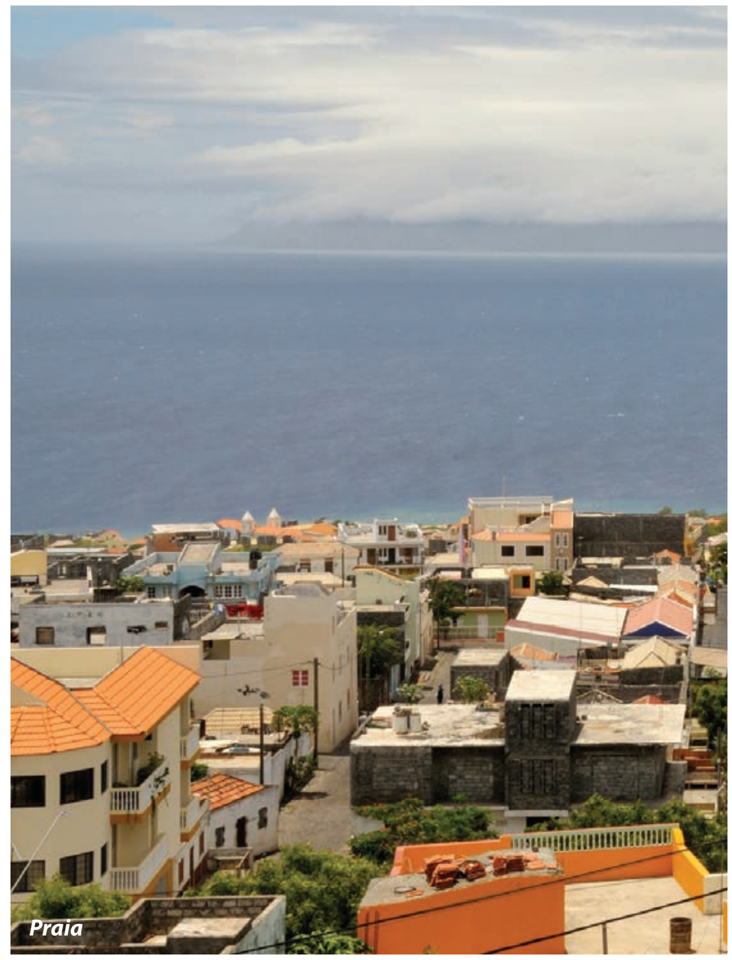


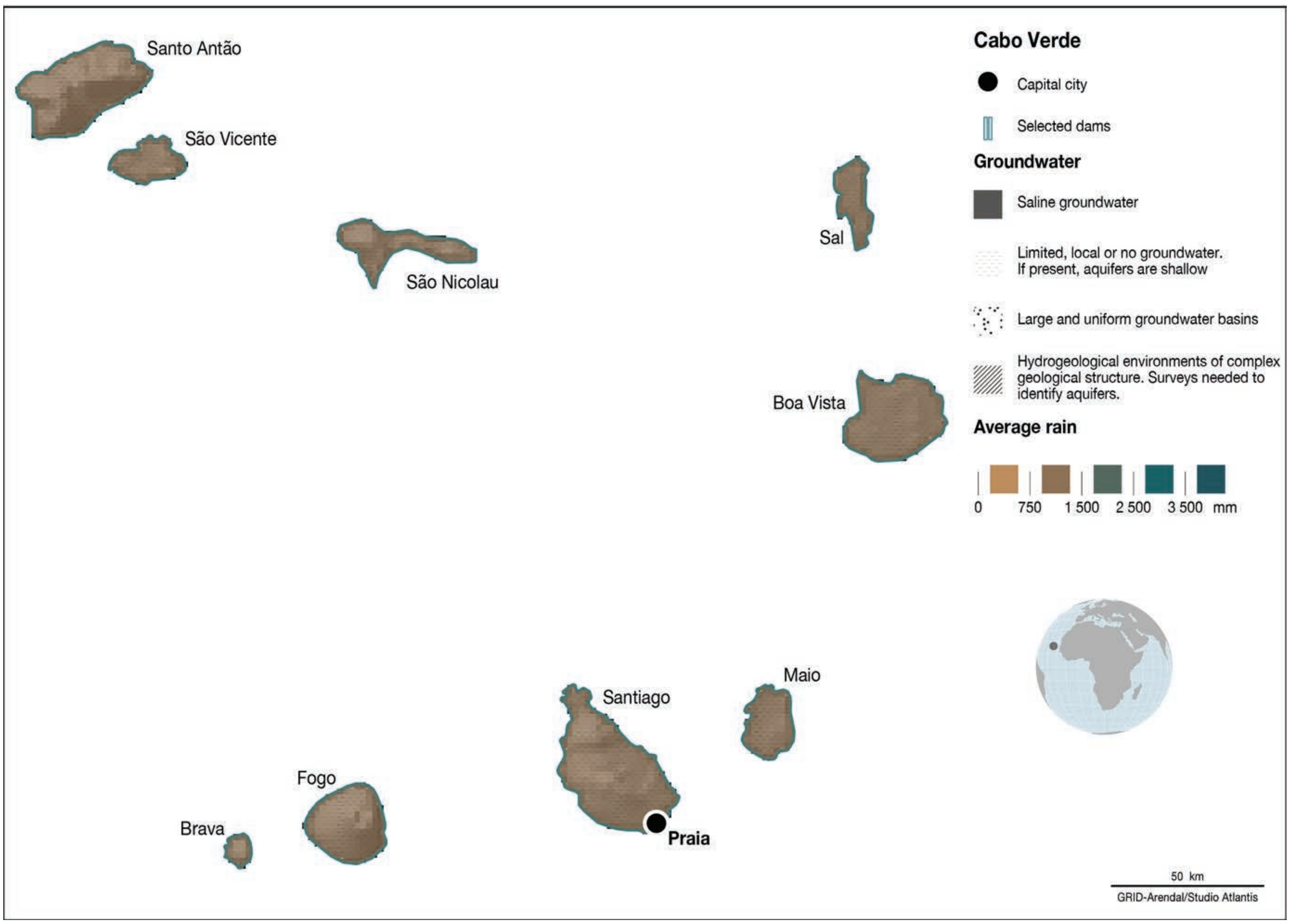
Source: AMCOW 2018.

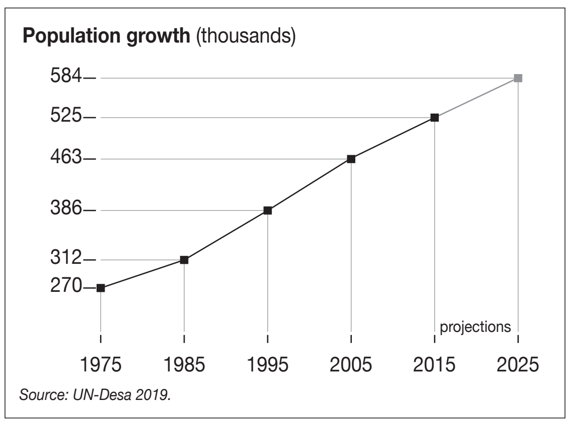
Water availability

	m^3/person and year
Total renewable freshwater	5 410
Total water withdrawal	89.3
Internal renewable water sources	1 060
of which are surface water	354
pressure on surface water	*8%*
of which are groundwater	751
pressure on groundwater	*7.65%*
Water stress	***1.70%***

Source: AMCOW 2018; FAO 2018 .


Praia

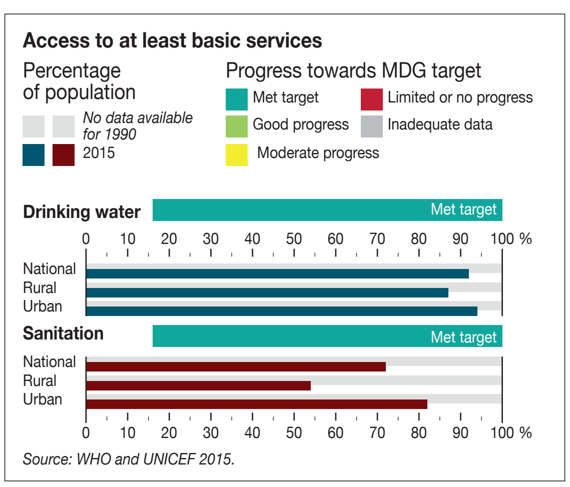




Wastewater management

There is a dearth of recent data regarding wastewater management. However, available data show that 38 million m^3/year of municipal wastewater was produced in 2007, which increased to 39 million m^3/year in 2009 (FAO 2018). In 2017, a new wastewater treatment plant was opened in Cabo Verde on the island of Sal.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	23.3	25.9	28.1	28.1
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm^3)	29.4			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				1.7
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• National Water Council (CNAG) • National Water Resources Management Institute (INRGH)
Presence of a functional water regulator	• Economic Regulatory Agency (ARE)
Environment for private sector participation	• Law No. 88/VIII/2015 of 14 April 2015 on the Public Procurement Code in Cape Verde
Legal, policy and strategy frameworks	
Current enabling policies	• Water Resources Master Plan, 1993 • National Integrated Water Resources Management Action Plan
Current enabling laws	• Legislative Decree No. 3/2015 approving the Water and Sanitation Code (CAS) • Decree-Law No. 8/2004 ruling on water quality and classification • Decree-Law No. 75/99 establishing the legal regime of licence and concession for water resources use, 1999 • Decree No. 7/2017 approving the Statutes of the Water and Sanitation Fund (FASA)

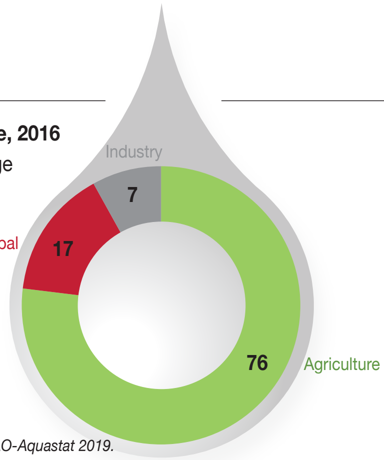
Sources: FAO 2016; World Bank 2018b.

Cameroon

Water resources

Cameroon has three climatic zones with rainfall gradually increasing from north to south. The country's annual rainfall is 1,604 mm, with a per capita water availability of roughly 42.7 m³/year (AMCOW 2018; FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.01 and is projected to remain the same by 2040 (Luo et al. 2015). A score of 0.01 indicates that there is low competition among water users relative to available surface-water resources.

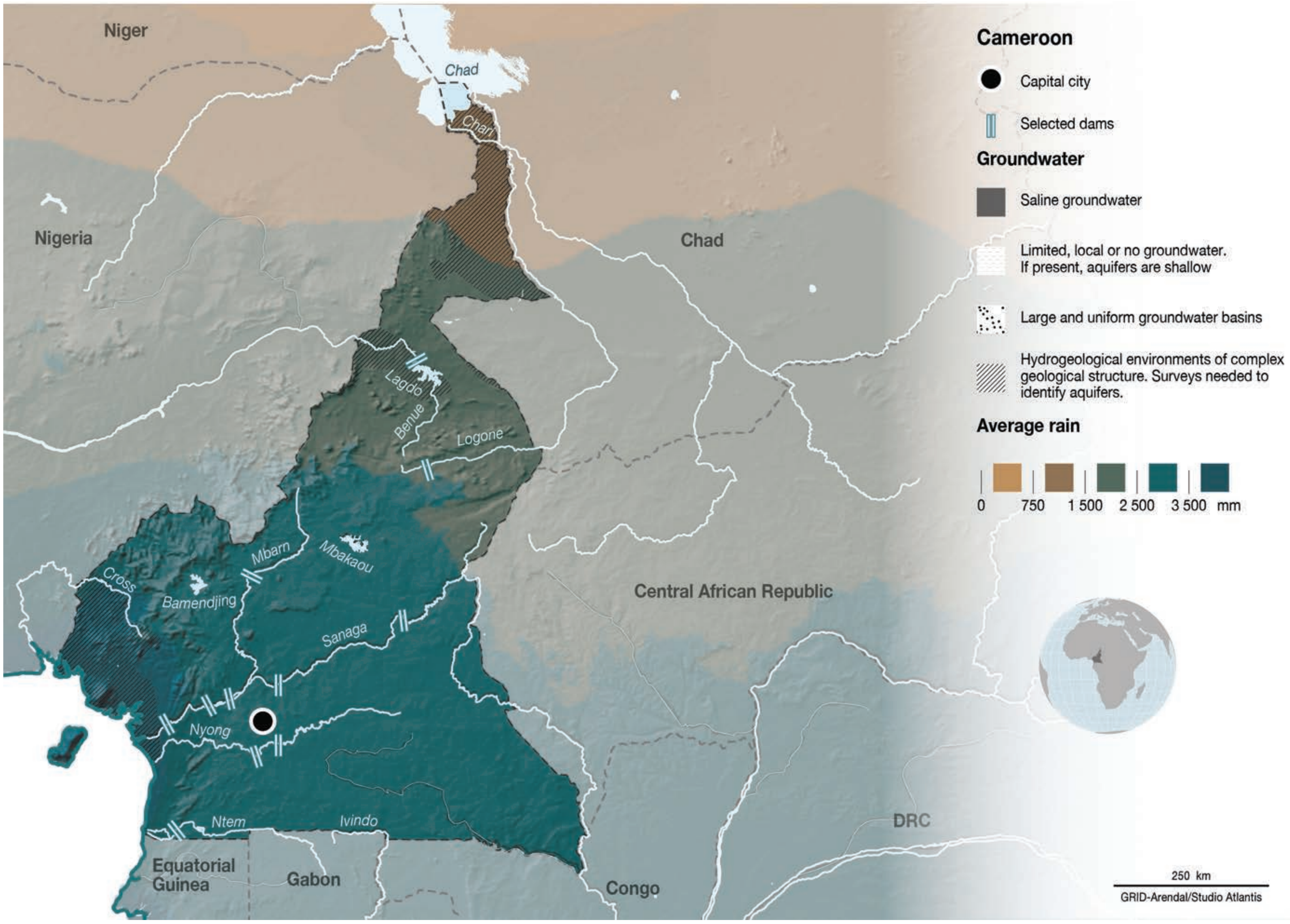


Water availability

	m³/person and year
Total renewable freshwater	2 490
Total water withdrawal	14.2
Internal renewable water sources	1 410
of which are surface water	1 240
pressure on surface water	*0.31%*
of which are groundwater	170
pressure on groundwater	*4.44%*
Water stress	***0.60%***

Source: AMCOW 2018; FAO 2018 .

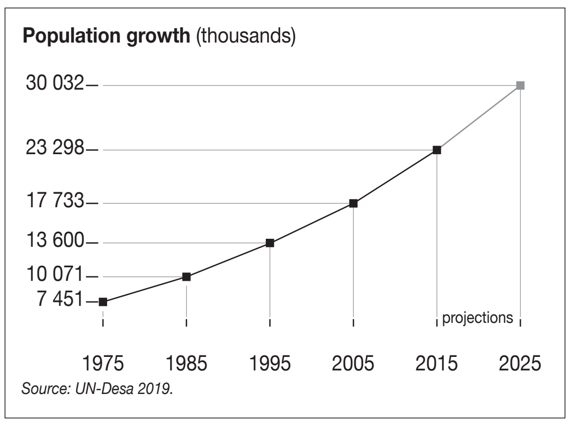
A market in Yaounde



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	7.4	7.3	7.2	7.1
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)			2.6	2.7
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)	12.3			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.6
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				34.0 (2017)

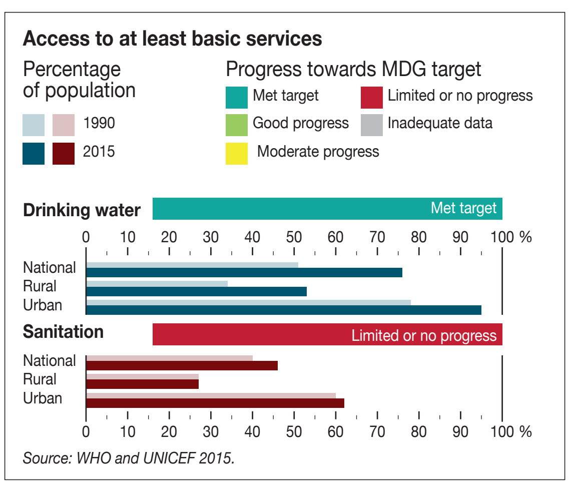
Source: UNSD 2019.



Wastewater management

Recent data on wastewater management are lacking, but historical records show that 66.2 million m³/year of municipal wastewater was generated in 2008 (FAO 2018).

Water and sanitation provision



Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water Resources and Energy • Cameroon Water Utilities Corporation • Camerounaise des Eaux [Cameroonian Water] • National Water Committee
Presence of a functional water regulator	• Ministry of Water Resources and Energy
Environment for private sector partnership	• Law No. 2006/012 of 29 December 2006 on the general scheme of partnership contracts • Support Council for the Realization of Partnership Contracts, established in 2009
Water pricing facility	• Decree No. 2005-3089-PM of 29 August 2005 specifying the rules of assessment, recovery and control of the sanitation tax and the water withdrawals levy
Legal, policy and strategy frameworks	
Current enabling policies	• Sectoral policy letter on urban water supply (April 2007) • Rural Drinking Water Supply and Sanitation Policy and 2008–2015 Action Plan • Regulation on the Provision of Drinking Water Distribution Service (December 2010) • National Liquid Sanitation Strategy (August 2011) • Sectoral policy letter on liquid sanitation (April 2011)
Current enabling laws	• Law No. 98/005 establishing the water regime of 1998 • Decree No. 2001/216 establishing a trust account for the financing of sustainable water and sanitation development projects

Sources: CAMWATER 2018; FAO, 2016; World Bank 2018b; World Bank 2018c.

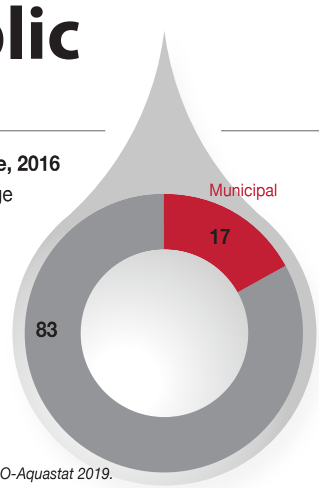
Central African Republic

Water resources

The Central African Republic has average rainfall of 1,343 mm and water availability of about 26,600 m^3/year per person (AMCOW 2018). Despite having a rich hydrographic network, the country's water quality and quantity are in decline (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.00 and is projected to remain the same by 2040 (Luo et al. 2015). This score indicates that there is low competition among water users relative to available surface-water resources. Water use in the agricultural sector is very low; this could partly be attributed to the insecurity in the country, which has displaced large populations and prevented people from engaging in agricultural activities.

Water use, 2016
Percentage

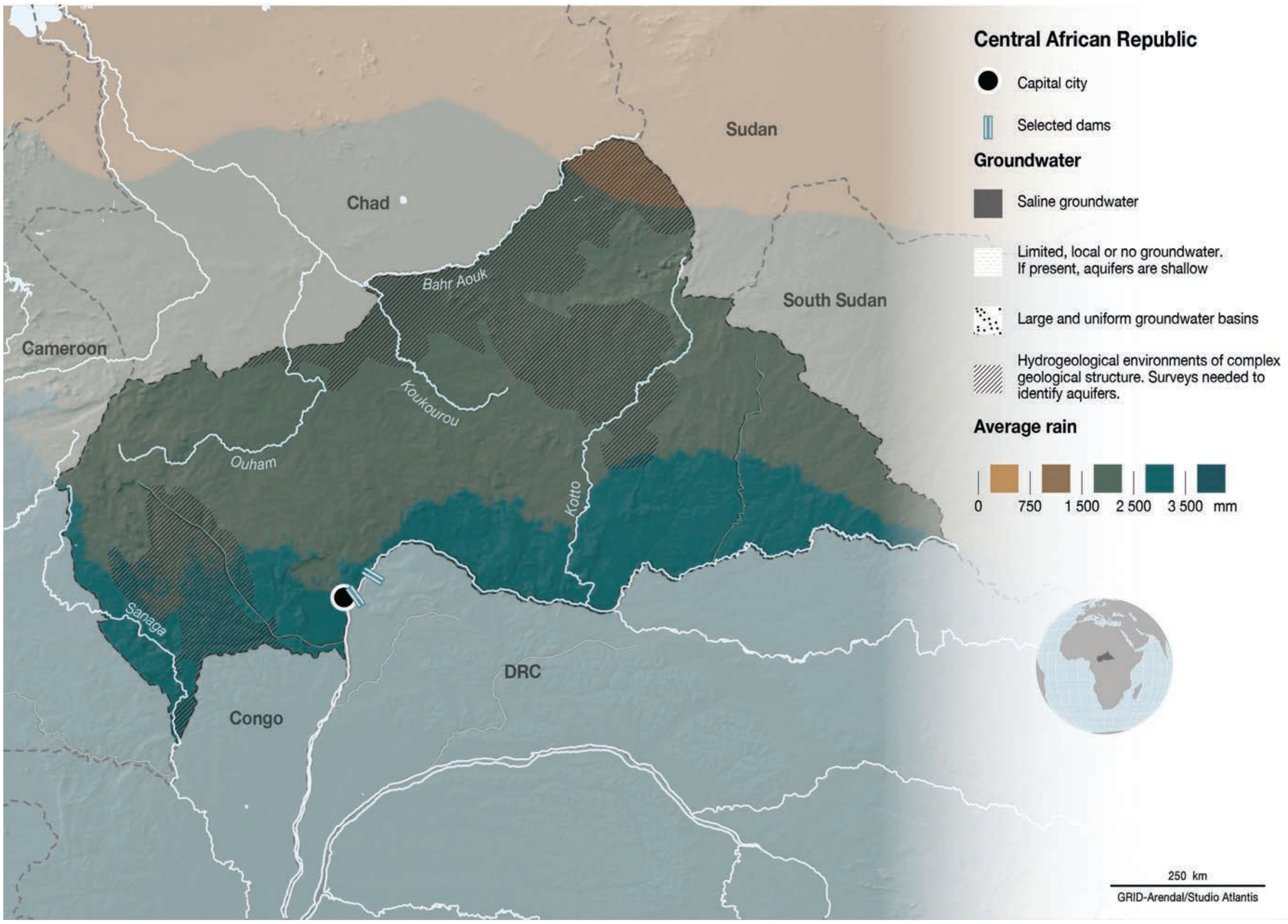


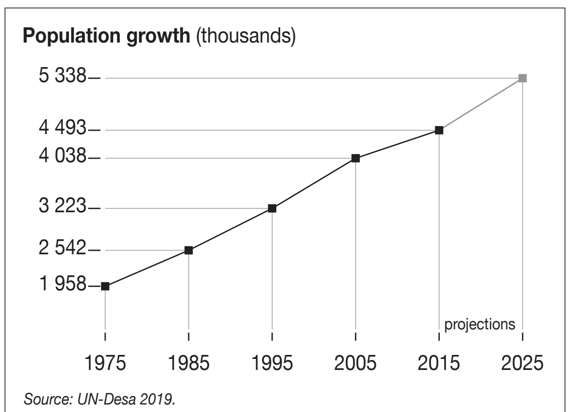
Source: FAO-Aquastat 2019.

Water availability

	m^3/person and year
Total renewable freshwater	476
Total water withdrawal	61.4
Internal renewable water sources	476
of which are surface water	476
pressure on surface water	*12.6%*
of which are groundwater	0
pressure on groundwater	*-*
Water stress	***12.90%***

Source: AMCOW 2018; FAO 2018 .

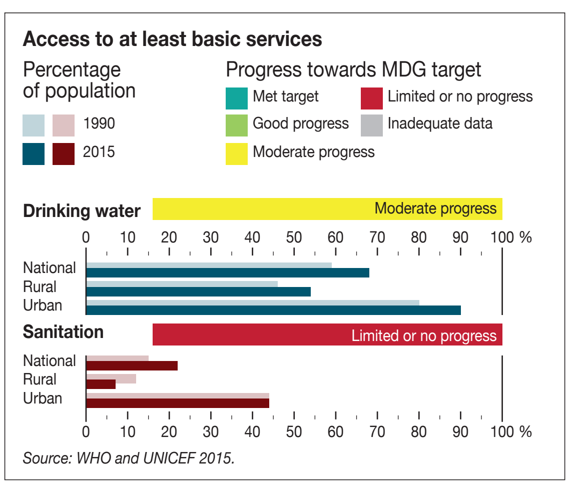




Wastewater management

There are no recent data regarding wastewater management.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	22.9	23.5	23.9	23.9
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		16.4 (2006)	16.5	16.6
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)			12.3 (2005)	
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				12.9
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Mines, Energy and Hydraulics • Ministry of Development of Energy and Water Resources (MDEWR) • National Agency for Rural Water Supply and Sanitation • Société Nationale des Eaux [National Water Company] (SNE), 1975 • Société de Distribution d'Eau de Centrafrique [Central African Water Distribution Company] (SODECA), 1991 • Water Supply and Sanitation Sector Committee, 2009 • Water Sector Round Table
Presence of a functional water regulator	• Regulatory Agency for the Water Supply and Sanitation Sector (ARSEA)
Environment for private sector participation	• Law No. 2008-17 of 6 June 2008 on the Code of Public Contracts and Public Service Delegations
Legal, policy and strategy frameworks	
Current enabling policies	• Water Supply and Sanitation Sector Action Plan (PASEA) • National Water Supply and Sanitation Policy and Strategies (PSNEA)
Current enabling laws	• Law No. 06.001 of 12 April 2006 on the Water Code of the Central African Republic • Decree No. 62-278 on well drilling, 1968

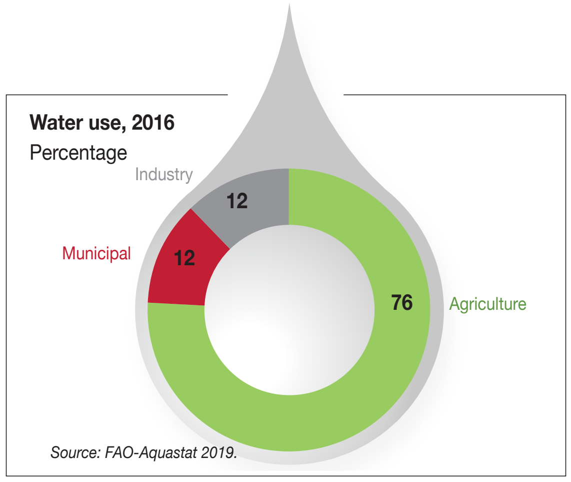
Sources: FAO 2016; World Bank 2018b; WSP 2011b.

Chad

Water resources

Chad has an annual rainfall of 322 mm (AMCOW 2018). The country has three climatic zones, with varying degrees of rainfall. Rainfall is 300 mm/year in the north of the country near the desert, 300–600 mm/year in the Sahelian zone and 600–1,200 mm/year in the Sudanian zone (FAO 2016). Water availability is about 92.8 m^3/year per person (AMCOW 2018).

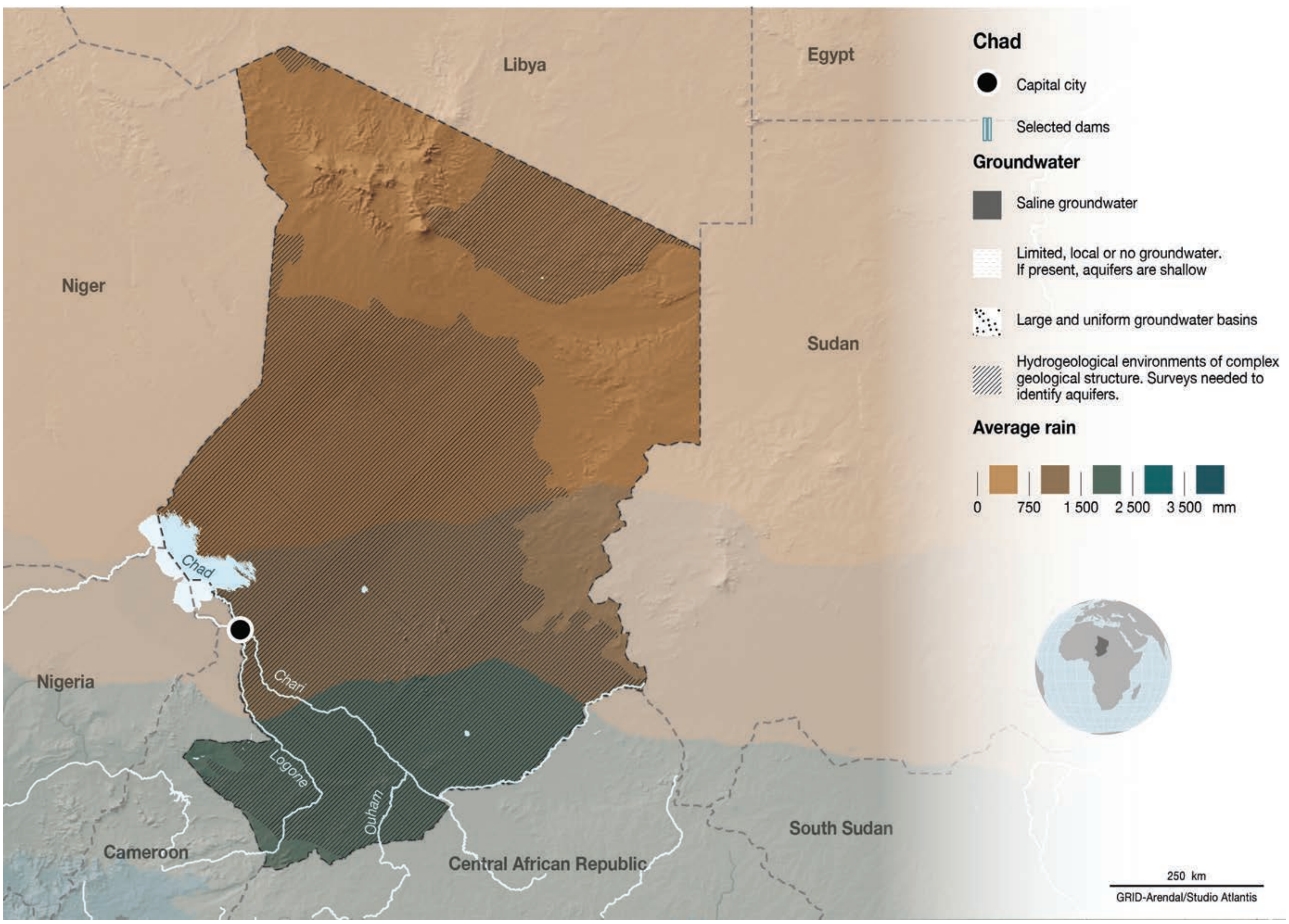
The country's aqueduct water stress for all sectors measured in 2010 was 0.37 and is projected to increase to 0.67 by 2040 (Luo et al. 2015). A score of 0.67 indicates that there is low competition among water users relative to available surface-water resources.

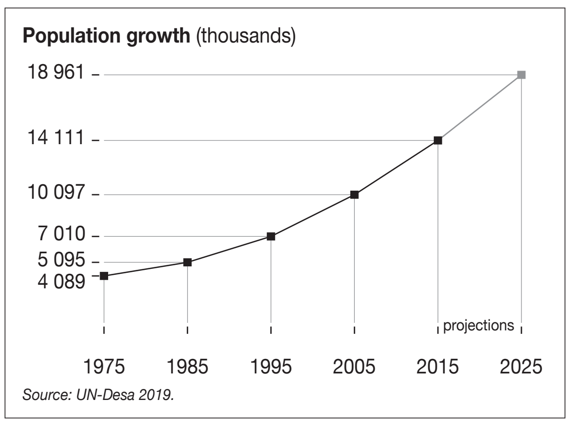


Water availability

	m³/person and year
Total renewable freshwater	5 750
Total water withdrawal	27.7
Internal renewable water sources	5 740
of which are surface water	5 620
pressure on surface water	*no data available*
of which are groundwater	2 250
pressure on groundwater	*no data available*
Water stress	***0.50%***

Source: AMCOW 2018; FAO 2018.

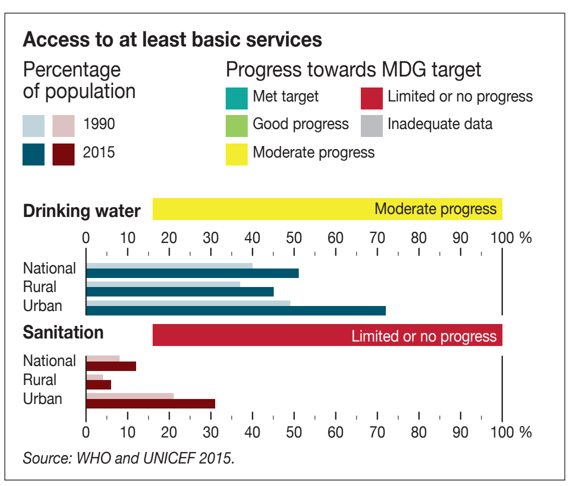




Wastewater management

There are no recent data regarding wastewater management.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	70.7	69.7	68.7	67.5
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)			5.7 (2011)	5.7
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm^3)			2.9 (2005)	
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.5
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				32.0 (2017)

Source: UNSD, 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Directorate of Water Resources and Meteorology (DREM) of the Ministry of Environment, Water and Fisheries • Ministry of Environment, Water and Fisheries
Presence of a functional water regulator	• Ministry of Water and Sanitation
Environment for private sector participation	• No dedicated agency • No dedicated law
Legal, policy and strategy frameworks	
Current enabling policies	• Irrigation Policy, 1970
Current enabling laws	• Law No. 016/PR/99 of 18 August 1999 enacting the Water Code • Order No. 22/MHUR/2011 of 7 November 2011 defining the national strategy for equipment and allocation of drinking water points • Order No. 24/MHUR/2011 of 3 November 2011 on defining and using village participation in the construction of drinking waterworks • Order No. 12/PR/PM/ME/MSP/2011 of 3 June 2011 on the modalities of the first water analysis of catchment works intended for human consumption • Order No. 13/PR/PM/ME/MSP/2011 of 3 June 2011 defining approval conditions for laboratories to carry out sampling and analysis of drinking water

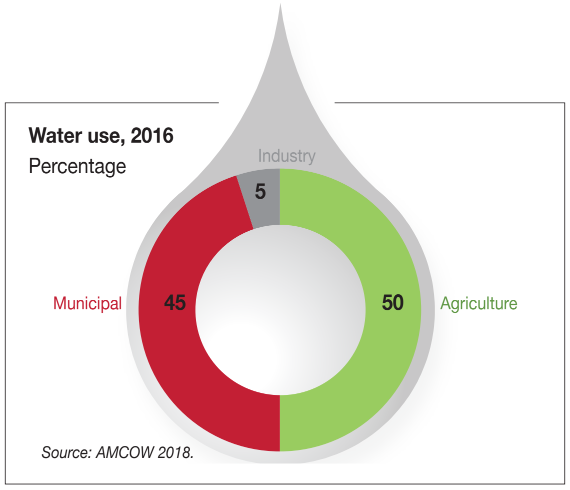
Sources: FAO 2016; World Bank 2018b.

Comoros

Water resources

Comoros has an annual rainfall of 900 mm (AMCOW 2018). The archipelago is made up of four islands and rainfall varies greatly, ranging from 2,000 to 4,000 mm/year depending on the altitude and orientation of the terrain (FAO 2016).

Although 90 per cent of the population has access to safe drinking water, water security remains an issue. Groundwater and rainwater harvesting are major sources of water for the population on the main island of Grande Comore, while on the islands of Anjouan and Mohéli, the populations rely on surface water.

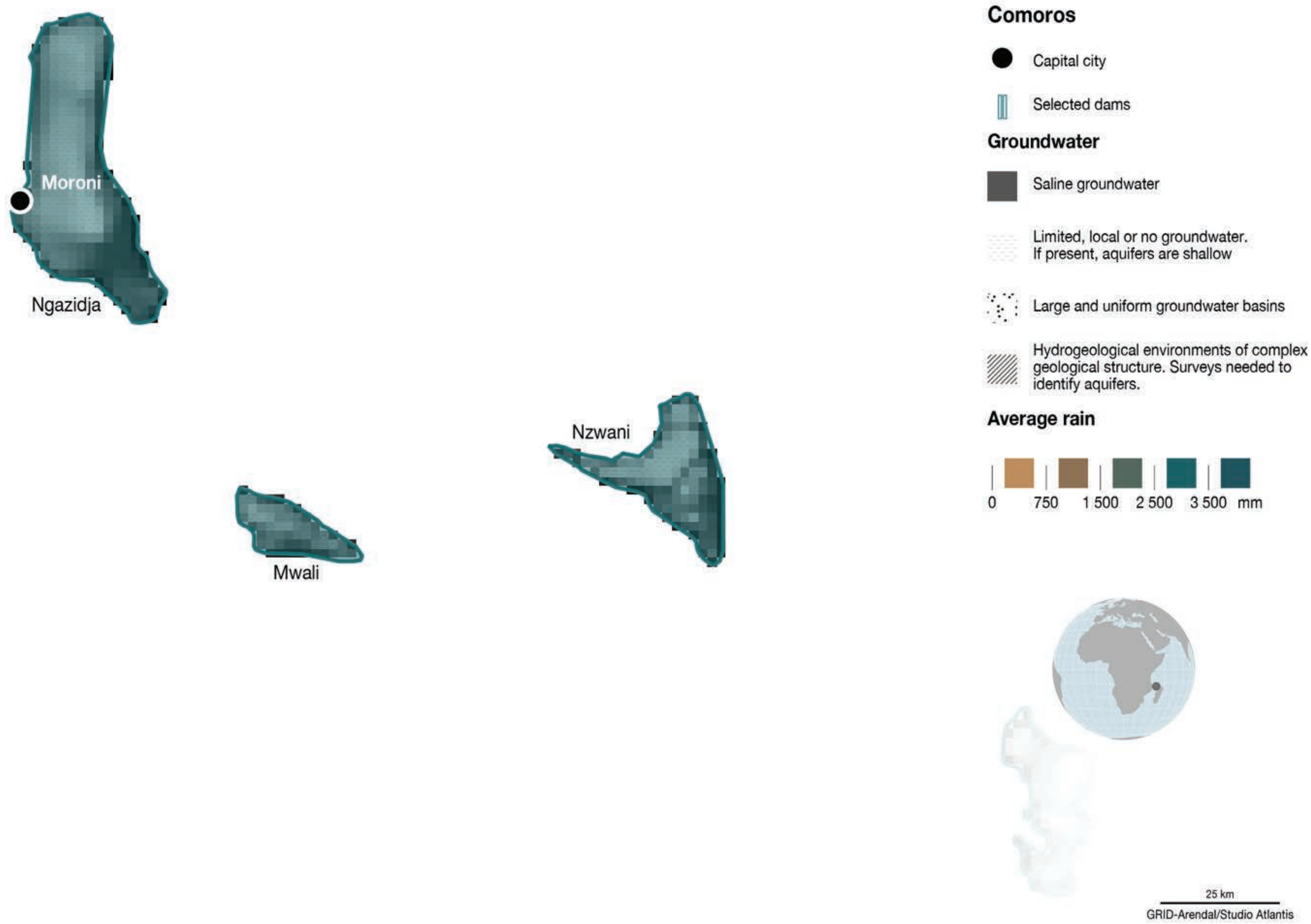


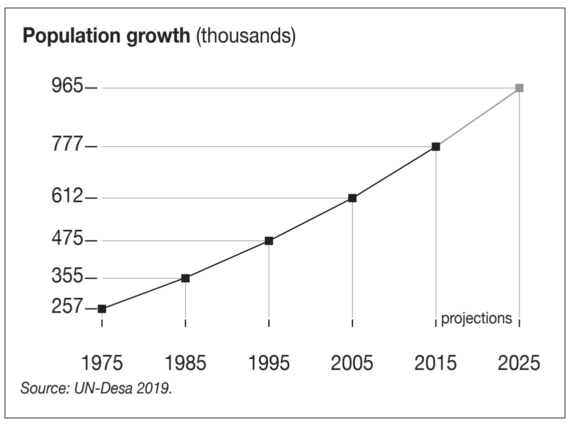
Source: AMCOW 2018.

Water availability

	m³/person and year
Total renewable freshwater	2 490
Total water withdrawal	14.2
Internal renewable water sources	1 410
of which are surface water	1 240
pressure on surface water	*0.31%*
of which are groundwater	170
pressure on groundwater	*4.44%*
Water stress	***0.60%***

Source: AMCOW 2018; FAO 2018.

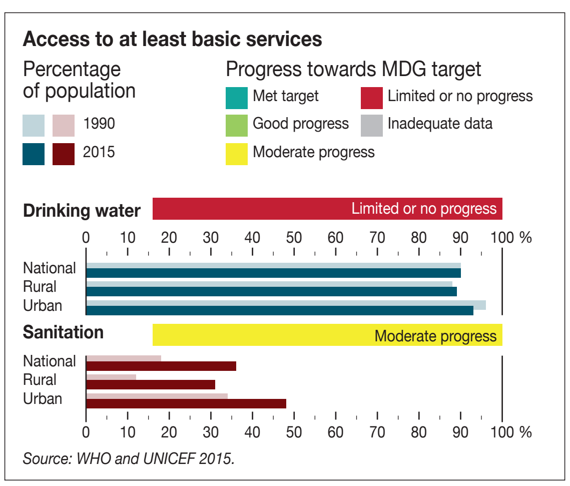




Wastewater management

There are no recent data regarding wastewater management.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	0.7	0.6	0.6	0.6
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		15.5 (2008)	15.6	15.6
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)	20.4			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.6
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				26.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Comorian Water and Electricity Corporation (MAMWE), responsible for managing water distribution
Environment for private sector participation	• No dedicated law • The National Investment Promotion Agency (NIPA) is the institution responsible
Legal, policy and strategy frameworks	
Current enabling policies	• National Environmental Policy adopted by the Decree of 31 December 1993 and the Environmental Action Plan (EAP) • National Water Supply Policy
Current enabling laws	• Framework Law No. 94-018 of 22 June 1994 on the Environment Code • Law No. 94-037 on the Water Code of 1994

Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

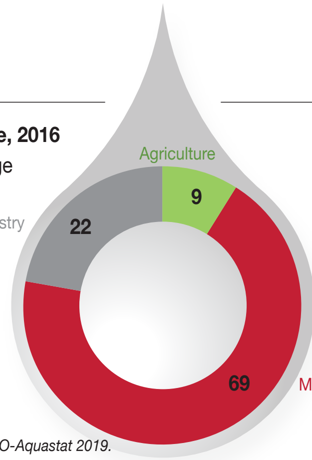
Congo

Water resources

Congo is a well-watered country with an annual rainfall of 1,646 mm (AMCOW 2018). The country has three basic climatic regions: equatorial in the north, humid and tropical in the south-west and subequatorial in the plateau and bowl regions (FAO 2016). Water availability is about 10.8 m^3/year per person with usage highest in the industrial sector (AMCOW 2018). Despite having extensive arable land, only 37.2 per cent of the population is employed in the agriculture sector, which contributed just 6.4 per cent to GDP in 2017 (World Bank 2018). This probably contributes to the low level of water usage in this sector.

The country's aqueduct water stress for all sectors measured in 2010 was 0.00 and is projected to remain the same by 2040 (Luo et al. 2015). This indicates that there is low competition among water users relative to available surface-water resources.

Water use, 2016
Percentage



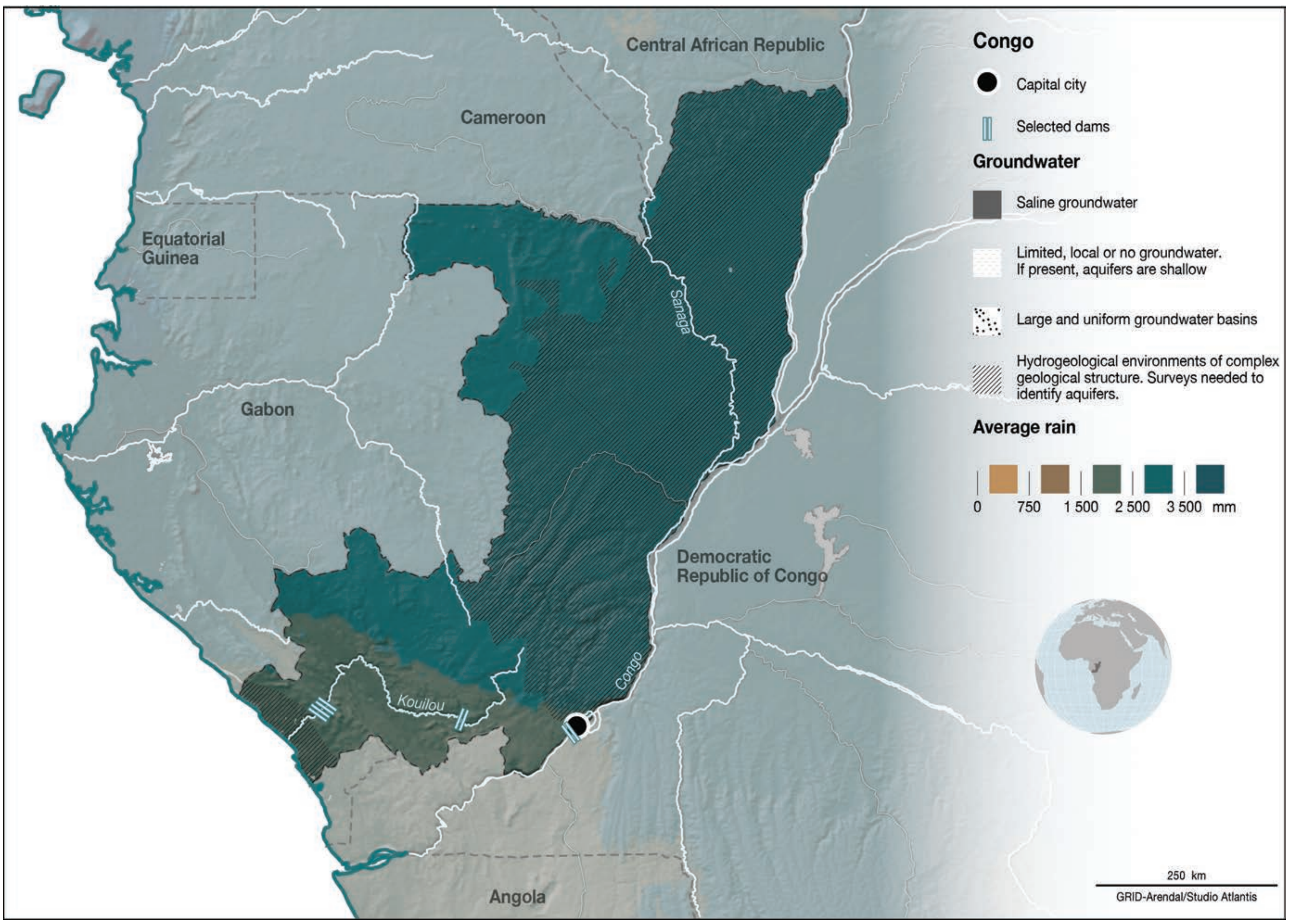
Source: FAO-Aquastat 2019.

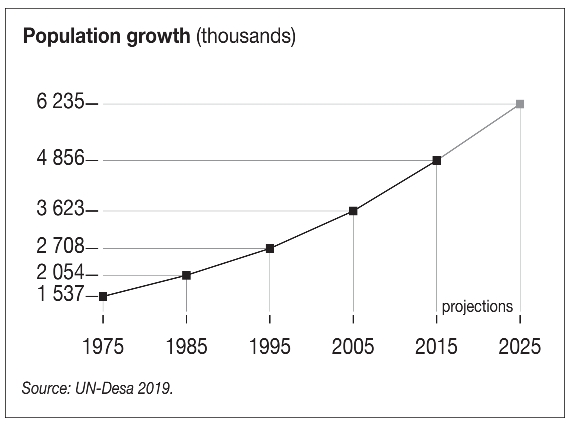
Water availability

	m^3/person and year
Total renewable freshwater	5 410
Total water withdrawal	89.3
Internal renewable water sources	1 060
of which are surface water	354
pressure on surface water	*8%*
of which are groundwater	751
pressure on groundwater	*7.65%*
Water stress	***1.70%***

Source: AMCOW 2018; FAO 2018.

Brazzaville

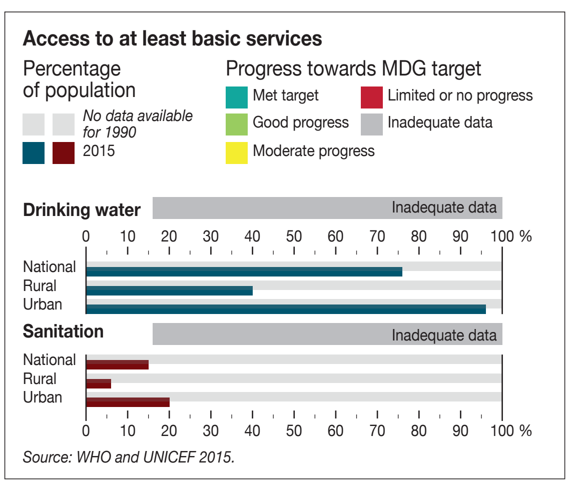




Wastewater management

There are no recent data regarding wastewater management.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)	29.9	31.6	34.5	37.0
Sanitation and hygiene	Proportion of population practising open defecation (%)	8.6	8.5	8.2	8.0
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)	97.9			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				1.7
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Mines, Energy and Hydraulics • Directorate-General of Hydraulics • Directorate of Water Resources Management
Presence of a functional water regulator	• Ministry of Mines, Energy and Hydraulics
Environment for private sector participation	• No dedicated public-private partnership unit • No dedicated public-private partnership law
Legal, policy and strategy frameworks	
Current enabling policies	• The national water policy is set out in the Law No. 13-2003 of 10 April 2003
Current enabling laws	• Law No. 13-2003 on the Water Code • Law No. 38-2008 establishing the National Agency for Rural Hydraulics • Decree No. 2017-253 of 17 July 2017 setting the terms for delegating the management of the public water service • Order No. 3135 MEH/CAB of 12 May 2009 defining the scope of operation of drinking water supply systems

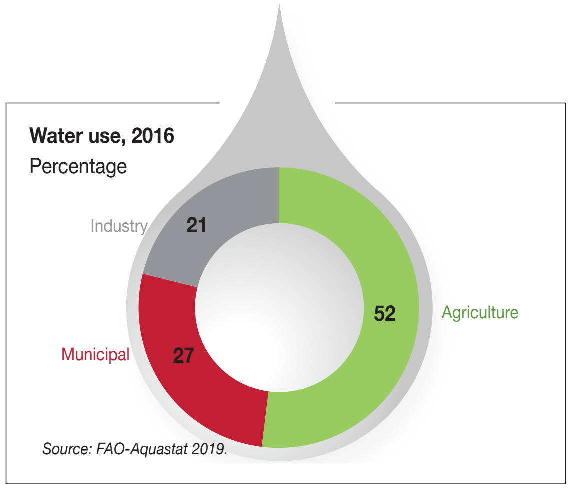
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Côte d'Ivoire

Water resources

Côte d'Ivoire has an average annual rainfall of 1,240 mm (AMCOW 2018). The country has three agroecological zones, with varying amounts of rainfall: in the north, the Sudanian zone receives 900–1,200 mm/year of rainfall, in the south, the Guinean zone receives more than 1,500 mm/year of rainfall, and in the centre, the Sudanian-Guinean zone receives 1,200–1,500 mm/year of rainfall (FAO 2016).

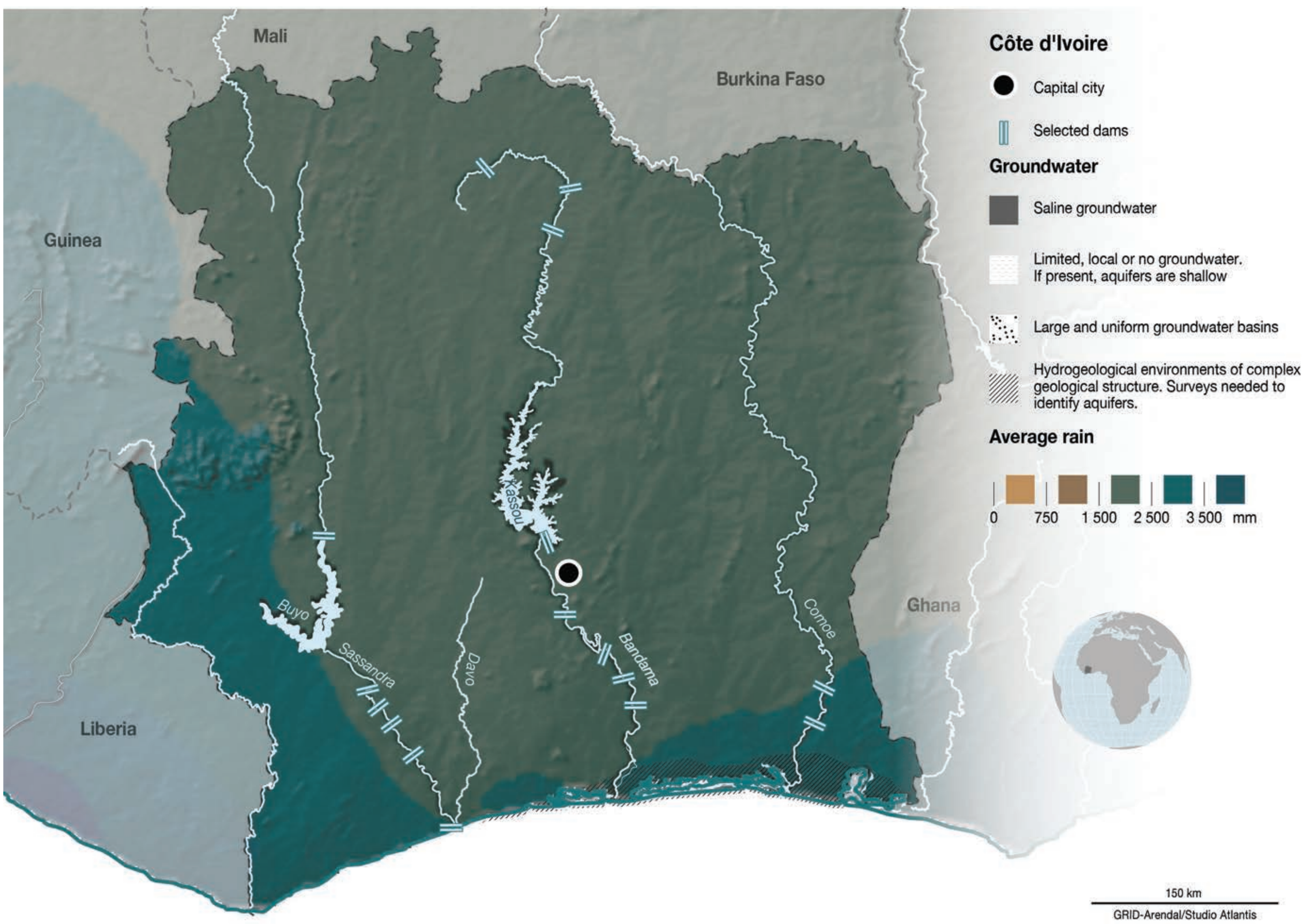
The country's aqueduct water stress for all sectors measured in 2010 was 0.00 and is projected to increase to 0.15 by 2040 (Luo et al. 2015). A score of 0.15 indicates that there is low competition among water users relative to available surface-water resources.

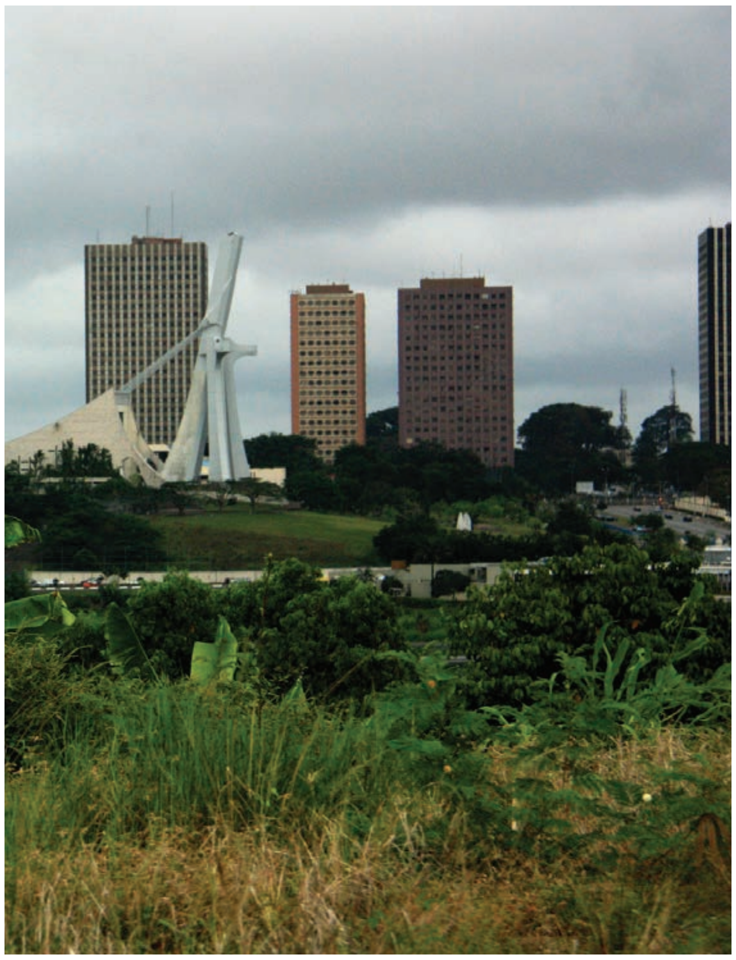


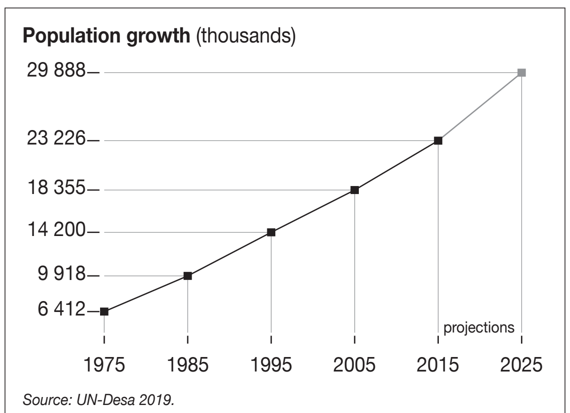
Water availability

	m³/person and year
Total renewable freshwater	476
Total water withdrawal	61.4
Internal renewable water sources	476
of which are surface water	476
pressure on surface water	*12.6%*
of which are groundwater	0
pressure on groundwater	*-*
Water stress	***12.90%***

Source: AMCOW 2018; FAO 2018.



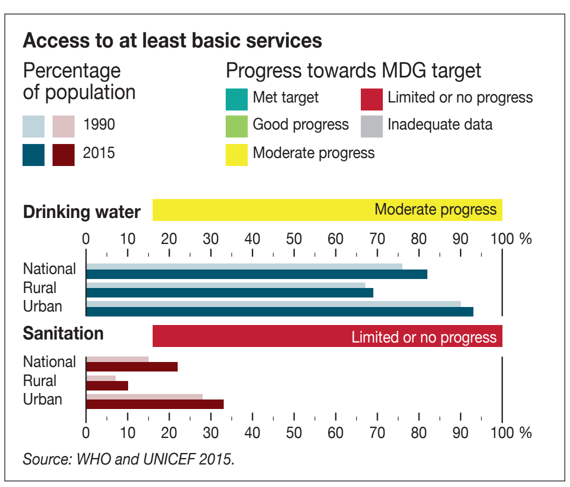




Wastewater management

There are no recent data regarding wastewater management. However, historical data show that only 100,000 m^3/year of municipal wastewater produced in 1994 was treated. The remaining wastewater is likely to have been collected through alternative sewerage systems, such as soak pits and septic tanks (FAO 2018). Data on the volume of treated wastewater is lacking.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)	36.4	39.7	42.9	45.8
Sanitation and hygiene	Proportion of population practising open defecation (%)	36.2	32.0	27.6	23.6
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		18.8 (2006)	19.4	20.0
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm^3)				16.1
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				12.9
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				32.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water and Forests • Ministry of Sanitation • Société de Distribution d'Eau de Côte d'Ivoire [Côte d'Ivoire Water Supply Company] (SODECI) • National Drinking Water Office (ONEP)
Environment for private sector participation	• Decree No. 2012-1151 of 19 December 2012 relating to public-private contracts (currently under revision)
Water pricing facility	• Decree fixing the water tariff for the 2003–2007 period • Order fixing the rate of the special tax on water consumption and respecting the manner of its recovery • Cross-subsidy through the water tariff policy • A fee for the Water Development Fund (FDE) and a surtax for the National Water Fund (FNH) finances investments and maintenance and also subsidizes new connections and the construction of new water plants
Legal, policy and strategy frameworks	
Current enabling policies	• National Sanitation Policy
Current enabling laws	• Law No. 98-755 of 23 December 1998 on the Water Code • Law No. 96-766 of 3 October 1996 on the Environmental Code • Decree No. 2006-274 of 23 August 2006 on the creation and organization of the State company, National Office of Drinking Water (ONEP) • Decree No. 2011-482 of 28 December 2011 on the establishment and organization of State corporation, the National Office of Sanitation and Drainage (NADO)

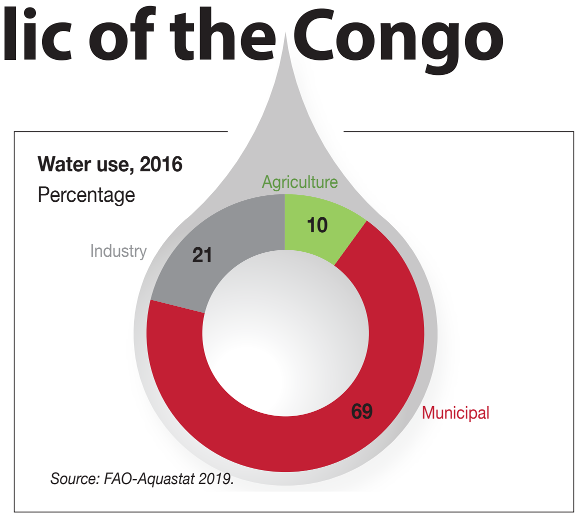
Sources: FAO 2016; World Bank 2018b; World Bank 2016c.

Democratic Republic of the Congo

Water resources

The Democratic Republic of the Congo has an average annual rainfall of 1,543 mm (AMCOW 2018). Rainfall is regular and plentiful, ranging from 800 to 1,800 mm across the country. The rainy season lasts eight months on average (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.00 and is projected to increase to 0.15 by 2040 (Luo et al. 2015). A score of 0.15 indicates that there is low competition among water users relative to available surface-water resources. Water use is low in the agriculture sector, and despite employing 81.9 per cent of the population in 2017, agriculture only contributed 19.9 per cent to the country's GDP (World Bank 2018).

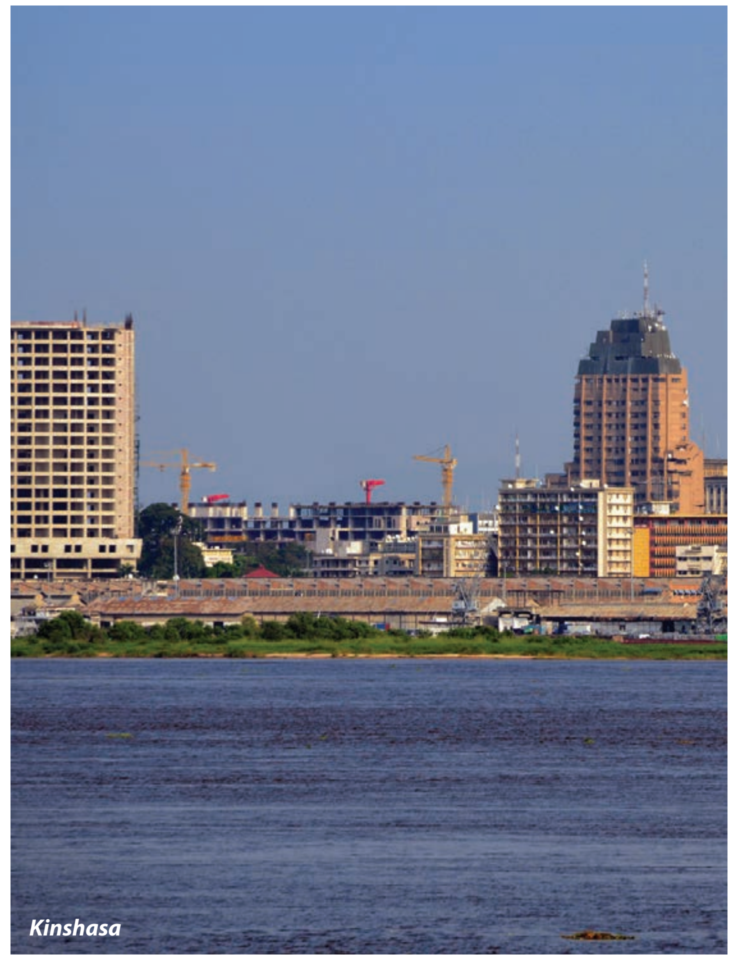


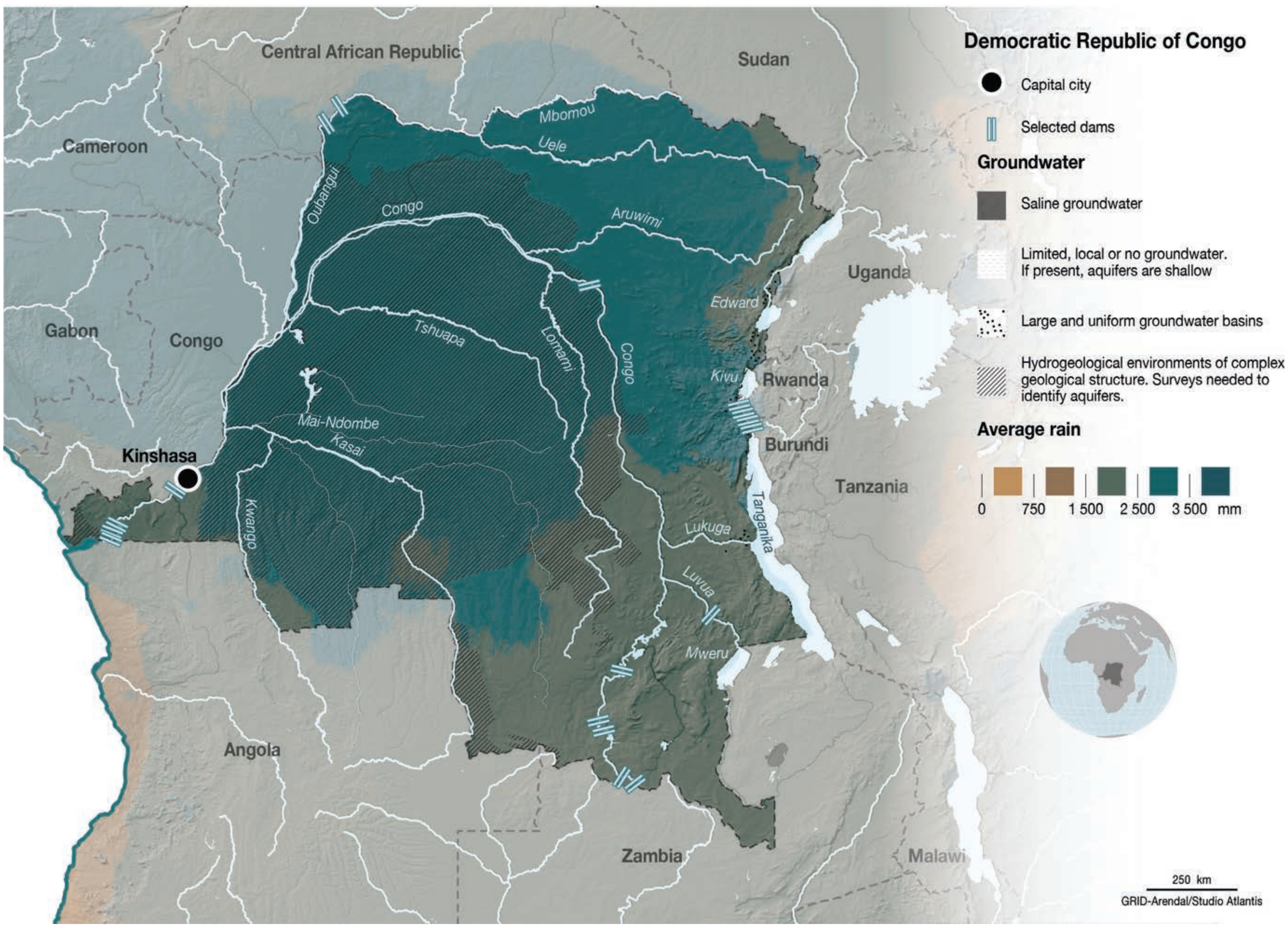
Source: FAO-Aquastat 2019.

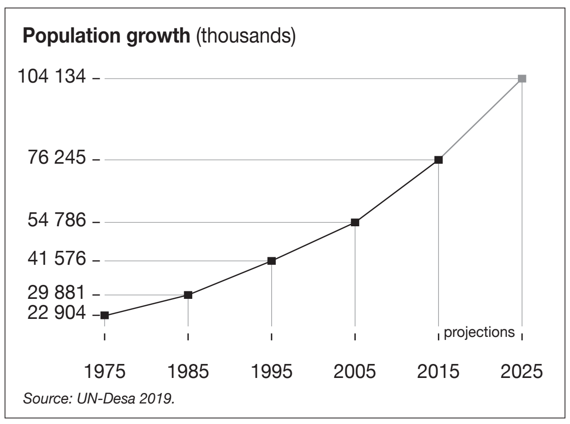
Water availability

	m³/person and year
Total renewable freshwater	11 600
Total water withdrawal	8.85
Internal renewable water sources	11 600
of which are surface water	11 600
pressure on surface water	*0.053%**
of which are groundwater	5 450
pressure on groundwater	*0.006%**
Water stress	***0.08%***

Source: AMCOW 2018; FAO 2018. * 2005



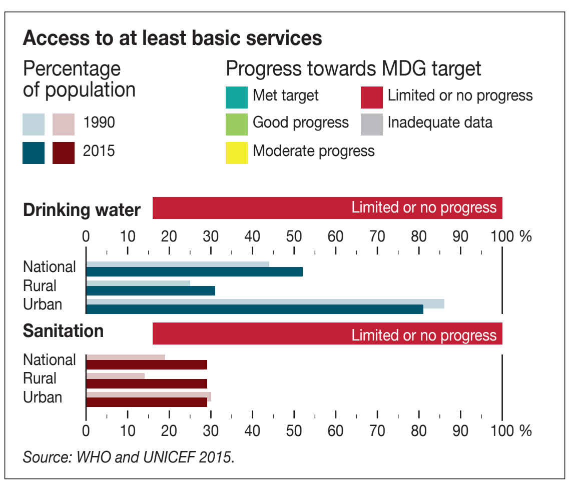




Wastewater management

Data on wastewater management are lacking.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	10.2	10.9	11.5	12.1
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		4.1	4.3	4.4
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)			23.8 (2005)	
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.08
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				31.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Environment, Nature Conservation and Tourism (MENCT) and its Water Resources Directorate • State Water Utility Company (REGIDESO) for urban areas • National Rural Waterworks Service (SNHR) for rural areas • National Sanitation Programme • Ministry of Energy
Presence of a functional water regulator	• National Water and Sanitation Committee (CNAEA) under the Ministry of Planning
Environment for private sector participation	• Law No. 14/005 on the tax system, customs, parafiscal, non-tax revenue and changes applicable to collaboration agreements and to cooperation projects (regulating public-private partnerships)
Water pricing facility	• REGIDESO's water tariff structure is under review
Legal, policy and strategy frameworks	
Current enabling policies	• Action plan for the further development of the drinking water sector by 2020
Current enabling laws	• Water Code, 2010 • Law No. 15/026 of 31 December 2015 on water • Ordinance No. 71-079 of 26 March 1971 defining State as regards rain- and wastewater • Ordinance No. 52-443 of 21 December 1952 on measures to protect springs, groundwater, lakes and rivers, to prevent water pollution and wastage and to control the exercise of user rights and conceded rights of occupancy

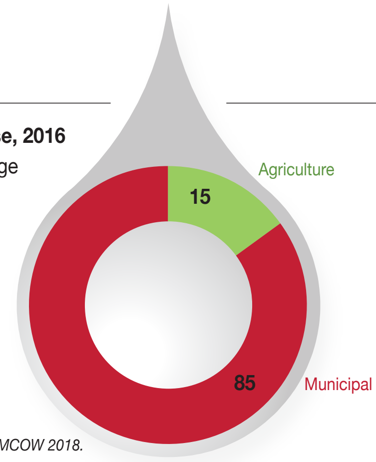
Sources: FAO 2016; UNEP 2011; World Bank 2018b; World Bank 2018c.

Djibouti

Water resources

Djibouti has an arid to semi-arid climate with an average annual rainfall of 220 mm (AMCOW 2018), and ranging between 80 and 340 mm from the northeast to the north of the country (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.12 and is projected to increase to 0.28 by 2040 (Luo et al. 2015). A score of 0.28 indicates that there is low competition among water users relative to available surface-water resources. The level of water stress for industrial water use was 1.17 in 2010, indicating low to medium water stress among users. The agriculture sector contribution contributed only 2.2 per cent to GDP in 2017 and employed 29.8 per cent of the population (World Bank 2018).



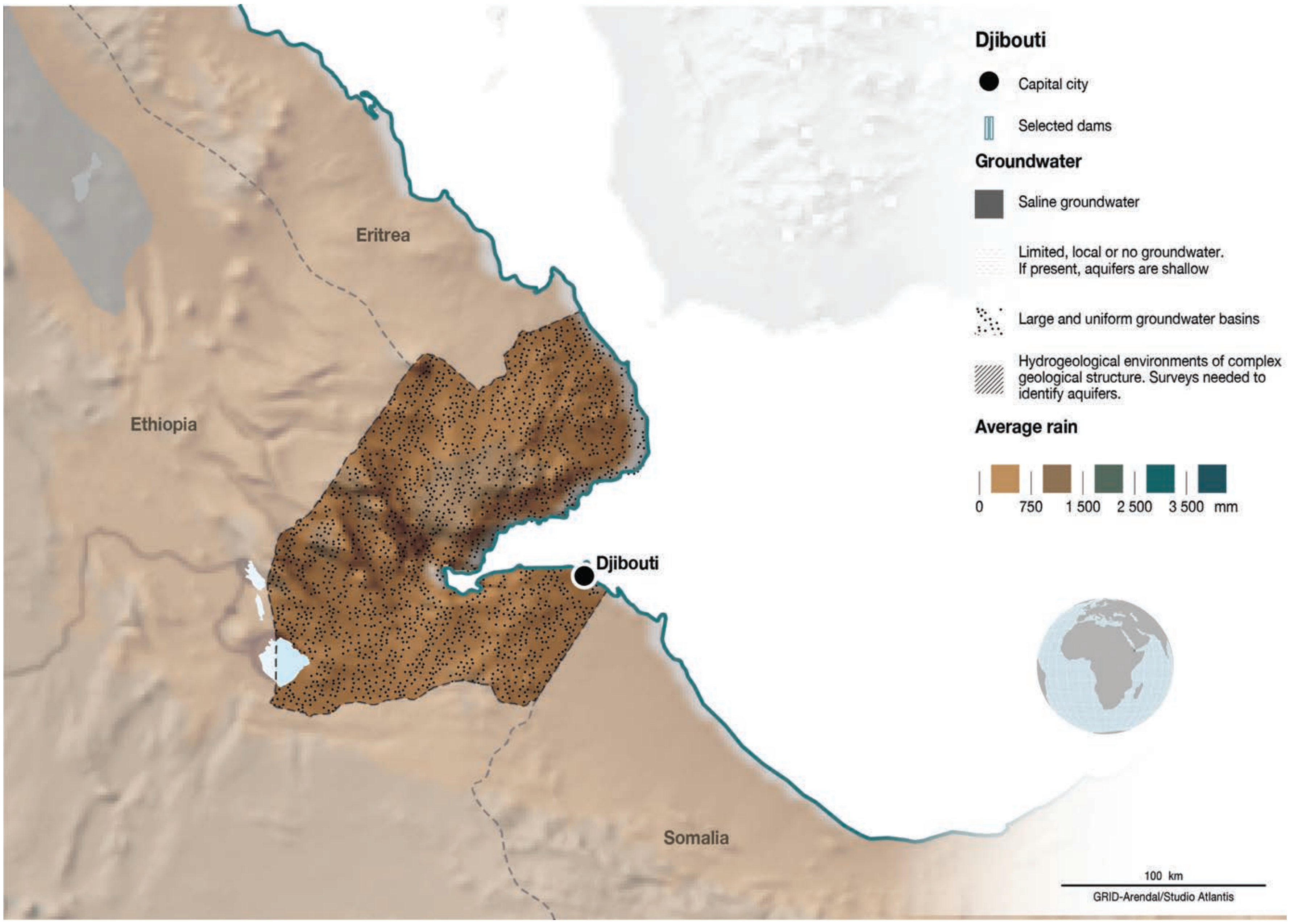
Source: AMCOW 2018.

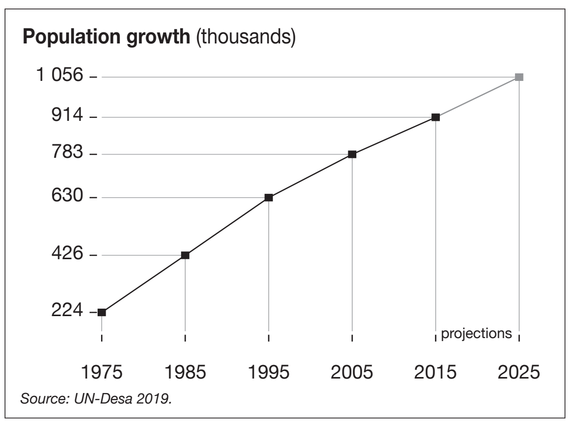
Water availability

	m³/person and year
Total renewable freshwater	338
Total water withdrawal	22.5
Internal renewable water sources	338
of which are surface water	338
pressure on surface water	*0.33%*
of which are groundwater	225
pressure on groundwater	*10%*
Water stress	***6.70%***

Source: AMCOW 2018; FAO 2018.

Djibouti

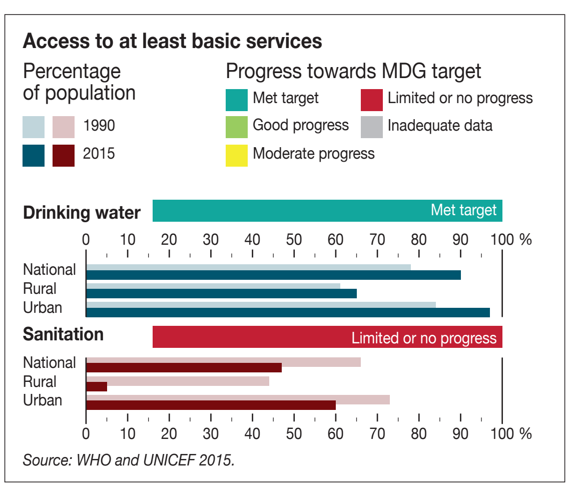




Wastewater management

There are no recent data regarding wastewater management. There are also no data for produced municipal wastewater. However, direct use of treated municipal wastewater in 2000 was 100,000 m^3/year (FAO 2018).

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	15.6	16.3	19.9	22.8
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/$cm^3$)				
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				6.7
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Djibouti National Office for Water and Sanitation (ONEAD) • National Water Resources Council (NECC) • Djibouti National Water Board (ONED), which manages hydraulic works supplying main urban areas • National Water, Hygiene and Sanitation Committee • National Fund for Water (FNE), 2001 • Djibouti Centre for Research and Studies (CERD)
Presence of a functional water regulator	• Ministry of Agriculture, Livestock and the Sea (MAEM), responsible for water resources
Environment for private sector participation	• No dedicated public-private partnership unit • No dedicated public-private partnership law
Water pricing facility	• Order No. 2001-0021/PR/MAEM of 8 January 2001 amending certain tariffs for the sale of water • Order No. 2007-0649/PR/MAEM of 10 June 2007 fixing the ONEAD tariffs for the sale of the water and the collection of liquid waste • Order No. 2014-738/PR/MAEPE-RH of 6 December 2014 fixing new ONEAD tariffs for the sale of the water and the collection of liquid waste
Legal, policy and strategy frameworks	
Current enabling policies	• Water Master Plan, 2000
Current enabling laws	• Law No. 145/AN/06/5th L establishing the Djibouti National Office for Water and Sanitation of June 2006 • Order No. 2008-0060/PR/MAEM of 20 January 2008 approving the terms of reference, the Water Supply Services Regulation, the ONEAD Sanitation Service Regulation • Decree No. 2001-0212/PR/MAEM establishing the National Water Fund (FNE) of November 2001 • Order No. 88-0066/PR/FIN establishing and attributing the National Water, Hygiene and Sanitation Committee of January 1988 • Decree No. 83-015/PR/MIDI on the statutes of the National Water Board (ONED) of February 1983 • Order No. 83-293 PRE MI approving the terms of reference and water regulations of February 1983

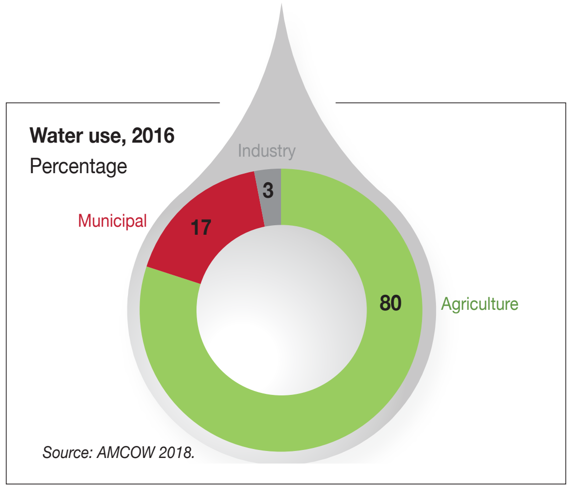
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Egypt

Water resources

Egypt's low annual rainfall of 15 mm is both irregular and unpredictable, since most of the country has a desert environment (AMCOW 2018; FAO 2016). Water availability highlights the importance of groundwater sources: internal renewable groundwater resources are estimated at 89.5 m^3/person/year compared with internal renewable surface-water resources, which are only 16.6 m^3/person/year (AMCOW 2018). Agriculture is the biggest water user by sector. Most (83 per cent) irrigated land obtains its water from surface-water flows (FAO 2018).

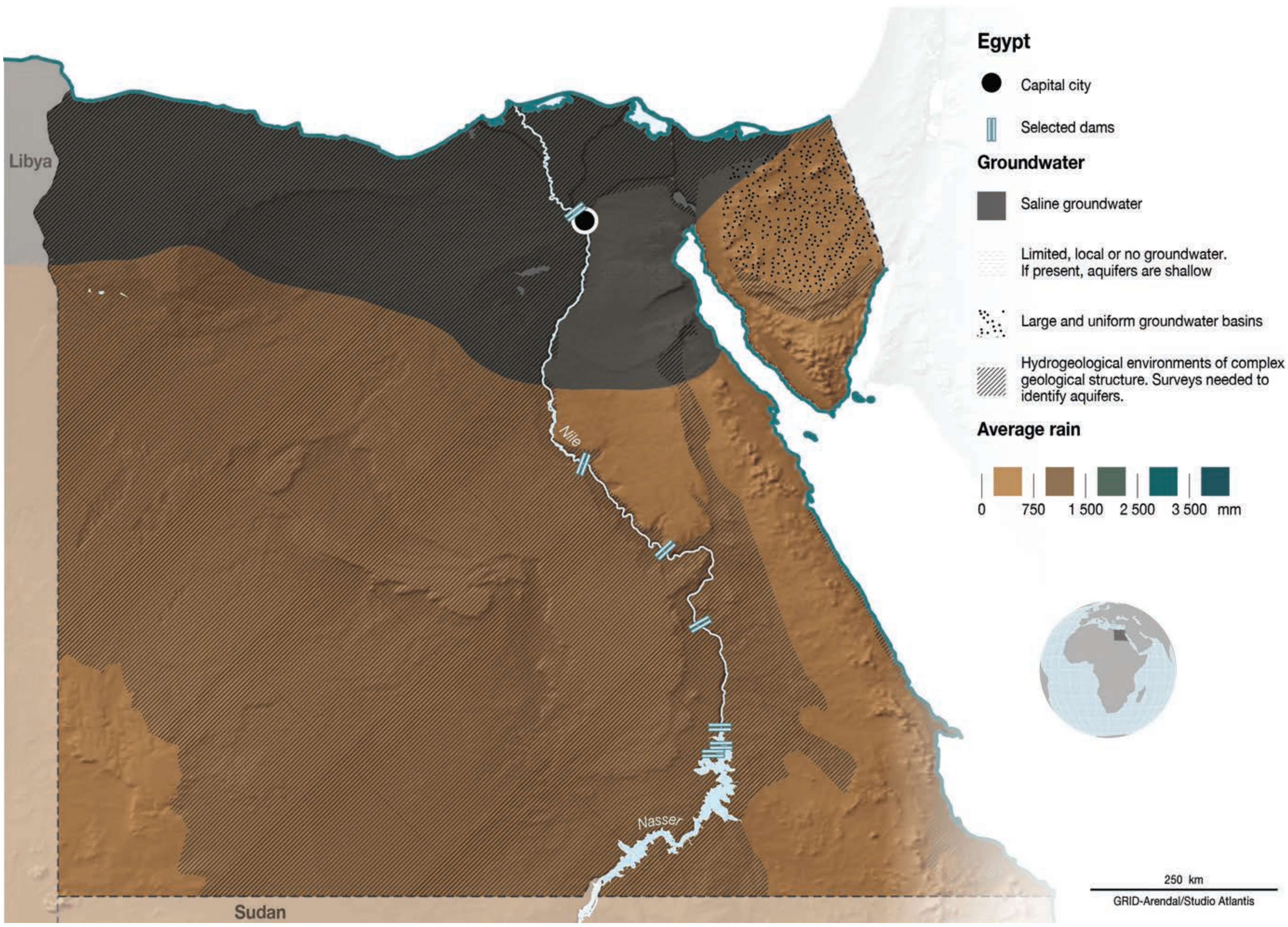
The country's aqueduct water stress for all sectors measured in 2010 was 1.19 and is projected to increase to 1.53 by 2040 (Luo et al. 2015). A score of 1.53 indicates that there is low to medium competition among water users relative to available surface-water resources. By 2040, water stress from industrial and domestic users is expected to rise from 1.19 to 2.07 and 2.25 respectively, indicating medium to high water stress among users (Luo et al. 2015).

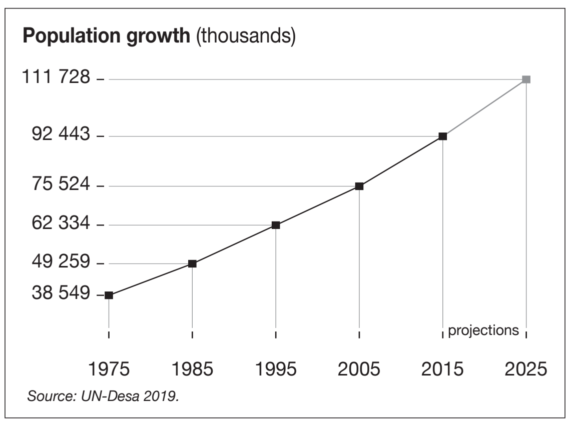


Water availability

	m^3/person and year
Total renewable freshwater	630
Total water withdrawal	652
Internal renewable water sources	106
of which are surface water	16.6
pressure on surface water	*3 700%*
of which are groundwater	89.5
pressure on groundwater	*105%*
Water stress	***103.5%***

Source: AMCOW 2018; FAO 2018 .

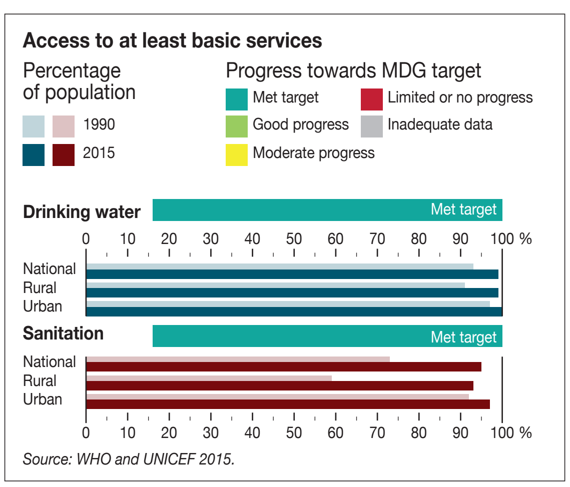




Wastewater management

Data available show that the volume of wastewater effluent from urban areas (produced municipal wastewater) was 7.078 million m^3/year in 2012. The amount collected by wastewater sewers and other formal wastewater collection systems within the municipalities in the same year was 6.497 million m^3/year, though only 4.013 million m^3/year was treated and released by the various municipal wastewater treatment facilities. In 2014, 382 treatment plants were operating with a capacity of 4.745 million m^3/year of treated wastewater (FAO 2018).

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	1.8	1.1	0.5	0.1
	Proportion of population using safely managed sanitation services (%)	52.7	55.4	57.9	60.6
	Proportion of population with basic handwashing facilities on premises (%)	66.0	73.5	80.9	88.3
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				57.6 (2018)
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm^3)				4.6
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				103.5
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				40.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Egyptian Environmental Affairs Agency (EEAA) • Ministry of Water Supply and Sanitation Facilities, created in 2012 • Holding Company for Water and Wastewater, 2004
Presence of a functional water regulator	• Egyptian Water Regulatory Agency (EWRA), 2006
Environment for private sector participation	• Egypt Public Private Partnership Law No. 67 of 2010 • Supreme Committee for Public Private Partnership Affairs • Public Private Partnership Central Unit (PPPCU), Ministry of Finance • Public-private partnership satellite units within the administrative authorities, whenever necessary • Concession Law No. 67 of 2010 on partnerships with the private sector in infrastructure projects, services and public utilities
Water pricing facility	• Residential Water tariff increases require approval by the Holding Company for Water and Wastewater, the EWRA, the Ministry of Water Supply and Sanitation Facilities, the Cabinet of Ministers, the President and the National Assembly. The most recent increase was in 2017.
Legal, policy and strategy frameworks	
Current enabling policies	• National Water Resources Plan, 2017 • Water and Wastewater Sector Policy Paper, September 2010
Current enabling laws	• Law No. 27 of 1978 on the organization of public sources of potable water and water for human use • Presidential Decree No. 178 of 2012 concerning the organization of the Ministry of Drinking Water and Sanitation • Ministerial Decree No. 219 of 2010 on the exploitation of water sewage • Resolution No. 458 of 2007 defining maximum limits for criteria and requirements necessary for drinking water and domestic use • Resolution No. 331 of 2007 adopting the Egyptian Code for drinking water and sewage water

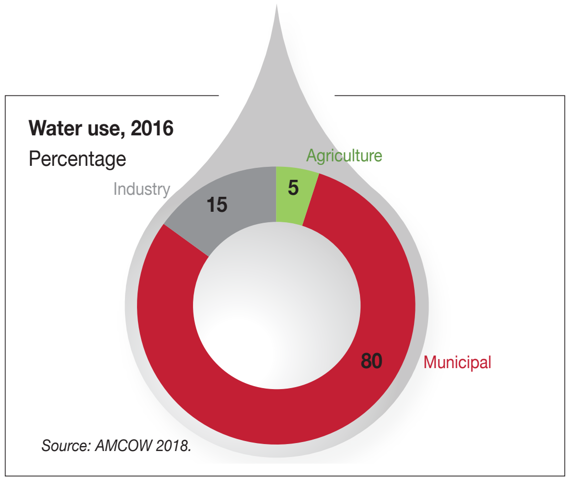
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Equatorial Guinea

Water resources

Equatorial Guinea is a small island nation with an annual rainfall of 2,156 mm, although some areas receive as much as 14,000 mm (AMCOW 2018; FAO 2016).

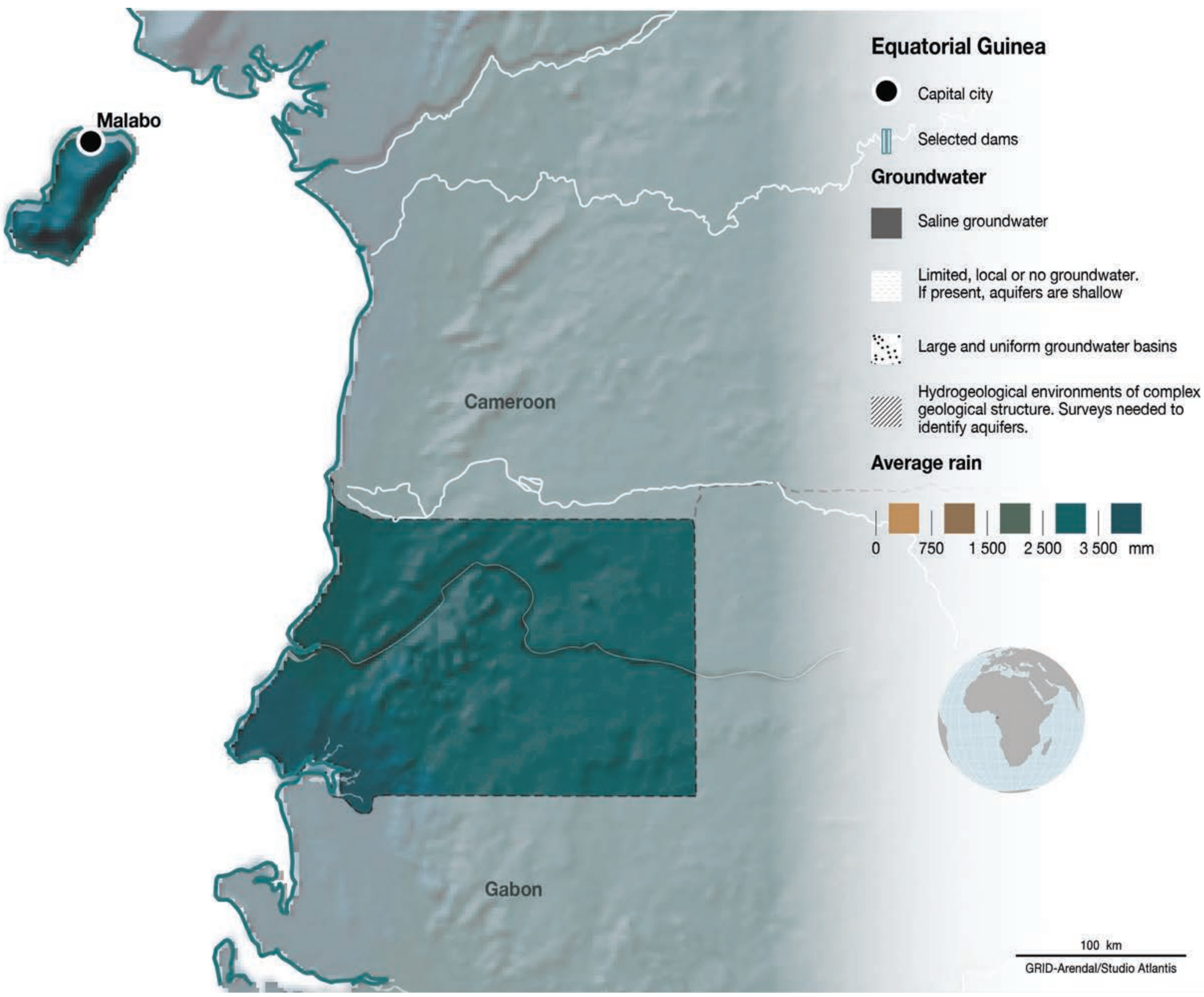
The country's aqueduct water stress for all sectors measured in 2010 was 0.00 and there is not expected to be any change by 2040 (Luo et al. 2015). A score of zero indicates that there is low competition among water users relative to available surface-water resources. Water withdrawals for agriculture account for only 5 per cent of total withdrawals. The agriculture sector contributed only 2.3 per cent to GDP and employed 59.5 per cent of the population (AMCOW 2018; World Bank 2018).

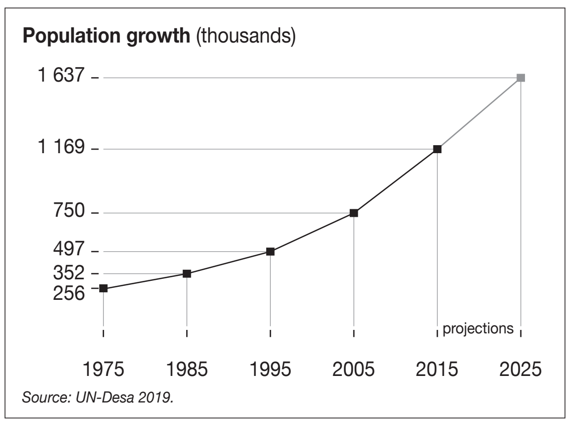


Water availability

	m³/person and year
Total renewable freshwater	30 800
Total water withdrawal	27.3
Internal renewable water sources	30 800
of which are surface water	29 600
pressure on surface water	*no data available*
of which are groundwater	11 800
pressure on groundwater	*no data available*
Water stress	***0.09%***

Source: AMCOW 2018; FAO 2018.

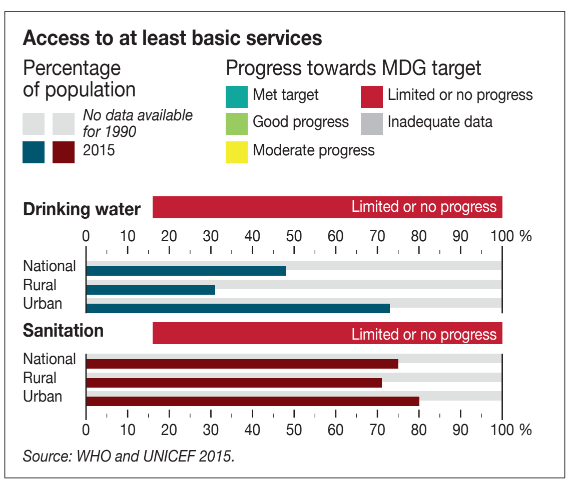




Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)		4.4 (2007)	4.4	4.4
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		22.6 (2007)	22.7	22.7
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)	337.8			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.09
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				24.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Agriculture and Rural Development, responsible for studies of drinking water supply in rural areas • Ministry of Infrastructure and Forests
Legal, policy and strategy frameworks	
Current enabling policies	
Current enabling laws	• Decree No. 9/1991 of 17 December 1991, which led to the adoption of the national report on environment and development • Law No. 3/2007 on water and coasts in the Republic of Equatorial Guinea

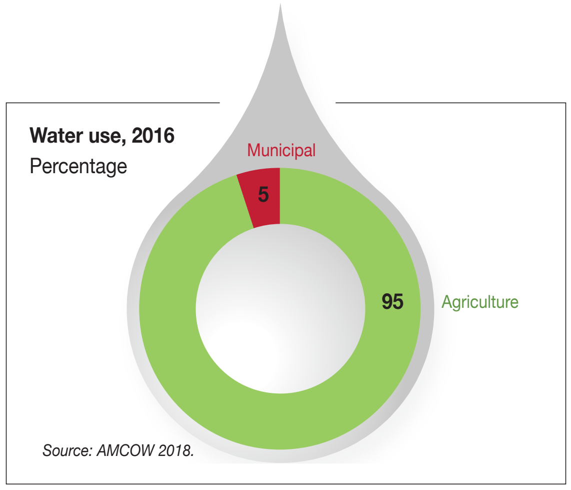
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Eritrea

Water resources

Eritrea is located in the Sahelian rainfall zone on the eastern coast of Africa. Average rainfall is 384 mm/year, and ranges from 50 to 1,000 mm (AMCOW 2018; FAO 2016).

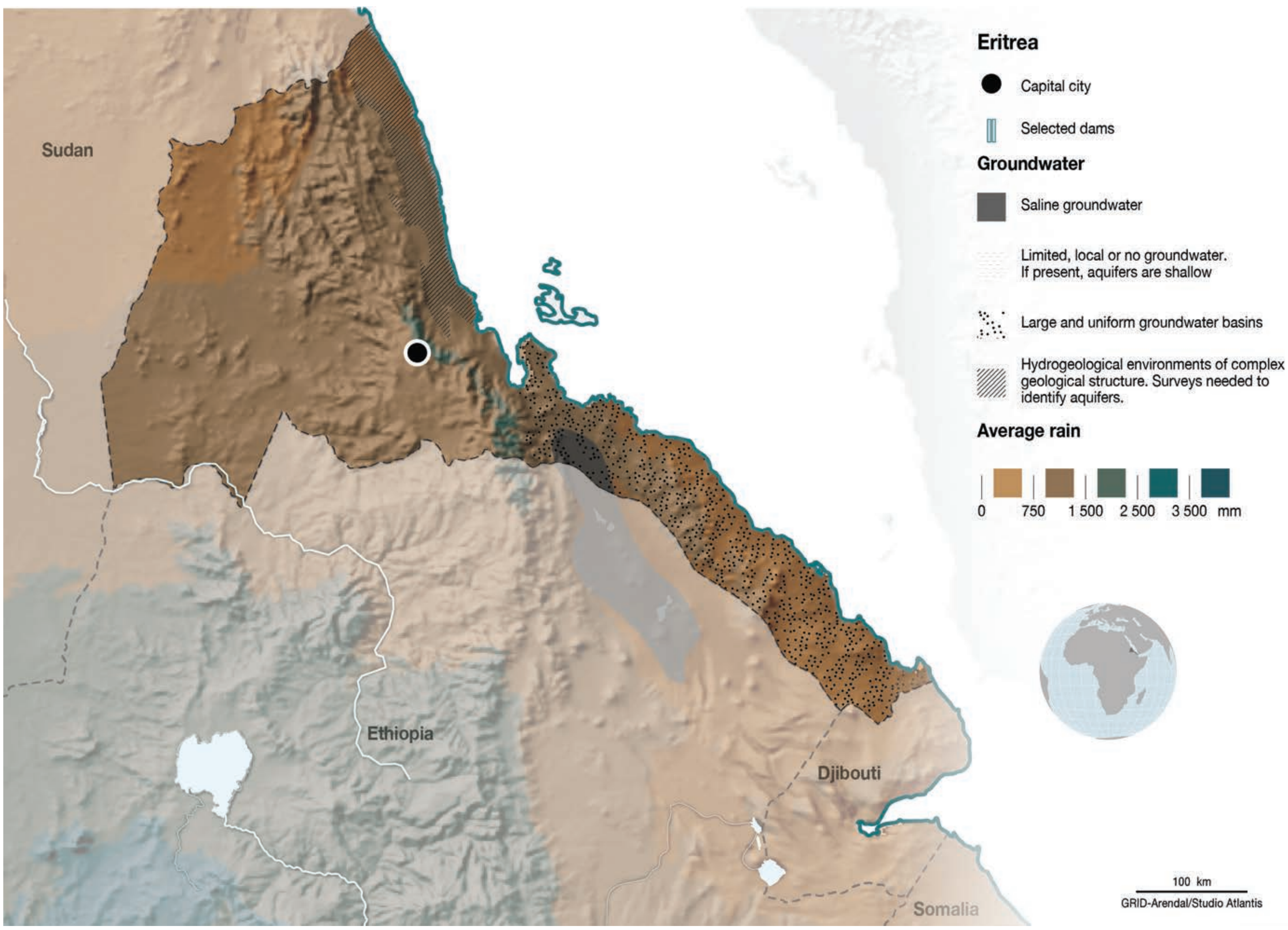
The country's aqueduct water stress for all sectors measured in 2010 was 3.34 and is projected to decrease to 3.00 by 2040 (Luo et al. 2015). A score of 3.00 indicates that there is high competition among water users relative to available surface-water resources. Eritrea is one of the few countries where water stress is expected to decrease according to the Luo, Young and Reig index. This may be due to improvements in water resources management and the implementation of water conservation strategies. In 2016, water withdrawals for agriculture accounted for 94.8 per cent of total water withdrawals (AMCOW 2018). Agriculture is an important sector in the country, employing over 80 per cent of the population (World Bank 2018).

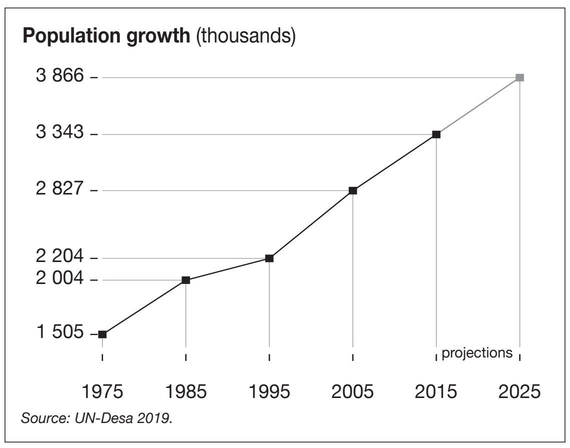


Water availability

	m³/person and year
Total renewable freshwater	1 370
Total water withdrawal	108
Internal renewable water sources	523
of which are surface water	504
pressure on surface water	*no data available*
of which are groundwater	93.4
pressure on groundwater	*no data available*
Water stress	***7.90%***

Source: AMCOW 2018; FAO 2018.

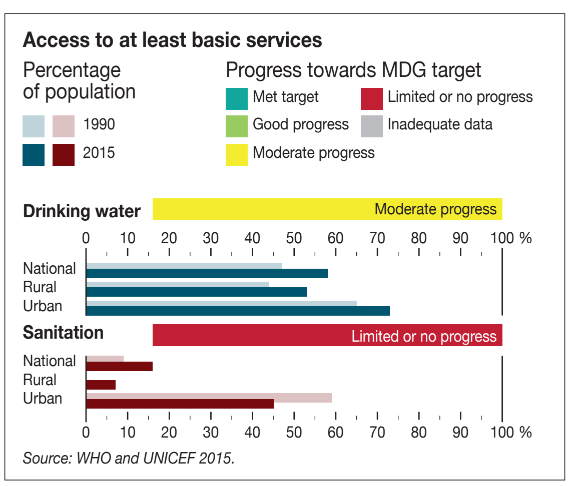




Wastewater management

Recent data on wastewater management are lacking. Available data show that 18 million m³ of municipal wastewater was produced in 2000 (FAO 2018).

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	87.8	83.3	78.6	76.0
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)		4.7		
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				7.9
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Land, Water and Environment • Ministry of Health (drinking water supply)
Presence of a functional water regulator	• Ministry of Land, Water and Environment
Environment for private sector participation	• No public-private partnership unit • No public-private partnership law
Water pricing facility	• Eritrean Water Proclamation No. 162/2010 in article 19
Legal, policy and strategy frameworks	
Current enabling policies	• Draft National Water Policy Framework, 1997 • Action Plan for Integrated Water Resource Management (IWRM) in Eritrea, 2008 • Draft strategy document on rural water supply and sanitation, 2000
Current enabling laws	• Eritrean Water Proclamation No. 162/2010 • Water Commission Proclamation • Draft Waste Water Permits Regulations • Draft Water Use Permits Regulations

Sources: FAO 2016; Habtezion 2011; World Bank 2018b; World Bank 2018c.

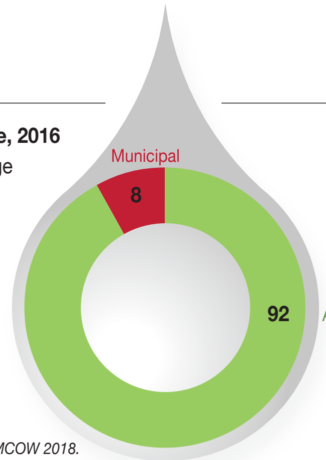
Ethiopia

Water resources

Ethiopia has an annual rainfall of 848 mm, ranging from 100 mm/year in the Afar lowlands in the northeast to 2,000 mm/year in certain areas in the southwest (AMCOW 2018; FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.81 and is projected to decrease to 0.66 by 2040 (Luo et al. 2015). A score of 0.66 indicates that there is low competition among water users relative to available surface-water resources. Ethiopia is one of few countries where water stress is expected to decrease according to the Luo, Young and Reig index. This may be due to improvements in water resources management, increased water storage, and the implementation of water conservation strategies. In 2016, water withdrawals for agriculture accounted for 91.8 per cent of total water withdrawals (AMCOW 2018).

Water use, 2016
Percentage

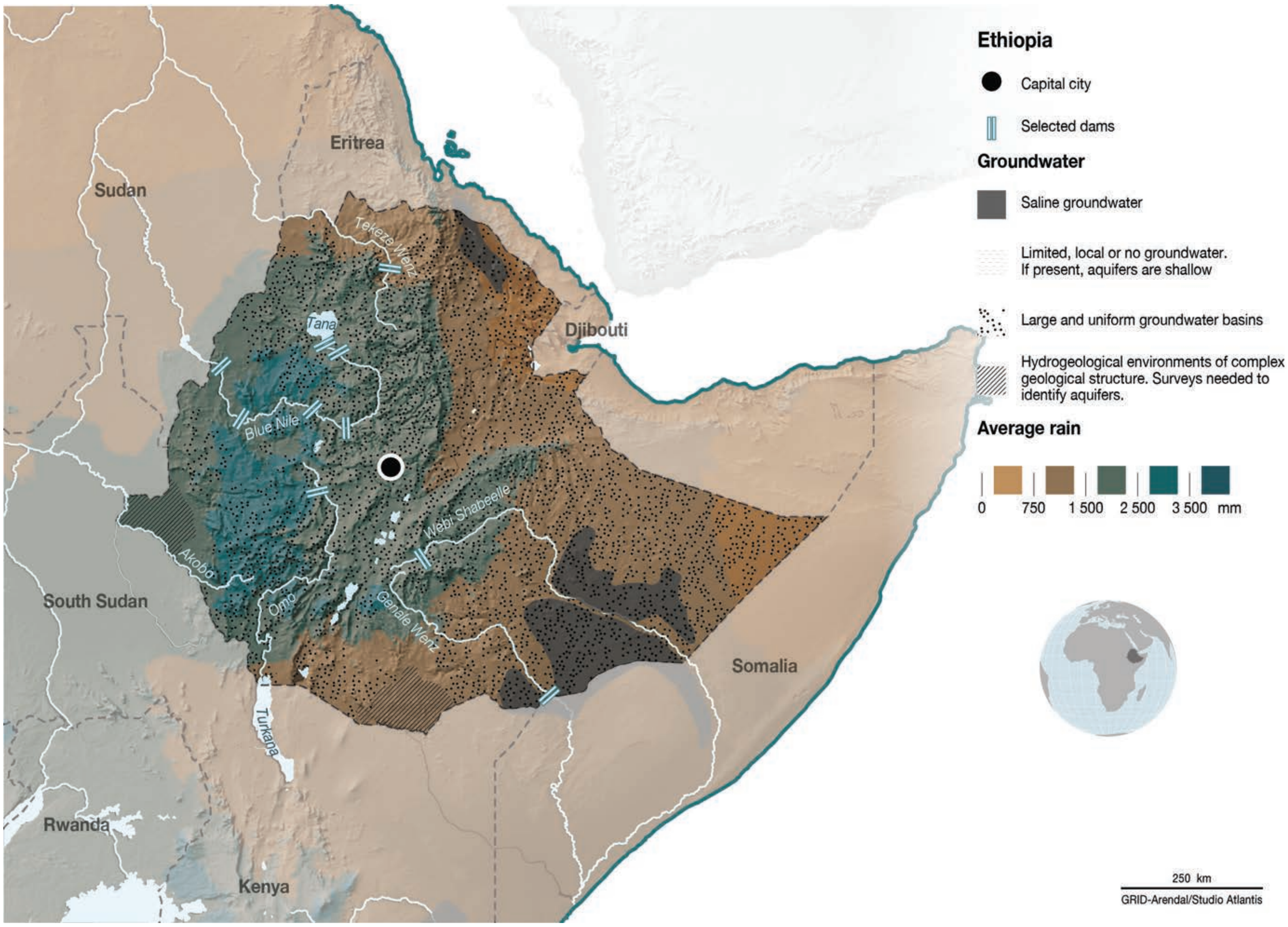


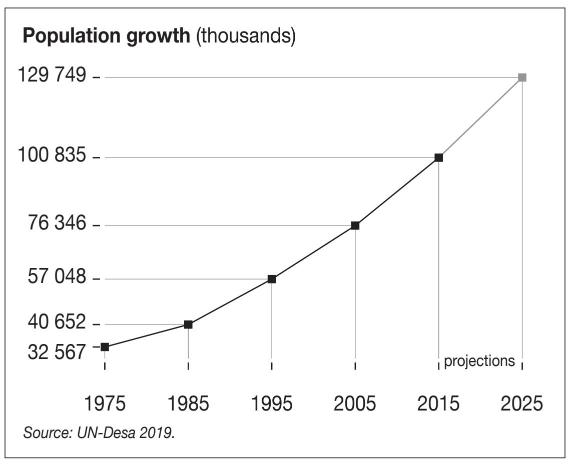
Source: AMCOW 2018.

Water availability

	m³/person and year
Total renewable freshwater	1 230
Total water withdrawal	106
Internal renewable water sources	1 230
of which are surface water	1 210
pressure on surface water	*no data available*
of which are groundwater	201
pressure on groundwater	*no data available*
Water stress	***8.6%***

Source: AMCOW 2018; FAO 2018.

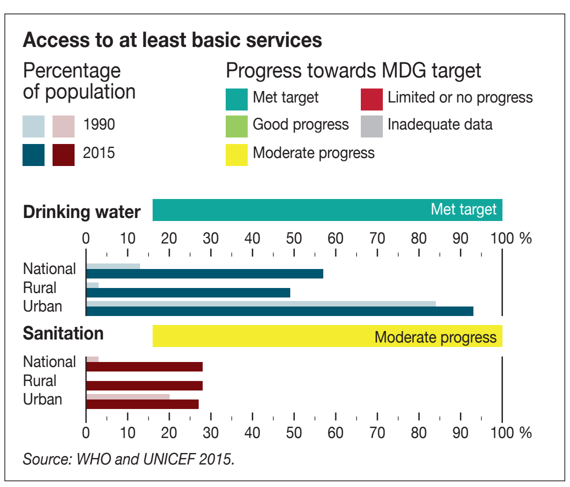




Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)	4.7	6.1	7.9	10.5
Sanitation and hygiene	Proportion of population practising open defecation (%)	79.8	62.1	44.5	27.1
	Proportion of population using safely managed sanitation services (%)	1.0	1.9	2.8	3.7
	Proportion of population with basic handwashing facilities on premises (%)			0.9 (2007)	1.0 (2008)
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)				2.0
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				8.6
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				31.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water and Energy (MWE)
Environment for private sector participation	• No dedicated public-private partnership law • There is no dedicated public-private partnership unit – public-private partnerships are governed by relevant line ministries
Water pricing facility	• National Guideline for Urban Water Utilities Tariff Setting
Legal, policy and strategy frameworks	
Current enabling policies	• Universal Access Plan (UAP), 2006 • National Hygiene and Sanitation Strategy • Water Sector Development Programme (2002–2016) • Water Resources Management Policy 2000 (No. 197) • Ethiopian Water Strategy 2001 • Water Resources Development Fund (WRDF)
Current enabling laws	• Ethiopian Water Resources Management Proclamation (No. 197/2000) • Water Supply and Sewerage Authority Establishment Proclamation No. 219/1981 • Water Resources Development Fund Establishment and its Administration Proclamation (No. 268 of 2002) • Ethiopian Water Technology Institute Establishment Council of Ministers Regulation No. 293/2013 • Municipal Public Health Rules 1950 issued with regard to water (10/1, 1950) • Revised Urban and Rural Potable Water Supply and Sewerage Services' Reorganizing Proclamation Implementation, Council of Regional Government Regulation (No. 94/2012) • Amhara National Regional State Urban and Rural Drinking Water Supply and Sewerage Services Organizing Proclamation Executive Council of Regional Government Regulation (No. 34/2005)

Sources: FAO 2016; World Bank 2018b; World Bank 2018c; Ministry of Water and Energy (MWE) 2013.

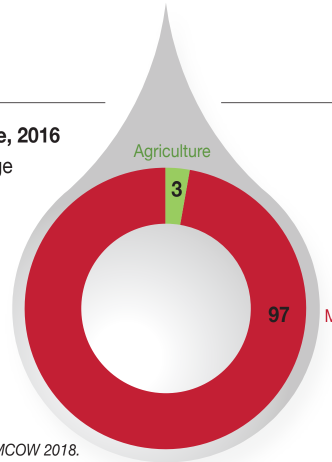
Gabon

Water resources

Located in Central Africa, Gabon has a dense hydrographic system with permanent rivers. Average rainfall is 1,800 mm/year (AMCOW 2018), ranging from 1,400 to 3,800 mm/year across the country (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was zero and is projected to remain the same by 2040 (Luo et al. 2015). This score indicates that there is low competition among water users relative to available surface-water resources. In 2016, water withdrawals by the municipal sector accounted for 96.6 per cent of total withdrawals. The oil sector accounts for 80 per cent of exports, which could explain the very low proportions of water used by the agriculture and industrial sectors (World Bank 2019).

Water use, 2016
Percentage



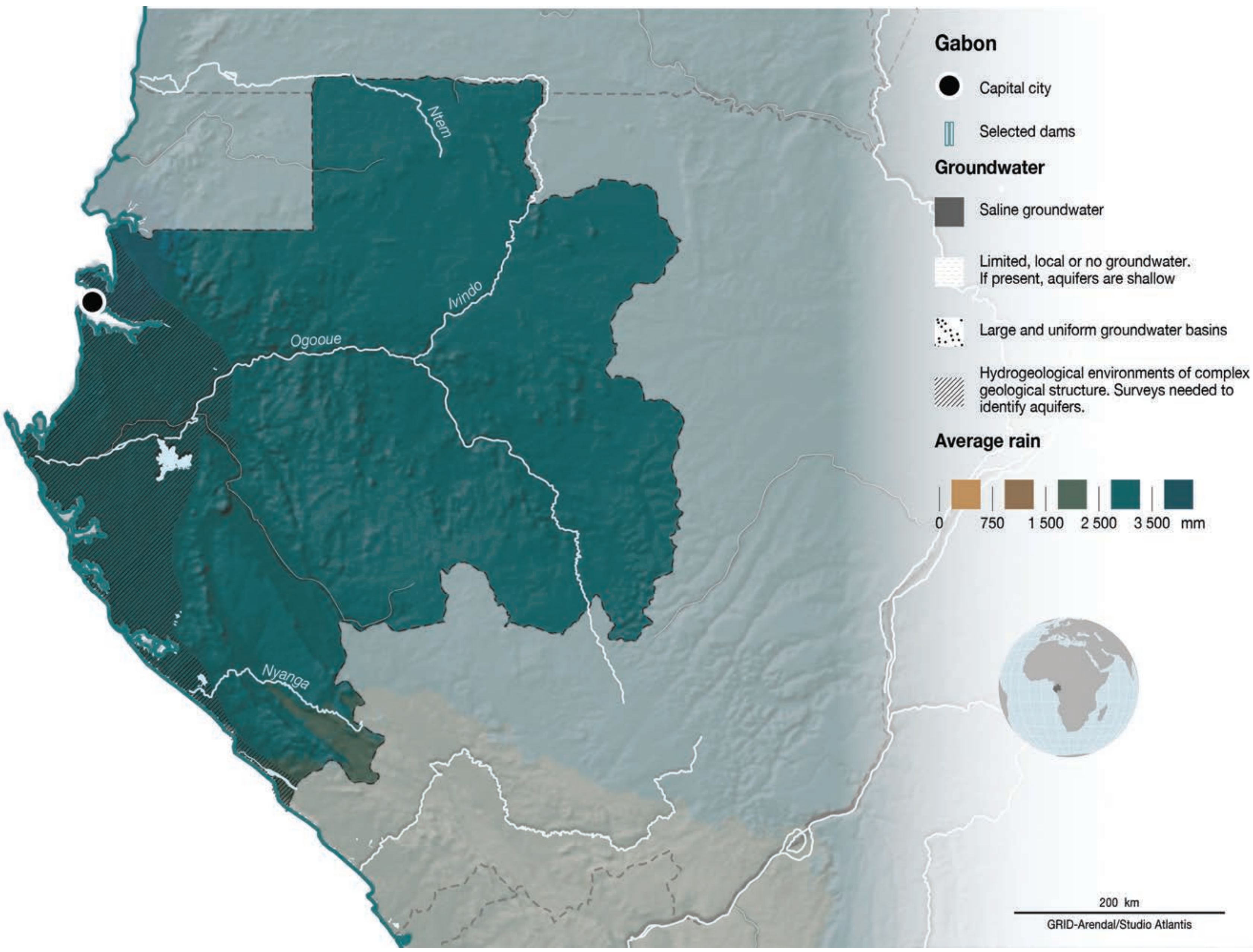
Source: AMCOW 2018.

Water availability

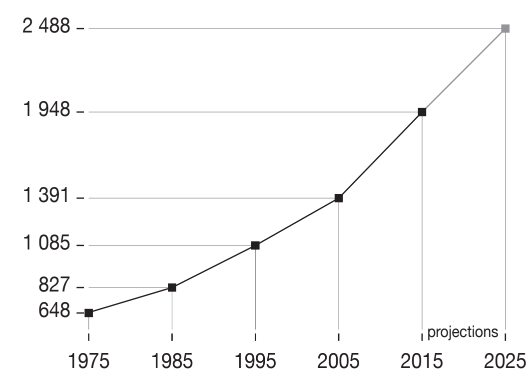
	m³/person and year
Total renewable freshwater	91 700
Total water withdrawal	801
Internal renewable water sources	48 100
of which are surface water	89 500
pressure on surface water	*0.62%*
of which are groundwater	34 200
pressure on groundwater	*0.65%*
Water stress	***0.90%***

Source: AMCOW 2018; FAO 2018.

Libreville



Population growth (thousands)

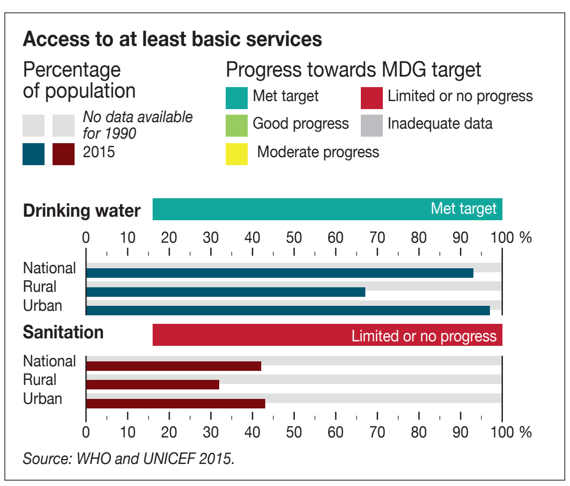


Source: UN-Desa 2019.

Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	1.7	2.2	2.6	3.0
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm^3)		70.1		
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.9
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				14.0

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Agriculture, Livestock and Rural Development • Ministry of the Forest Economy, Water and Fishing • Ministry of Mining, Energy, Oil and Water Resources • Société d'Energie et d'Eau du Gabon [Energy and Water Company of Gabon] (SEEG) • Heritage Company of Public Services, Drinking Water, Energy and Sanitation
Environment for private sector participation	• There is no dedicated public-private partnerships unit
Legal, policy and strategy frameworks	
Current enabling policies	
Current enabling laws	• Law No. 007/2014 on the protection of the environment

Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

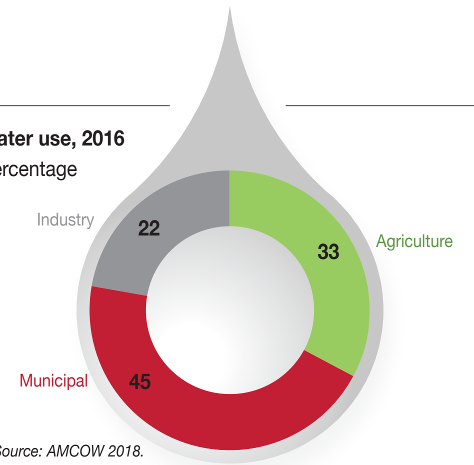
Gambia

Water resources

Gambia is located on the west coast of Africa and has an average rainfall of 991 mm/year (AMCOW 2018). Rainfall varies from about 1,000mm/year in the south to less than 800 mm/year in the north (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.54 and is projected to increase to 0.85 by 2040 (Luo et al. 2015). A score of 0.85 indicates that there is low competition among water users relative to available surface-water resources. Gambia's industrial sector has the lowest proportion of water withdrawals.

Water use, 2016
Percentage



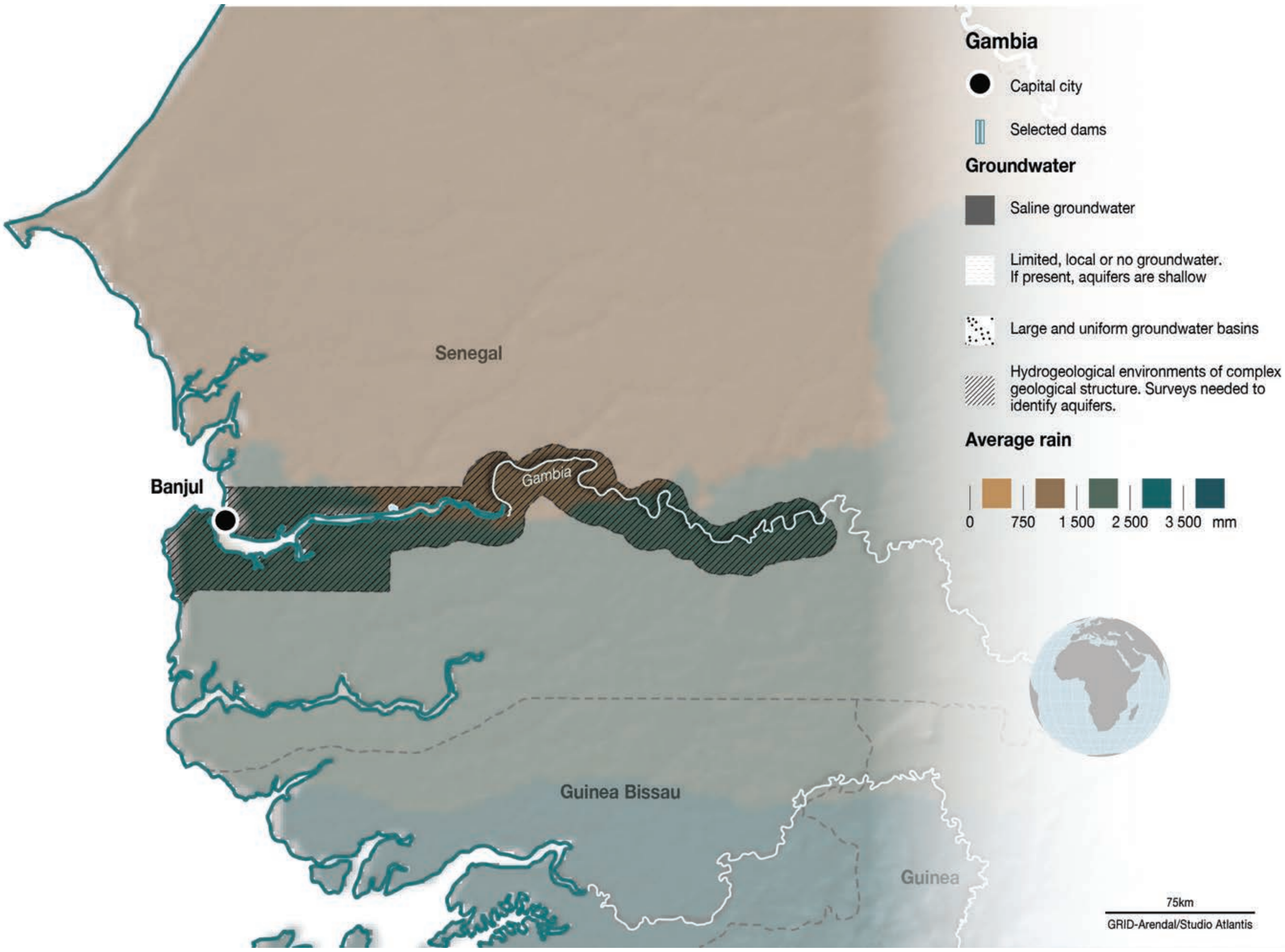
Source: AMCOW 2018.

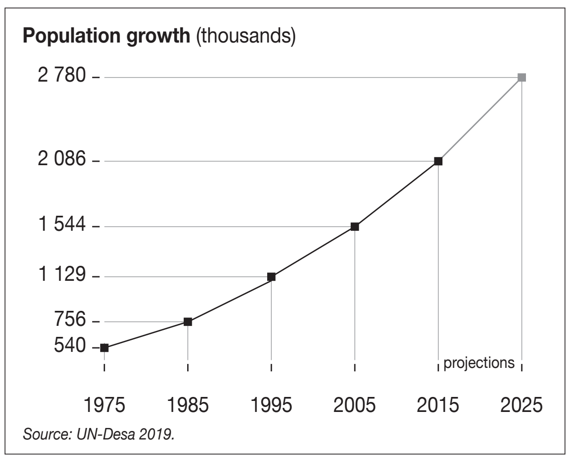
Water availability

	m³/person and year
Total renewable freshwater	4 210
Total water withdrawal	47.9
Internal renewable water sources	2 630
of which are surface water	1 580
pressure on surface water	*0%*
of which are groundwater	2 630
pressure on groundwater	*40%*
Water stress	***1.10%***

Source: AMCOW 2018; FAO 2018.

Banjul

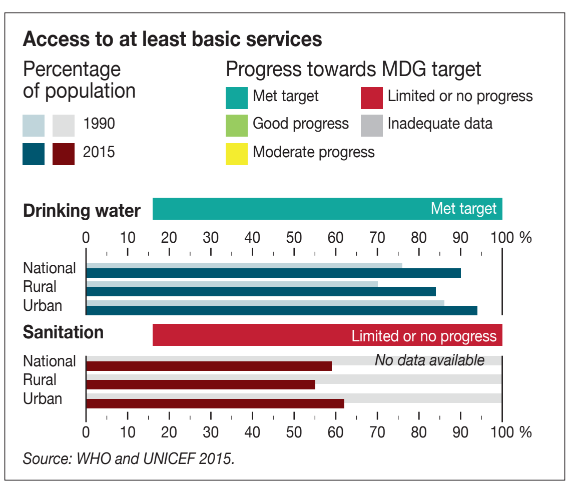




Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	5.9	3.9	2.1	0.6
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		6.9	7.3	7.7
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)	4.7			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				1.1
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				30.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Gambia National Water & Electricity Company (NAWEC)
Presence of a functional water regulator	• Public Utilities Regulatory Authority (PURA)
Environment for private sector participation	• National Public Private Partnership Policy, 2015–2020 • Directorate of Public Private Partnerships and Public Enterprises (public-private partnerships unit) • Gambia Public Procurement Act, 2001 • Gambia Public Procurement Regulations, 2003
Water pricing facility	• PURA Electricity and Water Retail Tariff Filing Guidelines
Legal, policy and strategy frameworks	
Current enabling policies	• National Strategy for Sanitation and Hygiene, 2011 • National Water Policy, 2006 • National Strategy for Sanitation and Hygiene (2011–2016)
Current enabling laws	• National Water Resources Council Act, 1979 • Gambia PURA Act of 2001 • PURA Enforcement Regulations, 2007

Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

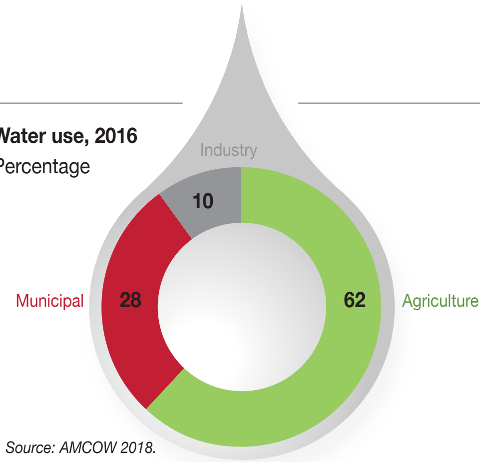
Ghana

Water resources

Ghana has a tropical climate with rainfall averaging 1,187 mm/year (AMCOW 2018).

The country's aqueduct water stress for all sectors measured in 2010 was 0.16 and is projected to increase to 0.57 by 2040 (Luo et al. 2015). A score of 0.57 indicates that there is low competition among water users relative to available surface-water resources. In 2016, the industrial sector accounted for the lowest proportion of water withdrawals at just 9.55 per cent (AMCOW 2018).

Water use, 2016
Percentage



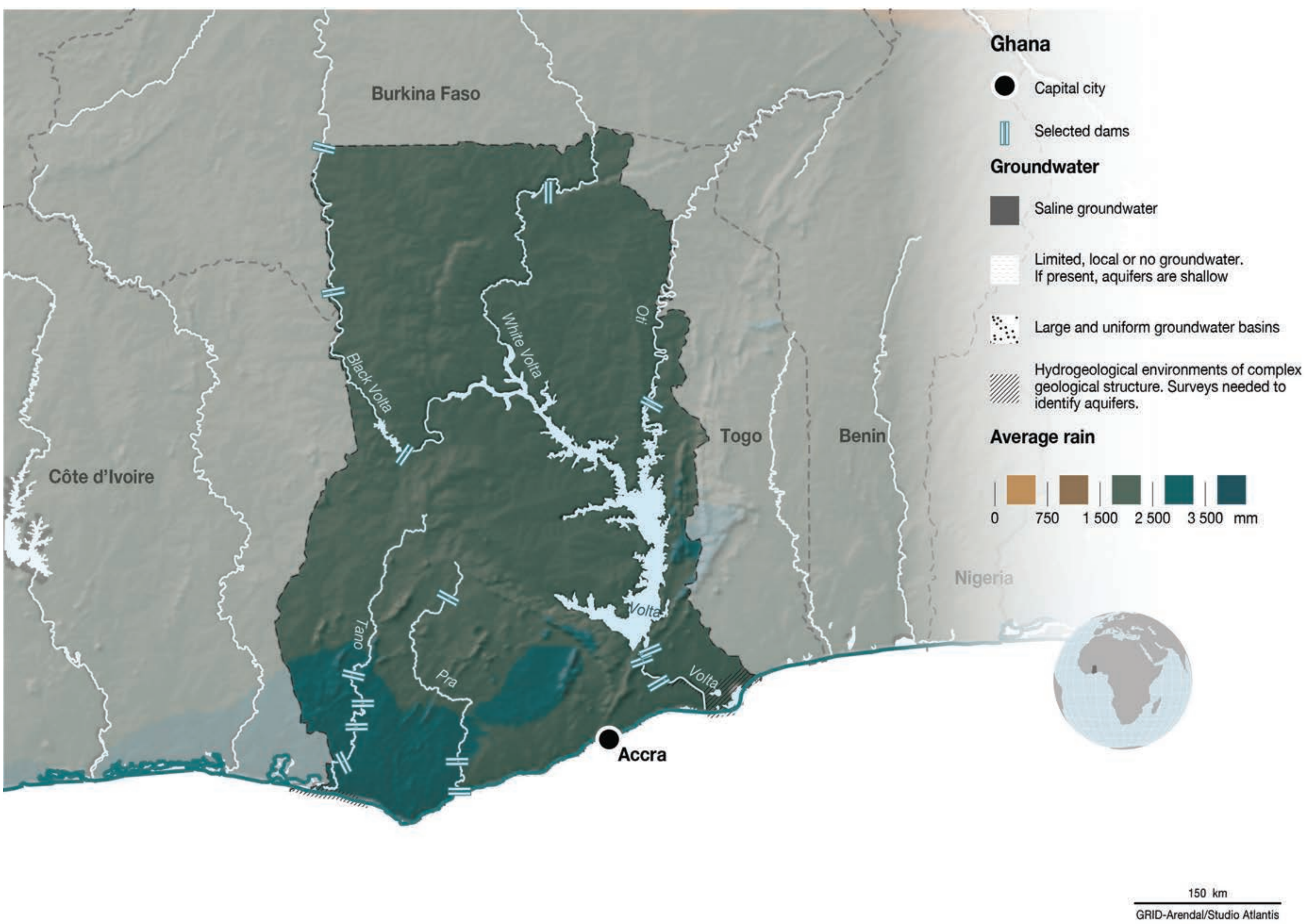
Source: AMCOW 2018.

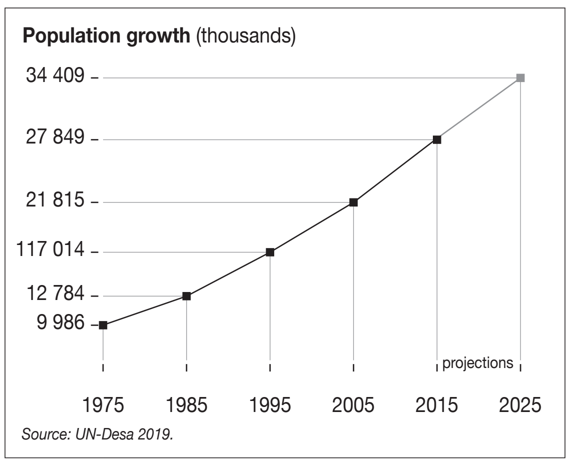
Water availability

	m³/person and year
Total renewable freshwater	2 030
Total water withdrawal	37.8
Internal renewable water sources	1 100
of which are surface water	10 50
pressure on surface water	*no data available*
of which are groundwater	950
pressure on groundwater	*no data available*
Water stress	***1.90%***

Source: AMCOW 2018; FAO 2018.

Fishing and transport boats in Accra

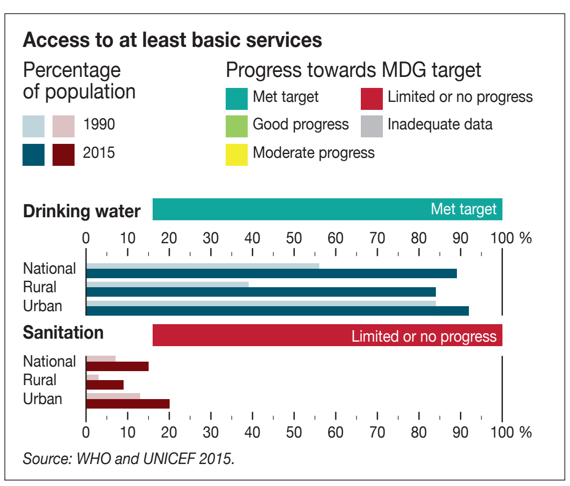




Wastewater management

Recent data on wastewater management are lacking. Available data show that 0.28 million m^3/year of municipal wastewater was produced in 2006 and that 0.028 million m^3/year was collected and 0.022 million m^3/year treated in the same year (FAO 2018).

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)	15.8	19.0	22.7	26.8
Sanitation and hygiene	Proportion of population practising open defecation (%)	21.8	20.8	19.7	18.7
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)	10.1	12.5	15.6	18.9
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)				18.0
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				1.9
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				49.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water Resources, Works and Housing • Ministry of Local Government and Rural Development • Water Resources Commission • Community Water and Sanitation Agency • Metropolitan, Municipal and District Assemblies • Ghana Water Company Limited
Presence of a functional water regulator	• Public Utilities Regulatory Commission, 1997
Environment for private sector participation	• National Policy on Public Private Partnerships, June 2011 • Draft Public Private Partnerships Bill No. 2, 2013, not yet adopted • Public-private partnerships in Ghana are supported by the Public Private Partnership Advisory Unit in the Public Investment Division of the Ministry of Finance
Water pricing facility	• Published under section 19 of the Public Utilities Regulatory Commission Act, 1997
Legal, policy and strategy frameworks	
Current enabling policies	• National Water Policy, 2007 • National Community Water Supply and Sanitation Programme
Current enabling laws	• Community Water and Sanitation Agency Act, 1998 • Water Resources Commission Act, 1996 • Ghana Water and Sewerage Corporation Act, 1965

Sources: FAO 2016; USAID 2010b; World Bank 2018b; World Bank 2018c.

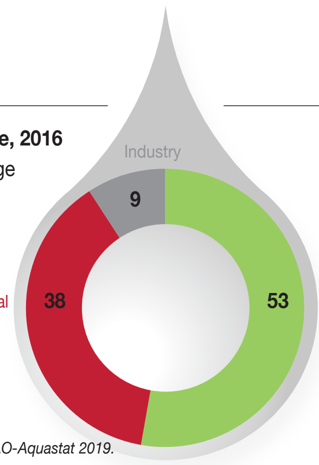
Guinea

Water resources

Guinea's rainfall averages 2,400 mm/year (AMCOW 2018), ranging from 1,200 to 4,200 mm/year in Upper and Lower Guinea respectively (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.05 and is projected to decrease to 0.02 by 2040 (Luo et al. 2015). A score of 0.02 indicates that there is low competition among water users relative to available surface-water resources. Data on water withdrawals by sector varies greatly depending on the source. For example, water withdrawals as a proportion of total withdrawals in 2001 were 52.9, 37.7 and 9.4 per cent for the agriculture, municipal and industrial sectors respectively (World Bank 2018).

Water use, 2016
Percentage

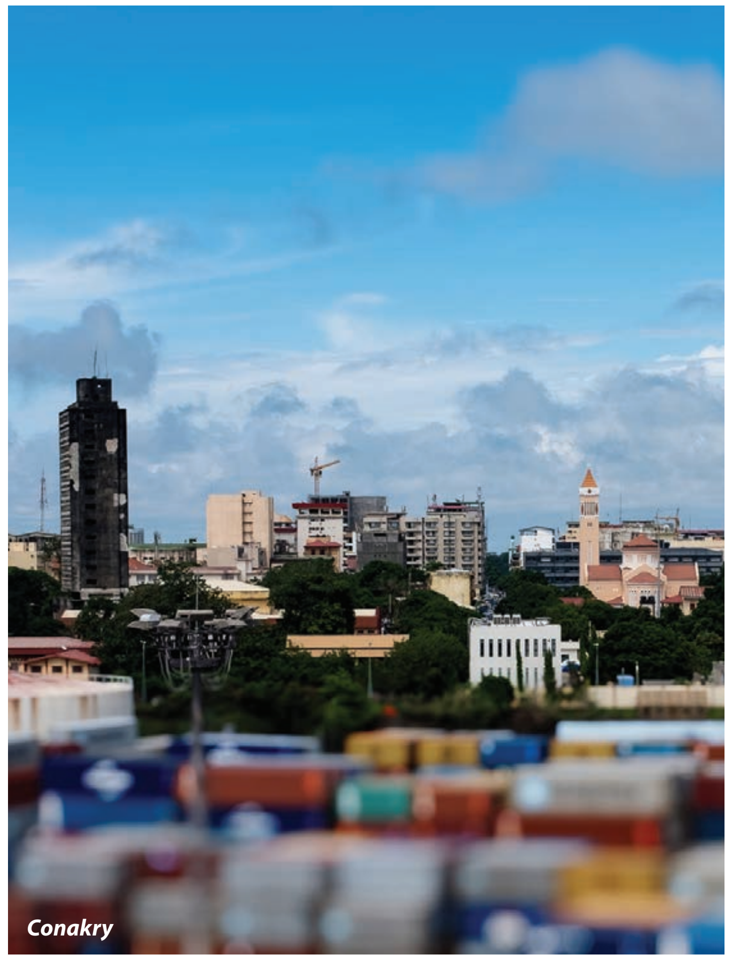


Source: FAO-Aquastat 2019.

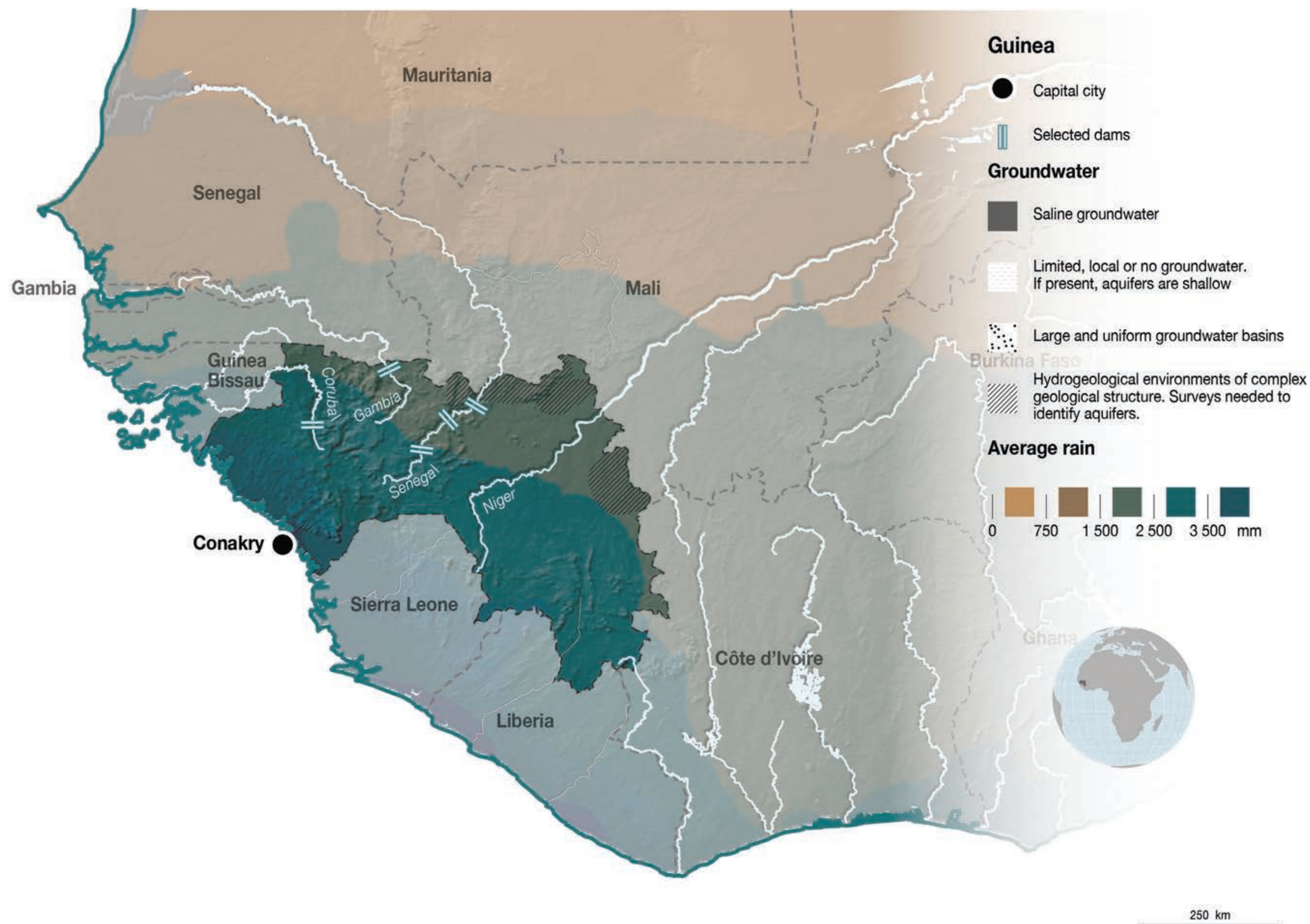
Water availability

	m³/person and year
Total renewable freshwater	20 900
Total water withdrawal	9.2
Internal renewable water sources	17 900
of which are surface water	14 900
pressure on surface water	*0.34%*
of which are groundwater	5 710
pressure on groundwater	*0.71%*
Water stress	***0.04%***

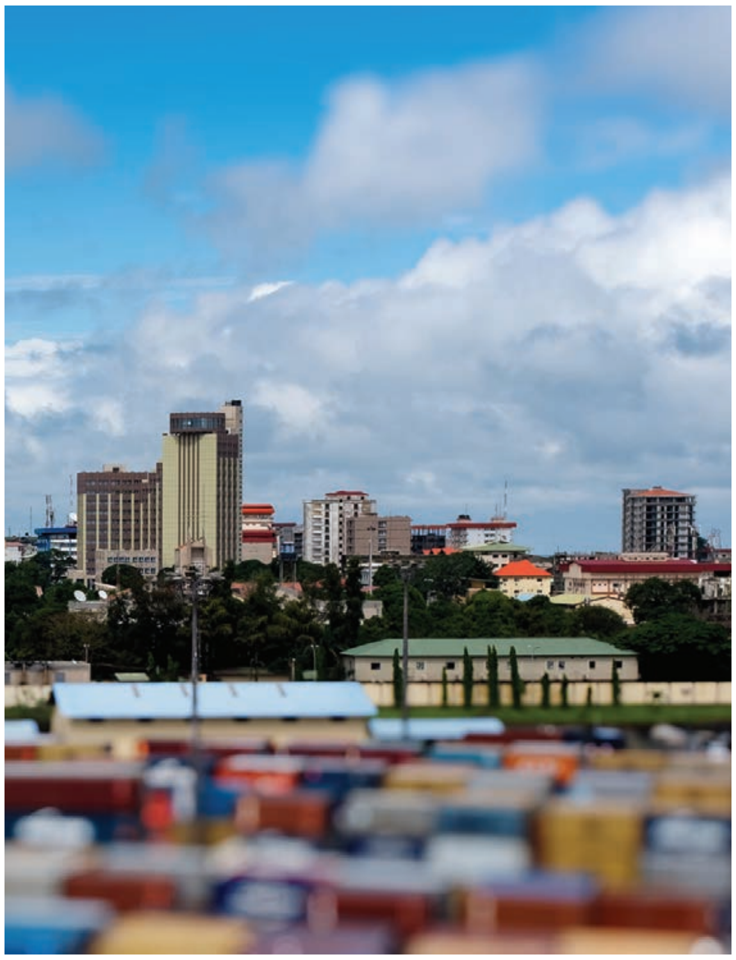
Source: AMCOW 2018; FAO 2018.

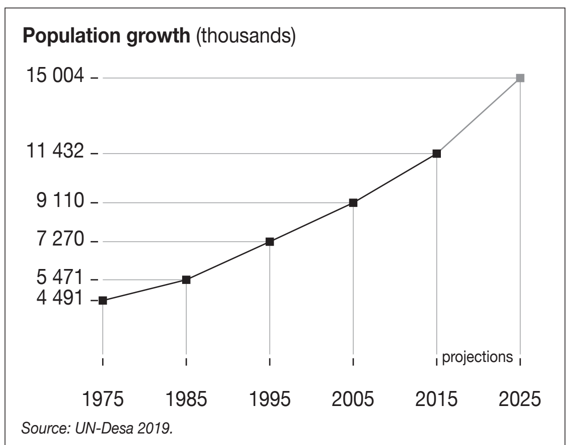


Conakry



GRID-Arendal/Studio Atlantis

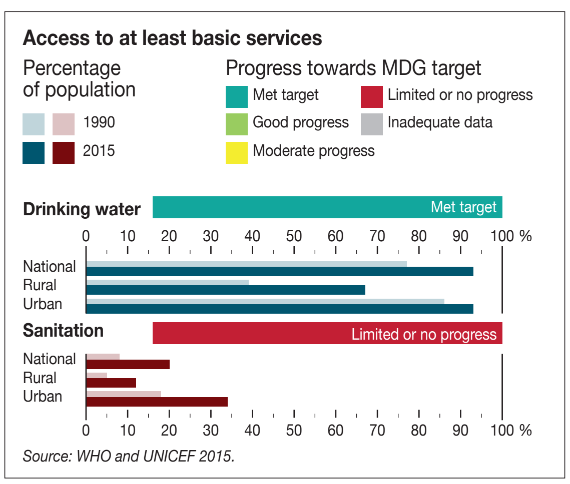




Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	27.4	23.3	19.2	15.3
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		8.6 (2006)	8.7	8.8
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)	5.3			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.04
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				24.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Environment, Water and Forestry • National Water Commission of the Ministry of Natural Resources, Energy and Environment • National Directorate of Hydraulics • Société Nationale des Eaux de Guinée [Guinea National Water Company] (SONEG) • Société d'Exploitation des Eaux de Guinée [Guinea Water Supply Company] (SEEG)
Environment for private sector participation	• Law No. 0032/2017 / AN of 4 July 2017 on Public-Private Partnerships
Water pricing facility	• Order No. A/2013/172/MEE/CAB/SGG of 12 February 2013 on the pricing of drinking water supply in rural and semi-urban areas
Legal, policy and strategy frameworks	
Current enabling policies	• Draft National Water Policy 2018
Current enabling laws	• Law No. L/94/005/CTRN on the Water Code, 1994 • Public Health Code, promulgated in 1997 • Order No. A/2013/173/MEE/CAB/SGG of 12 February 2013 on the procedures for establishing protection zones for water catchments intended for human consumption and for sanitation works in rural and semi-urban areas • Decree No. D/No.121/PRG/CNDD/SGPRG/2010 of 17 June 2010 amending the statutes of the National Water Point Management Service

Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

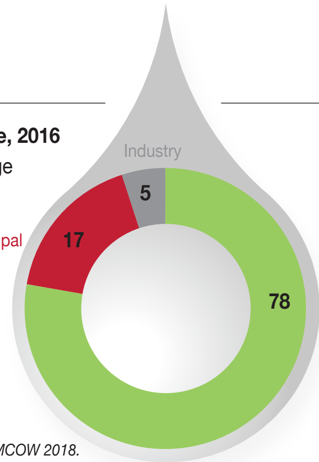
Guinea-Bissau

Water resources

Guinea-Bissau has average rainfall of 1,577 mm/year (AMCOW 2018), which varies across its three agroclimatic zones. In the north-east, the country has a Sudanese climate, where rainfall amounts range between 1,200 and 1,500 mm/year. In the south-east, the climate is humid and tropical, with rainfall amounts ranging between 2,000 and 2,550 mm/year. In the north-west, which has a maritime climate, rainfall is between 1,500 and 1,877 mm/year (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.00 and is projected to remain the same by 2040 (Luo et al. 2015). A score of 0.00 indicates that there is low competition among water users relative to available surface-water resources. In 2016, industry accounted for only 0.17 per cent of total water withdrawals (AMCOW 2018).

Water use, 2016
Percentage



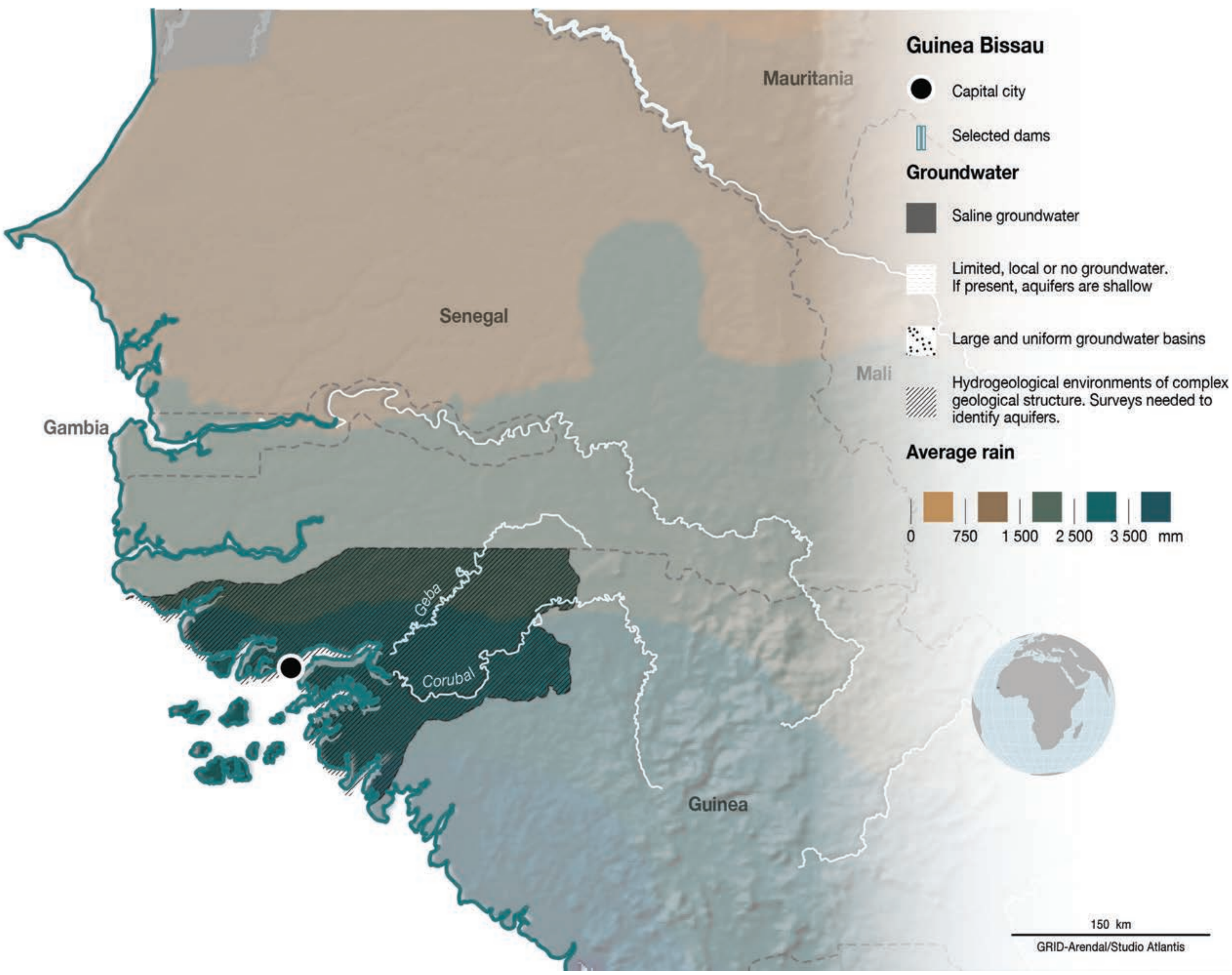
Source: AMCOW 2018.

Water availability

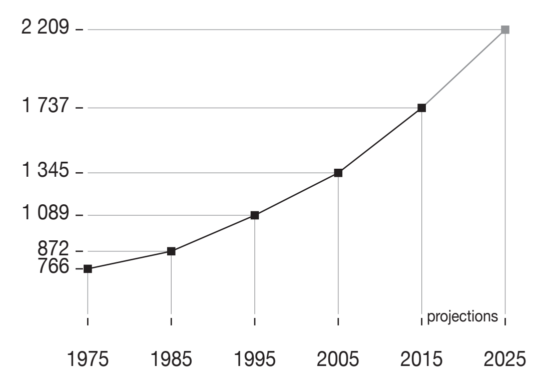
	m³/person and year
Total renewable freshwater	17 000
Total water withdrawal	97.6
Internal renewable water sources	8 680
of which are surface water	6 510
pressure on surface water	*1.17%*
of which are groundwater	7 590
pressure on groundwater	*0.21%*
Water stress	***0.60%***

Source: AMCOW 2018; FAO 2018.

Bissau



Population growth (thousands)



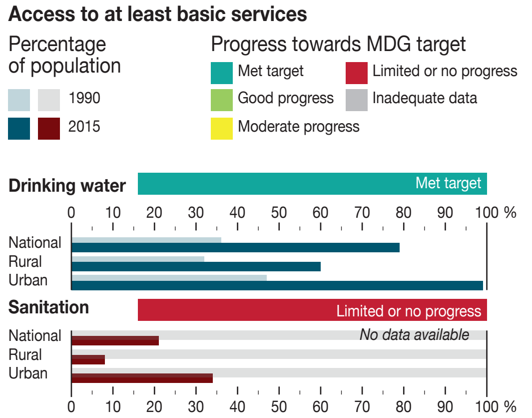
Source: UN-Desa 2019.

Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision

Access to at least basic services



Source: WHO and UNICEF 2015.

Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	35.9	28.7	22.0	16.0
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		6.3	6.5	6.6
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)	2.3			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.6
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Interministerial Committee on Water and Sanitation (CIMA) • Technical Water Committee (CTA)
Presence of a functional water regulator	• Ministry of Energy, Industry and Natural Resources
Environment for private sector participation	• No dedicated public-private partnership unit • No dedicated public-private partnership law
Legal, policy and strategy frameworks	
Current enabling policies	• National Water and Sanitation Action Plan • Framework Plan for Water and Sanitation
Current enabling laws	• Water Code, 1992

Sources: FAO 2016; World Bank 2018b; World Bank 2016c.

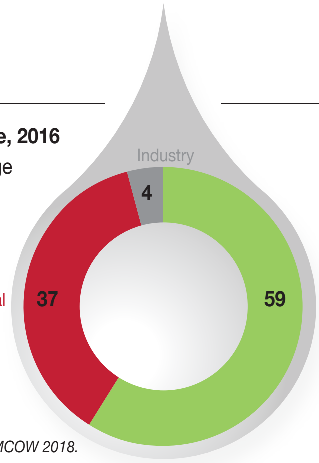
Kenya

Water resources

Kenya has a tropical climate with about 80 per cent of the land classified as arid or semi-arid. Rainfall averages 630 mm/year, ranging from less than 200 mm in the north to 1,800 mm on the slopes of Mount Kenya (AMCOW 2018; FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.76 and is projected to decrease to 0.64 by 2040 (Luo et al. 2015). A score of 0.64 indicates that there is low competition among water users relative to available surface-water resources. Water withdrawals as a proportion of total withdrawals are highest in the agriculture sector, averaging 59 per cent (AMCOW 2018).

Water use, 2016
Percentage



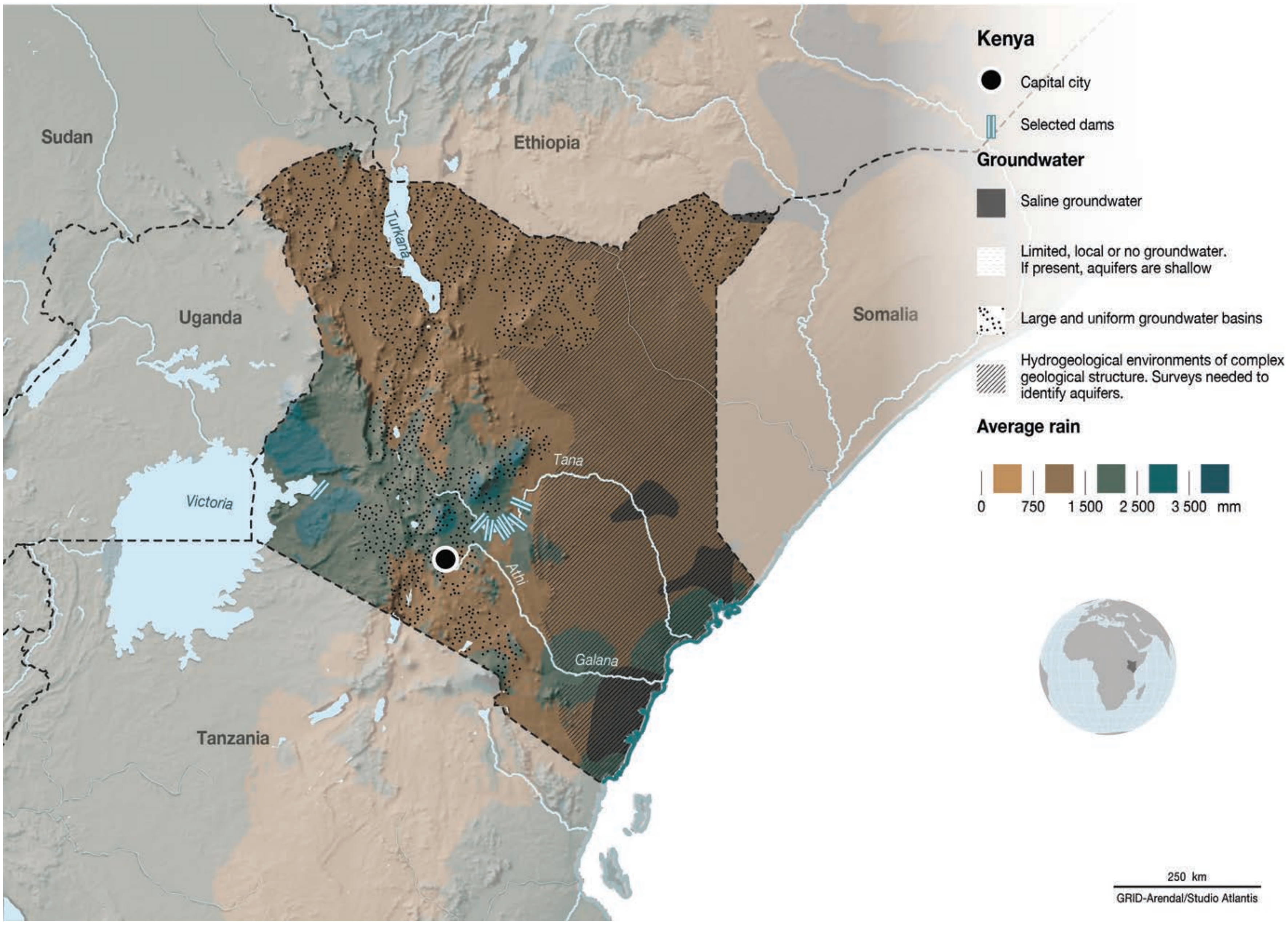
Source: AMCOW 2018.

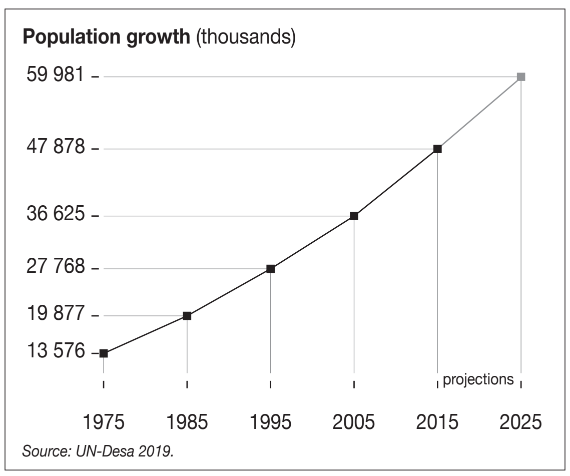
Water availability

	m³/person and year
Total renewable freshwater	667
Total water withdrawal	69.9
Internal renewable water sources	450
of which are surface water	439
pressure on surface water	*8.91%*
of which are groundwater	76
pressure on groundwater	*9.71%*
Water stress	***10.50%***

Source: AMCOW 2018; FAO 2018.

Nairobi

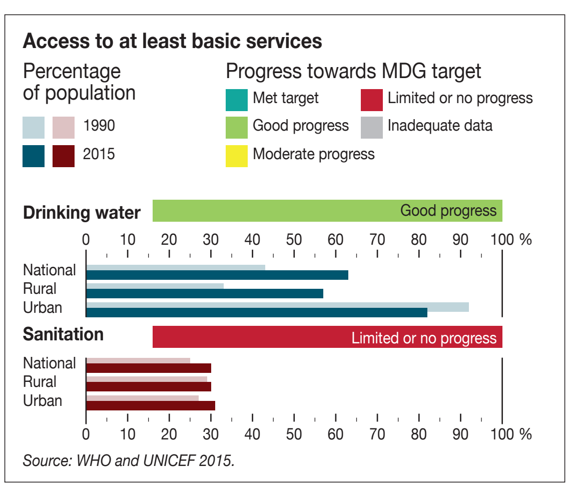




Wastewater management

Recent data on wastewater management are lacking. However, historical data show that in 2010, 27 treatment plants were operating with a capacity of 125 million m^3/year of treated wastewater (FAO 2018).

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	16.8	15.2	13.5	12.0
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)			13.6	13.9
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				35.5 (2017)
	Proportion of groundwater bodies with good ambient water quality (%)				42.2 (2017)
Water-use efficiency	Water-use efficiency (US$/cm³)				10.9
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				10.5
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				53.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water and Irrigation • Water Services Trust Fund (WSTF) • National Water Conservation and Pipeline Corporation (NWCPC) • Water Services Boards (WSBs)
Presence of a functional water regulator	• Water Services Regulatory Board (Wasreb)
Environment for private sector participation	• Public Private Partnership Unit (PPPU) – established as a Special Purpose Unit within the National Treasury of the Republic of Kenya • Public Private Partnership (PPP) Act, 2013 • Public Private Partnership Regulations, 2014
Water pricing facility	• Water (Water Service Levy) Regulations, 2008 (Cap. 372)
Legal, policy and strategy frameworks	
Current enabling policies	• Water (Services Regulatory) Rules, 2012 (L.N. No. 137 of 2012) • National Water Master Plan 2030 (NWMP) • National Water Services Strategy (NWSS) • National Water Policy, 1999
Current enabling laws	• Water Act, 2016 (No. 43 of 2016) • Kenya Water Institute Act, 2001 (Cap. 372A) • Machakos County Water and Sanitation Act, 2014 (No. 1 of 2014) • Kiambu County Water and Sanitation Act, 2015 (No. 2A of 2015) • Meru Water and Sewerage Services Registered Trustees Regulations, 2002 (L.N. No. 58 of 2002) • City of Nairobi (Water Supply) By-laws, 1974 • Water (Water Services Board) (Variation of Limits of Supply) Order, 2008 (L.N. No. 68 of 2008)

Sources: FAO, 2016; Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) 2011; World Bank 2018b; World Bank 2018c.

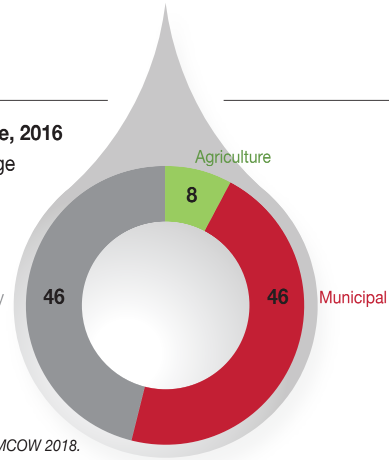
Lesotho

Water resources

Lesotho has a temperate climate with rainfall averaging 788 mm/year, which ranges from less than 300 mm/year in the western lowlands to 1,600 mm/year in the north-eastern highlands (AMCOW 2018; FAO 2005).

The country's aqueduct water stress for all sectors measured in 2010 was 1.17 and is projected to increase to 1.84 by 2040 (Luo et al. 2015). A score of 1.84 indicates that there is low to medium competition among water users relative to available surface-water resources. Water withdrawals for the agriculture sector as a proportion of total withdrawals is only 8.68 per cent. This could be attributed to the small size of irrigation development in the country. Some of the reasons for this include high installation and maintenance costs, inappropriate irrigation design schemes and a lack of farmer commitment. This has resulted in farmers abandoning some irrigation schemes and returning to dryland agriculture (FAO 2005).

Water use, 2016
Percentage

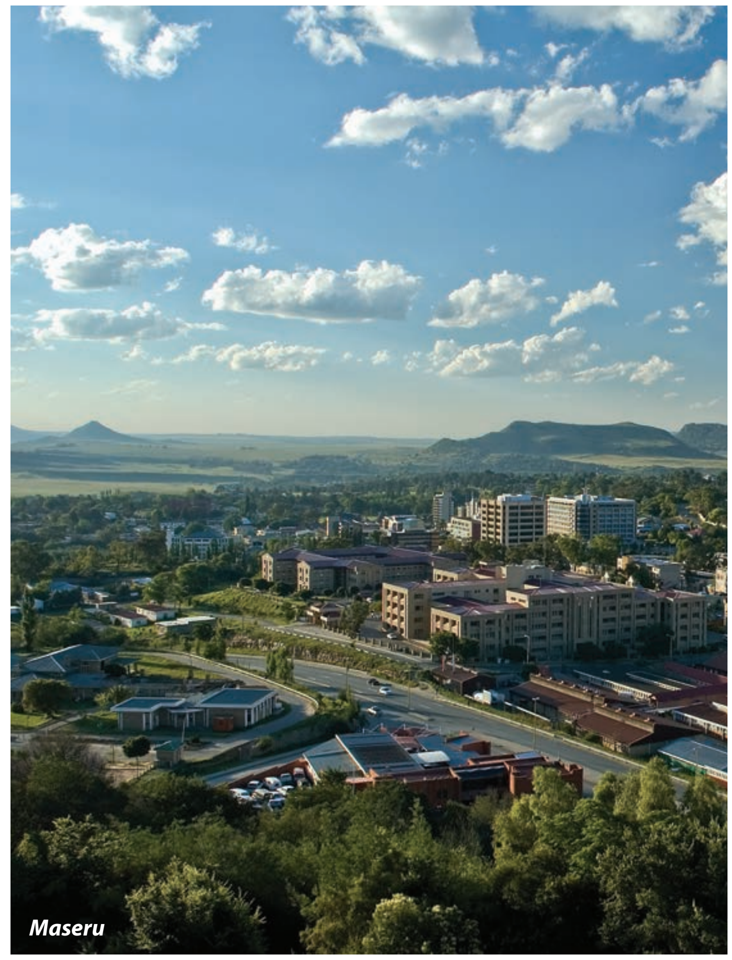


Source: AMCOW 2018.

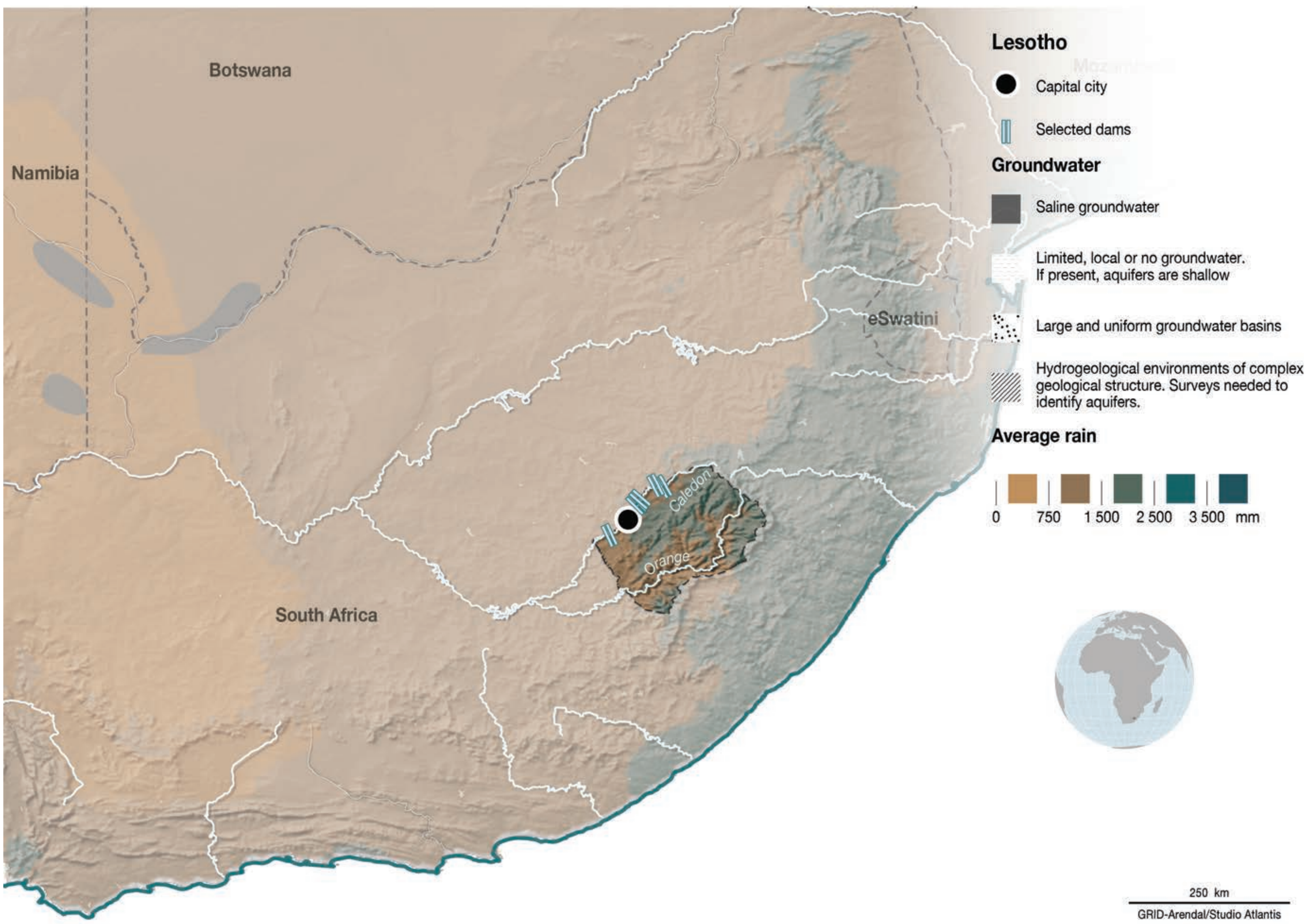
Water availability

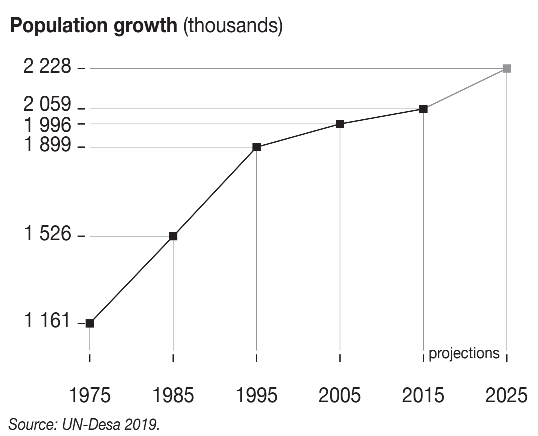
	m³/person and year
Total renewable freshwater	1 420
Total water withdrawal	20.5
Internal renewable water sources	2 450
of which are surface water	2 450
pressure on surface water	*no data available*
of which are groundwater	138
pressure on groundwater	*no data available*
Water stress	***1.40%***

Source: AMCOW 2018; FAO 2018.



Maseru

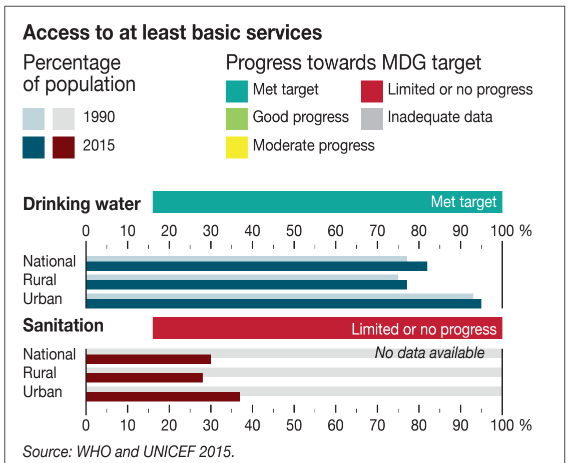




Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	45.7	40.3	35.1	30.0
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)			1.96	2.1
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				16.7 (2017)
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)				55.2
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				1.4
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				33.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Energy, Meteorology and Water Affairs • Water and Sewerage Company • Lesotho Lowlands Water Supply Unit • Metolong Authority
Presence of a functional water regulator	• Lesotho Electricity and Water Authority
Environment for private sector participation	• No dedicated public-private partnership law • Lesotho PPP Policy, 2018
Water pricing facility	• Tariff Filing and Review Procedure
Legal, policy and strategy frameworks	
Current enabling policies	• National water and wastewater quality standards • Long Term Water and Sanitation Strategy, 2014 • Lesotho Water and Sanitation Policy, 2007
Current enabling laws	• Water Act, 2008 (No. 15 of 2008) • Lesotho Electricity and Water Authority (Resolution of Complaints for Water and Sewerage Services) Rules, 2013 (L. N. No. 102 of 2013) • Lesotho Highlands Development Authority Order (No. 23 of 1986) • Metolong Authority Act, 2010 • Lesotho Environment Act, 2001 (Act 15 of 2001), amended in 2008 • Declaration of Water Emergency (L. N. No. 44 of 1980)

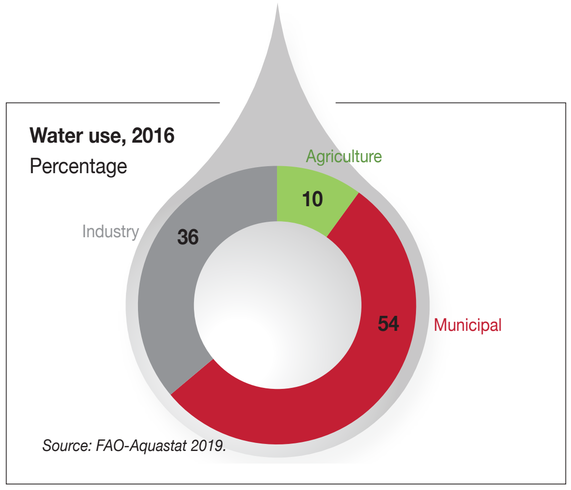
Sources: FAO 2005; World Bank 2018b; World Bank 2018c.

Liberia

Water resources

Liberia has a tropical, hot and humid climate (FAO 2016) with rainfall averaging 2,391 mm/year (AMCOW 2018).

The country's aqueduct water stress for all sectors measured in 2010 was 0.24 and is projected to decrease to 0.03 by 2040 (Luo et al. 2015). A score of 0.03 indicates that there is low competition among water users relative to available surface-water resources. Development of the agriculture sector is a priority in Liberia. The sector has low water usage (9.4 per cent) compared with municipal and industrial usage, which could be due to its low productivity. Investments in agriculture would support livelihoods and economic development.

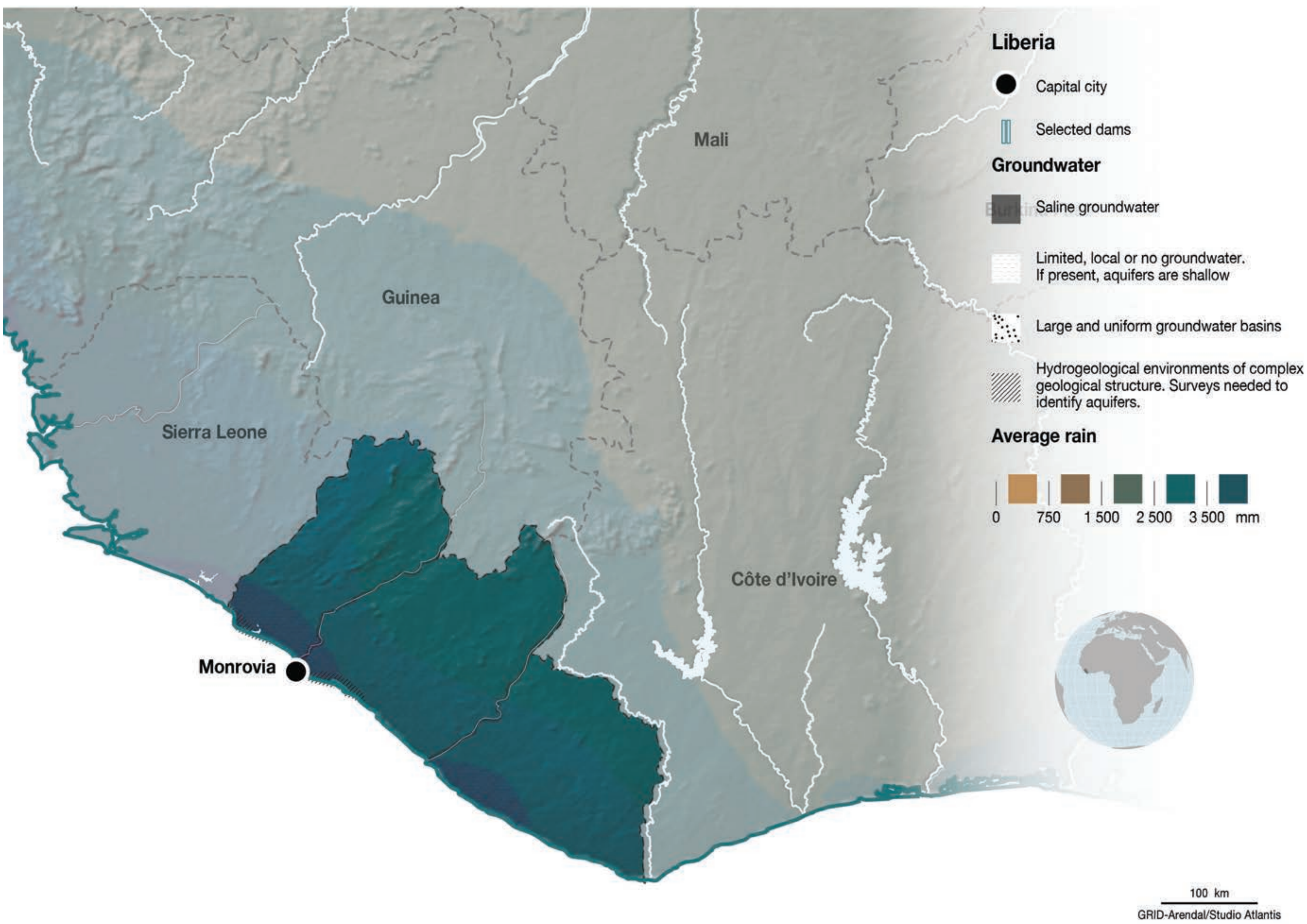


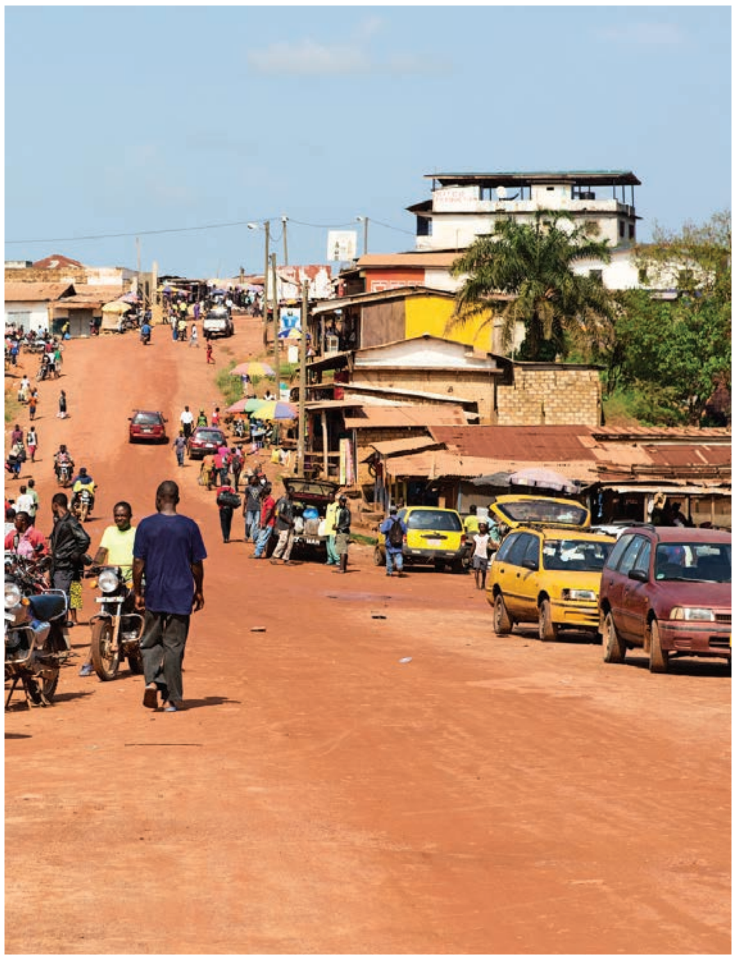
Water availability

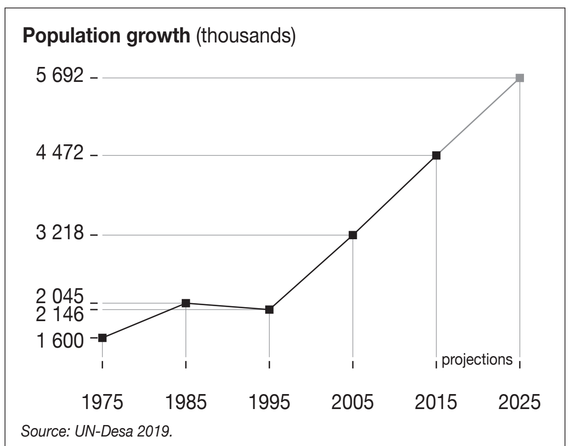
	m³/person and year
Total renewable freshwater	50 800
Total water withdrawal	no data available
Internal renewable water sources	50 000
of which are surface water	50 000
pressure on surface water	*no data available*
of which are groundwater	11 250
pressure on groundwater	*no data available*
Water stress	***0.08%***

Source: AMCOW 2018; FAO 2018.

A market in Monrovia





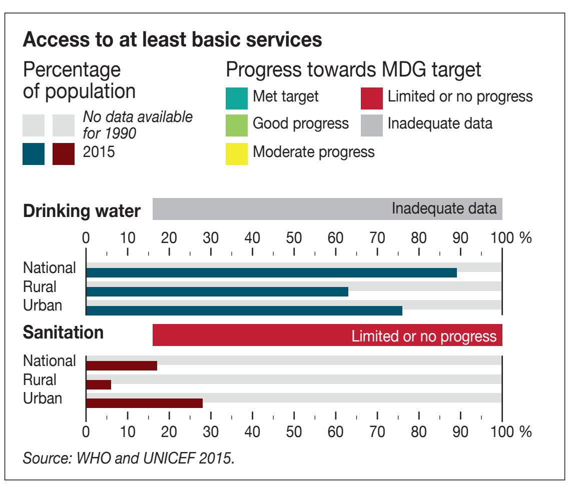


Source: UN-Desa 2019.

Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Source: WHO and UNICEF 2015.

Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	54.6	50.3	46.3	42.3
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)			1.2	1.2
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)	1.6			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.08
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				15.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• National Water Resources and Sanitation Board • Ministry of Public Works • Ministry of Health and Social Welfare • Ministry of Lands, Mines and Energy • Liberia Water and Sewerage Corporation • Environmental Protection Agency • National Water, Sanitation and Hygiene Promotion Committee • Water Supply and Sanitation Commission • Rural Water Supply and Sanitation Bureau • Directorate of Community Mobilization and Hygiene Promotion
Presence of a functional water regulator	• Water and Sanitation Regulatory Agency
Environment for private sector participation	• Public Procurement and Concessions Act, 2005 • National Bureau of Concessions • No dedicated public-private partnerships law
Legal, policy and strategy frameworks	
Current enabling policies	• Water and Sanitation Policy
Current enabling laws	• National Water Supply and Sanitation Commission Act, 2017 • Act to amend the Public Authorities Law to create the Liberia Water and Sewer Corporation, 1973 • Public Health Law, Title 33, Liberian Code of Laws Revised, 2017

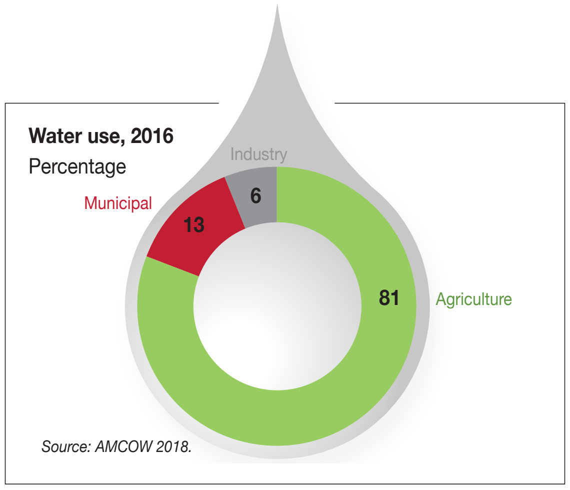
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Libya

Water resources

About 95 per cent of Libya is a desert environment that receives less than 100 mm of rainfall per year (FAO 2016). Since the country only has an average rainfall of 46 mm/year, its population is highly dependent on groundwater, with pressure on groundwater sources estimated at 1,550 per cent (AMCOW 2018).

The country's aqueduct water stress for all sectors measured in 2010 was 4.74 and is projected to increase to 4.77 by 2040 (Luo et al. 2015). A score of 4.77 indicates that there is extremely high competition among water users relative to available surface-water resources. Agriculture is an important sector for the country, employing 68.2 per cent of the population and contributing 34 per cent to GDP in 2017 (World Bank 2018). Water use in agriculture is very high as much of it depends on irrigation, with 98.7 per cent of the water coming from groundwater sources (FAO 2018).

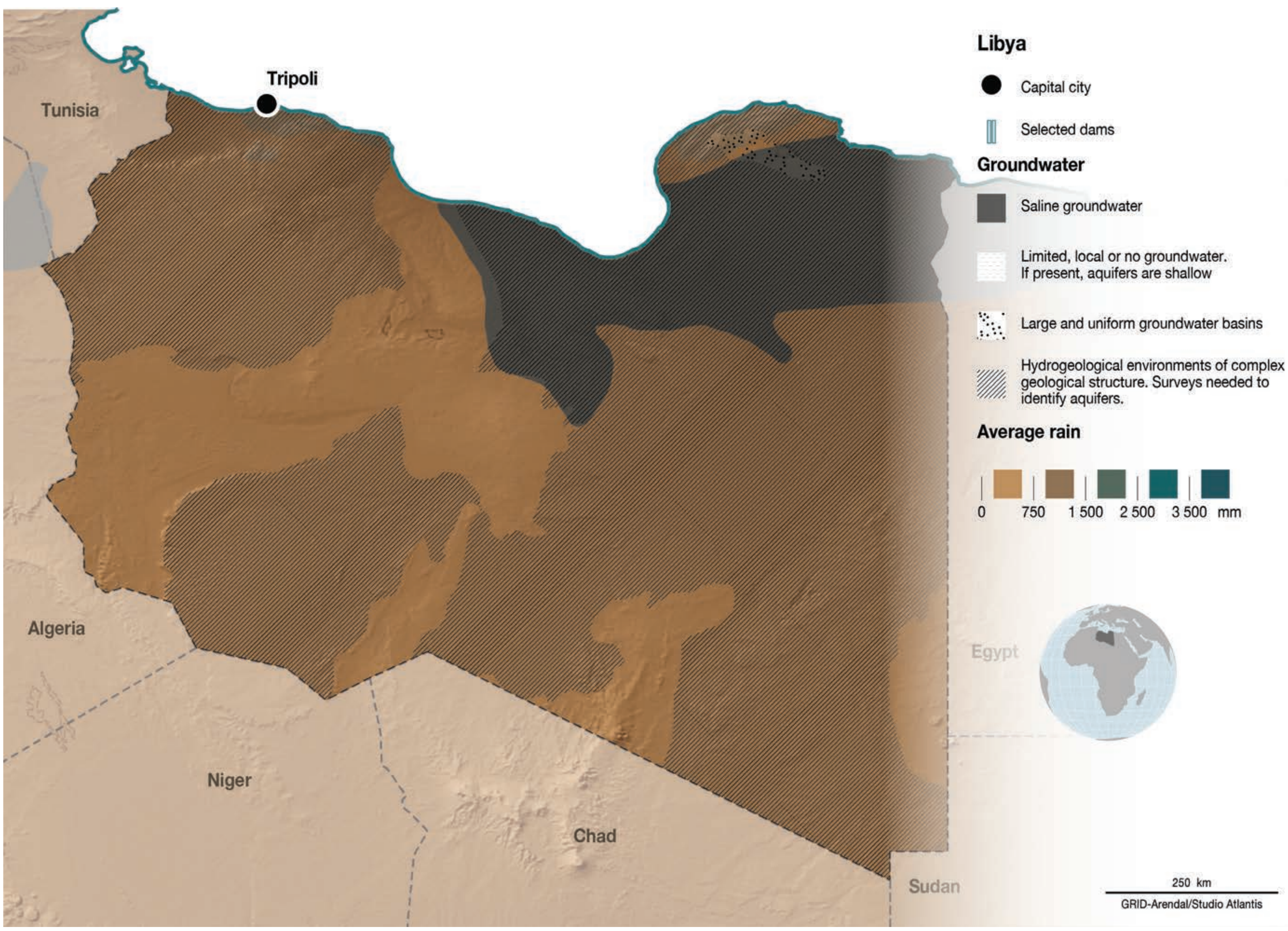


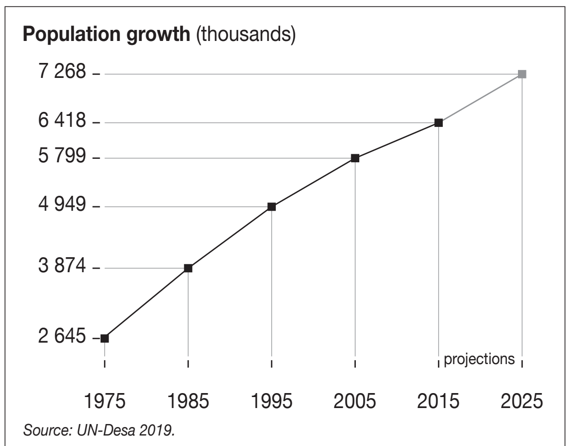
Source: AMCOW 2018.

Water availability

	m³/person and year
Total renewable freshwater	79.7
Total water withdrawal	708
Internal renewable water sources	105
of which are surface water	3.01
pressure on surface water	*0%*
of which are groundwater	90.2
pressure on groundwater	*1 550%*
Water stress	***888.3%***

Source: AMCOW 2018; FAO 2018.

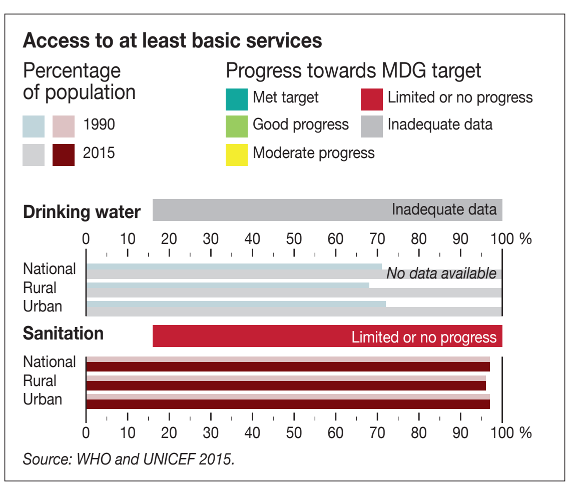




Wastewater management

Recent data on wastewater management are lacking. However, available data show 504 million m^3/year of municipal wastewater was produced in 2012. In 2008, 167 million m^3/year of municipal wastewater was collected, though only 4 million m^3/year of this was treated in the same year. Some of the remaining wastewater is channelled into alternative collection systems, such as septic tanks or soak pits. Historical data indicate that 506 million m^3/year of wastewater was disposed of in this manner in 1999. By 2010, 79 treatment plants were operating with a capacity of 74 million m^3/year of treated wastewater (FAO 2018).

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)				
	Proportion of population using safely managed sanitation services (%)	28.5	28.6	27.4	26.3
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				15.3 (2018)
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm^3)			18.5	
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				888.3
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				47.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• General Water Authority • General Company for Water and Wastewater • Ministry of Local Government
Environment for private sector participation	• No dedicated public-private partnership law • No dedicated public-partnership institution
Water pricing facility	• Resolution No. 218 to set the water pricing for the first phase of the Great Man-Made River Project, 1994
Legal, policy and strategy frameworks	
Current enabling policies	• National Strategy for Integrated Water Resources Management (2000–2025)
Current enabling laws	• Law No. 3 of 1982 to organize the utilization of water resources • Law No. 15 of 2003 on the protection and improvement of the environment

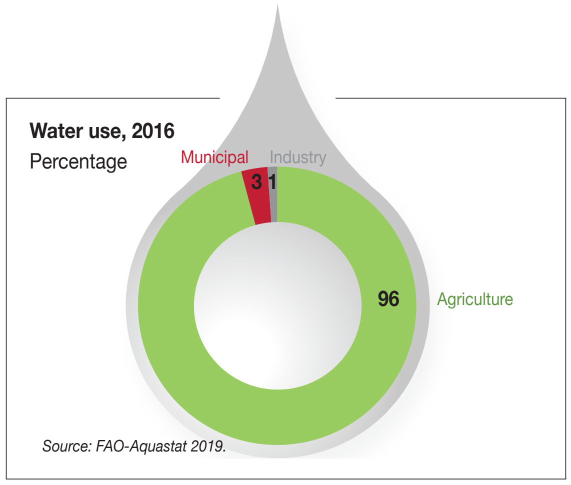
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Madagascar

Water resources

Madagascar has four agroclimatic zones and a national average rainfall of 1,513 mm/year (FAO 2016). The rainfall ranges from less than 400 mm/year in the semi-arid province of Toliara in the south to over 1,500 mm/year in the humid tropical climates in the north-western parts of the island (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 1.01 and is projected to decrease to 0.88 by 2040 (Luo et al. 2015). A score of 0.88 indicates that there is low competition among water users relative to available surface-water resources.

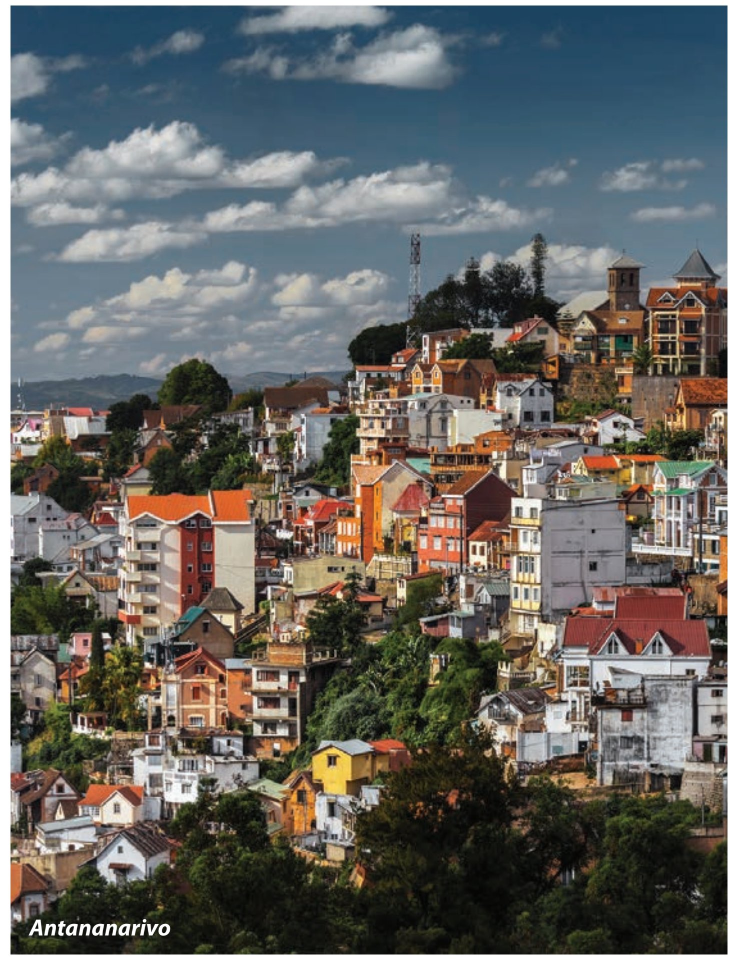


Source: FAO-Aquastat 2019.

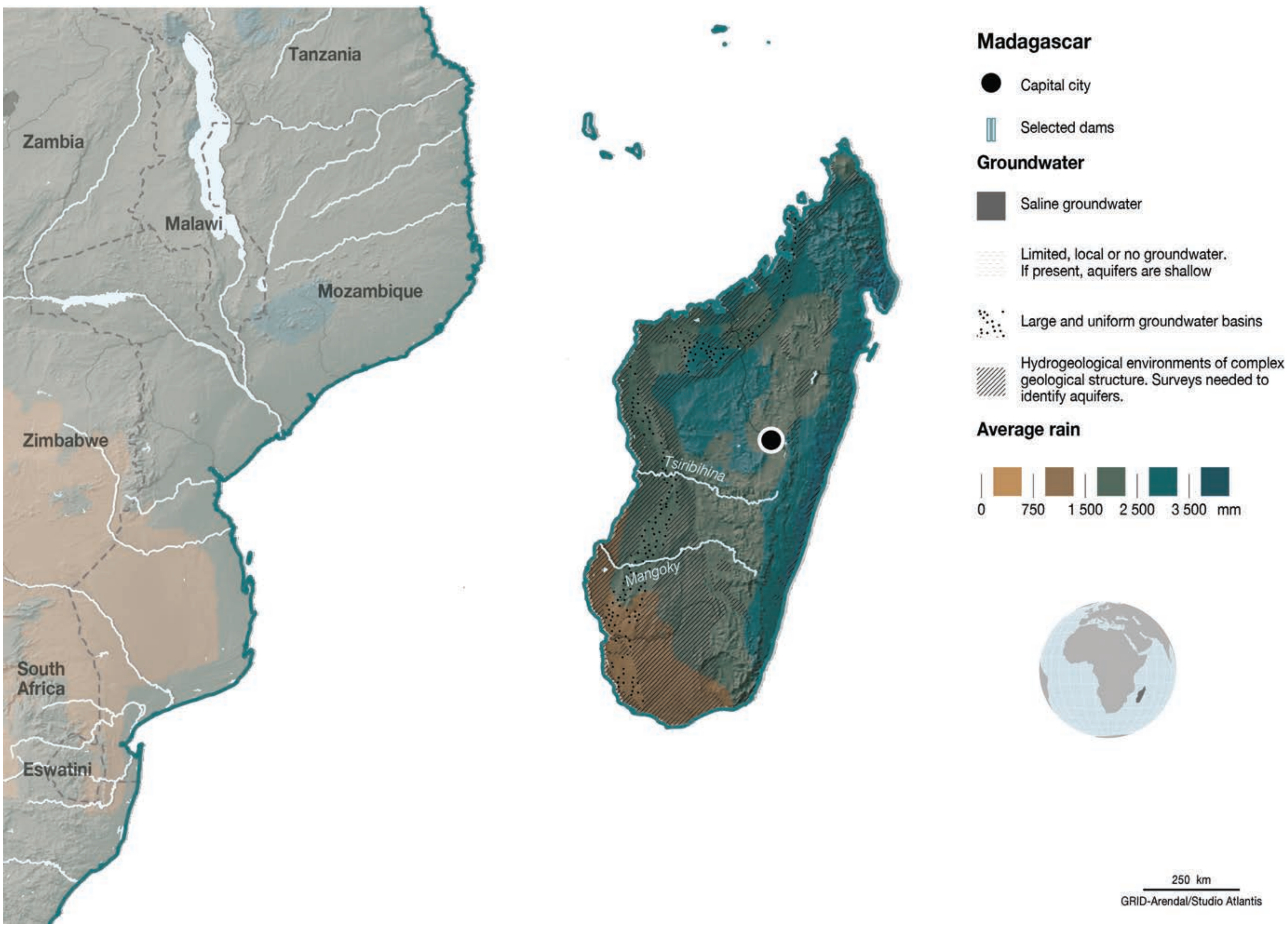
Water availability

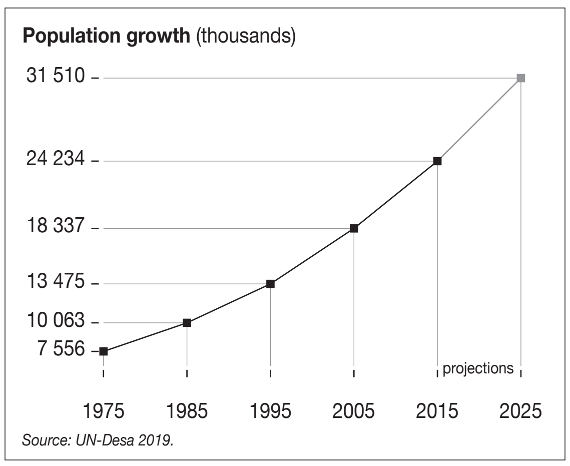
	m³/person and year
Total renewable freshwater	12 800
Total water withdrawal	66.9
Internal renewable water sources	12 800
of which are surface water	11 500
pressure on surface water	*0.41%*
of which are groundwater	1 250
pressure on groundwater	*1.61%*
Water stress	***0.50%***

Source: AMCOW 2018; FAO 2018.



Antananarivo

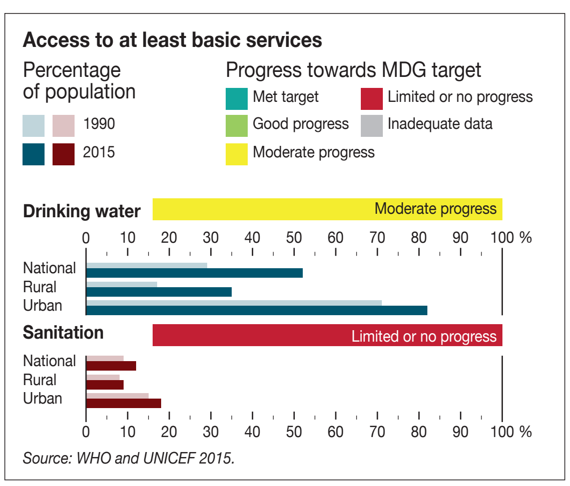




Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	37.8	40.2	42.1	43.9
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)	5.2	18.4	44.5	50.5
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				90.1 (2017)
	Proportion of groundwater bodies with good ambient water quality (%)				81.6 (2017)
Water-use efficiency	Water-use efficiency (US$/m^3)		0.5		
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.5
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				36.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Environment, Water, Forests and Tourism • National Water and Sanitation Authority • National Water and Sanitation Fund • Ministry of Energy and Mines • Ministry of Water, Sanitation and Hygiene • WASH Committee (Water, Sanitation and Hygiene), 2003 • Rural Water Supply and Sanitation Programme • JIRAMA – national water and electricity company • National Centre for Water, Sanitation and Rural Engineering
Presence of a functional water regulator	• Water and Sanitation Regulatory Agency
Environment for private sector participation	• There is no dedicated public-private partnership unit – public-private partnerships are governed by relevant line ministries • Law No. 2015-039 of 9 December 2015 on public-private partnerships
Water pricing facility	• Decree No. 2003-792 on charges of levies and spills • Tariffs governed by the New Water Code, Law No. 98-029 of 27 January 1999 • Order No. 2003-791 regulating the rates for public water and sanitation services
Legal, policy and strategy frameworks	
Current enabling policies	• National Strategy for Water, Hygiene and Sanitation 2013–2018 • National Water and Sanitation Policy
Current enabling laws	• Law No. 98-029 on the Water Code, 1999 • Decree No. 2015-1042 of 30 June 2015 on the National Directive for Drinking Water Supply Infrastructures at the community level resistant to climate hazards • Decree No. 2003-646 classifying surface water and regulating discharges of liquid effluents • Decree No. 2003-193 relating to the operation and organization of the services for drinking water and the sanitation of domestic wastewater • Decree No. 2003-941 on the monitoring of water, the control of water intended for human consumption and the priorities of access to water resources

Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

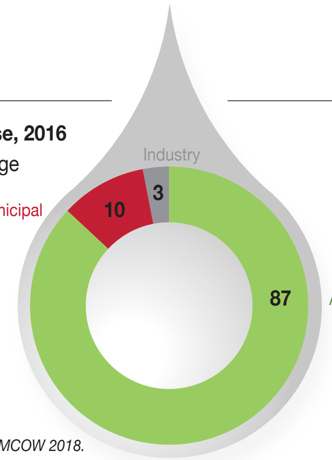
Malawi

Water resources

Located in southern Africa and wholly within the tropics, Malawi has rainfall averaging 1,181 mm/year (AMCOW 2018). The country has a tropical continental climate, with rainfall ranging between 700 and 2,400 mm/year (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.00 and is projected to increase to 0.08 by 2040 (Luo et al. 2015). A score of 0.08 indicates that there is low competition among water users relative to available surface-water resources.

Water use, 2016
Percentage



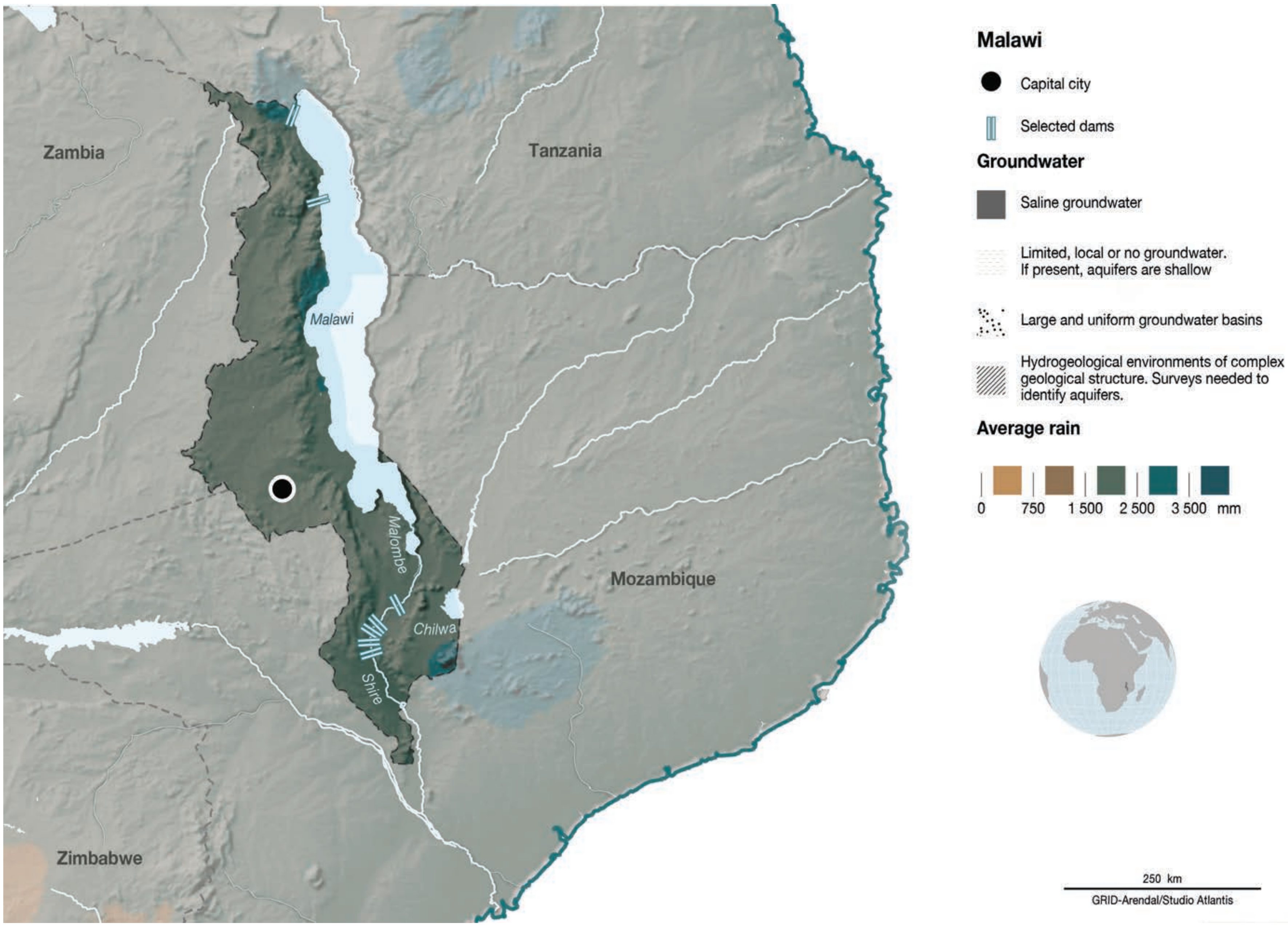
Source: AMCOW 2018.

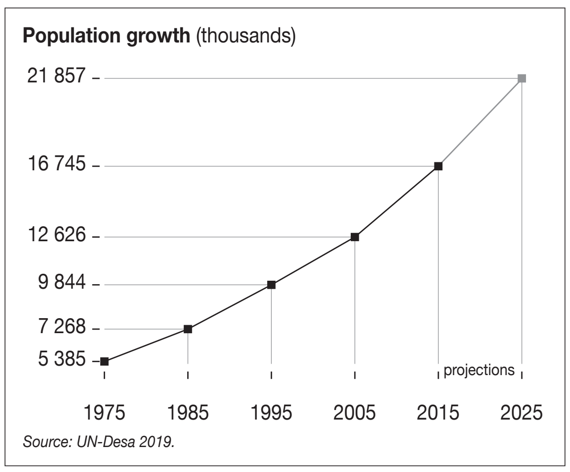
Water availability

	m³/person and year
Total renewable freshwater	1 000
Total water withdrawal	78.8
Internal renewable water sources	938
of which are surface water	938
pressure on surface water	*no data available*
of which are groundwater	145
pressure on groundwater	*no data available*
Water stress	***7.90%***

Source: AMCOW 2018; FAO 2018.

A market in Lilongwe

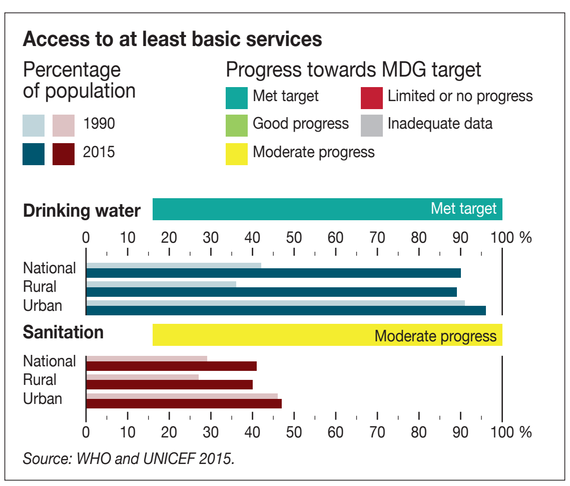




Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	15.7	12.6	9.5	6.4
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)	16.7	14.4	12.0	9.6
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)		2.0		
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				7.9
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				40.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• City and regional water boards • Water Resources Board • Ministry of Irrigation and Water Development • Ministry of Health and Population
Environment for private sector participation	• Public Private Partnership Act, 2013 • Public Private Partnership Policy Framework, 2011 • Public Private Partnership Commission
Legal, policy and strategy frameworks	
Current enabling policies	• Water Policy, 1996 • Water Resources Management Policy and Strategy, 2000 • Environmental Management Policy, 1996
Current enabling laws	• Water Resources Act, 1969 • Water Resources Act, 2013 (No. 2 of 2013) • Water Regulations, 1969 (Cap. 72:03) • Water Resources (Water Pollution Control) Regulations, 1978 (Cap. 72:03)

Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

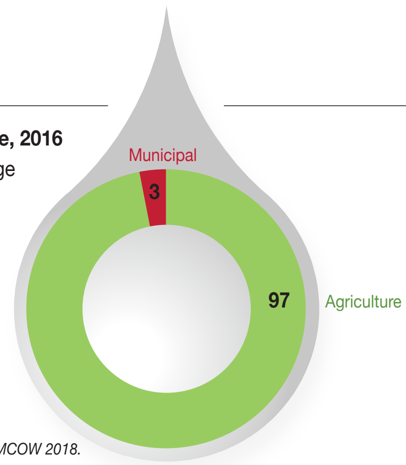
Mali

Water resources

Mali has average rainfall of 573 mm/year (AMCOW 2018). The country is divided into four major agroclimatic zones with rainfall decreasing in a south-north direction (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.26 and is projected to increase to 0.32 by 2040 (Luo et al. 2015). A score of 0.32 indicates that there is low competition among water users relative to available surface-water resources.

Water use, 2016
Percentage



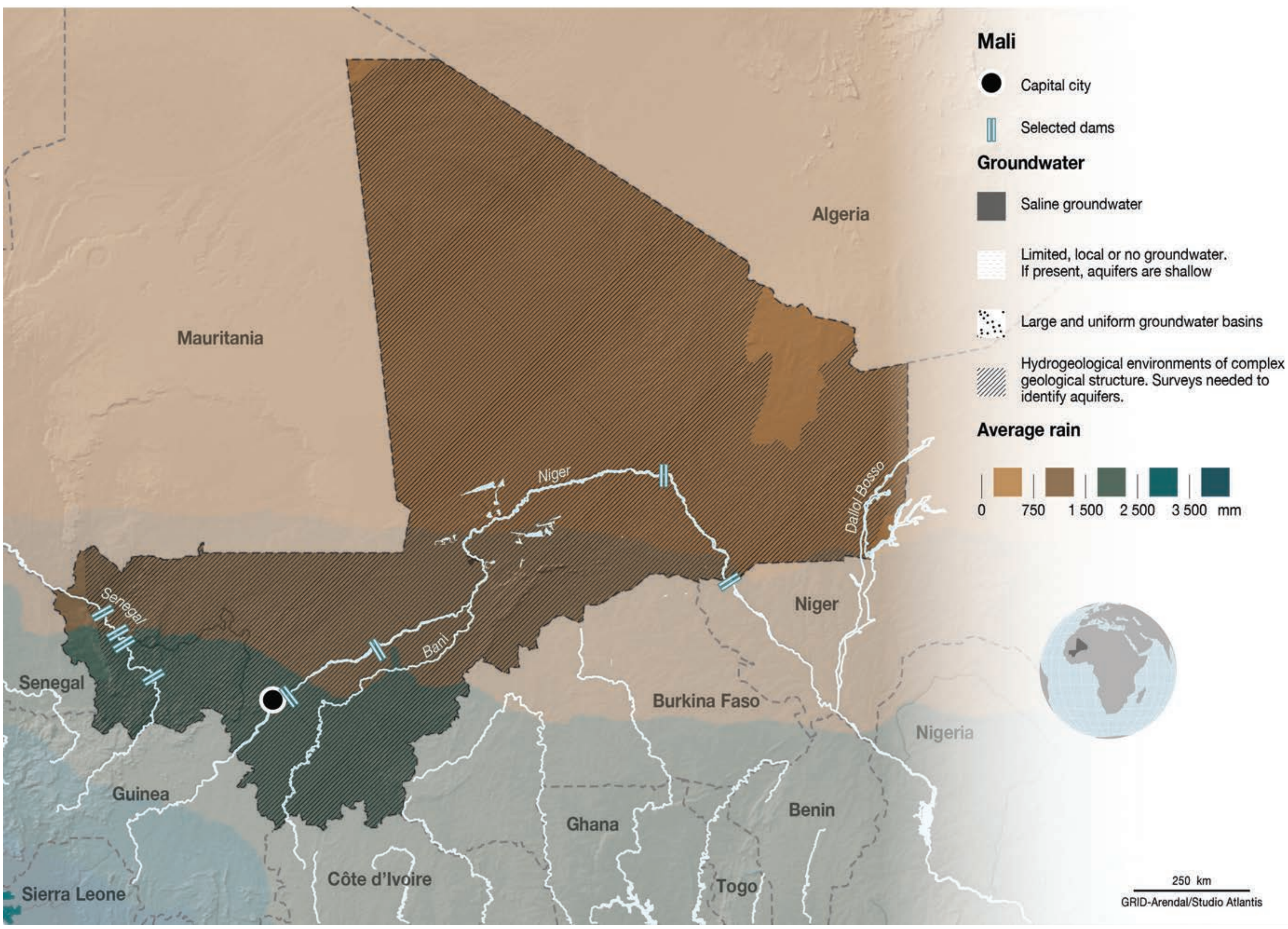
Source: AMCOW 2018.

Water availability

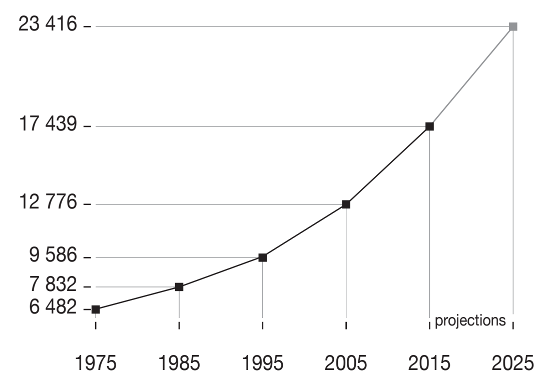
	m³/person and year
Total renewable freshwater	7 680
Total water withdrawal	573
Internal renewable water sources	4 640
of which are surface water	1 120
pressure on surface water	*46.5%*
of which are groundwater	3 520
pressure on groundwater	*0.47%*
Water stress	***7.50%***

Source: AMCOW 2018; FAO 2018.

A market in Bamako



Population growth (thousands)



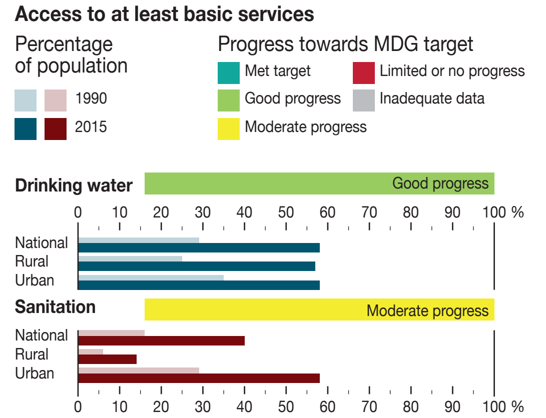
Source: UN-Desa 2019.

Wastewater management

Recent data on wastewater management are lacking. Available data show that 96.7 million m3/ year of wastewater was produced in 2009 up from 87.5 million m3/year in 2007 (FAO 2018).

Water and sanitation provision

Access to at least basic services



Source: WHO and UNICEF 2015.

Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	21.5	16.8	12.2	8.1
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)			16.2	16.3
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)		0.8		
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				7.5
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				53.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Energy, Mines and Water • Agency for Water Supply and Sanitation • National Water Council • Regional and local water boards • National Directorate for Sanitation and Environmental Nuisance Control • Ministry of Health • Ministry of Environment
Presence of a functional water regulator	• Regulatory Commission of Water and Energy regulates the urban water and sanitation sector
Environment for private sector participation	• Law No. 2016-061 of 30 December 2016 on public-private partnerships • There is no dedicated public-partnership unit
Water pricing facility	• Interministerial Order No. 01-1475-MMEEMICT-MEF of 28 June 2001 on water consumption tariffs
Legal, policy and strategy frameworks	
Current enabling policies	• Water Resources Development Framework • National Water Policy, 2006
Current enabling laws	• Law No. 02-006 on the Water Code, 2002 • Decree No. 01-395/P-RM on procedures for the management of wastewater and sludge of 2001 • Interministerial Order No. 09-0767/MEA/MEIC/MEME/SG of 6 April 2009, mandating the application of Malian wastewater discharge standards • Ordinance No. 00-020/p-rm of 15 March 2000 on the organization of drinking water public services • Ordinance No. 10-039/P-RM of 5 August 2010 establishing the Malian Drinking Water Heritage Society

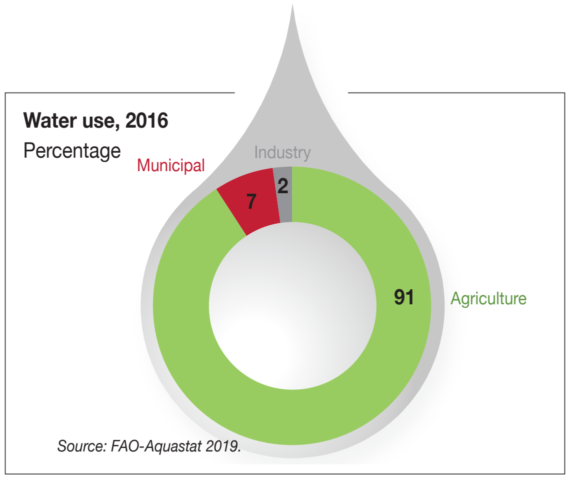
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Mauritania

Water resources

Mauritania has average rainfall of just 92 mm/year. Groundwater is therefore of great importance in the country, with pressure on sources at 43.3 per cent (AMCOW 2018). Over 50 per cent of the northern part of the country is desert, making the agriculture sector a major user of water (FAO 2016). Roughly 90 per cent of the water for irrigation comes from surface-water sources (FAO 2018). Internal renewable groundwater resources are 84.8 m^3/year per person compared with internal renewable water resources which are only 28.3 m^3/year per person (AMCOW 2018).

The country's aqueduct water stress for all sectors measured in 2010 was 0.47 and is projected to increase to 1.05 by 2040 (Luo et al. 2015). A score of 1.05 indicates that there is low to medium competition among water users relative to available surface-water resources.

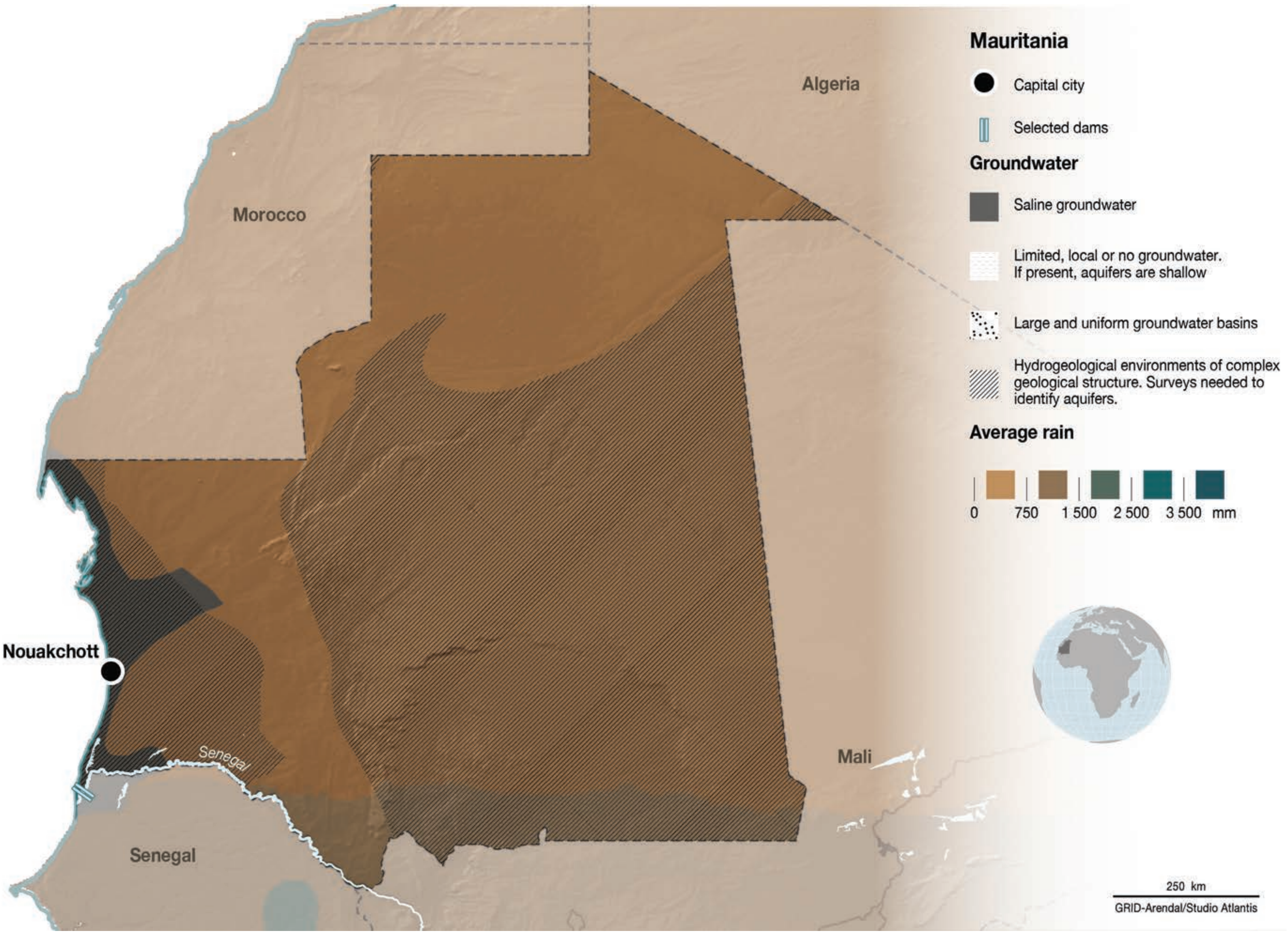


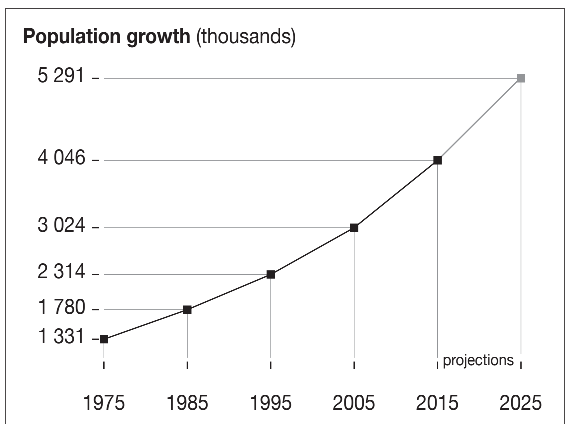
Water availability

	m³/person and year
Total renewable freshwater	3 220
Total water withdrawal	452
Internal renewable water sources	113
of which are surface water	28.3
pressure on surface water	*1 500%*
of which are groundwater	84.8
pressure on groundwater	*43.3%*
Water stress	***14.0%***

Source: AMCOW 2018; FAO 2018.

Nouakchott



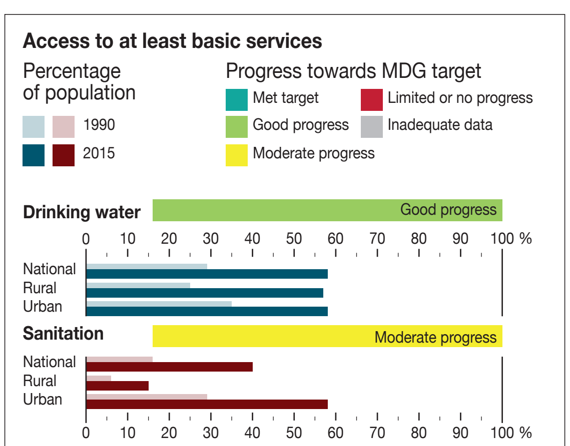


Source: UN-Desa 2019.

Wastewater management

There is not much recent data regarding wastewater management, although available data show that 21.4 million m³/year of municipal wastewater was produced in 2008. The amount of wastewater treated in 1998 was 0.7 million m³/year (FAO 2018).

Water and sanitation provision



Source: WHO and UNICEF 2015.

Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	48.9	42.3	36.1	30.1
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		15.9	16.4	16.8
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m³)		2.0		
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				14.0
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				45.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water and Sanitation • Directorate of Sanitation • National Office for Sanitation • National Office for Water Services in Rural Areas • National Centre for Water Resources • National Water Council • National Water Company • Agency for the Promotion of Universal Access to Basic Services • Ministry of Economic Affairs and Development • National Wells and Boreholes Company
Presence of a functional water regulator	• Multisector Regulation Authority
Environment for private sector participation	• Law No. 2015-039 of 9 December 2015 on public-private partnerships • There is no dedicated public-private partnerships unit
Water pricing facility	• Decree No. 2002-20 of 31 March 2020 establishing water withdrawal fees
Legal, policy and strategy frameworks	
Current enabling policies	• National Rural Sanitation Program • National Sanitation Policy and Strategy • Sector Policy Declaration • Water and Sanitation Strategy 2012
Current enabling laws	• Law No. 2005-30 on the National Water Code

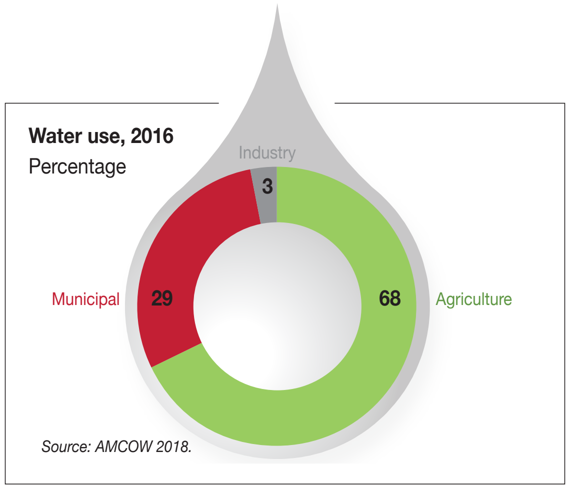
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Mauritius

Water resources

Located east of Madagascar in the Indian Ocean, Mauritius has rainfall average of 2,041 mm/year (AMCOW 2018).

Water stress data according to the Luo, Young and Reig index (2015) are not available. However, FAO data indicate that water stress has been increasing, rising from 20.57 per cent in 1990 to 26.35 per cent in 2003 (FAO 2018). Agriculture is the sector that uses the greatest proportion of the total water withdrawals.

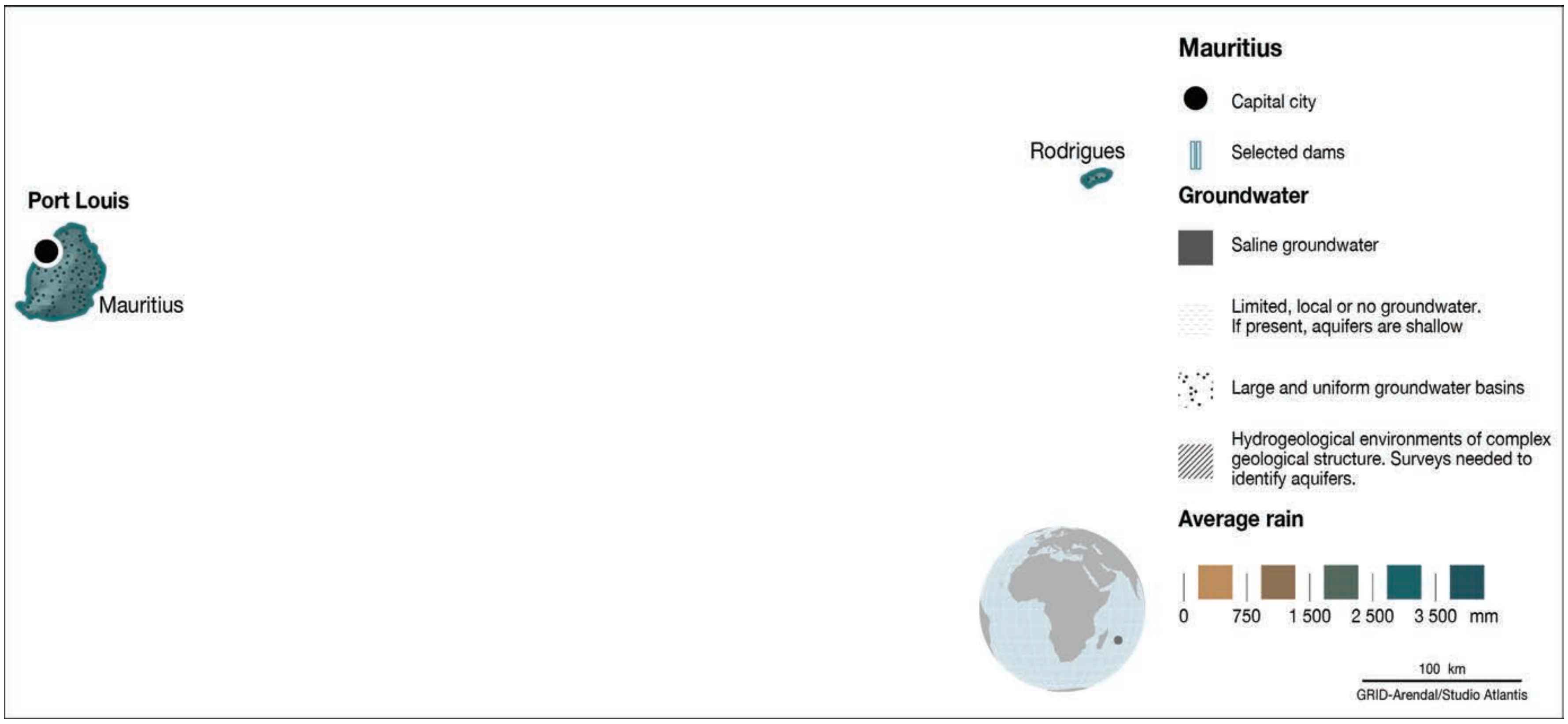


Water availability

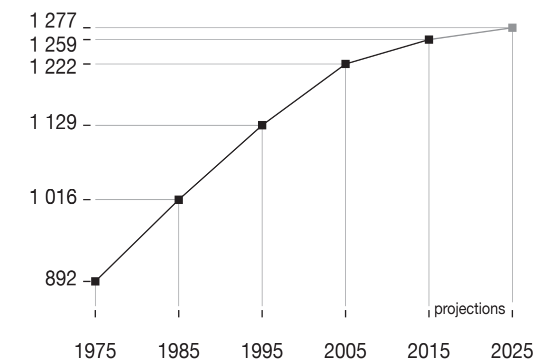
	m³/person and year
Total renewable freshwater	2 180
Total water withdrawal	574
Internal renewable water sources	2 180
of which are surface water	2 180
pressure on surface water	*24.5%*
of which are groundwater	707
pressure on groundwater	*16.6%*
Water stress	***26.3%***

Source: AMCOW 2018; FAO 2018.

Port Louis



Population growth (thousands)



Source: UN-Desa 2019.

Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	0.1	0.1	0.1	0.1
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)	7.6			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				26.3
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				64.0 (2017)

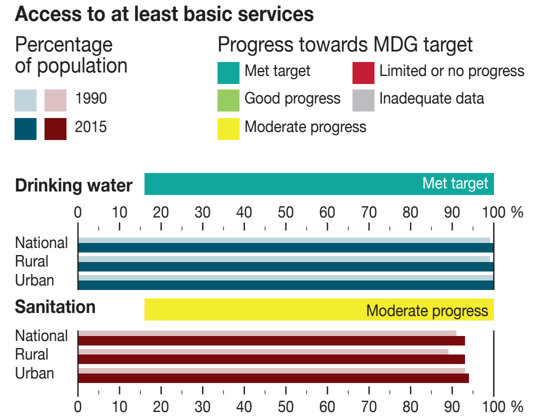
Source: UNSD 2019.

Wastewater management

Recent data on wastewater management are lacking. Available data show that 24.3 million m^3/year of municipal wastewater was produced in 2006, and that the amount of wastewater treated increased from 1 million m^3/year in 2006 to 41 million m^3/year in 2013 (FAO 2018).

Water and sanitation provision

Access to at least basic services



Source: WHO and UNICEF 2015.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Central Water Authority • Water Resources Unit • Ministry of Energy and Public Utilities • Wastewater Management Authority
Presence of a functional water regulator	• Central Water Authority
Environment for private sector participation	• Public-Private Partnership Act, 2004 • Build Operate Transfer Projects Act, 2016 • Public-Private Partnership Policy Statement, 2003 • Public Procurement Act (2006) and its PPP Regulations (2008) • Public-Private Partnerships Guidance Manual • Public-Private Partnership Unit established in the Ministry of Economic Development, Financial Services and Corporate Affairs
Water pricing facility	• Waste Water (Miscellaneous Waste Water Services) (Fees) (Amendment) Regulations 2017 (G.N. No. 194 of 2017)
Legal, policy and strategy frameworks	
Current enabling policies	• Water Master Plan, 2012 • National Water Policy
Current enabling laws	• National Water Act (draft) • Environment Protection (Drinking Water Standards) Regulations 1996 (G.N. No. 55 of 1996) • Central Water Authority (Amendment) Act, 2005 • Central Water Authority (Water Supply for Domestic Purposes) (Amendment) Regulations, 2008

Sources: FAO, 2016; Ministry of Energy and Public Utilities (MEPU) 2018; World Bank 2018b; World Bank 2018c.

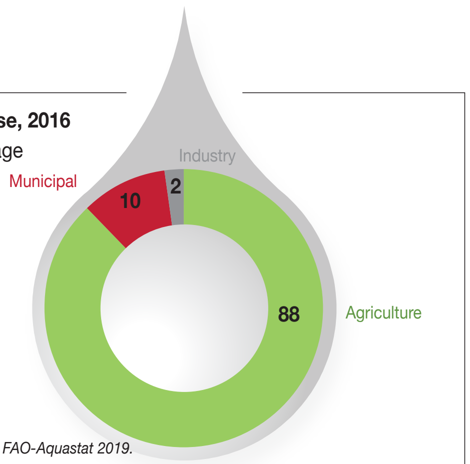
Morocco

Water resources

Morocco is located along the north-western coast of Africa. It is mostly a semi-arid country with a temperate north and a tropical south, and has average rainfall of 346 mm/year (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 3.85 and is projected to increase to 4.68 by 2040 (Luo et al. 2015). A score of 4.68 indicates that there is extremely high competition among water users relative to available surface-water resources.

Water use, 2016
Percentage



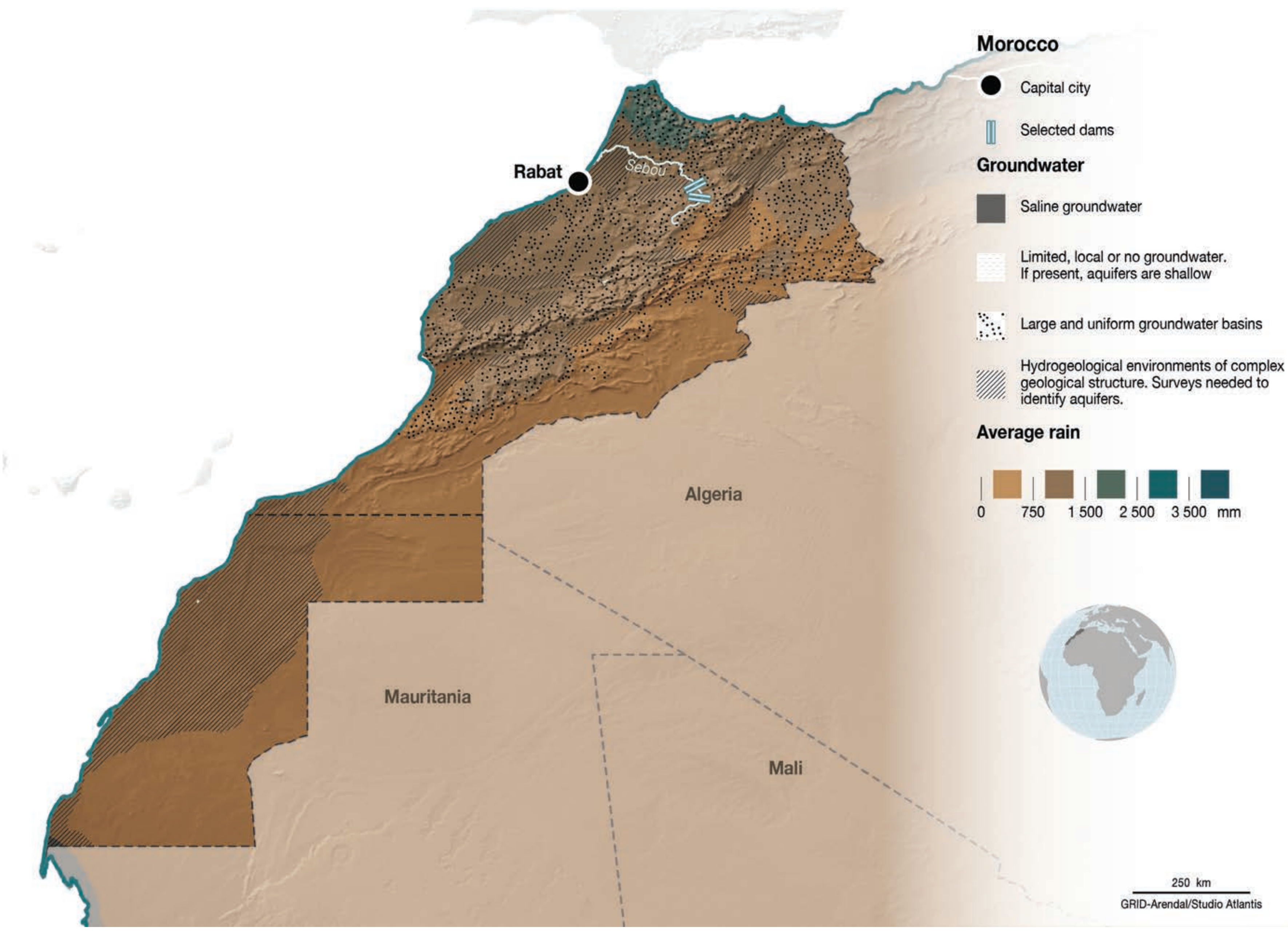
Source: FAO-Aquastat 2019.

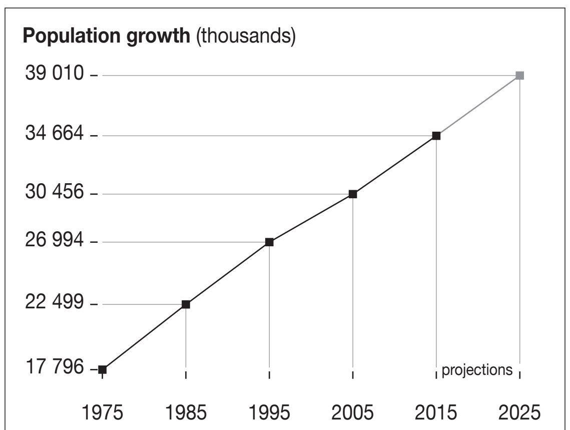
Water availability

	m³/person and year
Total renewable freshwater	no data available
Total water withdrawal	no data available
Internal renewable water sources	no data available
of which are surface water	no data available
pressure on surface water	*no data available*
of which are groundwater	no data available
pressure on groundwater	*no data available*
Water stress	***49.0%***

Source: AMCOW 2018; FAO 2018.

Rabat



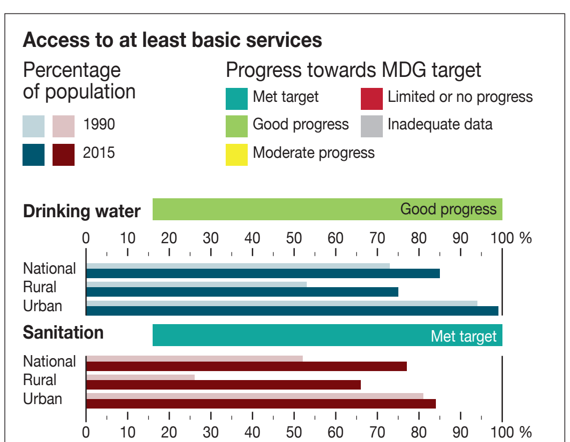


Source: UN-Desa 2019.

Wastewater management

Recent data on wastewater management are lacking. Available data show that 700 million m³/year of wastewater was produced in 2012. By 2012, there were 73 wastewater treatment plants in operation (FAO 2018).

Water and sanitation provision



Source: WHO and UNICEF 2015.

Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)	54.8	59.4	4.3	68.8
Sanitation and hygiene	Proportion of population practising open defecation (%)	24.3	18.0	11.4	7.6
	Proportion of population using safely managed sanitation services (%)	31.2	33.8	36.1	38.1
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				42.9 (2017)
	Proportion of bodies of water with good ambient water quality (%)				79.2 (2017)
	Proportion of groundwater bodies with good ambient water quality (%)				76.3 (2017)
Water-use efficiency	Water-use efficiency (US$/m³)			7.2	
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				49.0
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				64.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Energy, Mines, Water and Environment • National Office of Electricity and of Potable Water • National Drinking Water Authority
Environment for private sector participation	• Law No. 86-12 on public-private partnership contracts (Dahir No. 1-14-192 of 1 Rabii 1436 (24 December 2014)) • Decree No. 2-15-45 of 24 Rajab 1436 (13 May 2015) taken for the application of Law No. 86-12 on public-private partnership contracts • Department of Public Enterprises and Privatisation, Ministry of Economy and Finance • Interministerial PPP Committee to the Minister of Finance
Water pricing facility	• Order of the Minister Delegate to the Head of Government, in charge of General Affairs and Governance No. 375-13 of 25 Rabii I 1434 (6 February 2013) amending and supplementing Order No. 357-03 of 8 Hija 1423 (10 February 2003) fixing the rates for the sale of drinking water to production • Order of the Minister Delegate to the Head of Government, in charge of General Affairs and Governance No. 377-13 of 25 Rabii I 1434 (6 February 2013) amending and supplementing Order No. 427-06 of 2 Safar 1427 (3 March 2006) setting tariffs for the sanitation fee
Legal, policy and strategy frameworks	
Current enabling policies	• National Water Plan, 2015 • National Water Strategy, 2009 • Rural Water Supply and Sanitation Programme (PAGER), 1995 • National Liquid Sanitation and Wastewater Treatment Programme launched in 2005, setting targets for 2020 and 2030 for sanitation services and treatment rates
Current enabling laws	• Dahir No. 1-95-154 promulgating Law No. 10-95 on water • Dahir No. 1-10-104 promulgating Law No. 42-09 modifying and completing Law No. 10-95 on water

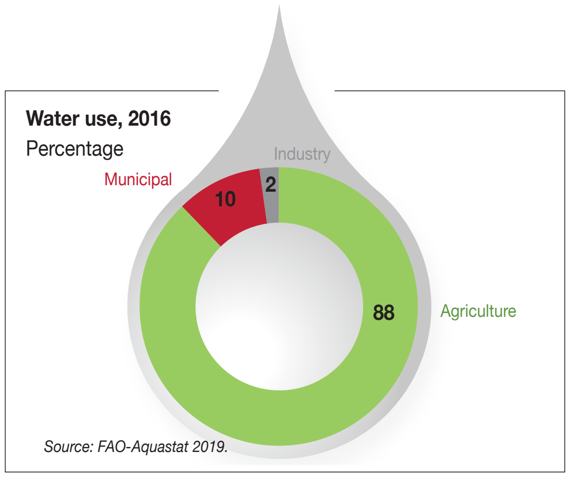
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Mozambique

Water resources

Mozambique receives an average of 1,032 mm/year of rainfall (AMCOW 2018), which varies from the coast to inland areas and from north to south. Along the coast, rainfall averages 800–1,000 mm. The northern and central part averages 1,000-2,000 mm decreasing to 400 mm towards the arid south (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.49 and is projected to decrease to 0.72 by 2040 (Luo et al. 2015). The score of 0.72 indicates that there is low competition among water users relative to available surface-water resources.



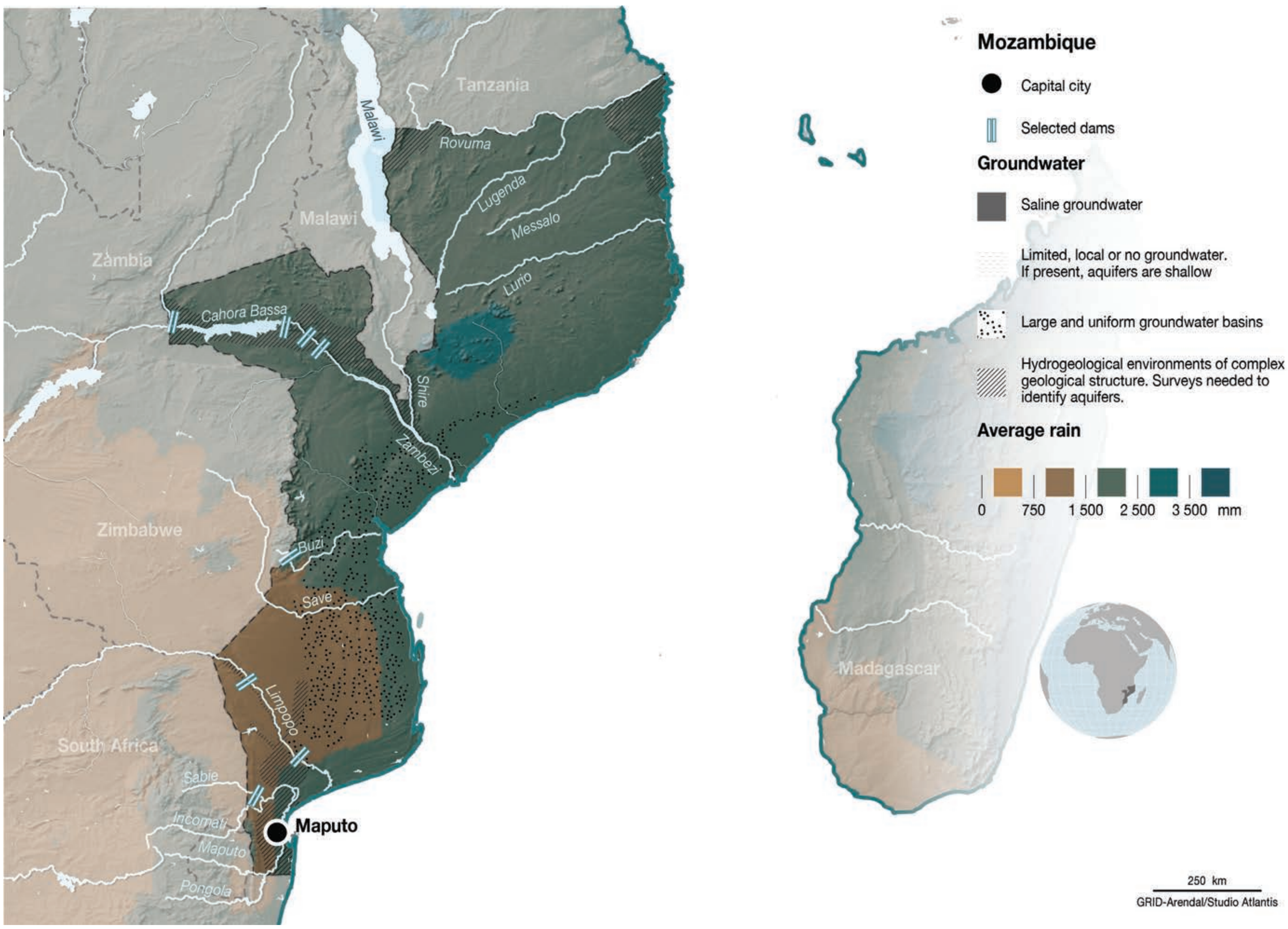
Source: FAO-Aquastat 2019.

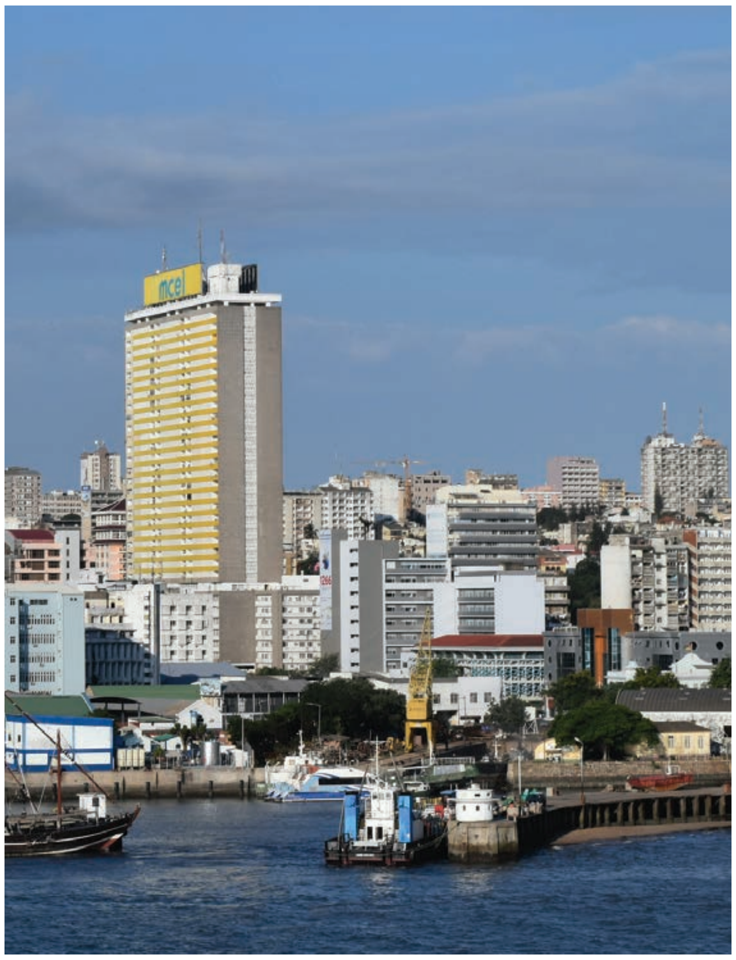
Water availability

	m³/person and year
Total renewable freshwater	8 220
Total water withdrawal	no data available
Internal renewable water sources	3 800
of which are surface water	no data available
pressure on surface water	*no data available*
of which are groundwater	no data available
pressure on groundwater	*no data available*
Water stress	***0.93%***

Source: AMCOW 2018; FAO 2018.


Maputo

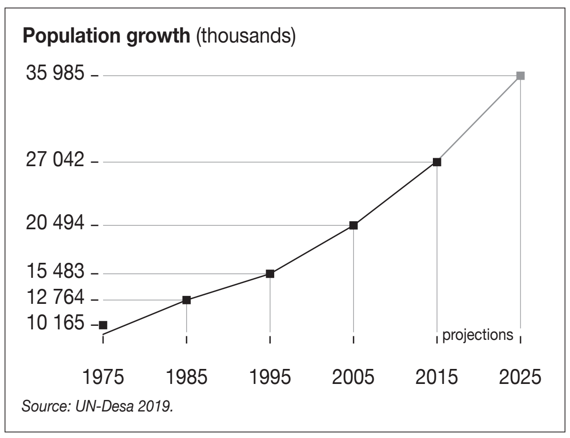




Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	56.7	49.8	42.9	35.9
	Proportion of population using safely managed sanitation services (%)	2.9	5.9	9.1	12.2
	Proportion of population with basic handwashing facilities on premises (%)			11.8	11.9
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)				6.5
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.93
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				55.0 (2017)

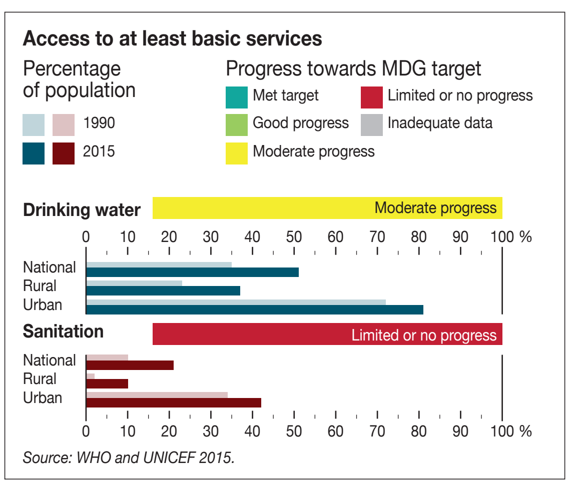
Source: UNSD 2019.



Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Public Works and Housing • National Water Council • Board of Water and Sanitation Infrastructure • Water Supply Investment and Assets Fund • Administration of Water Infrastructures and Sanitation
Presence of a functional water regulator	• Water Regulatory Council
Environment for private sector participation	• Public-Private Partnership Unit under the Ministry of Economy and Finance • Law No. 15/2011 of 10 August 2011 on public-private partnerships • Decree No. 16/2012 of 4 June 2012 on public-private partnerships
Water pricing facility	• 1998 Water Tariff Policy (Resolution No. 60/98)
Legal, policy and strategy frameworks	
Current enabling policies	• National Water Policy, 2007 • National Water Policy (Resolution No. 7/95)
Current enabling laws	• Water Law, 1991 • Decree No. 15/2004 approving the regulation on municipal water supply and wastewater treatment

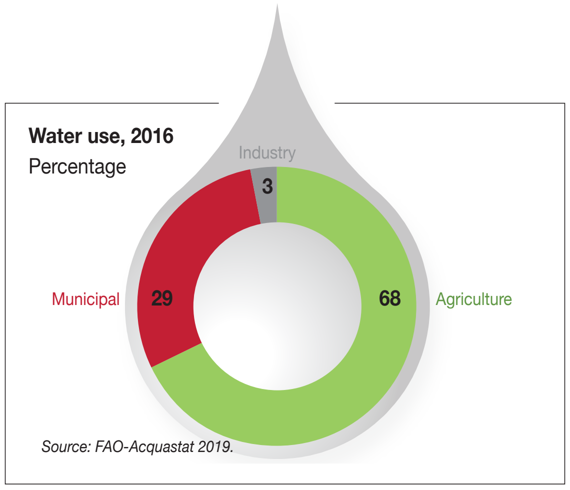
Source: FAO 2016; Wilson and Dias 2016; World Bank 2018b; World Bank 2018c.

Namibia

Water resources

Namibia is one of the most arid places in Africa (FAO 2016). Mean rainfall averages only 197 mm/year (AMCOW 2018), of which 83 per cent evaporates, 14 per cent is used up by vegetation, 2 per cent becomes run-off and only 1 per cent recharges groundwater (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 1.75 and is projected to increase to 3.18 by 2040 (Luo et al. 2015). A score of 3.18 indicates that there is high competition among water users relative to available surface-water resources. As with most African countries, the agricultural sector uses the greatest proportion of the total amount of water withdrawn.

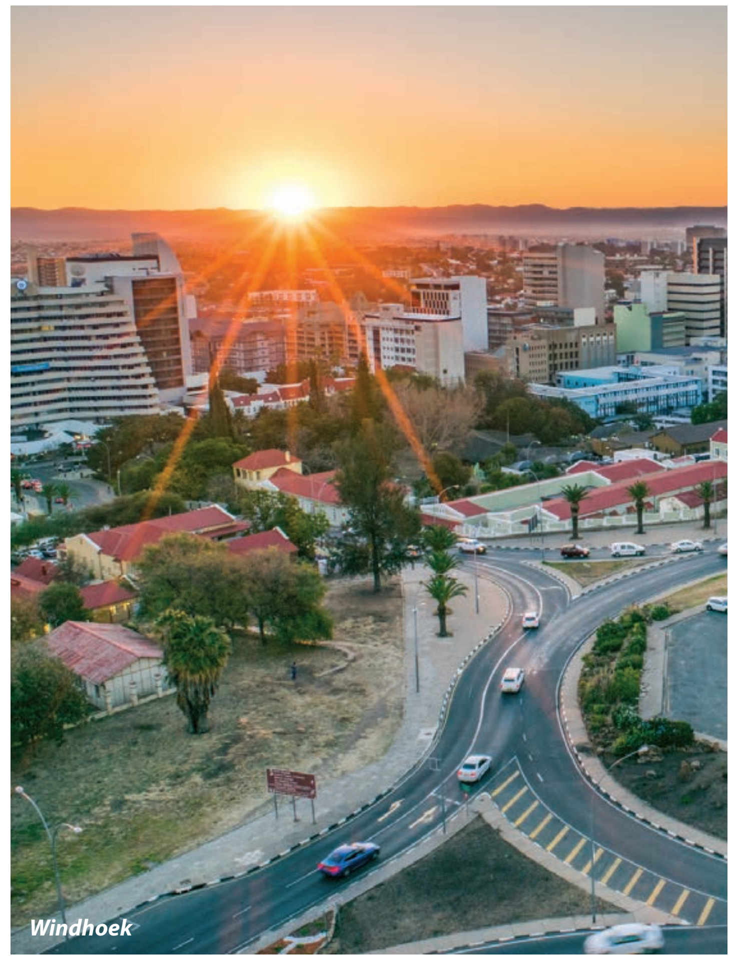


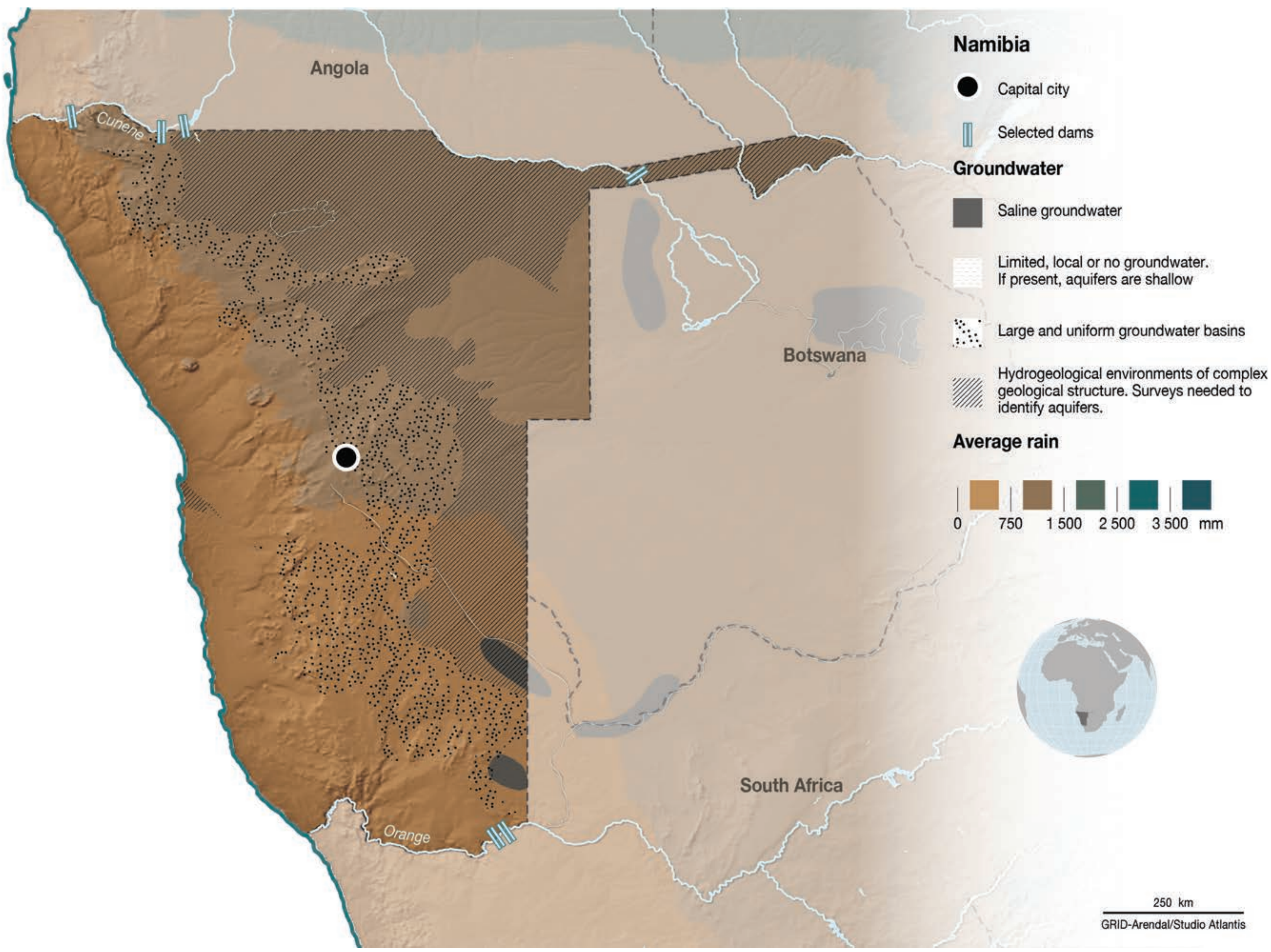
Source: FAO-Acquastat 2019.

Water availability

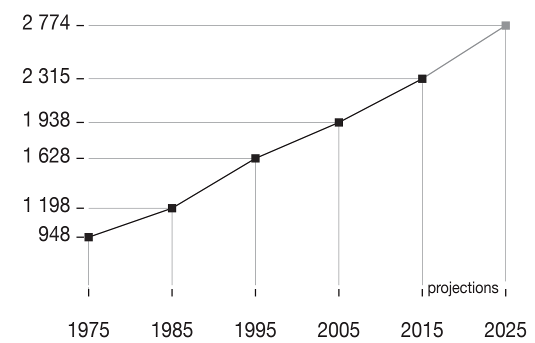
	m³/person and year
Total renewable freshwater	17 500
Total water withdrawal	57.9
Internal renewable water sources	2 700
of which are surface water	180
pressure on surface water	*268%*
of which are groundwater	92.1
pressure on groundwater	*15.2%*
Water stress	***0.30%***

Source: AMCOW 2018; FAO 2018.





Population growth (thousands)



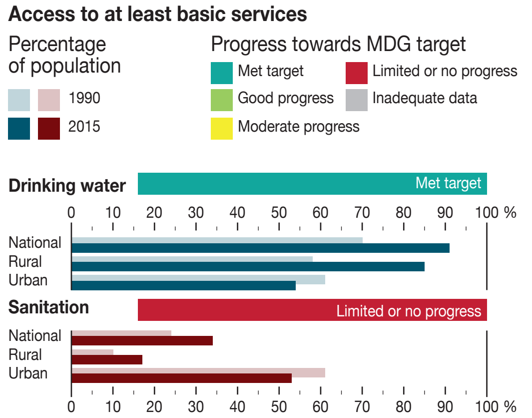
Source: UN-Desa 2019.

Wastewater management

Recent data on wastewater management are lacking. Available data show that 19.5 million m^3/year of municipal wastewater was produced in 2009 and that the amount treated in the same year was 6 million m^3/year. Although there are no data, some of the untreated wastewater is channelled into alternative systems such as septic tanks or soak pits. By 2013, the operational wastewater treatment plants had a capacity of 7 million m^3/year of treated wastewater (FAO 2018).

Water and sanitation provision

Access to at least basic services



Source: WHO and UNICEF 2015.

Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	55.7	53.9	51.9	49.8
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)			42.0	43.7
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)	17.3			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.3
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				59.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Namibia Water Corporation • Water Point Committees • Water Advisory Council, 2016 • Water Users' Associations • National Water Master Plan • Ministry of Lands and Resettlement • Ministry of Health and Social Services
Environment for private sector participation	• Public-Private Partnership Unit in the Ministry of Finance • Public Private Partnership Act, No. 4 of 2017 • Public Private Partnership Policy, 2012
Water pricing facility	• Gazette Notice No. 6385, Tariffs 2017/2018
Legal, policy and strategy frameworks	
Current enabling policies	• Water Supply and Sanitation Policy, 2008 • National Water Policy White Paper, 2000
Current enabling laws	• Water Act 54 of 1956 • Water Corporation Act 12 of 1997 • Model Sewerage and Drainage Regulations (G.N. No. 99 of 1996) • Model Water Supply Regulations (G.N. No. 72 of 1996)

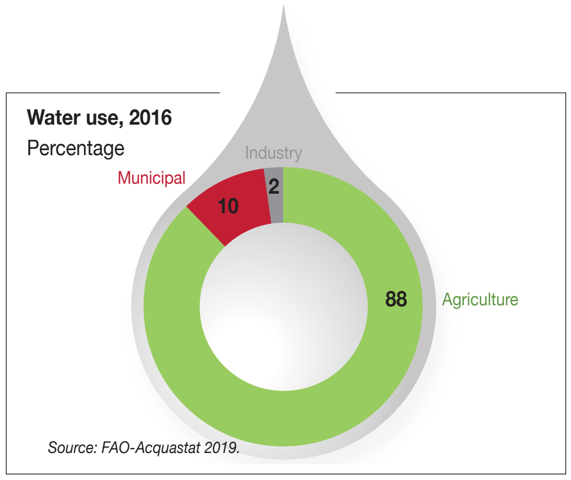
Sources: FAO 2016; Remmert 2016; World Bank 2018b; World Bank 2018c.

Niger

Water resources

Niger is located in West Africa and receives an average of 151 mm/year of rainfall (AMCOW 2018). The country has four climatic zones: the Saharan zone or desert, covering about 65 per cent of the land, with less than 100 mm/year; the Sahelian-Saharan zone, with rainfall between 100 and 300 mm/year; the Sahelian-Sudanian zone, with rainfall between 300 and 600 mm/year; and the Sudanian zone, with more than 600 mm of rainfall/year (FAO 2016).

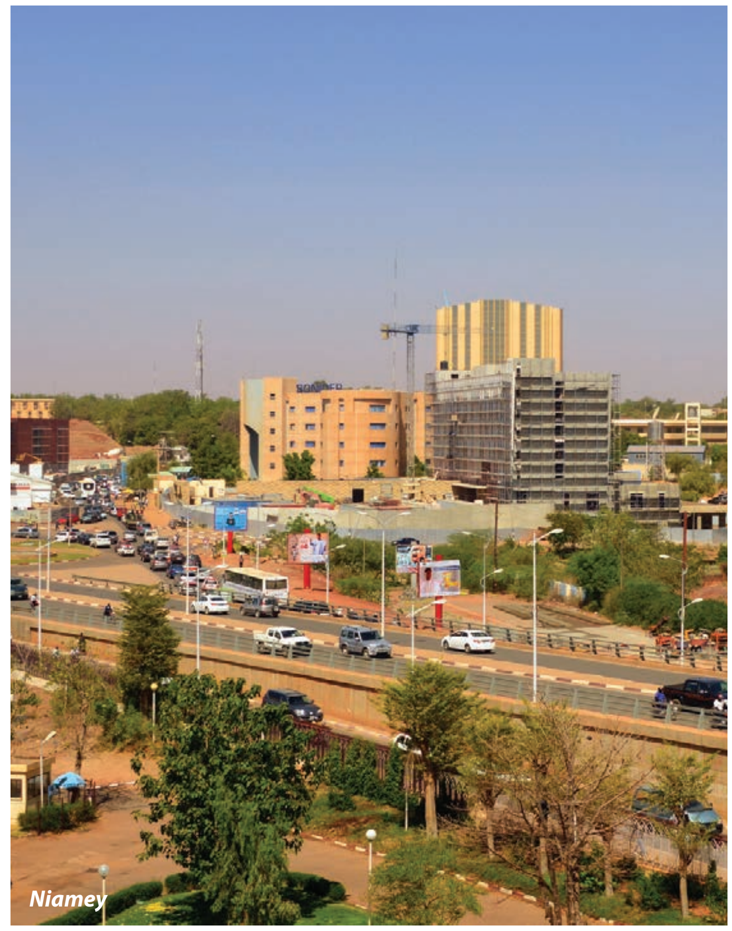
The country's aqueduct water stress for all sectors measured in 2010 was 0.12 and is projected to increase to 0.28 by 2040 (Luo et al. 2015). A score of 0.28 indicates that there is low competition among water users relative to available surface-water resources. The agriculture sector uses the greatest proportion of the total water withdrawals.

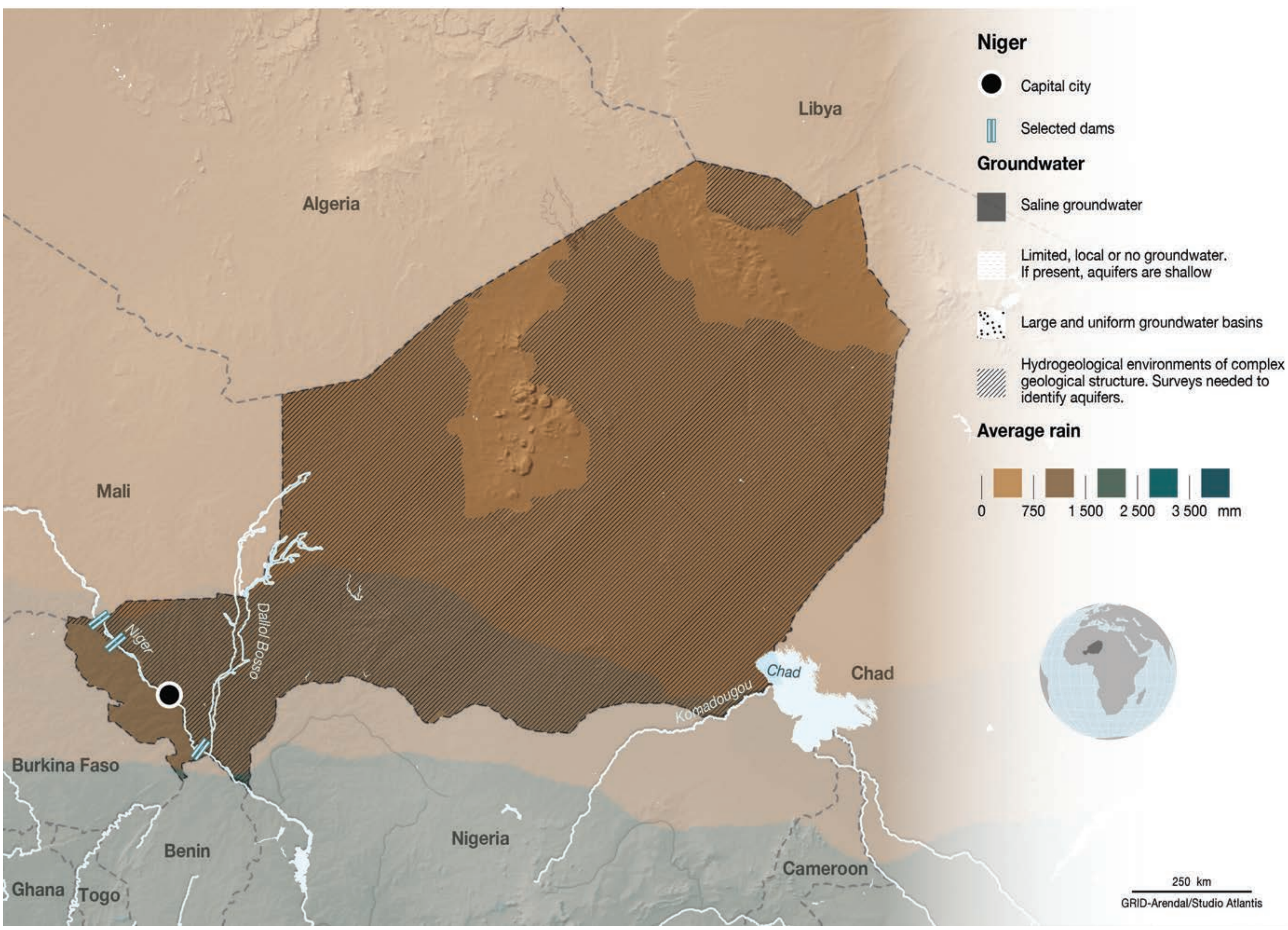


Water availability

	m³/person and year
Total renewable freshwater	1 780
Total water withdrawal	51.2
Internal renewable water sources	183
of which are surface water	52.3
pressure on surface water	*4%*
of which are groundwater	131
pressure on groundwater	*18.4%*
Water stress	***2.90%***

Source: AMCOW 2018; FAO 2018.

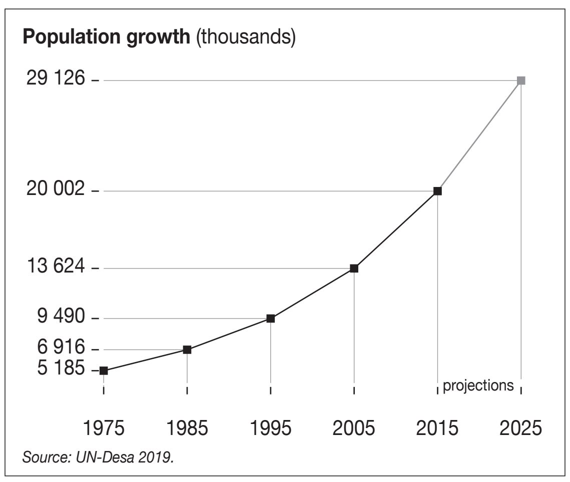




Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	81.5	78.3	74.9	71.3
	Proportion of population using safely managed sanitation services (%)	4.1	5.5	6.9	8.5
	Proportion of population with basic handwashing facilities on premises (%)		9.1	9.3	
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				3.4 (2017)
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)				2.4
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				2.9
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				50.0 (2017)

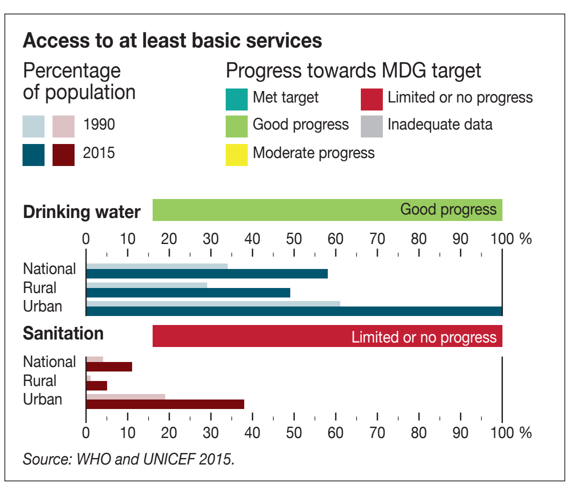
Source: UNSD 2019.



Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water Resources • National Water and Sanitation Commission • Regional Water and Sanitation Commissions • Niger Water Heritage Corporation • Niger Water Operator Company
Presence of a functional water regulator	• Public-Private Partnership Unit in the Division of Public Procurement and Management of Public Service, President's Office • Draft PPP law, 2014 (has not yet been adopted) • Law No. 2011-30 of 25 October 2011, ratifying Ordinance No. 2011-07 of 16 September 2011 on the general regime of public-private partnership contracts in the Republic of Niger (under revision) • Decree No. 2011-559/PRN/PM of 9 November 2011, laying down detailed rules for implementing Ordinance No. 2011-07 of 16 September 2011 on the general regime of public-private partnership contracts in the Republic of Niger • Decree No. 2011-560/PRN/PM of 9 November 2011, on the organization and functioning of the Public-Private Partnership Support Unit in the Republic of Niger • Decree No. 2013-569/PRN/PM of 20 December 2013 on the Public Procurement and Public Services Delegation Code
Environment for private sector participation	• Decree No. 99-539/PCRN/MH/E determining the tariffs for the sale of drinking water metered by the National Water Company (SNE) • Decree No. 2004-98/PCRN/MH/E/LCD automatically adjusting the price of water • Order No. 109/MHE/LCD of 22 December 2004 on restructuring the tariff scheme for the sale of water in urban and semi-urban centres
Legal, policy and strategy frameworks	
Current enabling policies	• 2012–2015 Economic and Social Development Plan (PDES) • Strategy for faecal sludge management (FSM) services in Niamey city • Public Rural Water Supply Services Guidance document
Current enabling laws	• Ordinance No. 2010-09 of 1 April 2010 on the Water Code • Decree No. 2003-145/PRN/MH/E/LCD approving the regulation of the drinking water distribution service in Niger and the document on the drinking water distribution service in Niger

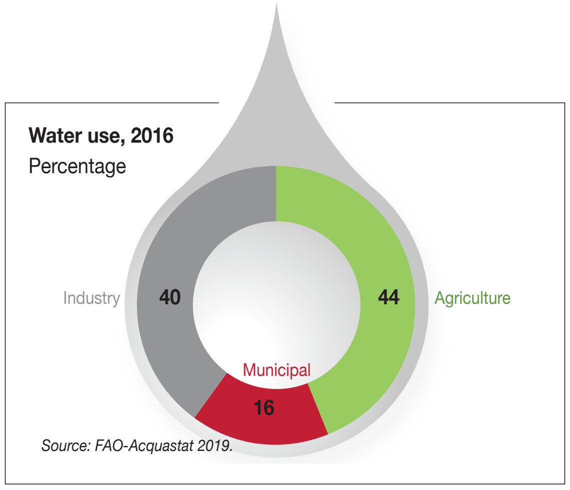
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Nigeria

Water resources

Nigeria receives an average of 1,150 mm/year of rainfall (AMCOW 2018). The north of the country is semi-arid but becomes more humid towards the coast (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.33 and is projected to increase to 0.90 by 2040 (Luo et al. 2015). A score of 0.90 indicates that there is low competition among water users relative to available surface-water resources. The proportion of water used is highest in the agriculture sector compared with total water withdrawals.

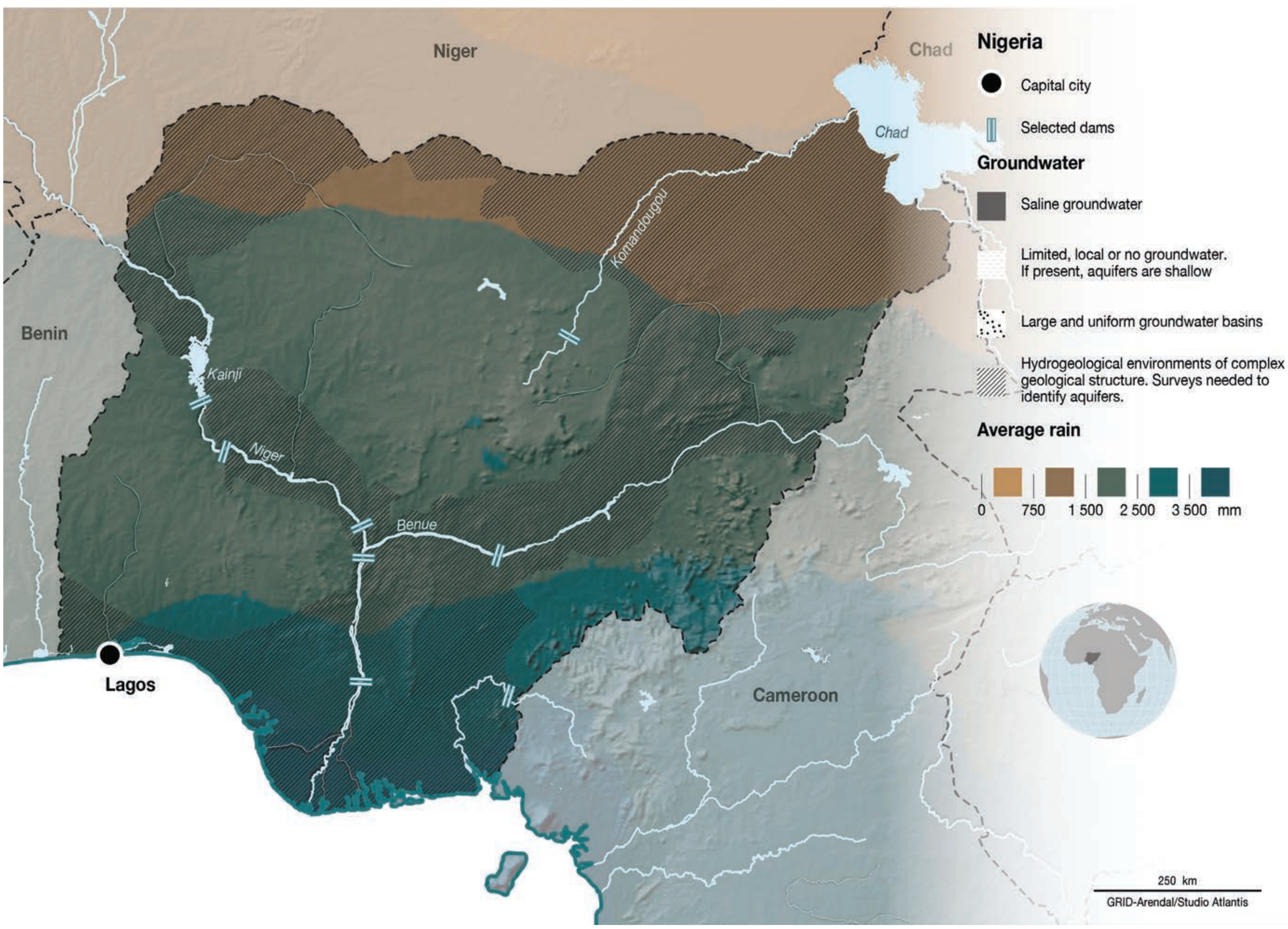


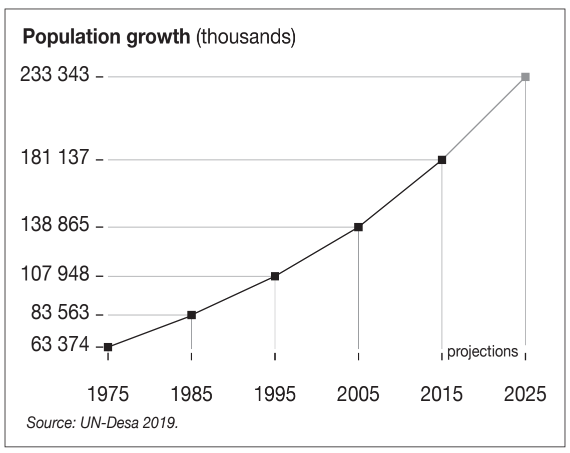
Water availability

	m³/person and year
Total renewable freshwater	2 120
Total water withdrawal	74
Internal renewable water sources	1 620
of which are surface water	1 380
pressure on surface water	*4.23%*
of which are groundwater	881
pressure on groundwater	*1.79%*
Water stress	***3.50%***

Source: AMCOW 2018; FAO 2018.


Street market in Lagos

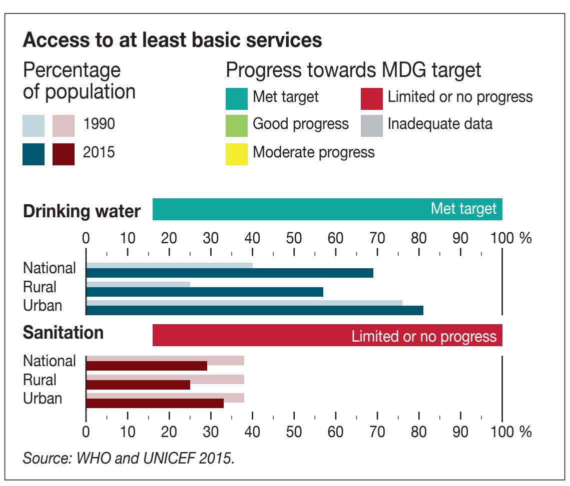




Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)	16.7	18.4	19.3	19.4
Sanitation and hygiene	Proportion of population practising open defecation (%)	22.6	23.6	24.6	25.5
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		12.1	12.6	13.1
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				52.5 (2017)
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)	6.7			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				3.5
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				3.5 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Federal Ministry of Water Resources • National Council on Water Resources • National Technical Committee on Water Resources • Nigeria Hydrological Services Agency • National Water Resources Institute
Environment for private sector participation	• Foundation for PPP Association • Infrastructure Concession Regulatory Commission • Lagos State Office of Public-Private Partnerships • PPP Division, Technical Services Department, Ministry of Finance • ICRC Act, 2005 • National Policy on Public Private Partnerships, 2009 • Public Procurement Act, 2007
Water pricing facility	• Utilities Charges Commission Act, 2013
Legal, policy and strategy frameworks	
Current enabling policies	• National Water Policy, 2009 (draft in 2016) • Water Resources Strategy, 2006 • Water Sector Roadmap, 2011
Current enabling laws	• Water Resources Act No. 101, 1993 • National Water Resources Bill (drafted from October 2006) • Model State Water Supply Service Regulatory Law • National Water Resources Master Plan • National Environmental (Effluent Limitation) Regulations, 2013 • National Environmental (Surface and Ground Water Quality Control) Regulations, 2011 (S.I. 22 of 2011)

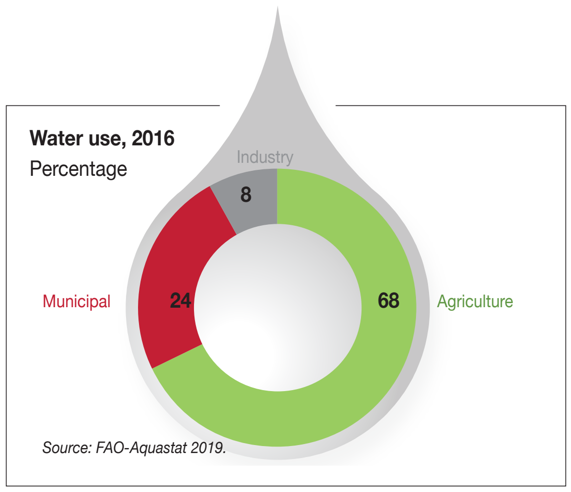
Sources: FAO 2016; Federal Government of Nigeria 2011; World Bank 2018b; World Bank 2018c.

Rwanda

Water resources

Rwanda is a landlocked mountainous country in East Africa with average rainfall of 1,200 mm/year (AMCOW 2018).

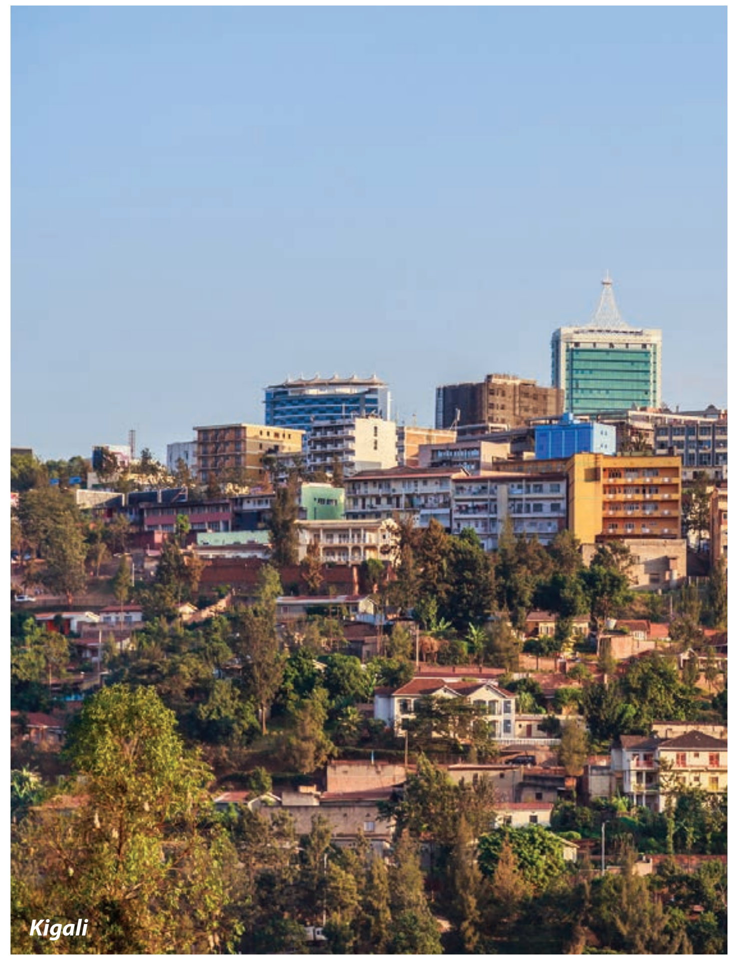
The country's aqueduct water stress for all sectors measured in 2010 was 0.00 and is projected to increase to 0.10 by 2040 (Luo et al. 2015). A score of 0.10 indicates that there is low competition among water users relative to available surface-water resources.

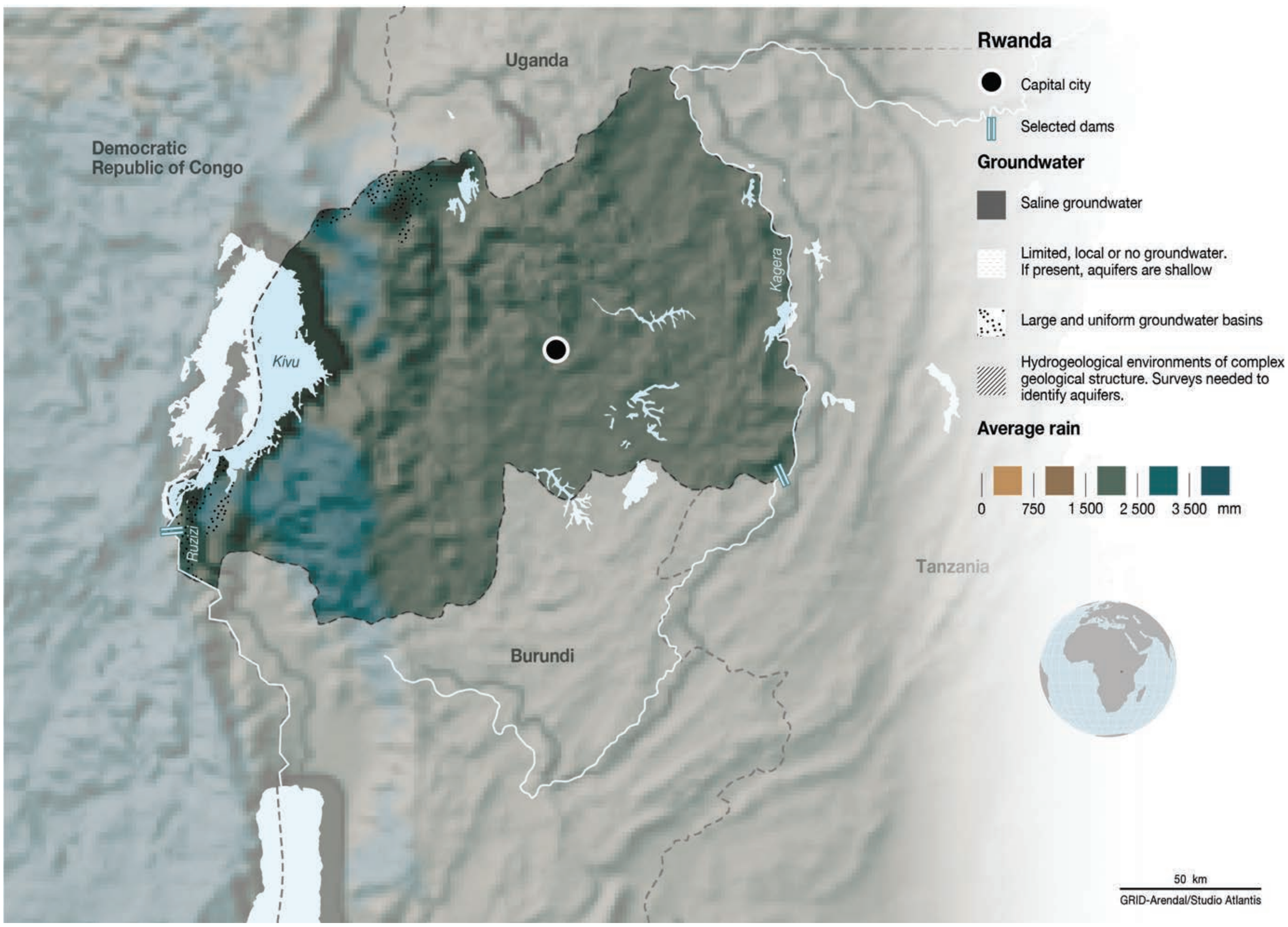


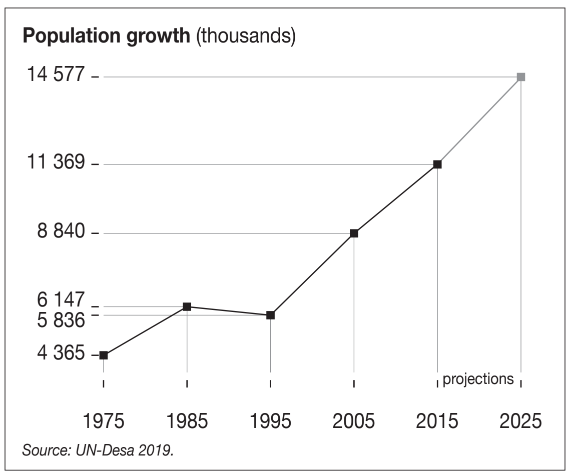
Water availability

	m³/person and year
Total renewable freshwater	1 150
Total water withdrawal	1 550
Internal renewable water sources	824
of which are surface water	824
pressure on surface water	*31.6%*
of which are groundwater	607
pressure on groundwater	*1.96%*
Water stress	***1.40%***

Source: AMCOW 2018; FAO 2018.


Kigali

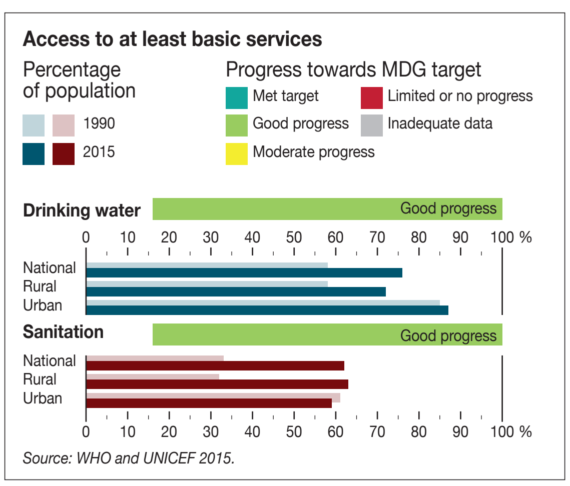




Wastewater management

Data on wastewater management are lacking.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)	25.9	29.3	3.8	36.4
Sanitation and hygiene	Proportion of population practising open defecation (%)	4.4	3.6	2.8	2.1
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)	1.2	2.5	3.9	5.4
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				30.0@ (2017)
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)	14.0			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				1.4
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				35.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

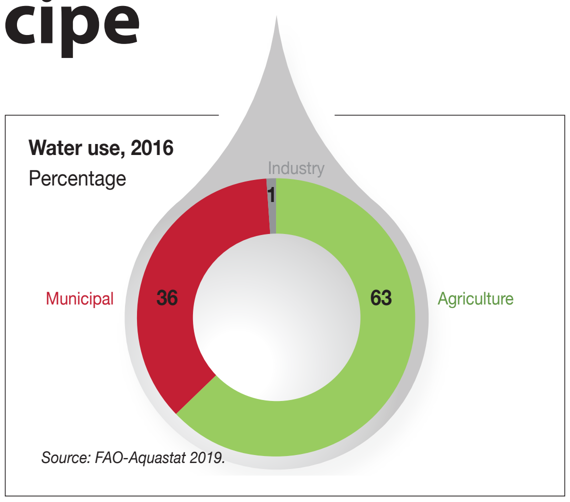
Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Lands, Environment, Forestry, Water and Natural Resources • Water and Forest Authority • Energy, Water and Sanitation Authority
Presence of a functional water regulator	• Rwanda Utilities Regulatory Authority
Environment for private sector participation	• Public-Private Partnership Unit of the Rwanda Development Board • Law No. 14/2016 of 2 May 2016 governing public-private partnerships • Law on public procurement
Water pricing facility	• Inter-ministerial Order No. 01/MINICOM/MINICOFIN/97 amending Inter-ministerial Order No. 01/MICOMART/MINIFIN/96 of 29 July 1996 fixing the sale prices of water, electricity and related services offered by Electrogaz and determining the methods of recovery and allocation of revenue, 1997
Legal, policy and strategy frameworks	
Current enabling policies	• National Policy for Water Resources Management, 2011
Current enabling laws	• Law No. 62/2008 laying down rules for the use, conservation, protection and management of water resources • Ordinance No. 52/443 on measures to protect sources, underground aquifers, lakes and rivers, to prevent pollution and wastage of water and to control the exercise of rights of use and rights of occupation conceded, 1952

Source: FAO 2016; World Bank 2018b; World Bank 2018c.

São Tomé and Príncipe

Water resources

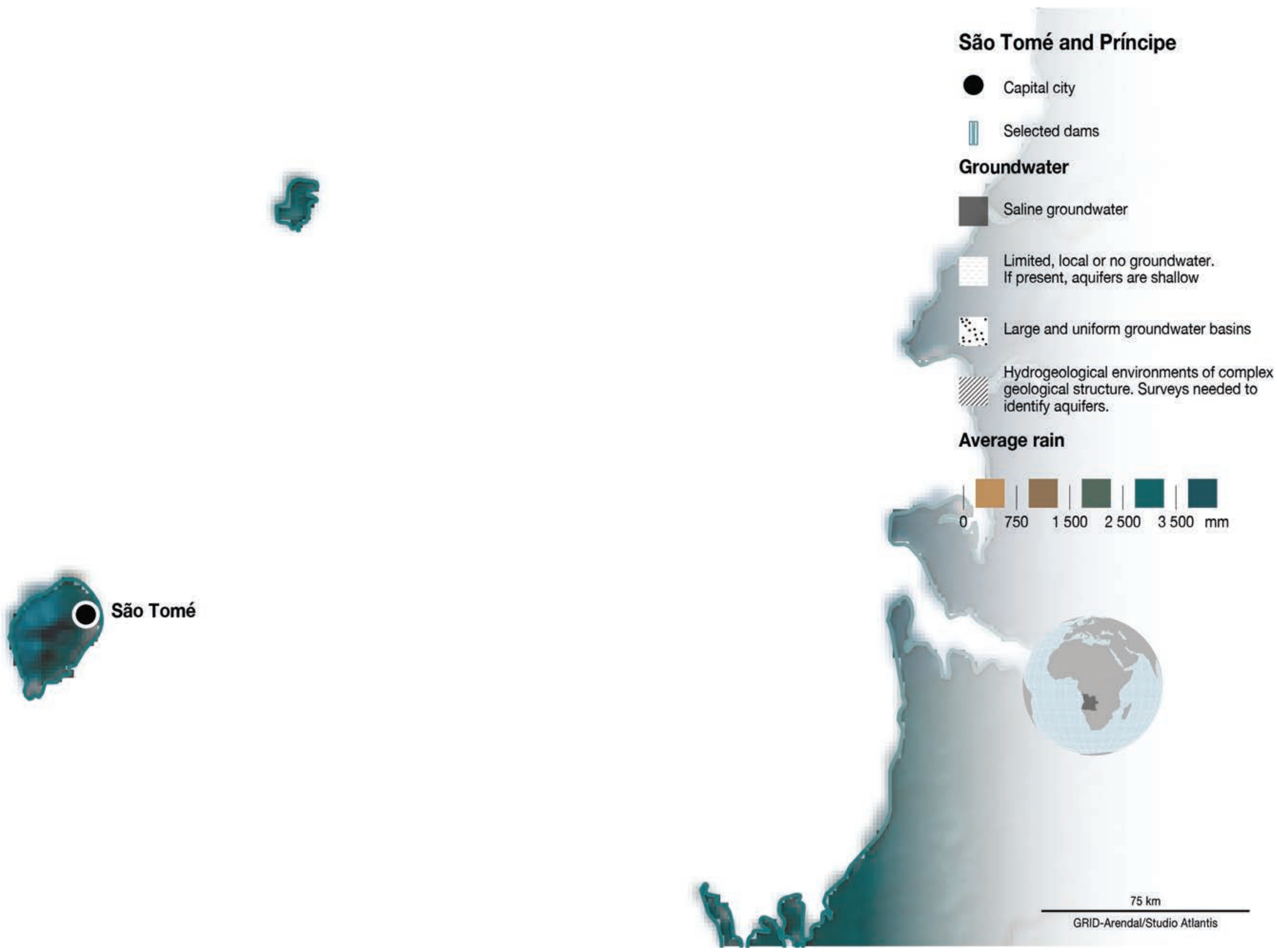
Located off the coast of Gabon in West Africa, São Tomé and Príncipe receives an average of 3,200 mm/year (AMCOW 2018) of rainfall. The climate is humid and rainfall varies greatly between the country's two main islands (FAO 2016). On the north-eastern São Tomé Island, rainfall ranges between 900 mm/year and over 6,000 mm/year in the south-west, while on the Príncipe Island, it ranges between 2,500 and 4,500 mm/year (FAO 2016).



Water availability

	m³/person and year
Total renewable freshwater	11 500
Total water withdrawal	36.8
Internal renewable water sources	11 500
of which are surface water	no available data
pressure on surface water	*no available data*
of which are groundwater	no available data
pressure on groundwater	*no available data*
Water stress	***0.30%***

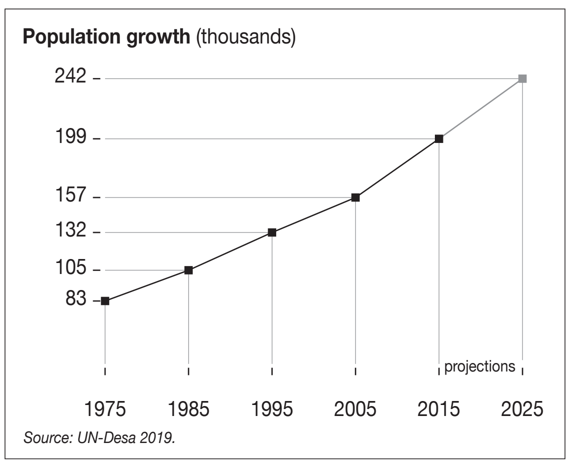
Source: AMCOW 2018; FAO 2018.



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	70.6	63.7	56.8	49.7
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)			42.2	41.9
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)				
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.3
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				23.0 (2017)

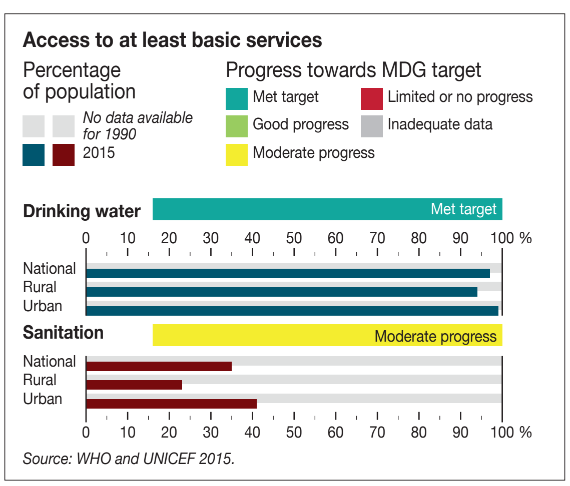
Source: UNSD 2019.



Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Public Company for Water and Electricity • Directorate-General for Natural Resources and Energy • Water and Sanitation Committee
Environment for private sector participation	• There is no dedicated public-private partnerships unit • There is no dedicated public-private partnerships law
Legal, policy and strategy frameworks	
Current enabling policies	
Current enabling laws	• Water Resources Framework Law No. 07/2018 • Order on the Statute of the Public Company for Water and Electricity, 2008

Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Senegal

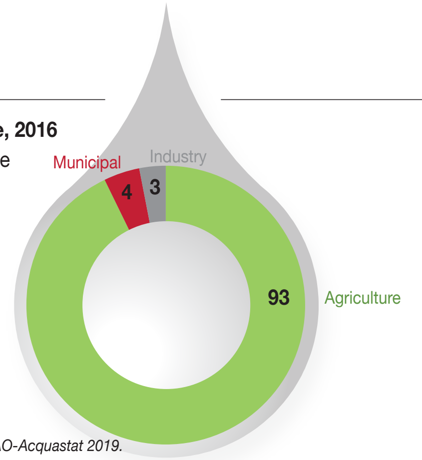
Water resources

Senegal has a Sahelian climate (FAO 2016), receiving 686 mm/year of rainfall that ranges between 200 mm/year in the north to 1,500 mm/year in the south (AMCOW 2018; FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.49 and is projected to increase to 0.98 by 2040 (Luo et al. 2015). A score of 0.98 indicates that there is low competition among water users relative to available surface-water resources.

Water use, 2016

Percentage



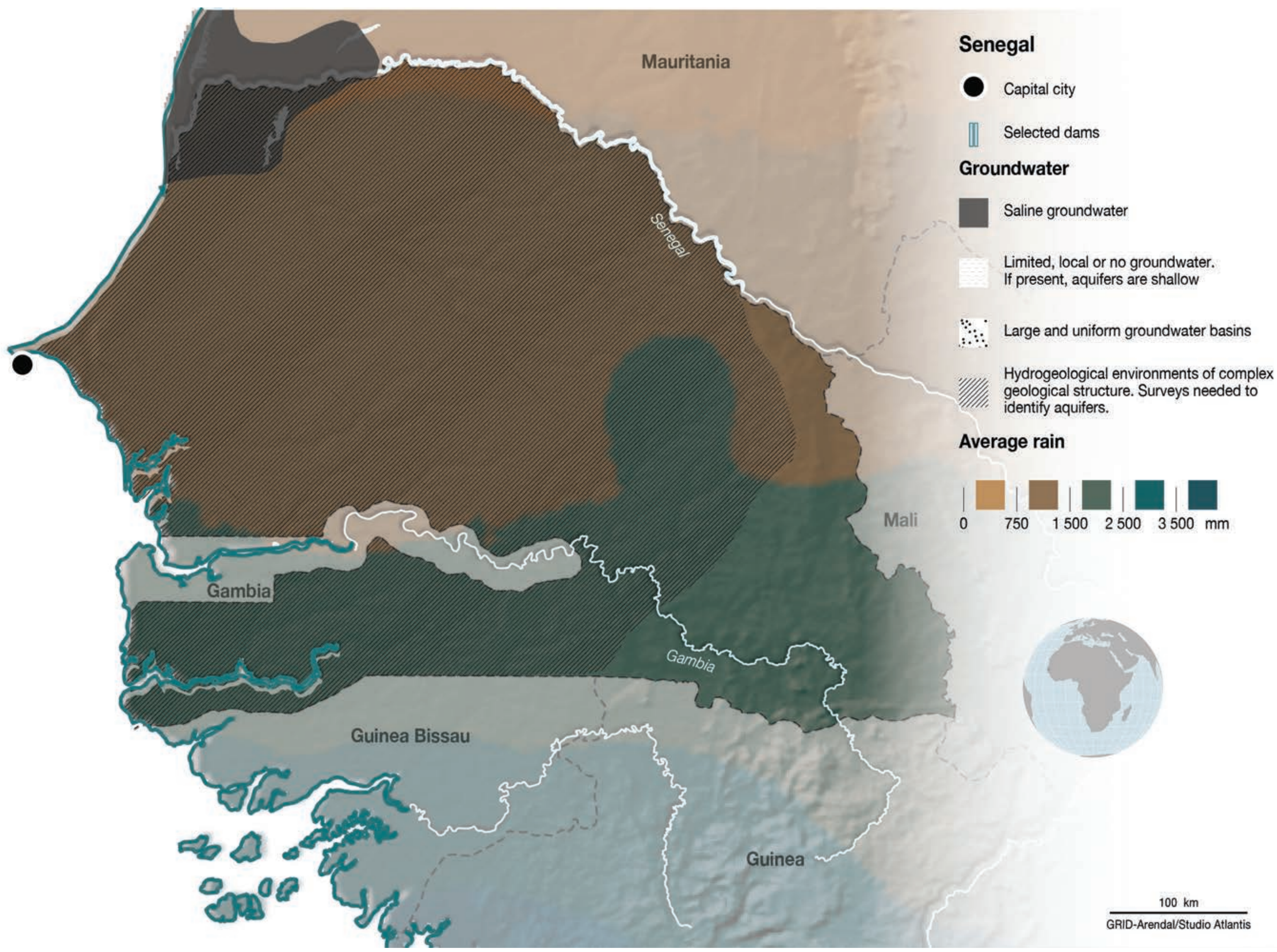
Source: FAO-Acquastat 2019.

Water availability

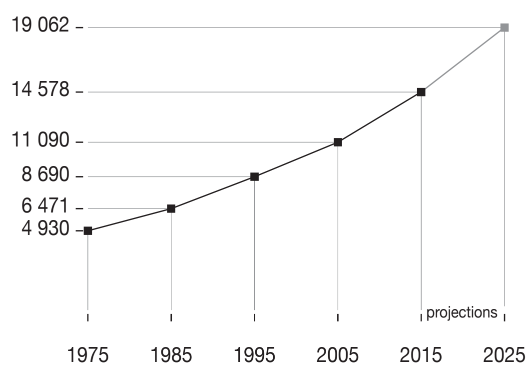
	m³/person and year
Total renewable freshwater	2 720
Total water withdrawal	156
Internal renewable water sources	1 800
of which are surface water	1 660
pressure on surface water	*6.72%*
of which are groundwater	244
pressure on groundwater	*18.4%*
Water stress	***5.70%***

Source: AMCOW 2018; FAO 2018.

Dakar



Population growth (thousands)



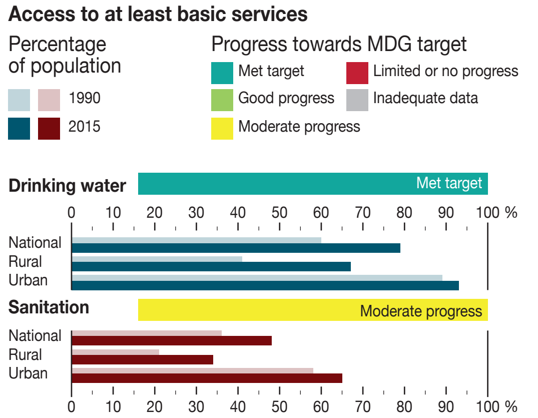
Source: UN-Desa 2019.

Wastewater management

There is a dearth of recent data regarding wastewater management. Available data show that 820 million m³/year of municipal wastewater was produced in 2012 and that 324 million m³/year was treated in the same year (FAO 2018). In 2012, there were 138 treatment plants, a significant increase from 44 in 2001, which operated with a capacity of 270 million m³/year of treated wastewater (FAO 2018).

Water and sanitation provision

Access to at least basic services



Source: WHO and UNICEF 2015.

Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	24.2	21.2	18.1	15.1
	Proportion of population using safely managed sanitation services (%)	17.6	19.7	21.9	24.1
	Proportion of population with basic handwashing facilities on premises (%)		15.1	15.3	15.4
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				14.5 (2018)
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m³)	2.7			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				5.7
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				53.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• National Water Company of Senegal • Senegalese Waters • National Sanitation Office of Senegal • Higher Council of Water • Rural Boreholes Agency
Presence of a functional water regulator	• No existing functional water regulator • Presence of an interministerial framework for regulation
Environment for private sector participation	• Public-Private Partnership Law and Application Decree • Public-Private Partnership Contacts Law • Directorate of Finance and Public-Private Partnerships in the Ministry of Investment Promotion and Partnerships, which acts as the national Public-Private Partnership Unit pending the effective settlement of the National Public-Private Partnership Committee
Water pricing facility	• Ministerial Order No. 8622 of 2 October 2008 revising water tariffs
Legal, policy and strategy frameworks	
Current enabling policies	• Integrated Water Resources Management Action Plan, 2007
Current enabling laws	• Law No. 81-13 of 4 March 1981 on the Water Code • A new Water Code is currently under review • Law No. 2009-24 on the Sanitation Code • Decree No. 98-556 implementing the provisions of the Water Code relating to the water police • Decree No. 98-1025 approving the Water Service Regulation, 1998

Source: FAO 2016; World Bank 2018b; World Bank 2018c.

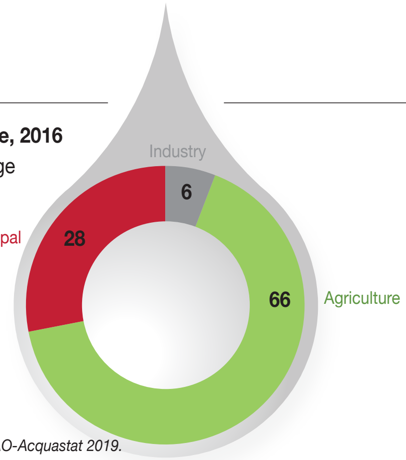
Seychelles

Water resources

Located about 1,500 km from the eastern African coast, Seychelles has an equatorial climate (FAO 2016), receiving rainfall of 2,330 mm/year (AMCOW 2018). The highest rainfall is received on Mahé Island, averaging 2,370 mm. This decreases to 1,990 mm and 1,620 mm on Praslin Island and La Digue Island, respectively. The other islands have a mean rainfall of 1,290 mm/year (FAO 2016).

Available data indicate that withdrawals from the municipal sector as a percentage of total withdrawals are 10 times higher than those in the agricultural sector (AMCOW 2018). Agriculture is not a significant contributor to the economy, representing only 1.9 per cent to GDP in 2017, which may account for the low water usage by the sector (World Bank 2018). According to historical data from 2003, municipal withdrawals were 65 per cent compared with 6.5 per cent and 27.7 per cent for agriculture and industry, respectively (FAO 2018).

Water use, 2016
Percentage

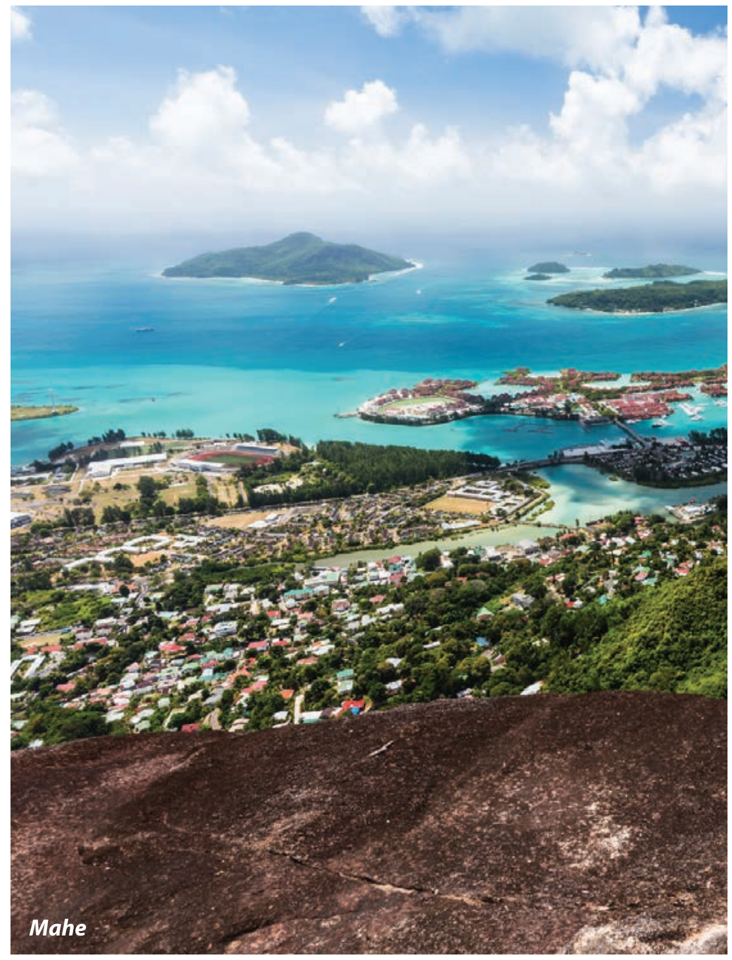


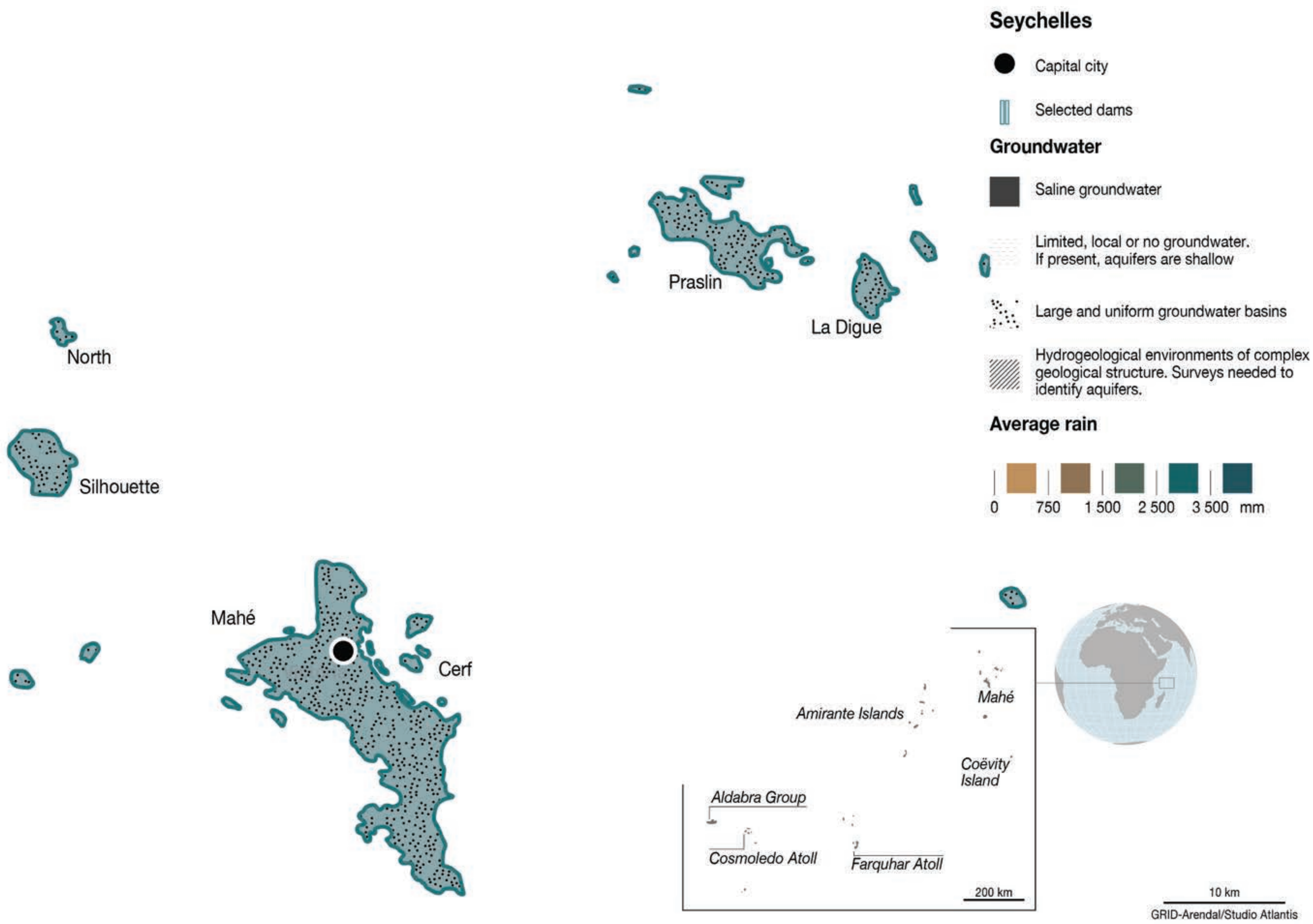
Source: FAO-Acquastat 2019.

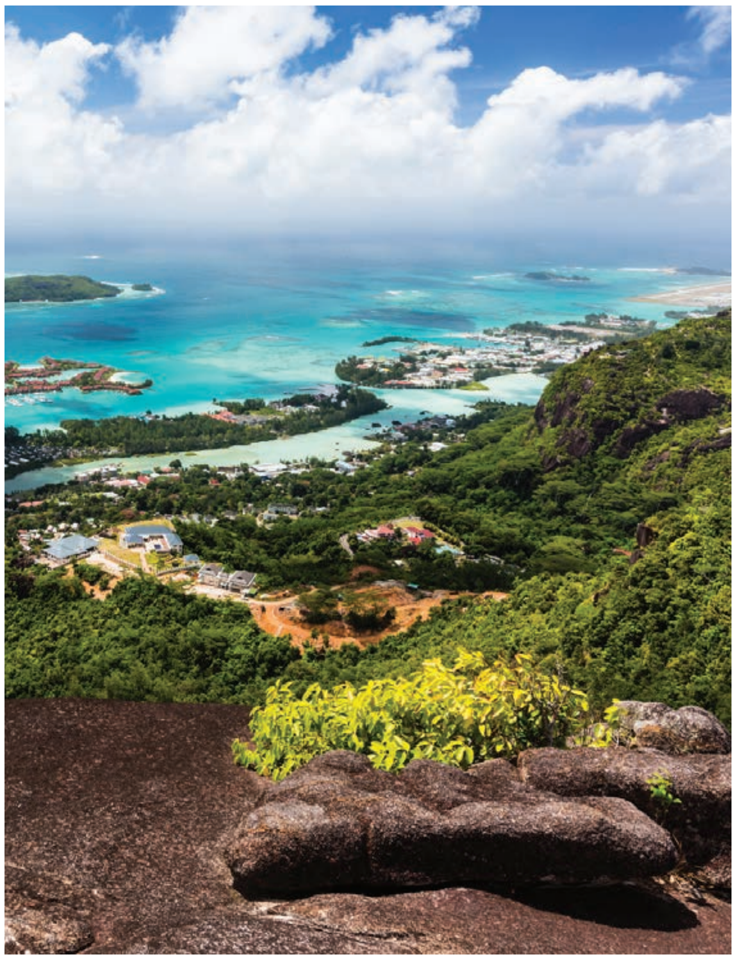
Water availability

	m³/person and year
Total renewable freshwater	no data available
Total water withdrawal	no data available
Internal renewable water sources	no data available
of which are surface water	no data available
pressure on surface water	*no data available*
of which are groundwater	no data available
pressure on groundwater	*no data available*
Water stress	***no data available***

Source: AMCOW 2018; FAO 2018.



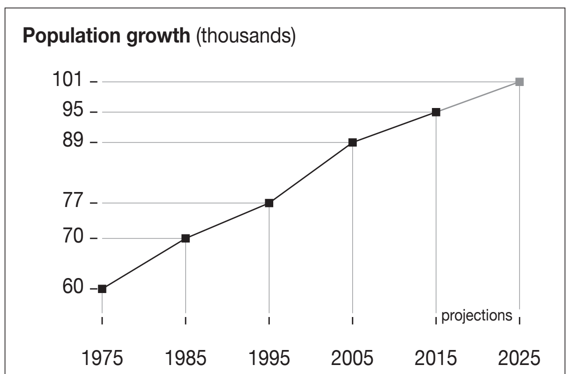




Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	1.4	1.0	0.7	0.4 (2013)
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)				
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				no data
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				45.0 (2017)

Source: UNSD 2019.

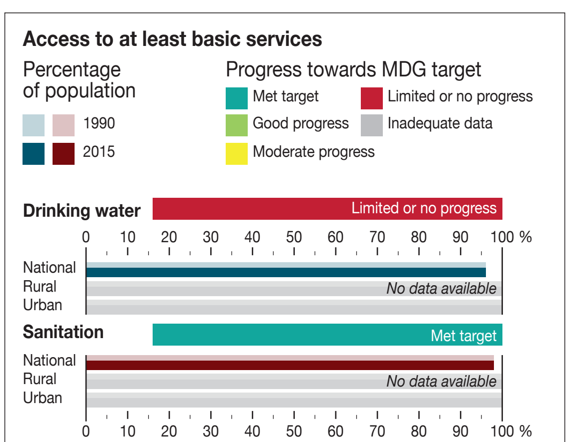


Source: UN-Desa 2019.

Wastewater management

Recent data on wastewater management are lacking. Available data show that 8.8 million m^3/year of municipal wastewater was produced in 2003 (FAO 2018).

Water and sanitation provision



Source: WHO and UNICEF 2015.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Rivers Committee • Public Utilities Corporation • Ministry of Environment and Energy
Environment for private sector participation	• Public-Private Partnership Law – Investment Act • No dedicated public-private partnership unit • The Seychelles Investment Board (SIB) acts as a coordinator and facilitator between the public and the private sectors
Legal, policy and strategy frameworks	
Current enabling policies	
Current enabling laws	• Public Utilities Corporation Act, 1985

Source: FAO, 2016; World Bank, 2018b; World Bank, 2018c.

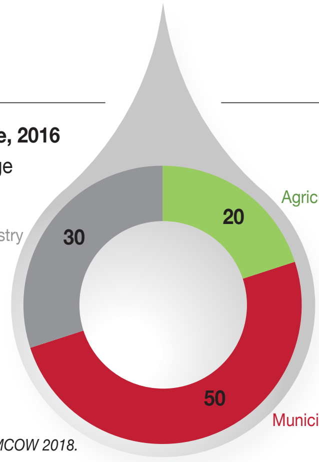
Sierra Leone

Water resources

Sierra Leone has rainfall of 2,526 mm/year (AMCOW 2018), ranging from 1,900 to 4,000 mm/year (FAO 2016). The country has a hot and humid tropical climate (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.01 and is projected to increase to 0.02 by 2040 (Luo et al. 2015). A score of 0.02 indicates that there is low competition among water users relative to available surface-water resources. Agriculture is an important part of the economy, employing 60.6 per cent of the population and contributing 60.3 per cent to GDP in 2017 (World Bank 2018). Despite this, water withdrawals by the sector are very low, which could be attributed to the long-term effects of the civil war.

Water use, 2016
Percentage



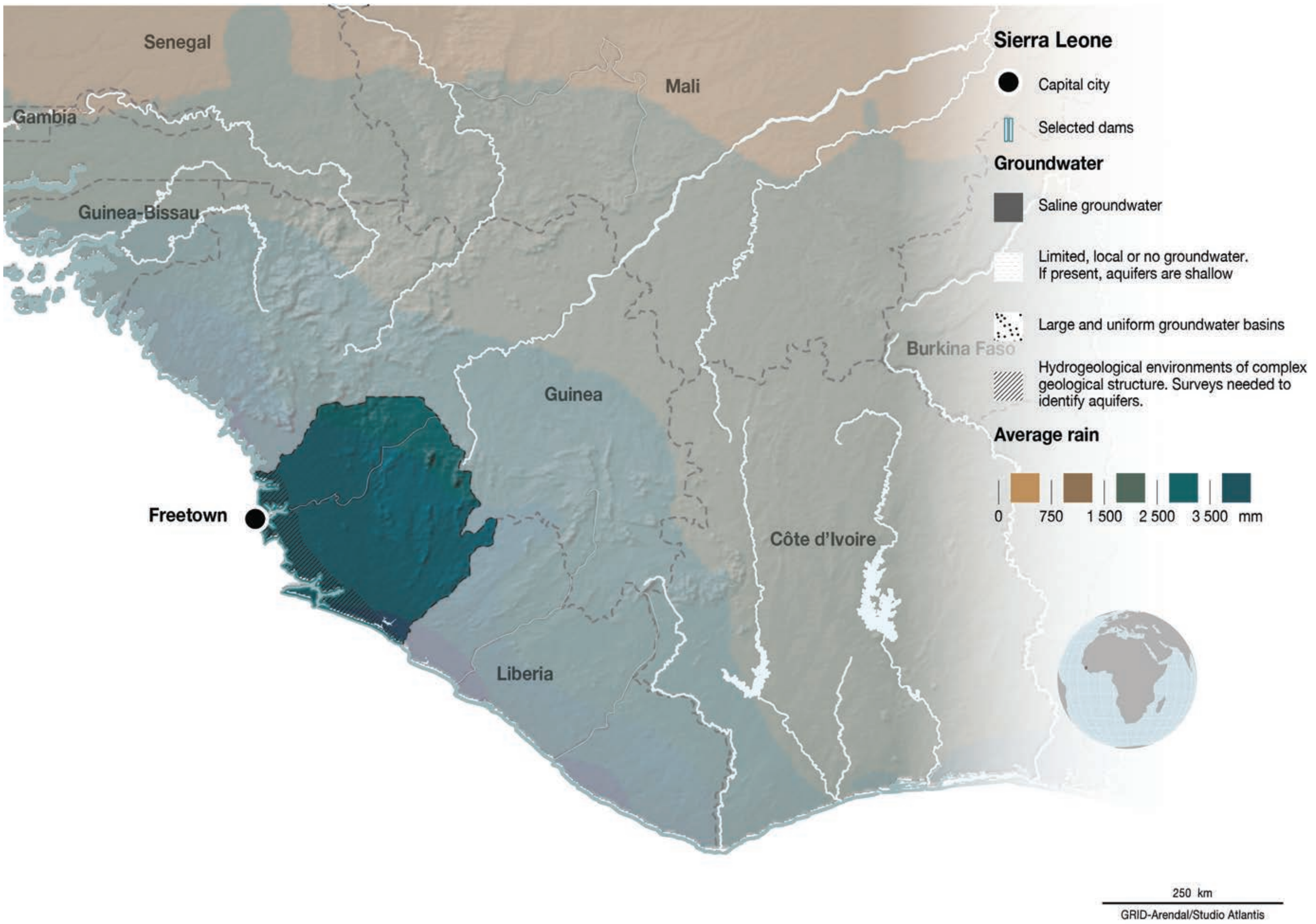
Source: AMCOW 2018.

Water availability

	m³/person and year
Total renewable freshwater	22 900
Total water withdrawal	28.6
Internal renewable water sources	22 900
of which are surface water	21 400
pressure on surface water	*no data available*
of which are groundwater	3 570
pressure on groundwater	*no data available*
Water stress	***0.12%***

Source: AMCOW 2018; FAO 2018.

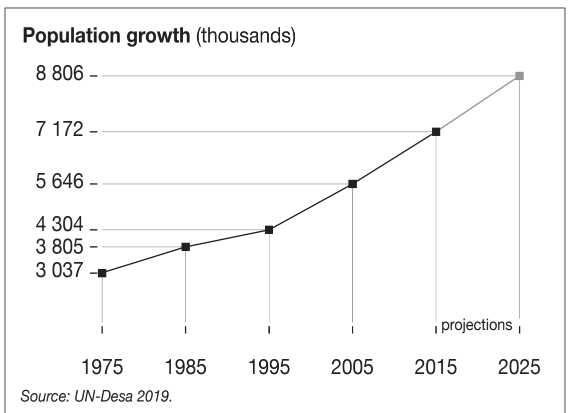
Freetown



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	26.3	23.7	21.3	18.8
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		12.9 (2006)	13.1	13.1 (2014)
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/$m^3$)		6.4		
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.12
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				19.0 (2017)

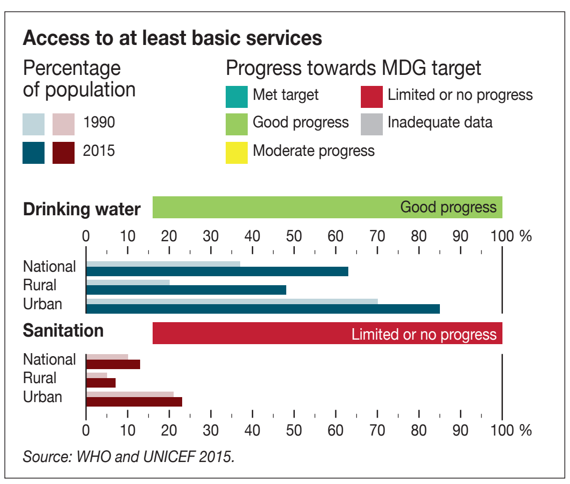
Source: UNSD 2019.



Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Energy and Water Resources • Sierra Leone Water Company
Presence of a functional water regulator	• Sierra Leone Electricity and Water Regulatory Commission
Environment for private sector participation	• Public Private Partnership Act, 2014 • Public-Private Partnership Unit, Office of the President
Legal, policy and strategy frameworks	
Current enabling policies	• National Water and Sanitation Policy, 2008 • National Water and Sanitation Policy Implementation Plan, 2010
Current enabling laws	• National Water Resources Management Agency Act (No. 5 of 2017) • Sierra Leone Water Company Act (No. 4 of 2017) • Sierra Leone Electricity and Water Regulatory Commission (No. 13 of 2011)

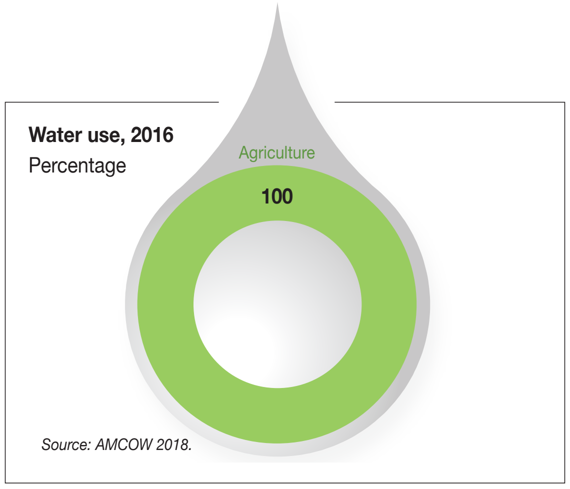
Source: FAO 2016; World Bank 2018b; World Bank 2018c.

Somalia

Water resources

Somalia is situated in the Horn of Africa and has an arid to semi-arid climate. Average rainfall is 282 mm/year and varies depending on the location, with around 50 mm of rainfall along the northern coast, 150 mm in the interior plateau, 350–500 mm in the south-west and 500 mm in the northern highlands (FAO 2016; AMCOW 2018).

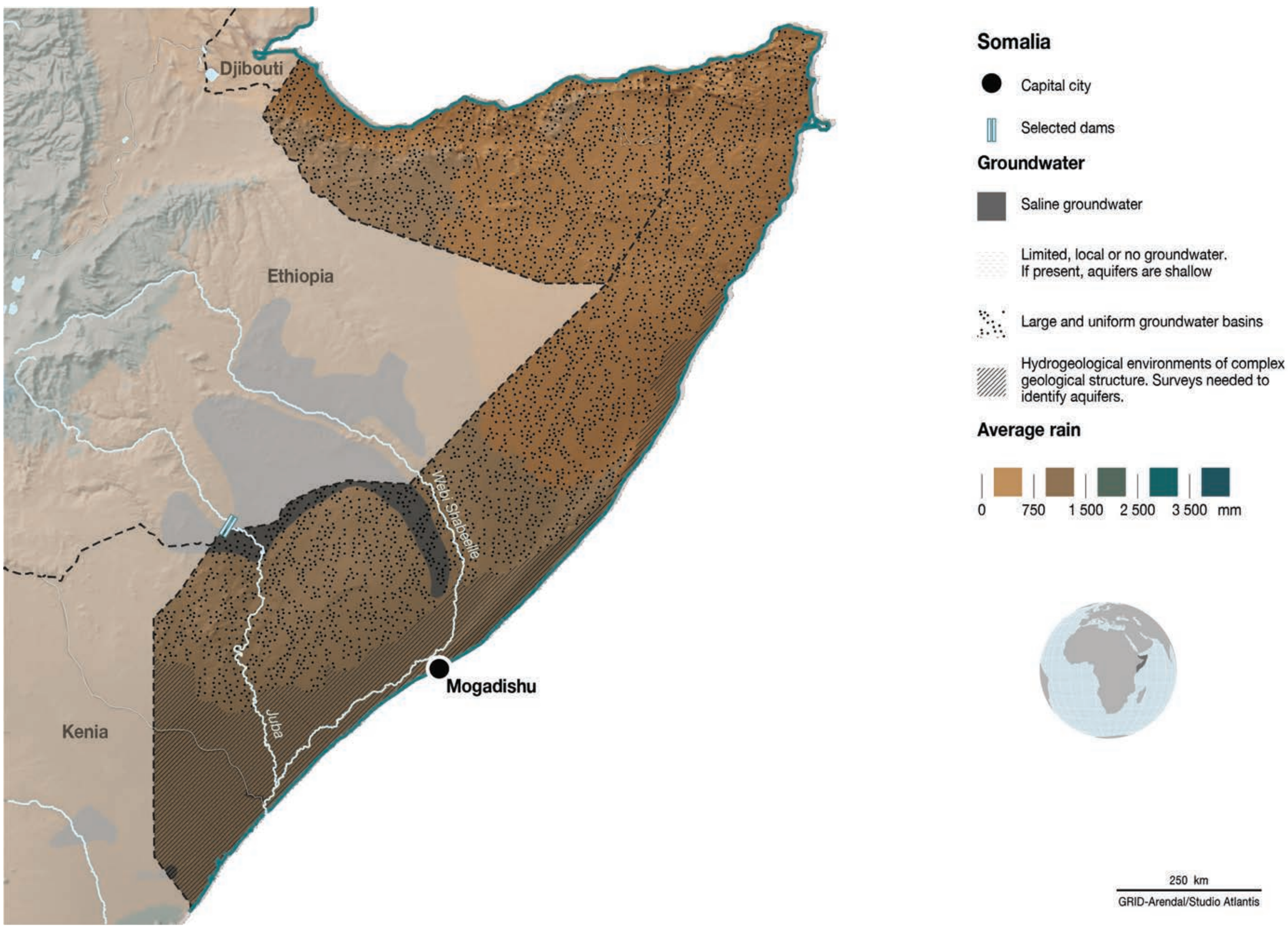
The country's aqueduct water stress for all sectors measured in 2010 was 1.79 and is projected to decrease to 1.66 by 2040 (Luo et al. 2015). A score of 1.66 indicates that there is low to medium competition among water users relative to available surface-water resources.



Water availability

	m³/person and year
Total renewable freshwater	1 360
Total water withdrawal	306
Internal renewable water sources	556
of which are surface water	528
pressure on surface water	*55.6%*
of which are groundwater	306
pressure on groundwater	*3.94%*
Water stress	***22.50%***

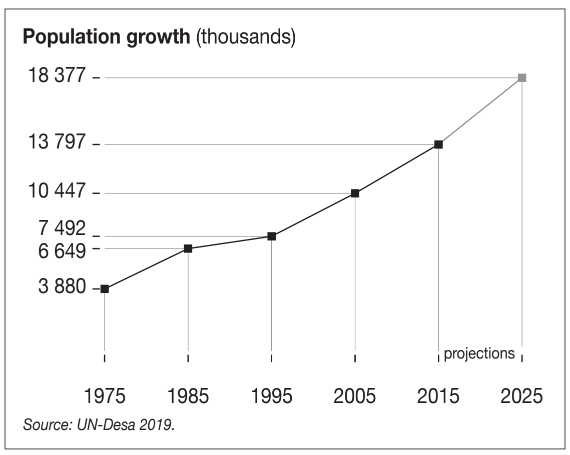
Source: AMCOW 2018; FAO 2018.



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	57.5	51.3	45.1	39.1
	Proportion of population using safely managed sanitation services (%)	19.5	17.9	16.1	14.1
	Proportion of population with basic handwashing facilities on premises (%)			9.6 (2011)	9.6
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				0.7 (2018)
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)	0.1			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				22.5
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				10.0 (2017)

Source: UNSD 2019.

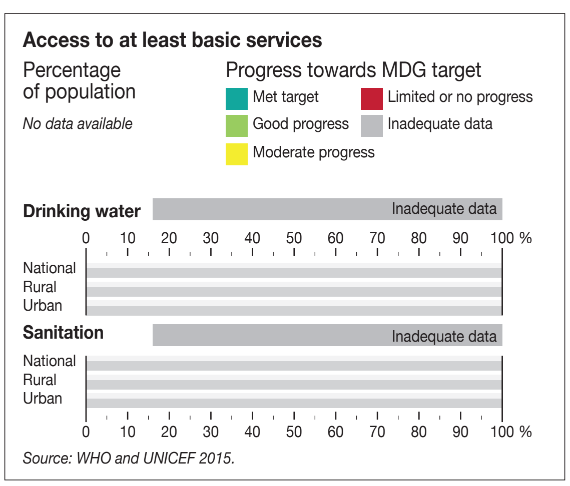


Source: UN-Desa 2019.

Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Source: WHO and UNICEF 2015.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water Resources • Water Development Agency
Environment for private sector participation	• Public Procurement, Concessions and Disposal Act, 2014 • Public-private partnerships are implemented by sector ministries
Legal, policy and strategy frameworks	
Current enabling policies	
Current enabling laws	• Law No. 28 of 20 February 1971 governing the Water Development Agency • National Water Act (No. 49 of 2011)

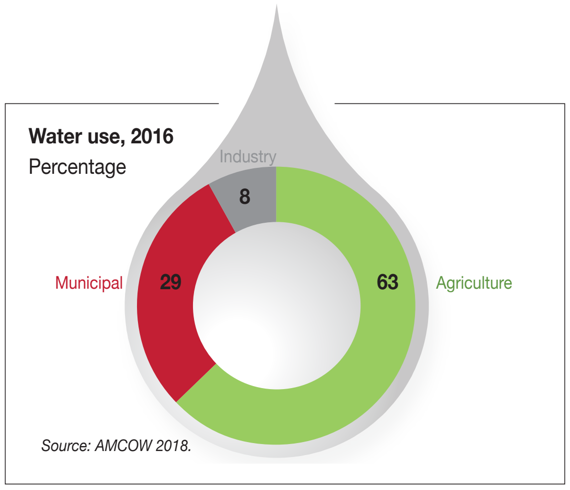
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

South Africa

Water resources

South Africa is a semi-arid country with average rainfall of 450 mm/year (AMCOW 2018). Rainfall varies across the country, ranging from a low of 100 mm/year in the western deserts to a high of 1,200 mm/year in the east (FAO 2016).

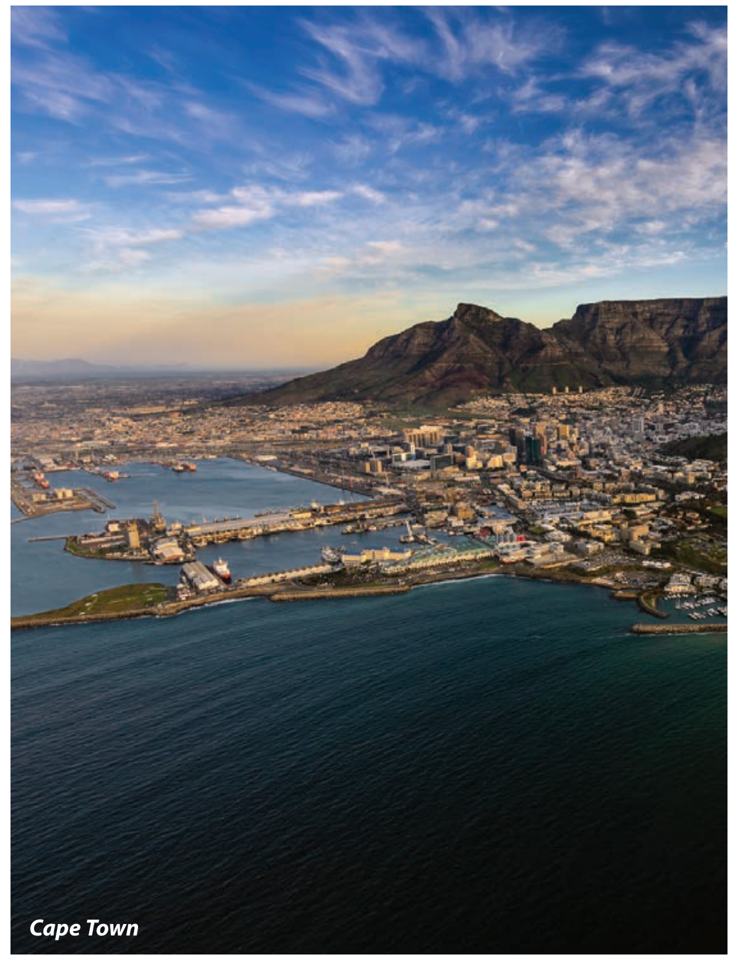
The country's aqueduct water stress for all sectors measured in 2010 was 2.90 and is projected to increase to 3.19 by 2040 (Luo et al. 2015). A score of 3.19 indicates that there is high competition among water users relative to available surface-water resources.

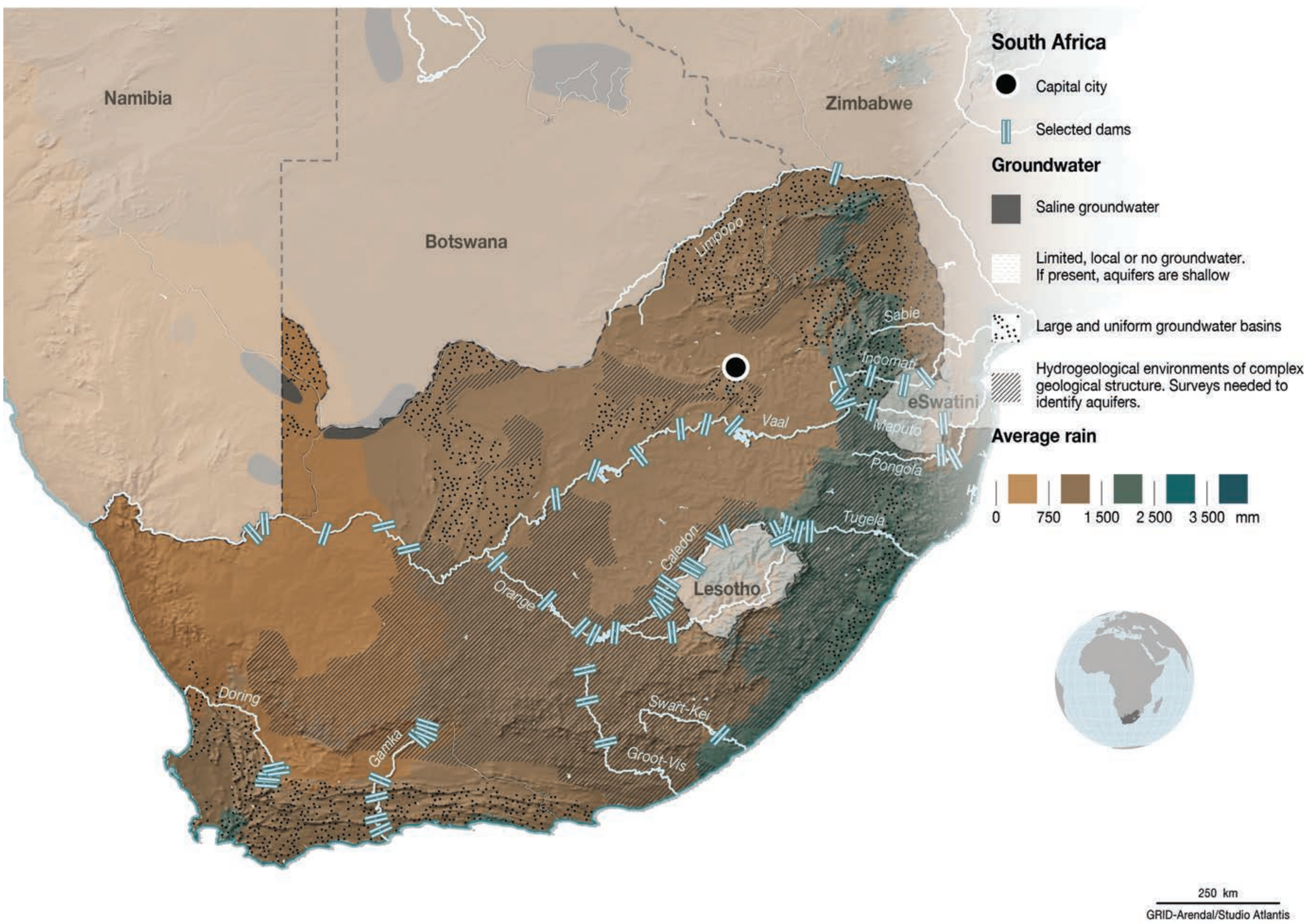


Water availability

	m³/person and year
Total renewable freshwater	910
Total water withdrawal	285
Internal renewable water sources	842
of which are surface water	790
pressure on surface water	*28.2%*
of which are groundwater	138
pressure on groundwater	*53.3%*
Water stress	***31.30%***

Source: AMCOW 2018; FAO 2018.

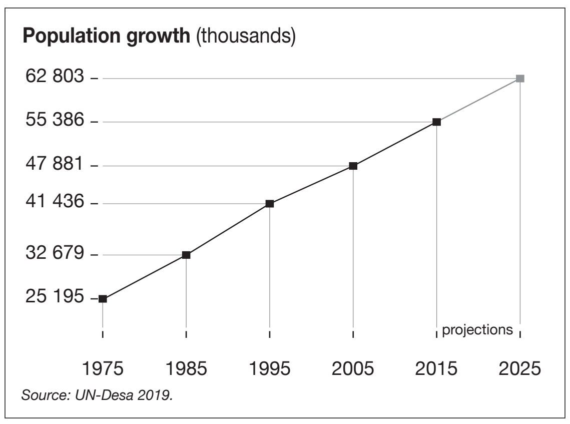

Cape Town



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	12.5	8.8	5.4	2.3
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				46.9 (2017)
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)				17.6
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				31.3
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				

Source: UNSD 2019.



Institutional and legal framework

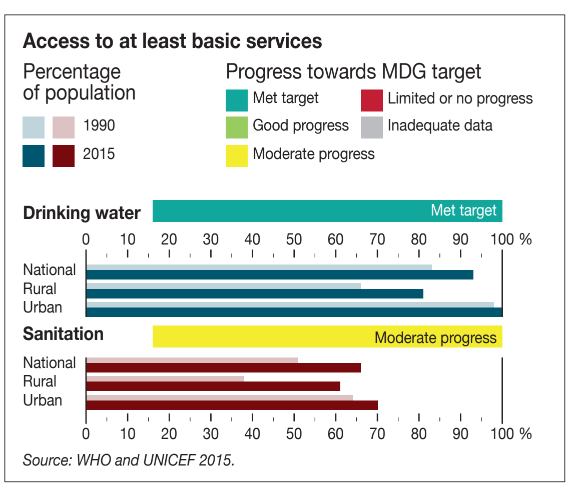
Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Department of Water and Sanitation • Water Boards • Water Services Authorities • Water Services Provider
Environment for private sector participation	• Public-Private Partnership Unit • Government Technical Advisory Centre • Preferential Procurement Policy Framework Act, 2000
Water pricing facility	• Regulations on Norms and Standards in Respect of Tariffs for Water Services in Terms of Section 10 (1) of the Water Services Act (Act No. 108 of 1997)
Legal, policy and strategy frameworks	
Current enabling policies	• National Water Resource Strategy, 2004 • National Water Resources Strategy, 2012 • National Groundwater Strategy, 2010 • Water for Growth and Development Framework, 2009 • National Sanitation Policy, 2016
Current enabling laws	• National Water Act, 1998 • Water Services Act, 1997 (No. 108 of 1997) • Water Research Act, 1996 • Water Use Licence Application and Appeals Regulations, 2017 (No. R. 267 of 2017)

Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Wastewater management

Recent data on wastewater management are lacking. Available data show that 3,524 million m^3/year of municipal wastewater was produced in 2009 and that the amount treated in the same year was 1,919 million m^3/year. The amount of municipal wastewater collected in 2009 was 2,690 million m^3/year, while the volume treated was 2,414 million m^3/year. The number of operational wastewater treatment plants had reached 923 by 2011 (FAO 2018).

Water and sanitation provision

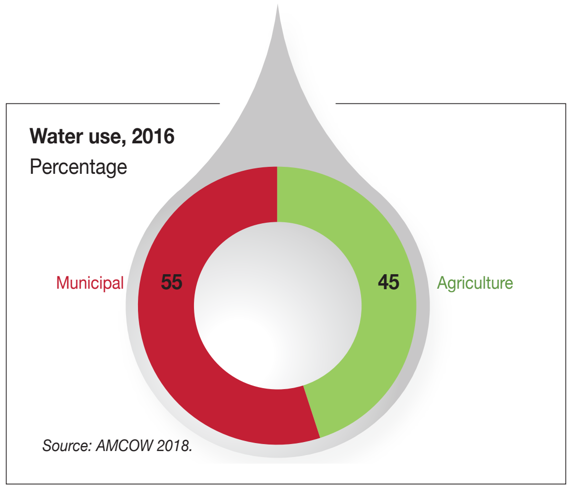


South Sudan

Water resources

South Sudan has a sub-humid climate with mean rainfall of 867 mm/year, and ranging between 700 and 2,200 mm/year (AMCOW 2018; FAO 2016).

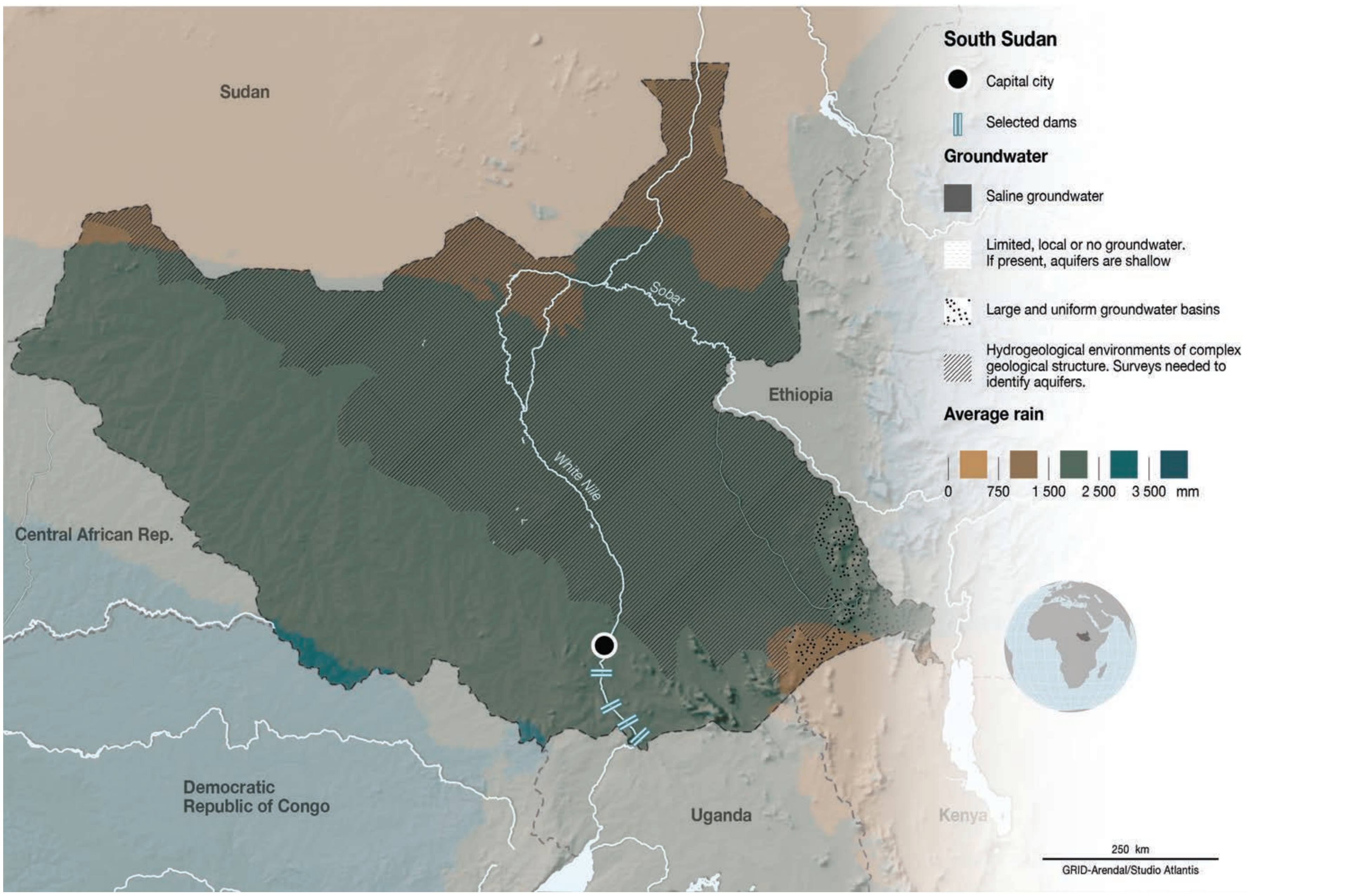
The country's aqueduct water stress for all sectors measured in 2010 was 0.00 and is projected to remain the same in 2040 (Luo et al. 2015). A score of zero indicates that there is low competition among water users relative to available surface-water resources.



Water availability

	m³/person and year
Total renewable freshwater	4 120
Total water withdrawal	24
Internal renewable water sources	2 100
of which are surface water	2 100
pressure on surface water	*0.86%*
of which are groundwater	25.2
pressure on groundwater	*24%*
Water stress	***0.58%***

Source: AMCOW 2018; FAO 2018.

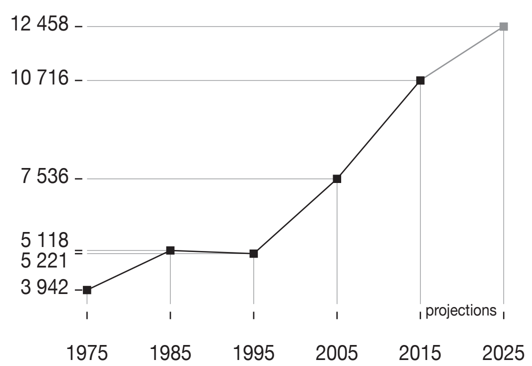


Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)			70.1 (2011)	60.9
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)				
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				0.58
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				28.0 (2017)

Source: UNSD 2019.

Population growth (thousands)



Source: UN-Desa 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Electricity, Dams, Irrigation and Water Resources • Ministry of Lands, Housing and Physical Planning • South Sudan Urban Water Coordination
Environment for private sector participation	• There is no dedicated public-private partnerships unit • There is no dedicated public-private partnerships law
Legal, policy and strategy frameworks	
Current enabling policies	• South Sudan Water Policy, 2007 • Water, Sanitation and Hygiene Strategic Framework, 2011
Current enabling laws	• Urban Water Corporation Act, 2011

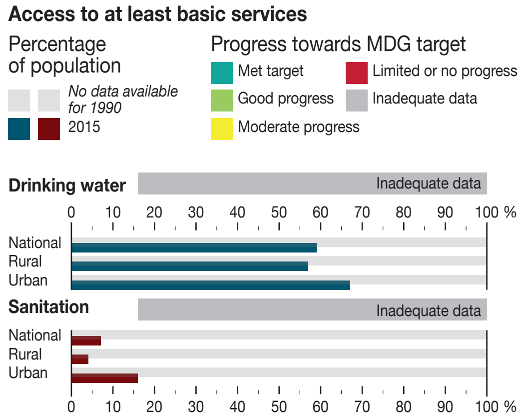
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision

Access to at least basic services



Source: WHO and UNICEF 2015.

Sudan

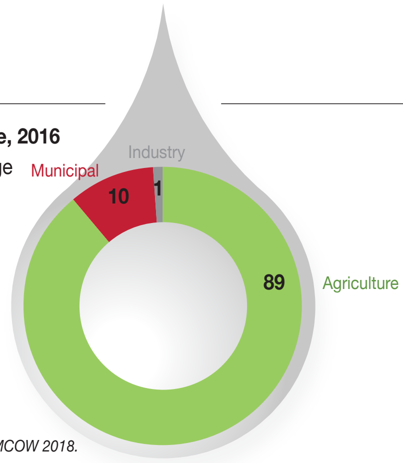
Water resources

Sudan receives an average of 225 mm/year of rainfall that ranges from 25 mm in the northern desert to 700 mm in the south. The country's climate is tropical subcontinental (AMCOW 2018; FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.95 and is projected to increase to 1.56 by 2040 (Luo et al. 2015). A score of 1.56 indicates that there is low to medium competition among water users relative to available surface-water resources.

Water use, 2016

Percentage



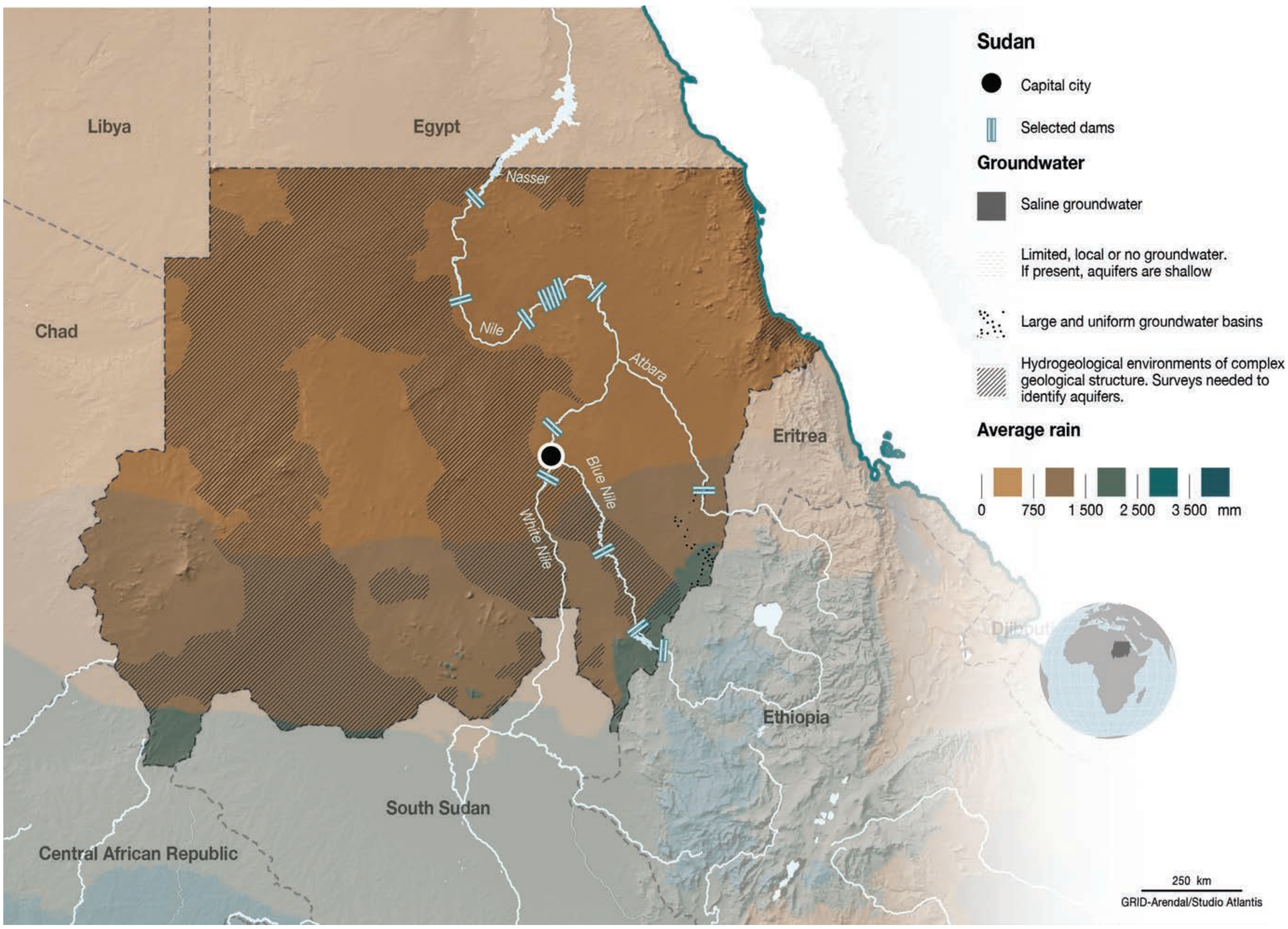
Source: AMCOW 2018.

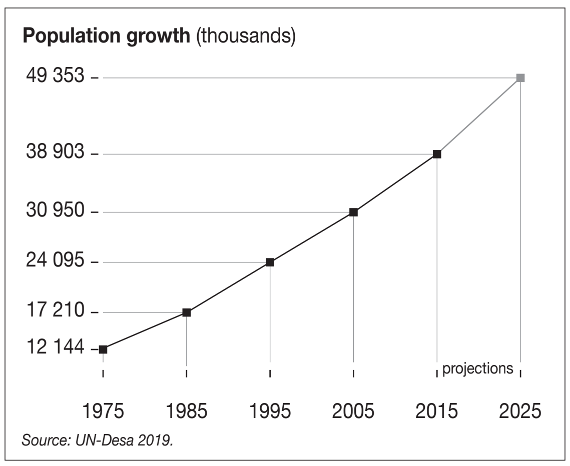
Water availability

	m³/person and year
Total renewable freshwater	1 050
Total water withdrawal	433
Internal renewable water sources	794
of which are surface water	689
pressure on surface water	*52.1%*
of which are groundwater	104
pressure on groundwater	*70.8%*
Water stress	***41.20%***

Source: AMCOW 2018; FAO 2018.

Khartoum

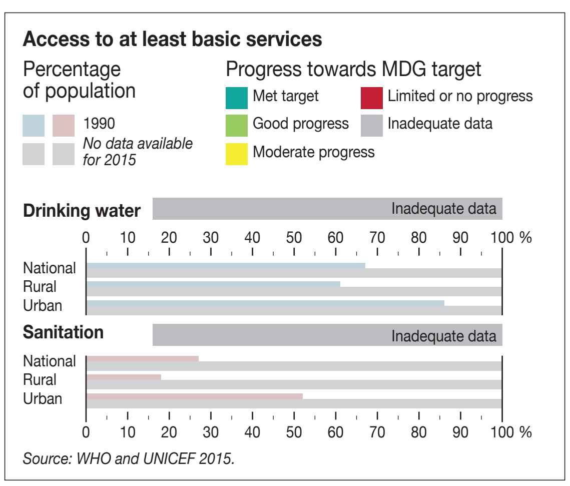




Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	50.9	48.7	37.7	26.7
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)			23.2	23.3
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				86.1 (2017)
	Proportion of groundwater bodies with good ambient water quality (%)				90.0 (2017)
Water-use efficiency	Water-use efficiency (US$/m^3)			1.6	
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				41.2
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				40.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water Resources, Irrigation and Electricity • National Water Resources Council • Public Water Corporation • General Water Authority • National Water Commission
Environment for private sector participation	• No dedicated public-private partnerships law • While Sudan does not prohibit public-private partnerships, it has implemented projects through private sector participation in infrastructure • A public-private partnerships unit has recently been established
Legal, policy and strategy frameworks	
Current enabling policies	• Water, Sanitation and Hygiene Sector National Strategic Plan (2012–2016)
Current enabling laws	• Water Resources Act, 1995 • Groundwater Regulation Act, 1998

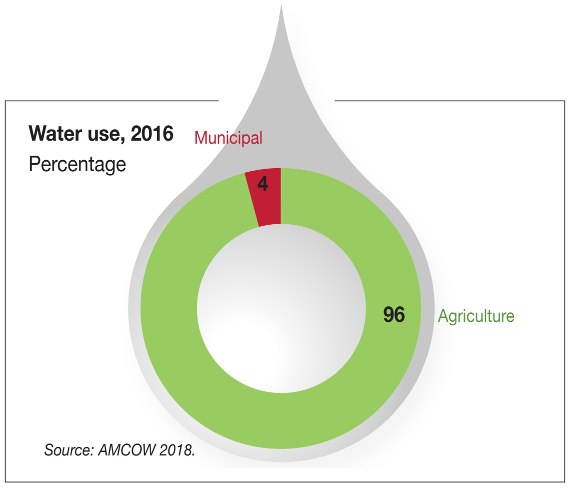
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

eSwatini

Water resources

eSwatini (formerly Swaziland) has average rainfall of 788 mm/year (AMCOW 2018).

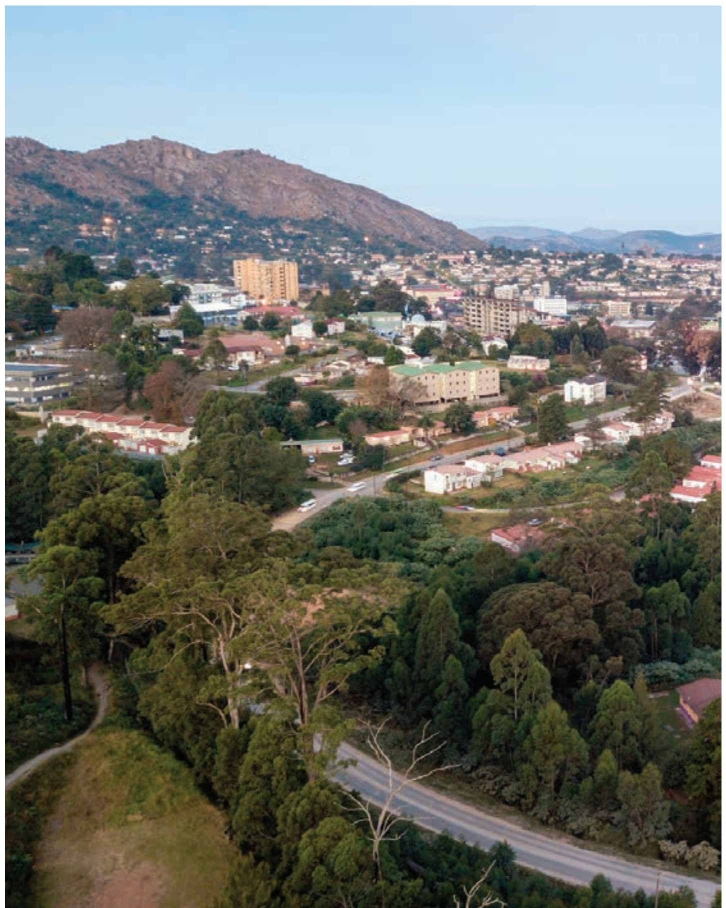
The country's aqueduct water stress for all sectors measured in 2010 was 2.41 and is projected to increase to 2.63 by 2040 (Luo et al. 2015). A score of 2.63 indicates that there is medium to high competition among water users relative to available surface-water resources.



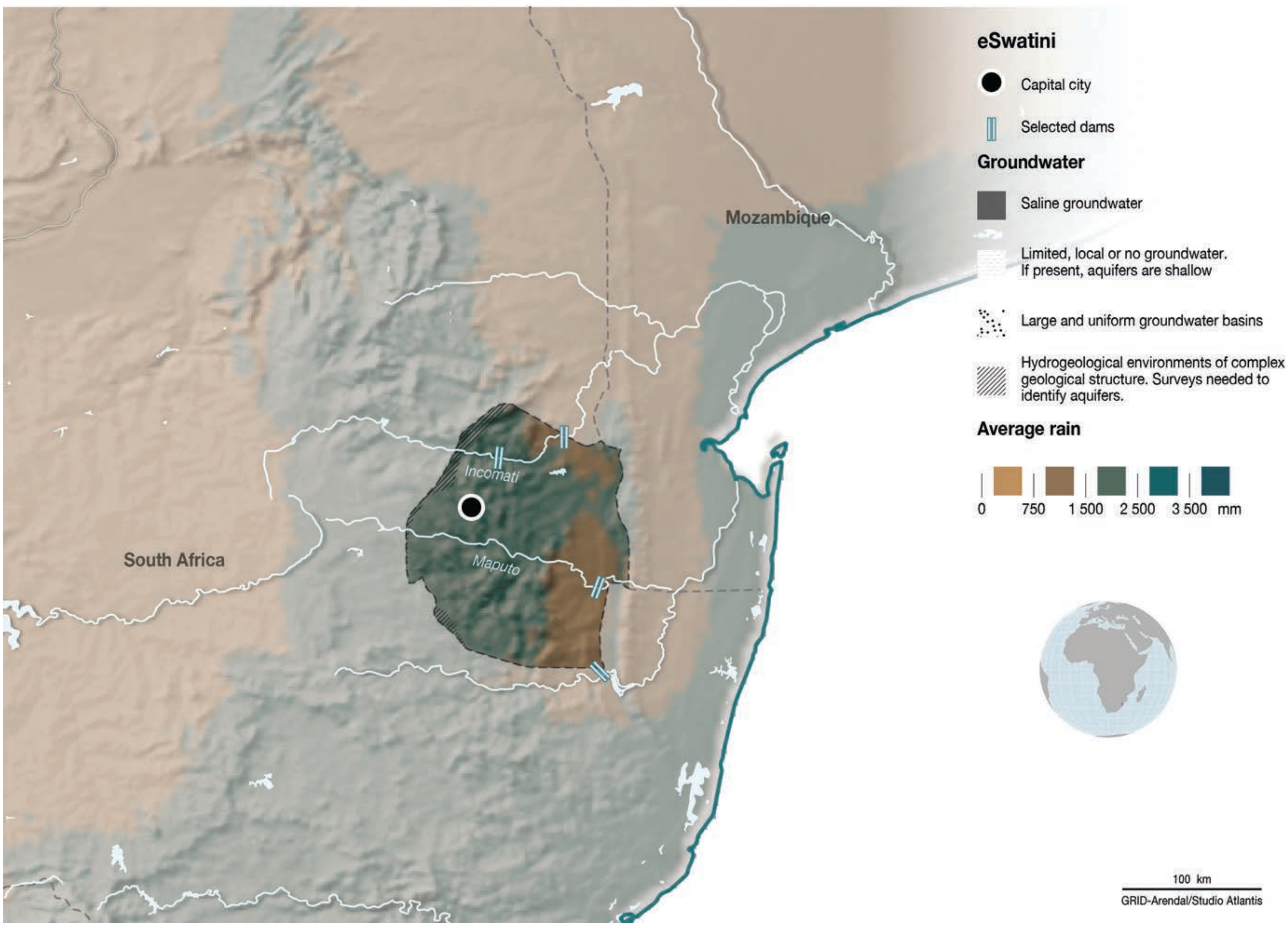
Water availability

	m³/person and year
Total renewable freshwater	3 500
Total water withdrawal	808
Internal renewable water sources	2 050
of which are surface water	2 050
pressure on surface water	*52.7%*
of which are groundwater	513
pressure on groundwater	*no data available*
Water stress	***23.10%***

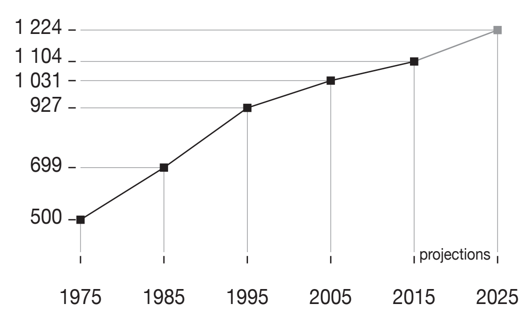
Source: AMCOW 2018; FAO 2018.



Mbabane



Population growth (thousands)



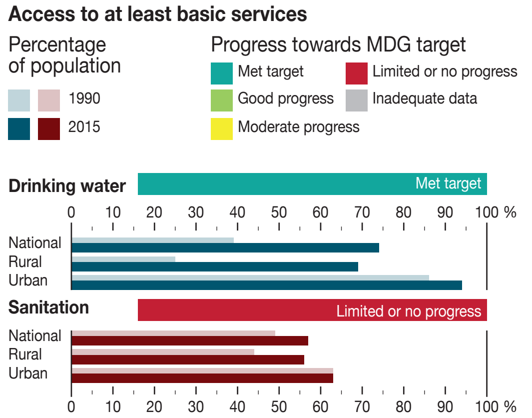
Source: UN-Desa 2019.

Wastewater management

While recent data on wastewater management are lacking, available data show that 13.2 million m³ of municipal wastewater was produced in 2013 (FAO 2018). The amount of municipal wastewater treated in 2002 was 9 million m³, with 3 million m³ left untreated (FAO 2018). It is important to note that some of the untreated wastewater includes discharges into alternative sewage collection systems, such as soak pits and septic tanks.

Water and sanitation provision

Access to at least basic services



Source: WHO and UNICEF 2015.

Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)	67.4	74.9	82.9	88.1
Sanitation and hygiene	Proportion of population practising open defecation (%)	23.1	19.2	15.1	10.9
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		23.6	23.4	23.3
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)	2.1			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				23.1
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				53.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Natural Resources and Energy • Eswatini Water Services Corporation • Eswatini Environment Authority
Environment for private sector participation	• There is no dedicated public-private partnerships unit; responsibility for such partnerships is with the Ministry of Finance • PPP Policy, 2008
Legal, policy and strategy frameworks	
Current enabling policies	
Current enabling laws	• Water Act 2003 (No. 7 of 2003) • Natural Resources Act 1951 (No. 71 of 1951) • Water Pollution Control Regulations, 1999 • Public Enterprises (Control and Monitoring) Act, 1989 (No. 8 of 1989) • Water Act 1967 (No. 25 of 1967) • Water Services Act, 1992

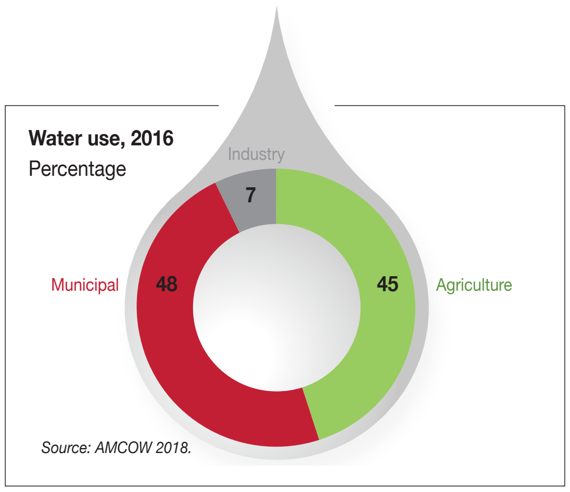
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Togo

Water resources

Togo borders the Gulf of Guinea in West Africa and has average rainfall of 1,168 mm/year (AMCOW 2018; FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.14 and is projected to increase to 0.32 by 2040 (Luo et al. 2015). A score of 0.32 indicates that there is low competition among water users relative to available surface-water resources.

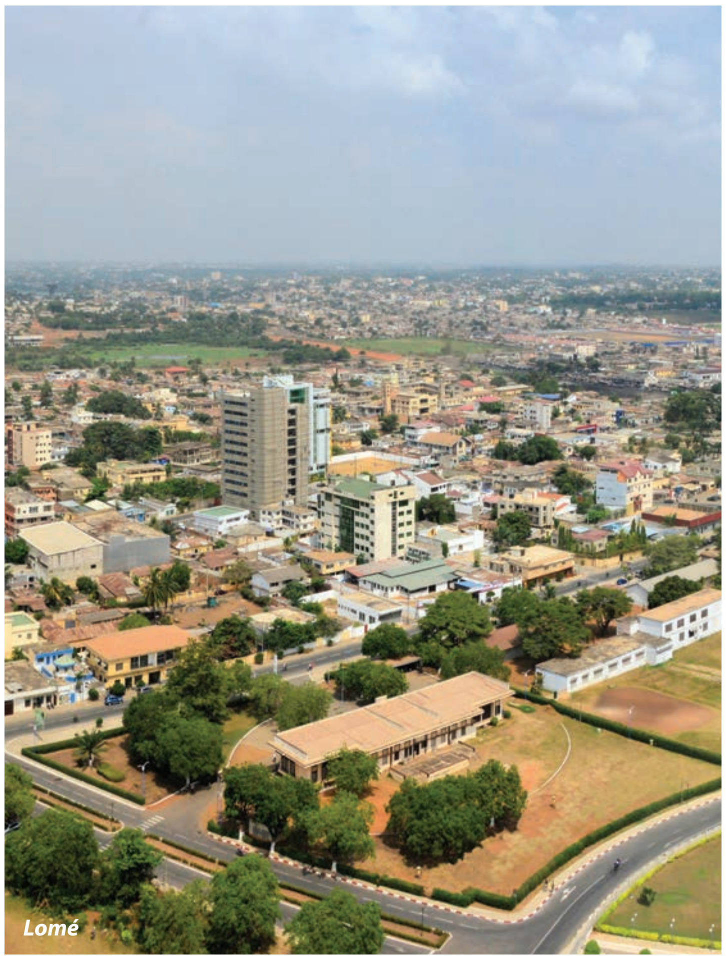


Source: AMCOW 2018.

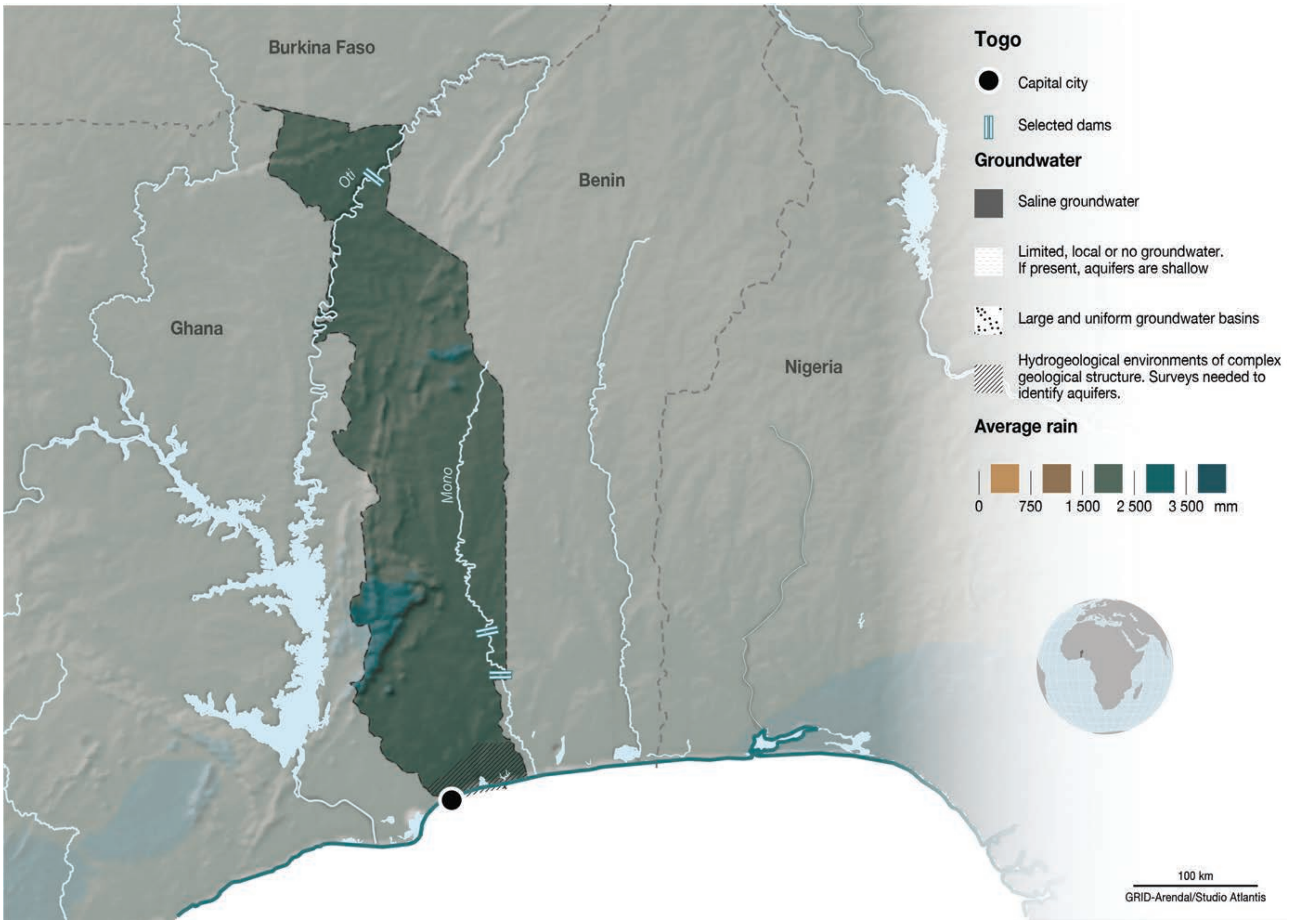
Water availability

	m³/person and year
Total renewable freshwater	2 010
Total water withdrawal	37.8
Internal renewable water sources	1 570
of which are surface water	1 480
pressure on surface water	*0.8%*
of which are groundwater	780
pressure on groundwater	*3.37%*
Water stress	***1.90%***

Source: AMCOW 2018; FAO 2018.



Lomé

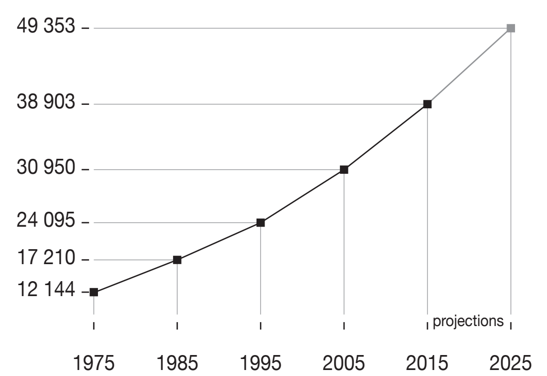


Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	57.5	55.4	53.2	50.7
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		9.5	9.9	10.3
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/cm³)	8.3			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				1.9
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				32.0 (2017)

Source: UNSD 2019.

Population growth (thousands)



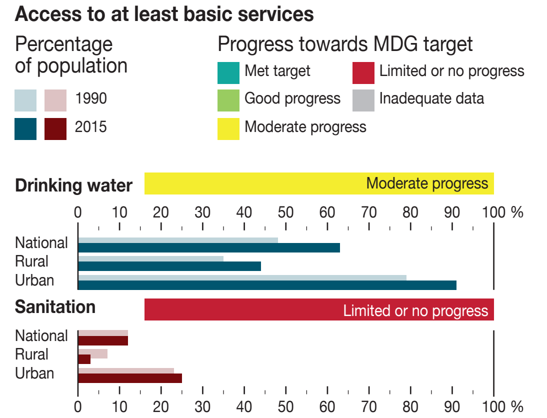
Source: UN-Desa 2019.

Wastewater management

Recent data on wastewater management are lacking.

Water and sanitation provision

Access to at least basic services



Source: WHO and UNICEF 2015.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• National Water Council • Ministry of Mines and Energy • National Water Board • Togolese Water Company • National Water and Electricity Company
Environment for private sector participation	• Law No. 2014-014 of 22 October 2014 on the modernization of State action for the benefit of the economy • Law No. 2009-13 of 30 June 2009 relative to public markets and services delegation • No dedicated public-private partnerships unit; such partnerships are handled by the Ministry of Finance
Water pricing facility	• Order No. 32/MMETPT/CAB establishing an ad hoc committee responsible for drawing up measures for the transfer to users of water at standpipes, 1997 • Interministerial Order No. 71/MMETPT/MIC/MSEDZF fixing the tariffs for the sale of water in Togo, 1996
Legal, policy and strategy frameworks	
Current enabling policies	• National Water Policy, 2010
Current enabling laws	• Water Act, 2010 • Law No. 2011-24 of 4 July 2011 amending article 16 of Law No. 2010-006 of 18 June 2010 on the organization of public services for drinking water and collective sanitation of domestic wastewater

Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

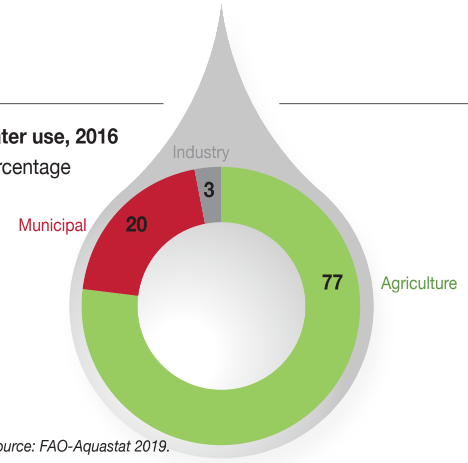
Tunisia

Water resources

Tunisia has a Mediterranean climate with 207 mm/year of rainfall, which ranges from a low of 100 mm/year in the south-western tip of the country to 594 mm/year in the north (AMCOW 2018; FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 3.27 and is projected to increase to 4.06 by 2040 (Luo et al. 2015). A score of 4.06 indicates that there is extremely high competition among water users relative to available surface-water resources. The agriculture sector uses a very low level of water, since it is not a major contributor to the economy. The sector employs only 13 per cent of the population and contributes 9.5 per cent to GDP (value added) (World Bank 2018).

Water use, 2016
Percentage

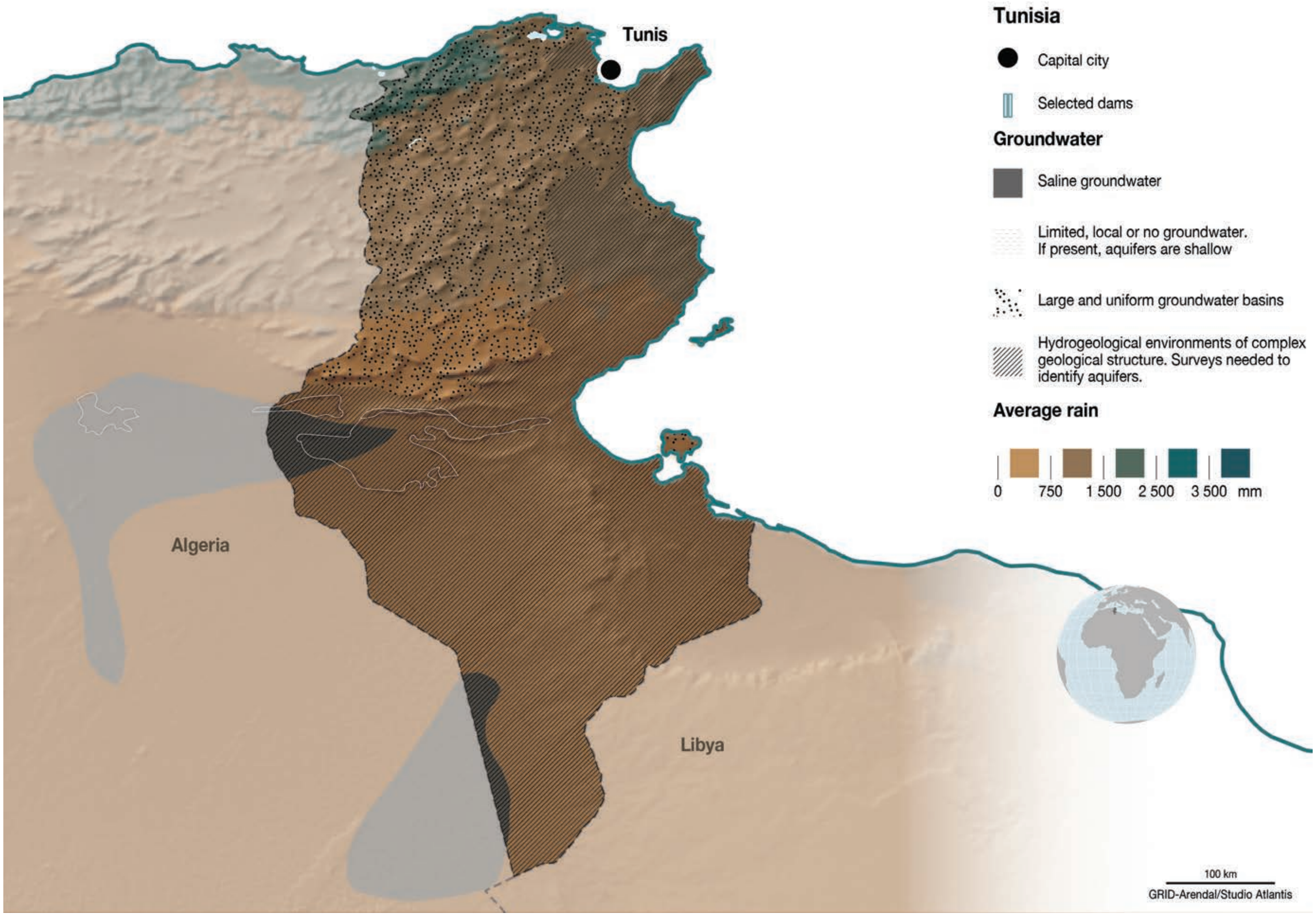


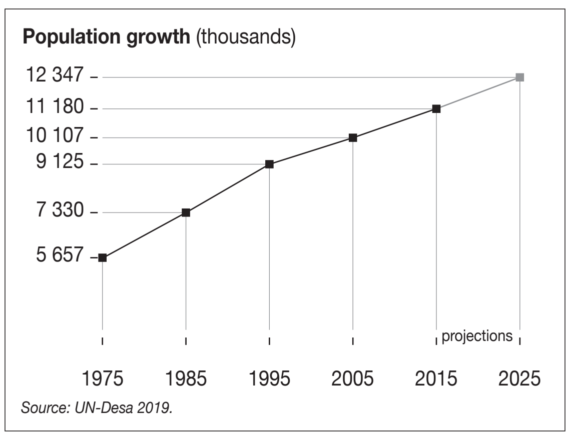
Source: FAO-Aquastat 2019.

Water availability

	m³/person and year
Total renewable freshwater	414
Total water withdrawal	557
Internal renewable water sources	376
of which are surface water	278
pressure on surface water	*37.1%*
of which are groundwater	134
pressure on groundwater	*138%*
Water stress	***134.5%***

Source: AMCOW 2018; FAO 2018.

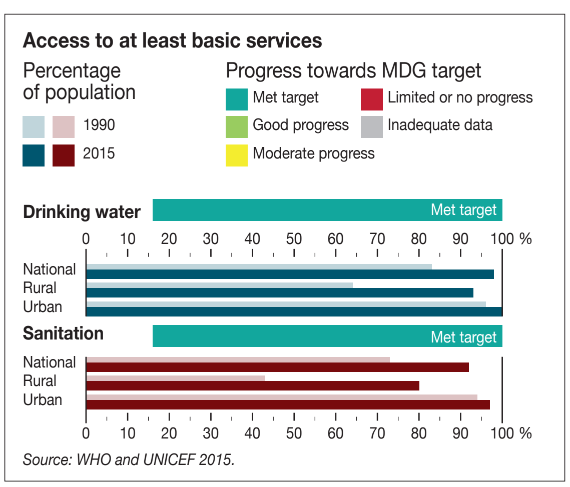




Wastewater management

Recent data on wastewater management are lacking, though available data show that 287 million m³ of municipal wastewater was produced in 2009 and that 226 million m³ was treated in 2010. Around 241 million m³ was collected through municipal wastewater sewers in 2019 and 109 treatment plants were operating with a capacity of 238 million m³/year of treated wastewater in 2010 (FAO 2018).

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)	37.1	62.5	89.0	92.7
Sanitation and hygiene	Proportion of population practising open defecation (%)	10.8	6.9	3.5	0.9
	Proportion of population using safely managed sanitation services (%)	57.7	63.0	69.0	73.4
	Proportion of population with basic handwashing facilities on premises (%)		85.9 (2008)	86.0	86.3
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				70.5 (2018)
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m³)				9.0
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				134.5
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				55.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• National Water Supply and Distribution Company • Société d'Exploitation du Canal et des Adductions des Eaux du Nord [Northern Water Supply Channel Company] • National Office of Sanitation • National Water Council • Directorate-General of Rural Engineering
Presence of a functional water regulator	• Ministry of Agriculture, Water Resources and Fisheries
Environment for private sector participation	• Law No. 2015-49 of 27 November 2015 on public-private partnership contracts • Government Decree No. 2016-771 of 20 June 2016 on the composition and powers of the Strategic Council for Public-Private Partnerships • Decree No. 2016-772 of 20 June 2016 laying down the conditions and procedures for awarding public-private partnership contracts • Decree No. 2016-782 of 20 June 2016 on the registration of real rights for buildings, enterprises and fixed equipment under public-private partnership contracts • Concessions Unit at the Office of the Prime Minister, which is the key decision-making body, acts at the Public-Private Partnership Unit, as well as the Ministry of Finance's department responsible for procurement issues
Water pricing facility	• Order of the Minister of Agriculture and the Minister of Finance of 13 June 2013, amending the Decree of 13 July 2010, fixing the price of drinking water, fixed and ancillary fees for water subscriptions and rate of the contributory part of the establishment costs of water meter connections
Legal, policy and strategy frameworks	
Current enabling policies	• Master Plans (1970–1990): Waters of the North, South and Central Tunisia • Decennial Strategy (1990–2000) for the Mobilization of Water Resources • Complementary Strategy (2001–2011) • 2030 Water Sector Strategy • Sustainable Management of Water Resources, 2007
Current enabling laws	• Water Code, 1975 (Law No. 75-61) and latest amendment, 2011

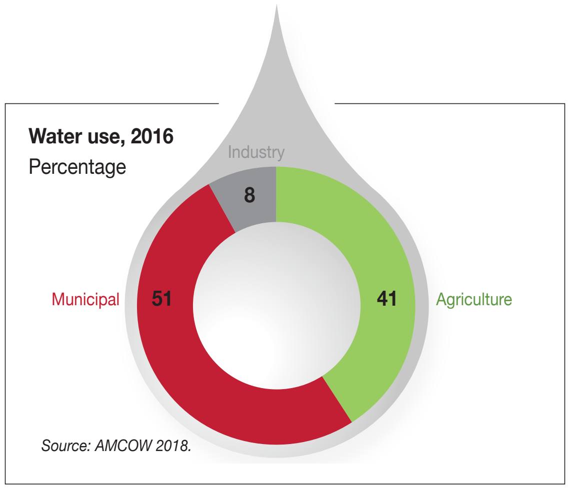
Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

Uganda

Water resources

Located in East Africa, Uganda has an equatorial climate with rainfall averaging 1,180 mm/year. The lowest rainfall occurs in the north-east of the country, averaging 750 mm/year, though areas with high rainfall along the shores of Lake Victoria can receive up to 1,500 mm/year (AMCOW 2018; FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.00 and is projected to increase to 0.01 by 2040 (Luo et al. 2015). A score of 0.01 indicates that there is low competition among water users relative to available surface-water resources. The agriculture sector uses less water than the municipal sector, possibly due to an overreliance on rain-fed agriculture, limited use of irrigation and the population's growing water demands, which increase the proportion of municipal water withdrawals. For instance, between 2014 and 2018, Uganda's urban population grew at a rate of 5.8 per cent (World Bank 2018). To address this growing demand, the Government has invested in improving water and sanitation infrastructure in key towns or areas, including Arua, Bushenyi, Gulu, Katwe-Kabatoro, Koboko, Kumi-Nyero-Ngora, Rukungiri and Pallisa (World Bank 2019).

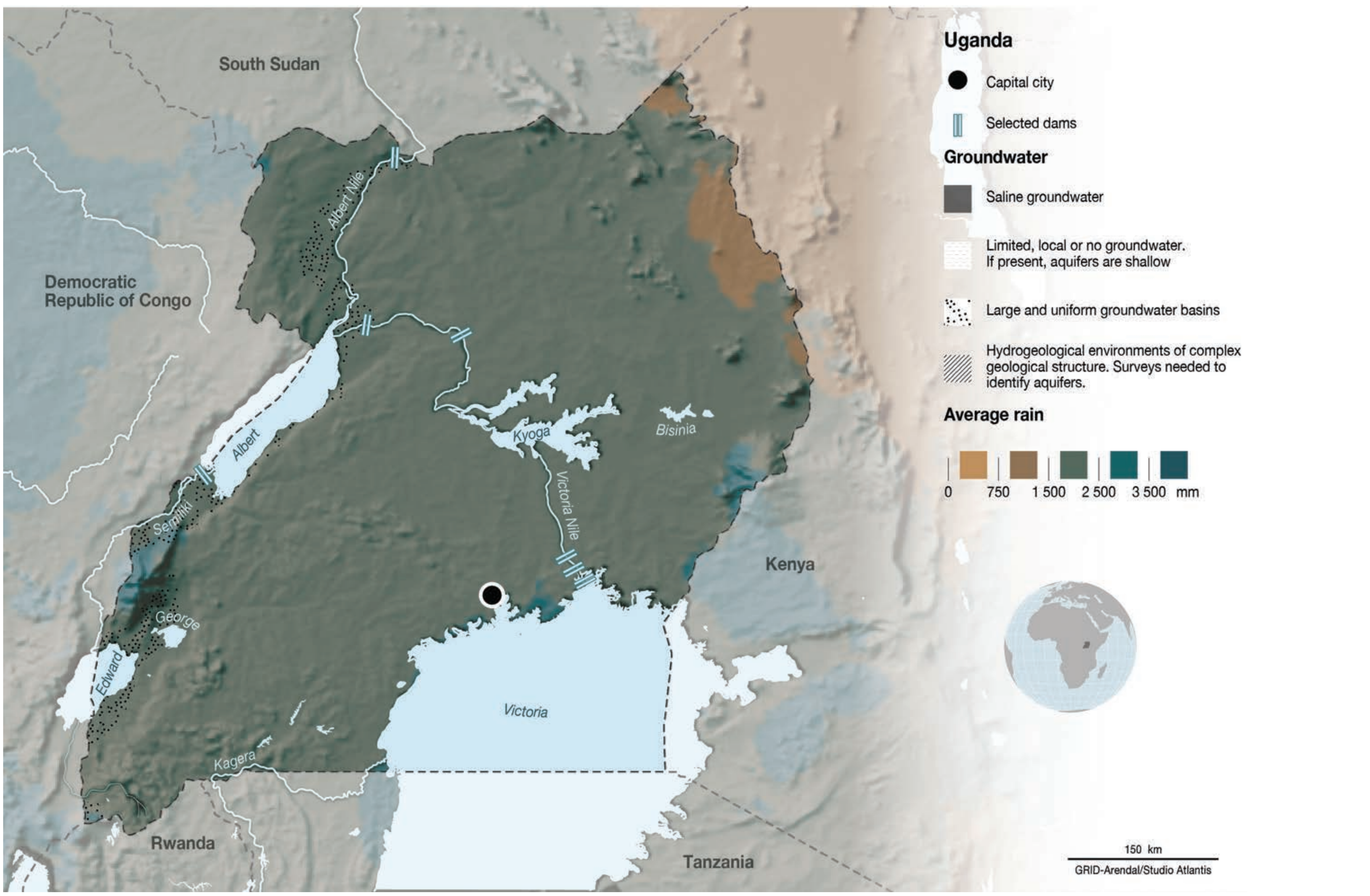


Water availability

	m³/person and year
Total renewable freshwater	1 540
Total water withdrawal	16.4
Internal renewable water sources	999
of which are surface water	564
pressure on surface water	*177%*
of which are groundwater	425
pressure on groundwater	*175%*
Water stress	***1.10%****

Source: AMCOW 2018; FAO 2018.

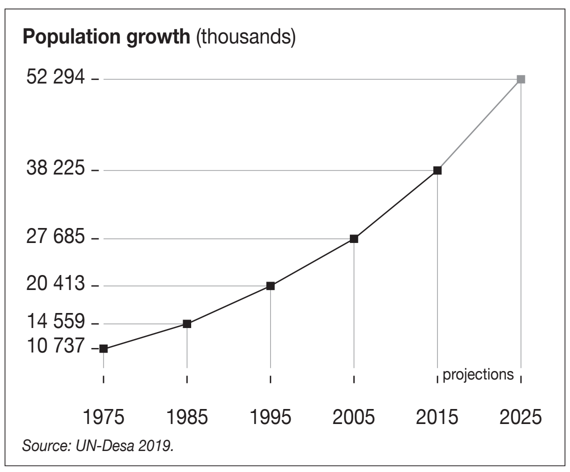
A bus terminus in central Kampala



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)	3.9	4.6	5.5	6.4
Sanitation and hygiene	Proportion of population practising open defecation (%)	15.5	12.3	9.2	6.2
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)	5.4	6.2	7.0	7.6
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				3.8 (2018)
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m³)		14.4		
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				1.1
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				59.0 (2017)

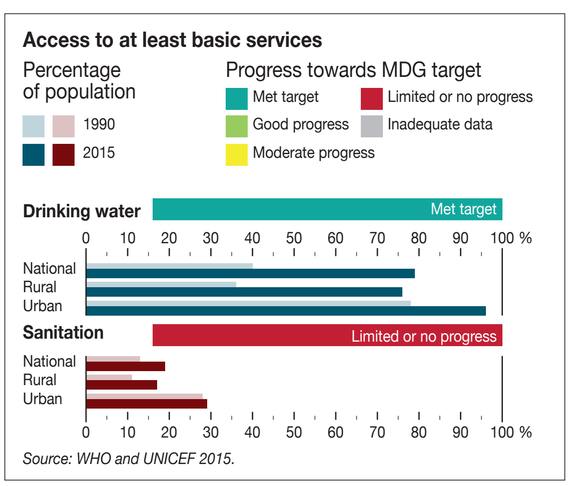
Source: UNSD 2019.



Wastewater management

Recent data on wastewater management are lacking. According to FAO (2018), 41.9 million m³ of municipal wastewater were produced in 2009.

Water and sanitation provision



Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water and Environment • Directorate of Water Development for urban and rural water and sanitation services • National Water and Sewerage Corporation • Water Policy Committee
Presence of a functional water regulator	• Water Utility Regulation Department under the Directorate of Water Development
Environment for private sector participation	• Public Private Partnerships Act, 2015 • Public Private Partnerships Framework Policy, 2010 • Public-Private Partnership Unit, Ministry of Finance, Planning and Economic Development
Water pricing facility	• Water (Disconnecting and Reconnecting Charges) Regulations (S.I. 152-7) • Water (Uganda Schools) (Charges by Meter) Regulations (S.I. 152-9) • Water Act (General Rates) Instrument, 2017 (S.I. No. 33 of 2017)
Legal, policy and strategy frameworks	
Current enabling policies	• Water and Environment Sector Development Plan 2015/16–2019/20 • National Water Policy, 1999 • Water and Sanitation Sub-Sector Gender Strategy (2010–15)
Current enabling laws	• Water and Sanitation Sector – Sectoral Specific Schedules/Guidelines 2009/10 • Water (Waste Discharge) Regulations, 1998 (No. 32 of 1998) • Water Statute, 1995 (Statute No. 9 of 1995) • National Water and Sewerage Corporation Act 1995 (Cap. 317) • Water (Water Supply) Regulations (S.I. 152-2) • Draft Water (Amendments) Act, 2013

Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

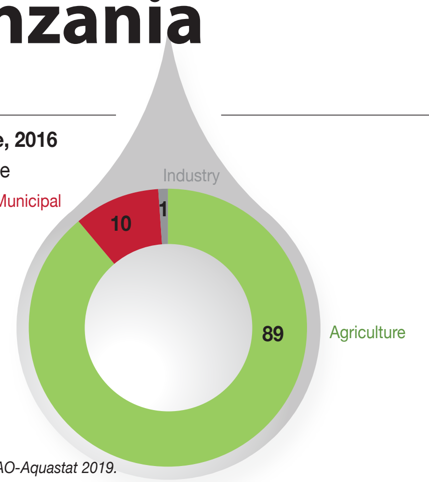
United Republic of Tanzania

Water resources

The United Republic of Tanzania has rainfall averaging 1,071 mm/year (AMCOW 2018). The highest levels of rainfall are received in the Lake Tanganyika area in the north-east and in the southern highlands (FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 1.38 and is projected to decrease to 1.00 by 2040 (Luo et al. 2015). A score of 1.00 indicates that there is low competition among water users relative to available surface-water resources.

Water use, 2016
Percentage

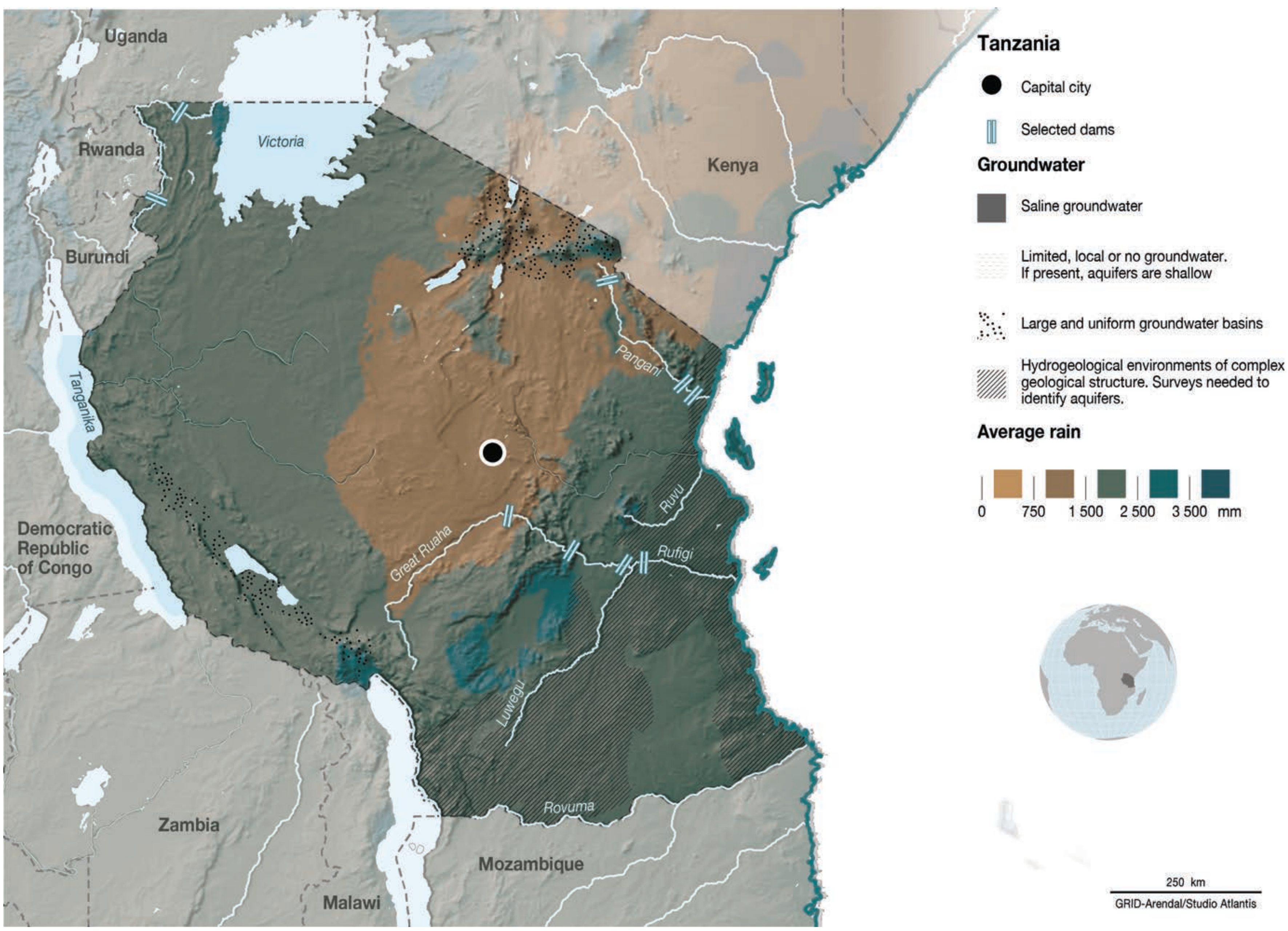


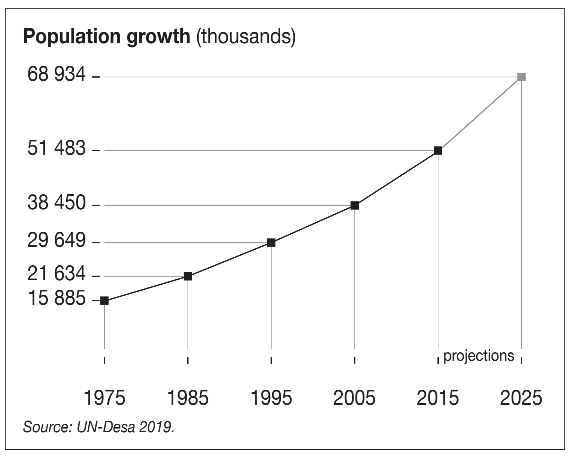
Source: FAO-Aquastat 2019.

Water availability

	m³/person and year
Total renewable freshwater	no data available
Total water withdrawal	no data available
Internal renewable water sources	no data available
of which are surface water	1 600
pressure on surface water	*no data available*
of which are groundwater	602
pressure on groundwater	*no data available*
Water stress	***7.45%***

Source: AMCOW 2018; FAO 2018.

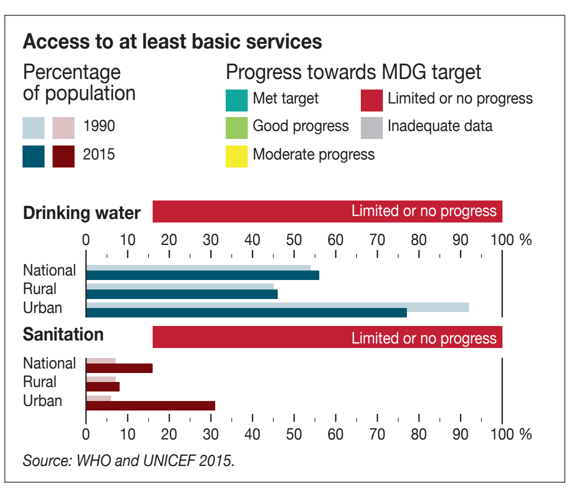




Wastewater management

Recent data on wastewater management are lacking, though available data show that 28 million m^3/year of municipal wastewater was collected in 2012 (FAO 2018).

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)	8.4	13.7	27.2	33.6
Sanitation and hygiene	Proportion of population practising open defecation (%)	9.6	10.3	10.8	11.3
	Proportion of population using safely managed sanitation services (%)			47.1 (2012)	47.6
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/$m^3$)	1.9			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				7.45
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				50.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water • National Water Board • Dar es Salaam Water and Sewerage Authority • Dar es Salaam Water and Sewerage Corporation • Community-owed Water Supply Organizations are in charge in rural areas • Water Supply and Sanitation Authorities are in charge in urban areas
Presence of a functional water regulator	• Energy and Water Utilities Regulatory Authority
Environment for private sector participation	• Public Private Partnership Act (Amended), 12 May 2014 (as PPP Act) • Public Private Partnership Regulations (Amended), 27 November 2015 (as PPP Regulations) • Public Procurement Act, 2011, as amended in 2014 • National Public Private Partnership Policy, 2009 • Tanzania Investment Centre (Public-Private Partnership Unit), Prime Minister's Office
Water pricing facility	• Energy and Water Utilities Regulatory Authority (Tariff Application and Rate Setting) Rules, 2017
Legal, policy and strategy frameworks	
Current enabling policies	• National Water Policy, 2002 • National Water Sector Development Strategy, 2006 • Water Sector Development Programme 2006–2025
Current enabling laws	• Water Resources Management Act, 2009 • Water Supply and Sanitation Act, 2009 (Act No. 12 of 2009) • Urban Water Supply Act, 1981 (Act No. 7 of 1981) • Water Supply Regulations, 2013 (G.N. No. 90 of 2013)

Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

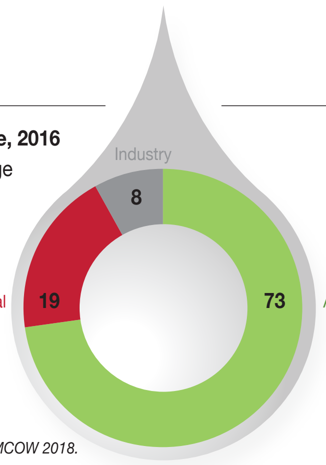
Zambia

Water resources

Zambia has average rainfall of 1,020 mm/year, which varies throughout the country, with the south receiving around 750 mm, the central regions between 900 and 1,200 mm, and the north 1,400 mm. Most of the country has a subtropical climate (AMCOW 2018; FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.00 and is projected to increase to 0.20 by 2040 (Luo et al. 2015). A score of 0.20 indicates that there is low competition among water users relative to available surface-water resources.

Water use, 2016
Percentage



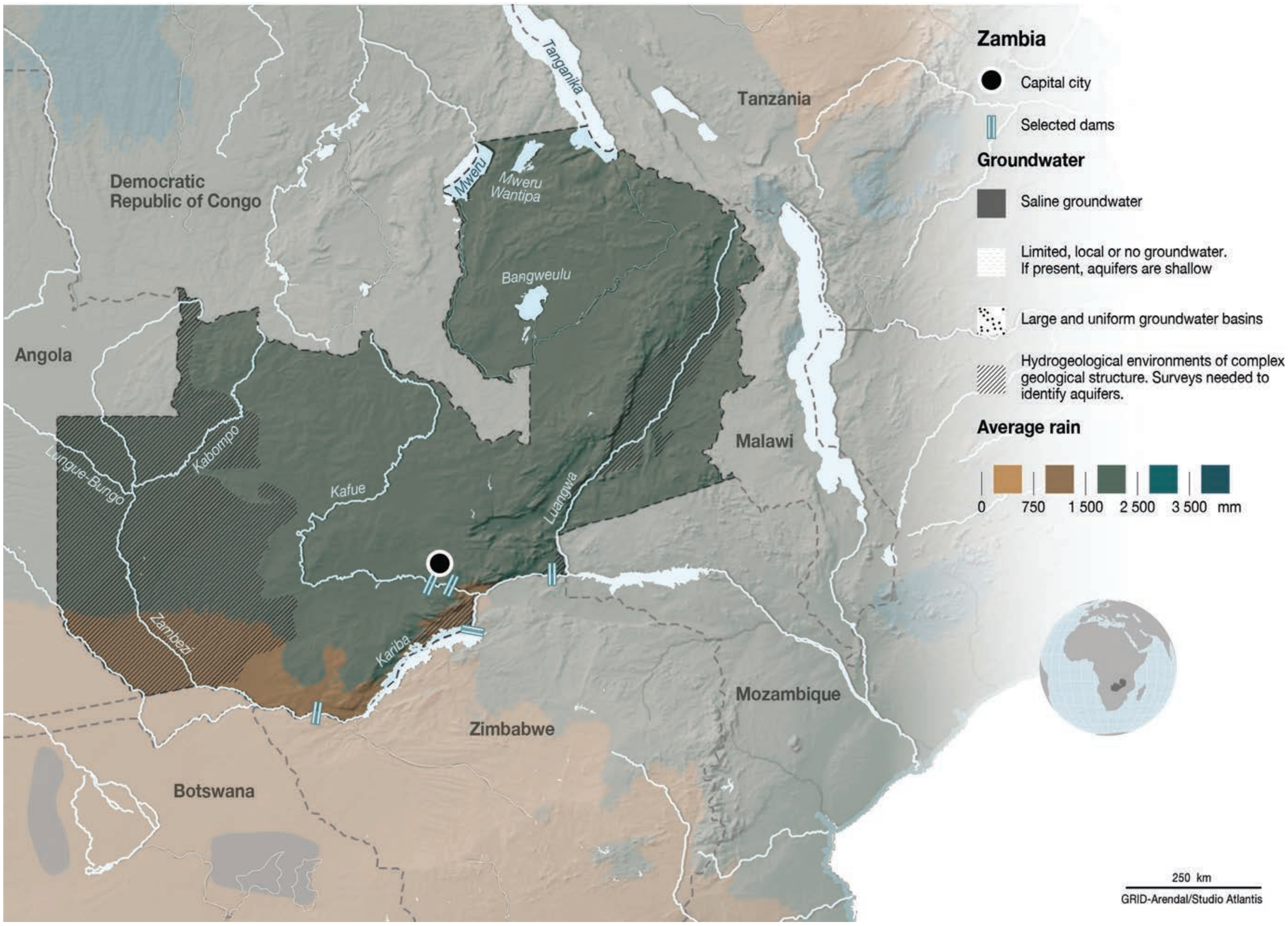
Source: AMCOW 2018.

Water availability

	m³/person and year
Total renewable freshwater	6 760
Total water withdrawal	102
Internal renewable water sources	5 170
of which are surface water	5 170
pressure on surface water	*2.09%*
of which are groundwater	3 030
pressure on groundwater	*0.15%*
Water stress	***1.50%***

Source: AMCOW 2018; FAO 2018.

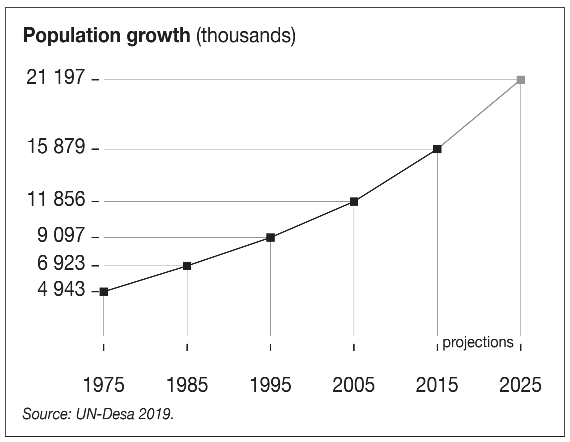
A market in Lusaka



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	24.1	21.1	18.1	15.2
	Proportion of population using safely managed sanitation services (%)			13.1	13.5
	Proportion of population with basic handwashing facilities on premises (%)				
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)	4.2			
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				1.5
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				46.0 (2017)

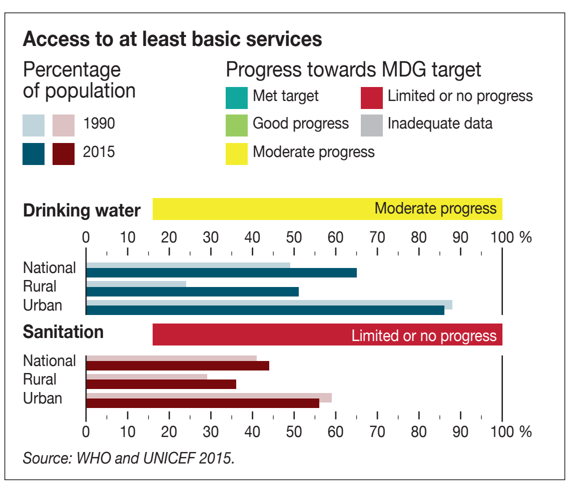
Source: UNSD 2019.



Wastewater management

Recent data on wastewater management are lacking, although available data show that 118.4 million m^3 of municipal wastewater was generated in 2013 (FAO 2018).

Water and sanitation provision



Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Local Government and Housing • Ministry of Health • Rural Water Supply and Sanitation Unit under the Department of Housing and Infrastructure Development in the Ministry of Local Government and Housing
Presence of a functional water regulator	• National Water Supply and Sanitation Council
Environment for private sector participation	• Zambia Development Agency • Public-Private Partnerships Act, 2009 • Public Procurement Act, 2008
Water pricing facility	• Approved water supply and sewerage tariffs, May 2018 • National Water Policy • Guidelines on tariff setting, 2014
Legal, policy and strategy frameworks	
Current enabling policies	• National Water Supply and Sanitation Council Strategic Plan 2016–2020 • National Water Policy, 2010 • National Urban Water Supply and Sanitation Programme 2011–2030
Current enabling laws	• Water Act (Cap 198), 2006 • Water Supply and Sanitation Act, 1997 (No. 28 of 1997) • Water Board (Charges and Fees) Regulations (Cap. 198), 1990 (2006) • Public Health (Drainage and Latrine) Regulations (Cap. 295), 1932 (2006) • Water Resources Management (Charges and Fees) Regulations, 2018 (S.I. No. 18 of 2018) • Water Resources Management Act, 2011

Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

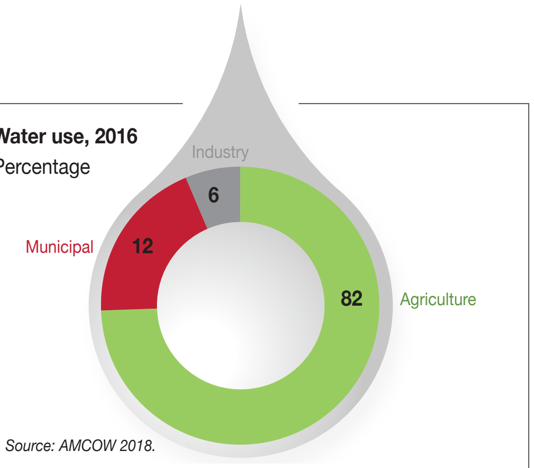
Zimbabwe

Water resources

Zimbabwe receives an average of 657 mm/year of rainfall, which ranges from 300 mm in the southern lowveld to more than 1,000 mm in the eastern highlands. The country is prone to droughts associated with El Niño events (AMCOW 2018; FAO 2016).

The country's aqueduct water stress for all sectors measured in 2010 was 0.56 and is projected to increase to 1.02 by 2040 (Luo et al. 2015). A score of 1.02 indicates that there is low to medium competition among water users relative to available surface-water resources.

Water use, 2016
Percentage

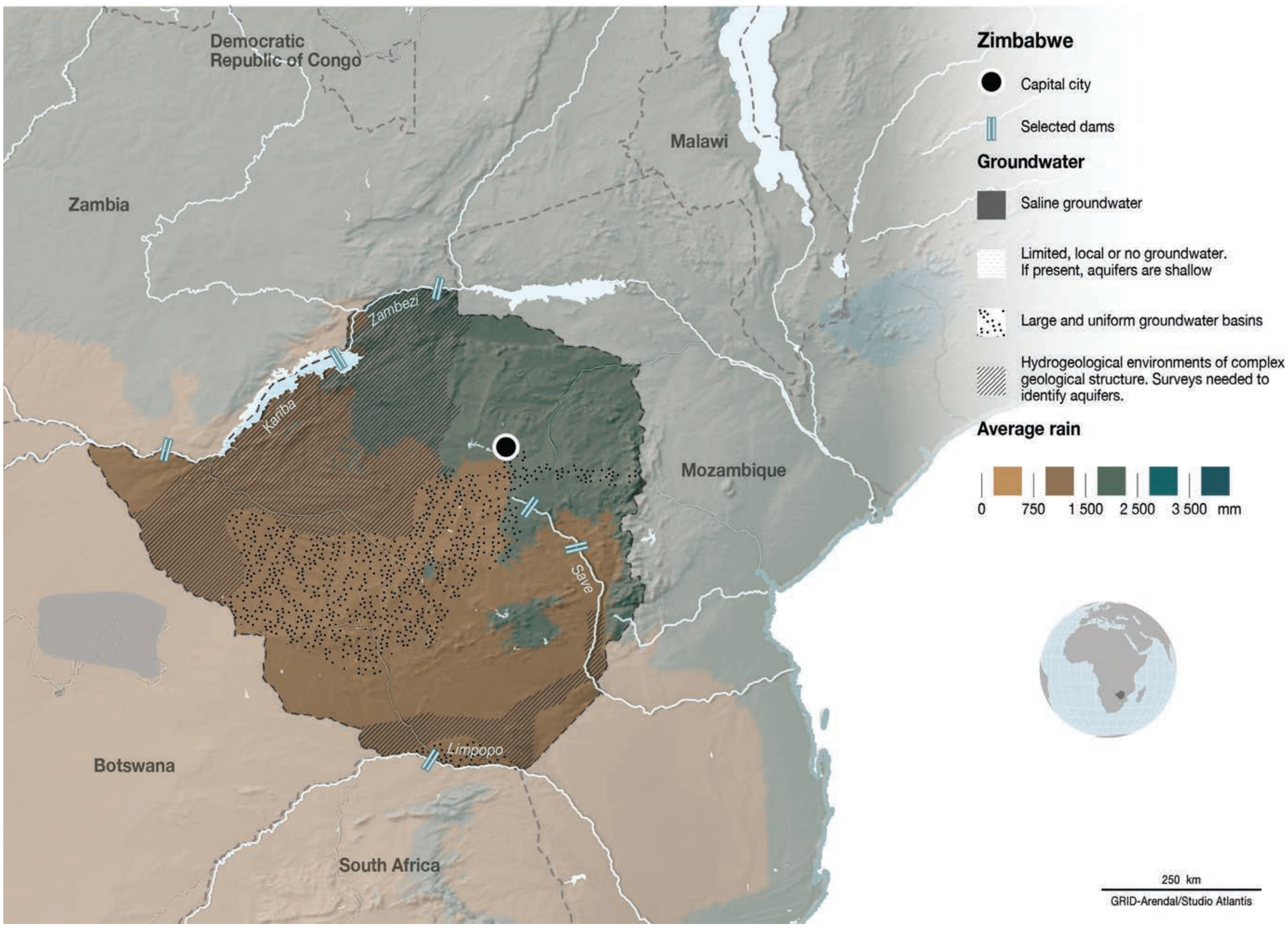


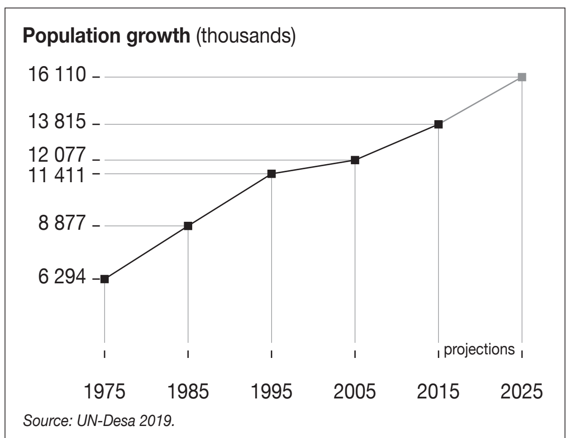
Source: AMCOW 2018.

Water availability

	m³/person and year
Total renewable freshwater	1 530
Total water withdrawal	273
Internal renewable water sources	939
of which are surface water	862
pressure on surface water	*33.7%*
of which are groundwater	459
pressure on groundwater	*7.0%*
Water stress	***17.80%***

Source: AMCOW 2018; FAO 2018.

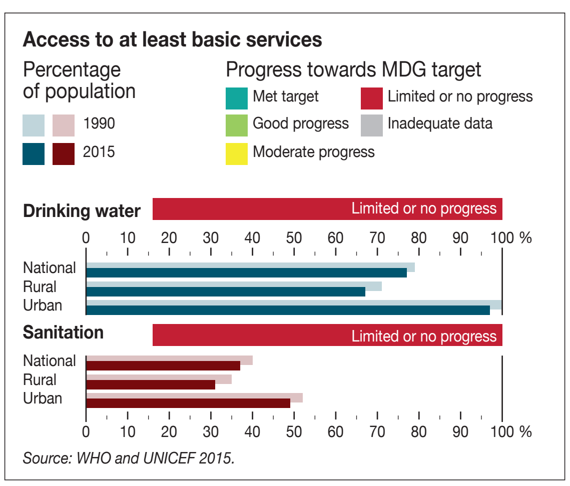




Wastewater management

Recent data on wastewater management are lacking. In 2012, 194 million m^3 of municipal wastewater was produced, with 95 million m^3 treated at 137 treatment plants (FAO 2018).

Water and sanitation provision



Using MDG 7.C to benchmark progress towards achieving SDG 6

Goal	Indicator	2000	2005	2010	2015
Drinking water	Proportion of population using safely managed drinking water services (%)				
Sanitation and hygiene	Proportion of population practising open defecation (%)	29.3	28.2	27.3	26.5
	Proportion of population using safely managed sanitation services (%)				
	Proportion of population with basic handwashing facilities on premises (%)		31.1	30.9	30.7
Wastewater treatment	Proportion of safely treated domestic wastewater flows (%)				
	Proportion of bodies of water with good ambient water quality (%)				76.5 (2017)
	Proportion of groundwater bodies with good ambient water quality (%)				
Water-use efficiency	Water-use efficiency (US$/m^3)		1.2		
Water stress	Freshwater withdrawals as a proportion of available freshwater resources (%)				17.8
Water resources management	Degree of integrated water resources management (IWRM) implementation (%)				61.0 (2017)

Source: UNSD 2019.

Institutional and legal framework

Basic elements	Response
Institutional framework	
Presence of an enabling institutional framework for sustainable water, wastewater and sanitation development and services	• Ministry of Water Resources Development and Management • Zimbabwe National Water Authority • National Action Committee for Water, Sanitation and Hygiene • Rural District Councils • Water Environmental Sanitation Working Group • Water Environmental Sanitation Working Group
Environment for private sector participation	• No dedicated public-private partnership law • PPP Guidelines (2004) are under review by the Government • PPP Policy, 2010 • There is no dedicated public-private partnership unit; such partnerships are implemented by the Ministry of Finance and relevant line departments
Water pricing facility	• National Water Policy, 2000 • Zimbabwe National Water Authority (Raw Water Tariffs) Regulations, 2016 (S.I. 48 of 2016)
Legal, policy and strategy frameworks	
Current enabling policies	• National Water Policy, 2000 • National Water Strategy, 2000
Current enabling laws	• Water Act, 1998 • Water Act (Cap. 20:24), 2002 • Water Pollution Control (Waste Effluent Water Standards) Regulations (Government Notice No. 609 of 1971)

Sources: FAO 2016; World Bank 2018b; World Bank 2018c.

NOTES
REFERENCES
ACRONYMS
CONTRIBUTORS
APPENDIXES

Notes

CHAPTER 1

1. GEMI is composed of the United Nations Economic Commission for Europe (UNECE), UN Environment, the United Nations Human Settlements Programme (UN Habitat), UNICEF, the United Nations Food and Agriculture Organization (FAO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Health Organization (WHO) and the World Meteorological Organization (WMO).
2. See https://www.viawater.nl/projects/pula-app-for-faecal-sludge-management-mozambique-and-zambia
3. The Dutch fund VIA Water (www.viawater.nl) has supported more than 60 innovative water and sanitation projects across Africa.
4. Desludgers are operators, usually private, that empty on-site sanitation systems, latrines and septic tanks, for a fee. Formal deslugers usually empty these systems with trucks that are then used to transport the faecal sludge to the designated treatment sites.
5. See https://www.ux.co.mz/
6. See https://www.mopa.co.mz/#servicos
7. A dialog menu can be accessed in Mozambique using *311#, the call is free.
8. See https://www.viawater.nl/projects/map-action-bamako-mali
9. See https://www.viawater.nl/projects/flash-flood-forecasting-app-ghana

CHAPTER 5

1. MoWRDM = Ministry of Water Resources, Development and Management; MoHCW = Ministry of Health and Child Welfare; MoTCID = Ministry of Transport, Communication and Infrastructure Development; MoA = Ministry of Agriculture; MoLGRUD = Ministry of Local Government Rural and Urban Development; MoEn = Ministry of Environment; MoE = Ministry of Education; MoWAGCD = Ministry of Women Affairs, Gender and Community Development; MoF = Ministry of Finance; DDF = District Development Fund; WRM = Water Resources Management; NAC = National Action Committee; NCU = National Coordinating Unit; WASH = Water Sanitation and Hygiene; WSS = Water Supply and Sanitation; Donors Group AfDb = African Development Bank; AusAid = Australian Agency for International Development; DFID=Department for International Development; EU = European Union; GTZ = German Technical Cooperation Agency; NGOs = Non-governmental Organizations; UNICEF = United Nations Children's Fund; WB = World Bank.
2. Decentralization describes the transfer of central government powers, competences and resources to the local government, closer to the people and citizens. The concept can be applied to infrastructures (for example, decentralized wastewater treatment).
3. Monthly expenditure was considered a surrogate metric for income in the citywide survey (1,200 households) carried out by [1].
4. In Mozambique, hierarchy and community relations are very strong aspects of day-to-day livelihoods. In several sanitation projects, local institutions and external donors make use of these networks for project implementation and reporting, in a bottom-up approach. Of particular importance are the block leaders (Chefes de Quarteirão, in Portuguese), who report to the Neighborhood Secretaries (Secretários do Bairros, in Portuguese) and then on to the administration of the Municipal District (Distrito Municipal, in Portuguese). This institution is then responsible for reporting to the Municipality. All these actors are elected by the people.

CHAPTER 6

1. Benin, Burkina Faso, Central African Republic, Chad, Congo, Democratic Republic of the Congo, Ghana, Kenya, Liberia, Madagascar, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Tanzania, Uganda, Zambia.
2. Operation and maintenance.
3. Liquid faecal sludge is sourced from vacuum trucks and collected from public toilets and households. While it is mainly non-decomposed waste that is needed for high biogas generation, decomposed faecal sludge can be processed towards compost generation.
4. When stringent standards are adopted, wastewater treatment plant systems may struggle to attain the required performance at an affordable cost.
5. Pathogens are defined as disease-causing organisms.
6. In the Windhoek case, a very strict health risk management programme was required, and is being implemented. This is structured around laboratory analysis to assess water quality at all stages, performed through online automated and regular (four-hourly or weekly) sampling.

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CHAPTER 6

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Acronyms and abbreviations

AfDB	African Development Bank
AIT	Asian Institute of Technology
AMCOW	African Ministers' Council on Water
AU	African Union
BOD	biochemical oxygen demand
CAADP	Comprehensive Africa Agriculture Development Programme
CBOs	Community-Based Organisations
CEA	circular economy approach
CLTS	community led total sanitation
COD	Chemical Oxygen Demand
CVM	Cruz Vermelha de Moçambique (Mozambique Red Cross)
DO	dissolved oxygen
ECOWAS	Economic Community of West African States
ERU	Equivalent Residential Unit
ESCAP	(United Nations) Economic and Social Commission for Asia and the Pacific
FAO	Food and Agriculture Organization of the United Nations
GBD	Global Burden of Disease
GDP	Gross Domestic Product
GEMI	Global Enhanced Monitoring Initiative
GHG	Greenhouse gas emissions
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Development Agency)
GLAAS	UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water
GPA	Global Programme of Action for the Protection of the Marine Environment from Land-based Activities
GWP	Global Water Partnership
HLPW	High-Level Panel on Water
ICT	Information and communication technologies
IDP	internally displaced people
IEES	International Ecological Engineering Society
IFC	International Financial Cooperation
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
ITA	International Trade Administration
IWMI	International Water Management Institute
IWRM	integrated water resources management
JMP	Joint Monitoring Programme for Water Supply, Sanitation and Hygiene
KCCA	Kampala Capital City Authority
LDCs	Least Developed Countries
MDGs	Millennium Development Goals
METAP	Mediterranean Environmental Technical Assistance Programme
NEMA	National Environment Management Authority (of Uganda and of Kenya)
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organisation
OCV	oral cholera vaccine
OECD	Organisation for Economic Co-operation and Development
OSS	on-site sanitation systems
REMA	Rwanda Environment Management Authority
RWSSI	Rural Water Supply and Sanitation Initiative
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
STHs	Soil transmitted helminths
SWIM	Sustainable Water Integrated Management (Programme)
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TS	Total Solids
TSS	Total Suspended Solids
UDDTs	urine diversion dry toilets
UN	United Nations
UN Habitat	United Nations Human Settlements Programme
UNAIDS	Joint United Nations Programme on HIV and AIDS
UNDESA	United Nations Department of Economic and Social Affairs
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UNFPA	United Nations Population Fund
UNGA	United Nations General Assembly
UNICEF	United Nations Children's Fund
UNSD	United Nations Statistics Division
USEPA	United States Environmental Protection Agency
UNWWAP	United Nations World Water Assessment Programme
VIP	ventilated improved pit (latrine)
VOCs	Volatile Organic Compounds
WASH	Water, Sanitation and Hygiene
WEF	World Economic Forum
WHO	World Health Organization
WMO	World Meteorological Organization
WSP	Water and Sanitation Programme
WSUP	Water and Sanitation for the Urban Poor
WUA	water user association
WWTPs	wastewater treatment plants
WWDR	World Water Development Report

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Appendix 1. Wastewater streams

	Municipality	Industry	Agriculture	Hospitals	Storm water
Contaminants	Pathogens, solids, organic matter, nutrients, heavy metals, salts, micropollutants.	Organic matter, suspended solids, coloured materials, toxic metals, oil and grease, nutrients, micropollutants (dioxins, polychlorinated biphenyls [PCBs])	Nutrients, organic matter, pathogens, pesticides, sediments, metals	Pharmaceuticals, personal health-care products and pesticides, organic compounds, ammonia, heavy metals, solids, pathogens	Nitrogen, chlorides, copper, zinc, manganese, nickel, cadmium, polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), pathogens, oil and grease.
Possible treatment: Technology	• Centralized treatment plant. • Waste stabilization ponds.	• Cleaner production as the first treatment step in pollution control. • Centralized treatment plant (and municipal sewage treatment plant in instances when pre-treatment is required). • Waste stabilization ponds • Constructed wetlands (reedbed system)	• Best management practices are the first step in the treatment process (e.g. erosion control, nutrient management to reduce excessive application of synthetic fertilizers, integrated pest management which includes biological pest control to reduce reliance on chemical pesticides) • Centralized treatment plant • Constructed wetlands • Anaerobic lagoons	• Pre-treatment (disinfection, chemical, autoclave) • Centralized treatment plants with municipal wastewater, using activated sludge systems.	• No treatment. Collect run-off and channel it to the nearest water bodies • Sustainable Drainage Systems (SuDS) approach.
Volumes	500 to 450,000 m^3 per day*	0.01m^3/d up to 10,000m^3/d for constructed wetlands**		362 to 745 litres per occupied bed per day	Variable
Economic opportunity/ burden	Employment opportunities through afforestation programmes; Public health and environmental protection through wastewater reuse.	Employment opportunities, public health and environmental protection through cleaner production; Wastewater reuse for non-potable uses even within the industry; Recovery of by-products, thus minimizing the financial costs associated with treatment and disposal	Employment opportunities, public health and environmental protection through best management practices; Wastewater reuse in irrigation; Financial burden in treatment and disposal	Highly pathogenic, no country reported wastewater reuse. Financial burden in treatment and disposal.	Financial burden in treatment of polluted water bodies. Flooding can also destroy property.
Policy regulations institutional frameworks	• Presence of government bodies and institutions for wastewater treatment and disposal. • Policies and regulations in support of treatment and discharge of wastewater are available, but poorly enforced. • Design standards or guidelines for waste stabilization ponds available for North and Southern Africa.	• Presence of government bodies and institutions for industrial effluent treatment and disposal. • Policies and regulations in support of treatment and discharge of industrial effluents are available, but remain poorly enforced.	• Presence of government bodies and institutions for wastewater treatment and disposal • Policies in support of controlling excessive use of synthetic pesticides and fertilizers, and excessive water extraction for irrigation need to be developed and implemented.		• By-laws on sustainable drainage systems in South Africa. • A need to establish the legal frameworks and institutional capacity to charge service fees for storm water management in African countries.
Final product (s) can be used for:	Treated wastewater can be used for irrigation purposes and groundwater recharge. It has the capacity to produce organic fertilizer, reed grass in the constructed wetland and energy.	Treated wastewater can be used for some industrial processes, irrigation purposes, groundwater recharge and the production of energy and/or by-products that can be used as raw materials in production processes.	Treated wastewater can be used for irrigation purposes and groundwater recharge. It has the capacity to produce organic fertilizer and reed grass in the constructed wetland.	No documented reuse in African countries, but can potentially provide wastewater for irrigation purposes and groundwater recharge.	Water for groundwater and surface water recharge. Can be used for irrigation purposes.

* Resource Recovery from Waste: Business models for Energy, Nutrient and water in Low- and Middle-income Countries (2018)
** Werner et al., 2001

Appendix 2. Impacts, risks and lessons from implementation of Circular Economy Approaches (CEA)

CEA 1	Positive impacts	Risks	Lessons
Environmental	• Using treated wastewater to cultivate forests enhances microclimate, increases biomass availability and biodiversity, and improves environmental sanitation. • Availability of nutrients in treated wastewater reduces the demand for inorganic fertilizers, thereby reducing crop production cost for farmers.	• Simple treatment processes cannot effectively treat the inflow of industrial wastewater to ensure safe reuse in agriculture. • Lack of efficient water treatment and irrigation methods, e.g. flood and drip irrigation to minimize contact with crops	• Reuse of wastewater has environmental, social and economic benefits.
Social	• New forests serve leisure purposes for tourists and neighbouring communities. CEA 1 can help develop golf tourism. • Jobs and livelihoods are supported in areas around the secondary forests.	• Poor quality water is very likely if treatment is inefficient. • Negative impact of community social stigma associated with wastewater reuse	• Need to manage negative perception and potential stigmatization through appropriate awareness-raising and education programmes • Treated wastewater quality must be monitored to minimize long-term negative impacts. • Sanitation safety planning must be implemented to safeguard public health.
Profitability/ cost recovery	• Private-sector organizations can support the management of the treatment facility e.g. in Tiznit (Morocco), the treated wastewater tariffs are managed by a farmer association.	• Unstable water tariffs affect cost recovery. In Morocco, golf courses pay 3.6 times higher fees than farmers. • Lower demand for treated wastewater usage due to the subsidized rates for availability of, or accessibility to, freshwater • Difficulties in aligning wastewater selling rates with the operation and maintenance (O&M) cost of water treatment and transfer	• The payback period for investments in perennial plants, such as trees for wood production or evergreen citrus trees that can absorb water year-round, does not start until the first harvest, which does not support quick returns on investment. Many farmers call in particular for advanced treatment to grow highly profitable cash crops such as vegetables. • Water reuse based on tariffs alone may not be cost-effective. • To ensure success, it is important to present a compelling value proposition against the competing water or resources.
Innovation	• Simple treatment technologies such as lagoons can deliver adequate quality water for reuse in agriculture, especially if drip irrigation is used.	• Wrong selection of crops and tree varieties could make the CEA financially and economically unfeasible.	• Operating and maintaining wastewater treatment plants to meet treated water quality is challenging. Cost recovery is required to ensure adequate operation and maintenance of wastewater treatment plants.
Scalability – replicability	• The Marrakech wastewater treatment plant is financed through a public-private partnership between the State and 17 golf operators (30 per cent of the investment cost borne by the golf operators and they pay a connection fee to use the treated wastewater). This has increased treated wastewater use and reduced financial burden on the State.	• Application restricted to certain types of crop • Limited private-sector investments in wastewater treatment and reuse in Africa • Water conveyance challenges are expected if the wastewater treatment plant is not suitably sited.	• Soil conditioning is required to improve plant growth; the nutrients in water are not sufficient. • Capital-intensive; long timespan for payback.
Policy	• Enforcement of regulations outside conventional schemes is challenging.	• Unfavourable policy environment for the use of treated wastewater for irrigation • Reuse standards might require regular revision. • Overlapping responsibilities disturb enforcement and implementation of reuse guidelines.	• Scientific studies to demonstrate safety and benefits could help advance policies.

CEA 2	Impacts	Risks	Lessons
Environmental	• Long-term wastewater reuse may have limited negative impacts on soil and groundwater when industrial wastewater is diverted and levels of heavy metals in the water are low. • Wastewater reuse can revive areas that were previously unliveable due to lack of water.	• Treatment performance of soil aquifer treatment and recharge performance are highly dependent on several geological factors and are location-specific.	• When designed properly, soil aquifer treatment could constitute a simple, low-cost treatment method for wastewater. • Operational barriers that provide backup or standby for essential aspects of the treatment processes must be in place.
Social	• Wastewater reuse can be a sustainable and abundant source for arid areas. • Groundwater recharge yields profits for other sectors.	• Health risks resulting from exposure to pathogens or chemicals in inadequately treated wastewater can affect wastewater treatment plants workers and water consumers.* • Concerns over crop/drinking water quality • Social barriers to the acceptance of the model	• Perception of untreated wastewater or treated wastewater use could change negatively if monitoring is not enforced. Address possible stigma, especially if alternative water sources are available. • Avoid recurrent negative incidents that would harm trust. • Continuous engagement and effective communication and outreach are required to mitigate any emerging issues. • Despite initial health and aesthetic concerns, public acceptance can be achieved with open communication. • Water quality and health impacts must be closely controlled.
Profitability/ cost recovery	• Costs of accessing water are reduced. • Extra treatment of water may not be required in the case of groundwater recharge. • Possible environmental impacts and costs related to sourcing water from other sources (e.g. construction of new dams and water transfer systems) are also avoided.	• Cutting-edge technologies with high capital expenditures and operation and maintenance are required for wastewater reclamation for drinking purposes. • Suitable investment is required to ensure the right affordable technology is adopted.	• Though wastewater treatment is essential to mitigate health risks, the treatment also removes organic matter and nutrients, which could lower farmers' interest in using it. • Attention must be paid to cases with industrial wastewater input (which may contain high loads of heavy metals).
Innovation	• Water productivity is enhanced through multiple, circular uses.	• Validation of technologies through pilots is necessary to facilitate adoption.	• Water banking can be practised when wastewater has been treated and is not going to be used immediately. The water stored in the ground can be used when needed, after many years.
Scalability – replicability	• High economic and ecosystem services benefits could make the system worthwhile, even without immediate sufficient cost recovery. • Savings could be made by public authorities, as they do not need to invest in running a sophisticated wastewater treatment system.	• Long-term monitoring of water quality and impacts is essential. • The water-swapping model (CEA 2B) between urban and rural areas has potential where cities outgrow local water supply.	• For some soils only, irrigation also constitutes a sustainable means of groundwater recharge. • Inclusive planning is key to ensuring success. Fair contract negotiations are a must. • Implementation process is simplified when a single entity is responsible for treated wastewater and drinking water supply. • Direct potable reuse of wastewater can be practised.
Policy	• There is a need for open and transparent public-sector monitoring of water and soils.	• To accompany the implementation, some policy measures supporting water conservation must be in place. • Social responsibility requires the different players to meet their commitments. All parties must be provided with proper incentives.	• Favourable policy support is essential to encourage reuse of treated wastewater for drinking. • In the swapping model, regulations (e.g. on water abstraction) are required.

* In the Windhoek case, a very strict health risk management programme was required, and is being implemented. This is structured around laboratory analysis to assess water quality at all stages, performed through online automated and regular (four-hourly or weekly) sampling.

CEA 3	Impacts	Risks	Lessons
Environmental	• Production of duckweed and fish rearing is a low-cost and simple process to treat wastewater. • The applied solution improves the final condition of wastewater, which would otherwise remain untreated.	• Water quality after fish production may remain insufficient, if fish food is added.	• Free water supply is attractive to private-sector investors. • Pre-existence of basic wastewater treatment infrastructure such as ponds increases the attractiveness of this model.
Social	• Fish production creates jobs. Livelihoods and nutrition are improved. • Secondary reuse of treated wastewater in irrigation would yield additional benefits.	• Health risks resulting from exposure to pathogens in inadequately treated wastewater affect wastewater treatment plant workers, fish products, fish processors and fish consumers. • Worries about fish marketing and acceptance • Stigma, even with good quality water	• Fish are stolen from some production sites. • Monitoring of system safety is important to address any negative public perceptions that might emerge.
Profitability/ cost recovery	• This CEA requires limited capital cost (especially when the treatment plant is simply rehabilitated). This results in higher potential for cost recovery and profitability. • Treated wastewater use can benefit from additional externalities such as reduced carbon footprint, reduced use of freshwater, etc.	• Waste stabilization ponds is an extensive process that requires sufficient land, which could be difficult to secure for the long term in an urban area.	• The fish-based CEA is a viable business model, which has multiple strong revenue streams. • Economies of scale are achieved in the long term due to low production costs and gained expertise.
Innovation	• Only selected fish species can be reared in wastewater ponds. • The profit incentives remove the need for external oversight of wastewater treatment performance.	• Impacts of emerging contaminants are still uncertain.	• Since aquaculture is not a consumptive use of treated wastewater, this water could be reused in irrigation.
Scalability – replicability	• Private-sector investments are common for this CEA. • Savings are made by public authorities, since they do not need to invest to run the wastewater treatment system. • High land requirement may be seen as a constraint in densely populated areas.	• Availability of high surface land to implement this initiative • Industrial wastewater inflow in wastewater treatment plants should be avoided.	• Stigma surrounding products is more an anticipated than current issue. • Adoption of (treated) wastewater farming is challenging, despite a long tradition of practice e.g. in Asia and WHO guidelines published to direct the process. • This CEA typology is easy to replicate if sewers and ponds/land are in place. • This CEA typology shows interesting prospects to revive abandoned wastewater treatment plants.
Policy	• The challenge is to ensure public-sector monitoring of fish quality..	• Changes in policy, resulting in conditions that are not favourable to operations	• Favourable policy support is essential to promote treated wastewater use for aquaculture.

CEA 5	Impacts	Risks	Lessons
Environmental	• The need to secure water could be a driving force towards setting up basic treatment plants. • In farmer-led designs, the focus might be on removing visible pollutants, such as plastics. Therefore, the targeted treatment level of the wastewater may be insufficient.	• Health risks due to exposure to pathogens in poorly treated wastewater affecting farm workers and consumers. • High salinity in wastewater can lead to soil degradation. • Contamination of crops with heavy metals • Groundwater pollution	• Although best practices target first of all pathogenic risk, the model can also address chemical risks if the sources can be controlled by the participating private-sector entities through source pre-treatment and a 'zero-waste' policy. • Financing of wastewater treatment plants remains a challenge in many cities. Systems demanding low operation and maintenance that can be upgraded with time should be preferred.
Social	• Social marketing campaigns and trainings for women constitute an important step towards social integration and poverty alleviation.	• Increased risk awareness is required for this model to be successful. • Awareness and demand creation could take time to materialize.	• Such initiatives could learn from or be combined with other ongoing and well-established programmes, e.g. for handwashing.
Profitability/ cost recovery	• Every dollar spent on risk reduction from 'farm to fork' will return US$5 in savings on consumer health care.	• Market for premium customers must be created at a sufficient scale.	• The social nature of the costs of implementing this model justifies the need for public investments in incentives to promote best practices and minimize risks.
Innovation	• These models offer improved safety compared to business-as-usual models.		• Models building on corporate social responsibility (CSR) can catalyse change where public-sector policies and regulations are only emerging.
Scalability – replicability	• This model helps to reduce risks where wastewater treatment systems are lacking and farmers use directly or indirectly untreated, partially treated or diluted wastewater. • Only a few successful cases have been recorded globally.		• The model aligns with the World Health Organization recommendation to adopt a step-by-step and stakeholder-inclusive approach to risk mitigation as an intermediate step until (a) comprehensive wastewater collection and treatment systems are in place, and (b) strict safety guidelines can be implemented and enforced.
Policy	• Public-sector involvement and monitoring of practices is essential.		• Compliance of interventions with standards and procedures must be monitored.

CEA 6	Impacts	Lessons
Environmental	• Treating faecal sludge prevents it from being released untreated into the environment. • Faecal sludge can be processed simultaneously with the organic fraction of solid waste, thus enabling two key challenges to be addressed.	• Sourcing quality waste is often challenging, though abundant waste is generated.
Social	• Faecal sludge treatment plant management creates jobs. • Higher yields of products can be generated. • Potential to improve nutrition and livelihoods. • A safe environment is conducive to tourism.	• Validation and monitoring of faecal sludge-based compost quality by recognized public authorities is essential if it is to be accepted and adopted. • Open communication, awareness-raising and dissemination of reliable information are essential at all times to manage expectations.
Profitability/ cost recovery	• Profits are made from sales of compost as well as savings from conventional waste management practices. Strong off-take agreements will help attract more interest from the private sector. • Faecal sludge recycling can benefit from additional externalities such as reduced carbon footprint, improved freshwater quality and reduced fertilizer use.	• Innovative funding mechanisms are required to bridge the gap for financing faecal sludge treatment plants for recycling. • Availability of competing products (e.g. inorganic fertilizers or electricity) at subsidized rates will lower demand in faecal sludge-based products. • Marketing of faecal sludge compost only makes sense in locations that are close to agricultural areas. Long transportation will render the business unsustainable.
Innovation	• The model is highly impacted by the location. Innovative mechanisms must cater for case-by-case variations. • Low-cost treatment technologies may also suffer from performance variations with the feedstock.	• The operation and maintenance of the faecal sludge treatment plant should balance competing demands such as manual labour (low electricity consumption) and process duration (accelerated by mechanization).
Scalability – replicability	• Potential for replicability is tied to construction of adequate infrastructure, which is the responsibility of Governments. • Private-sector investments in faecal sludge treatment and reuse sector are not yet common in Africa. However, this could change if the current limiting factors are addressed.	• Demand for soil conditioning to enhance productivity is high in sub-Saharan Africa. • Ownership and partnership terms should grant the private entity the time needed to operate and recover invested moneys.
Policy	• The challenge is to ensure enforcement in areas outside conventional schemes where restrictions are not/cannot be enforced.	• Favourable policy support is essential to encourage recycling of faecal sludge for energy or compost.