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.

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

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.

Open defecation is a result lack of basic sanitation facilities

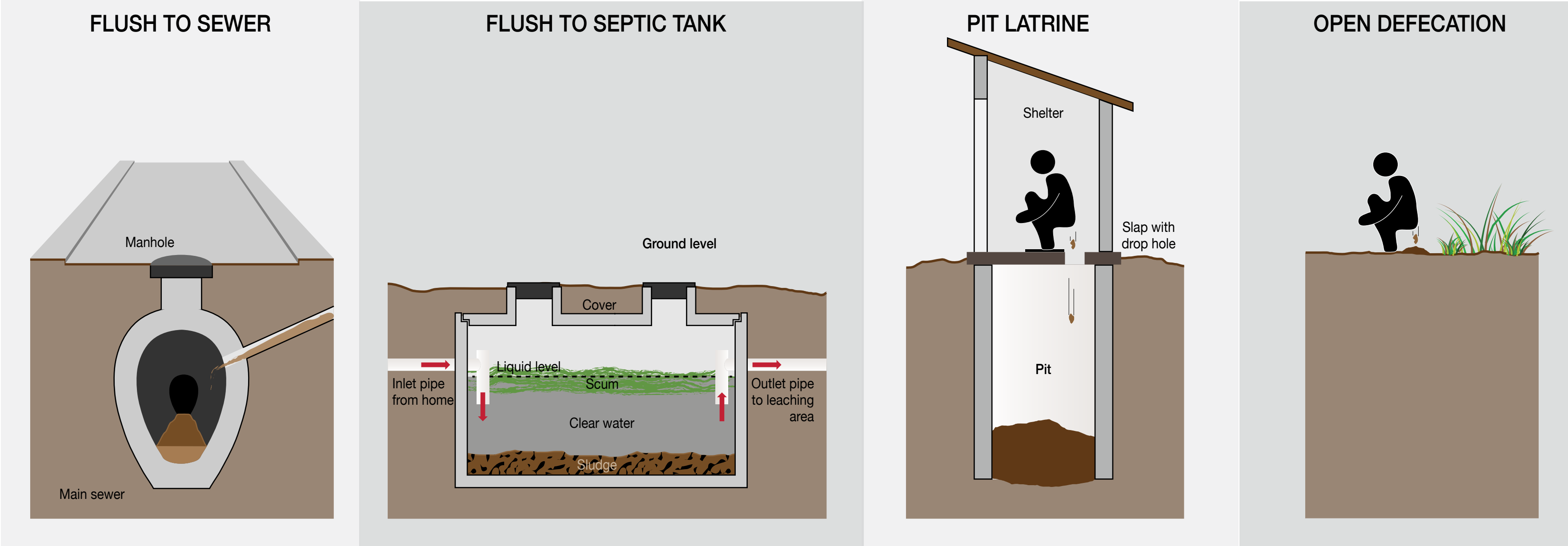


Figure 2.1. Visual presentation of existing household sanitation facilities in Africa

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.

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.

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

Case Study 2.2. Eutrophication of Lake Victoria

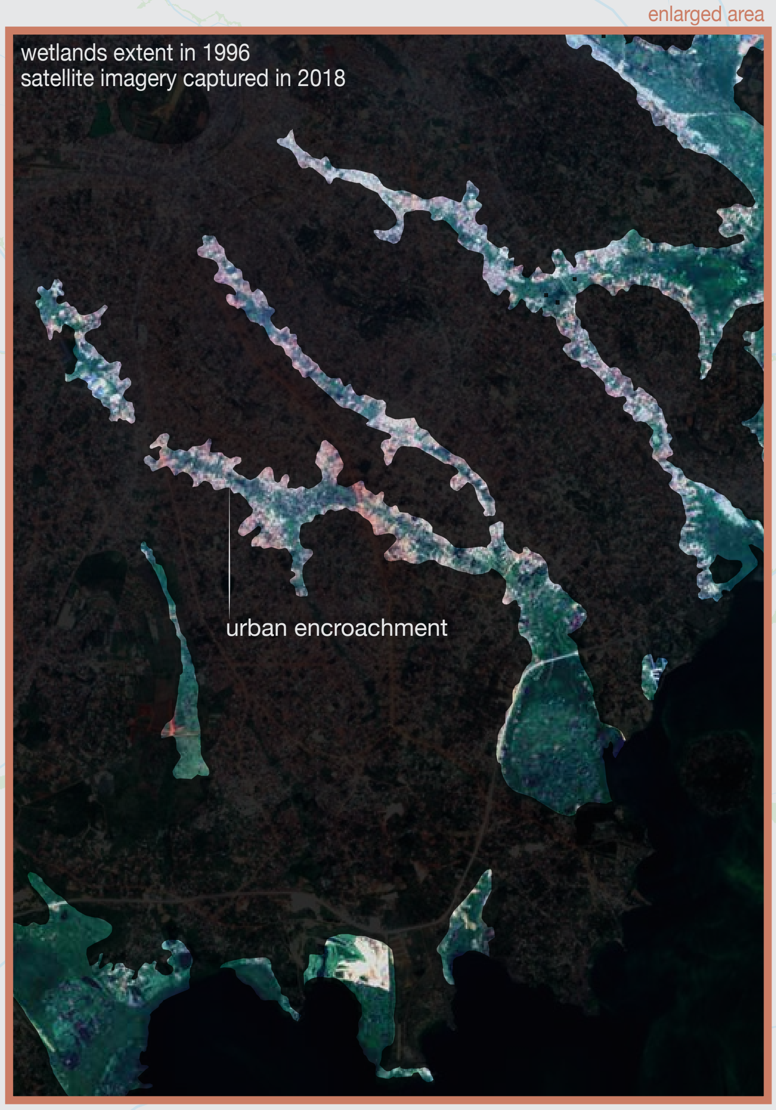
At 68,800 km^2, Lake Victoria is Africa's largest freshwater lake, whose shoreline is shared by the East African states of Kenya (6 per cent), Uganda (45 per cent) and Tanzania (49 per cent). Pollution, mainly resulting from increased human activities such as discharge of wastes, has resulted in severe 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)

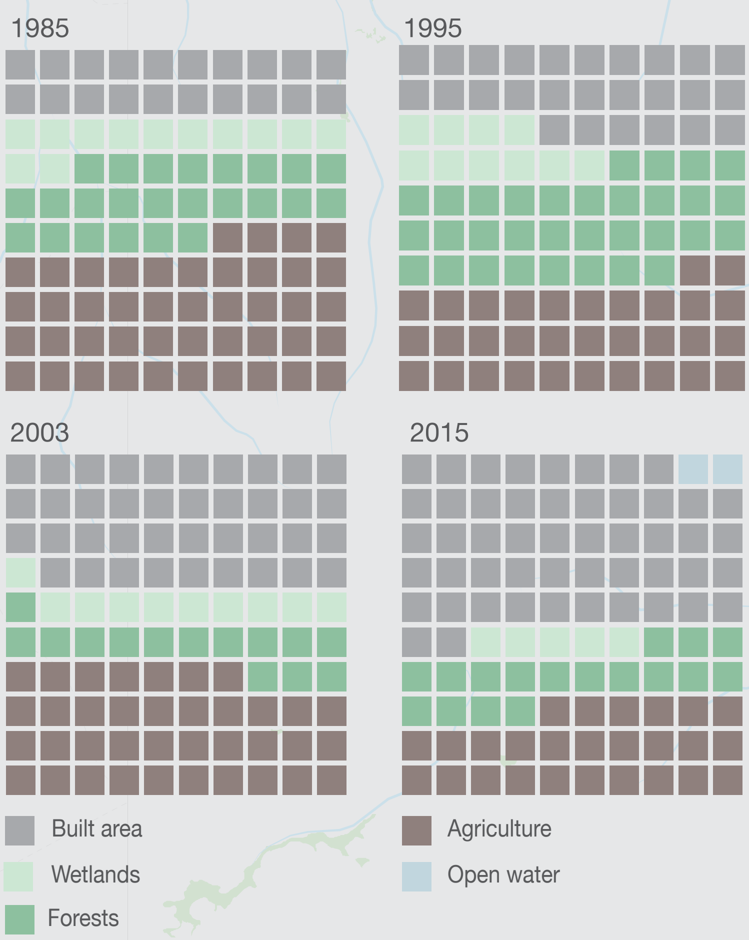
Pollution in the Murchison Bay, Lake Victoria

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



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

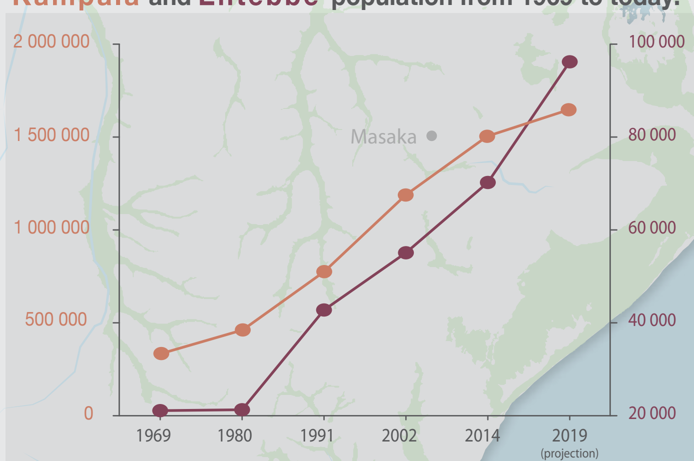


Urban expansion

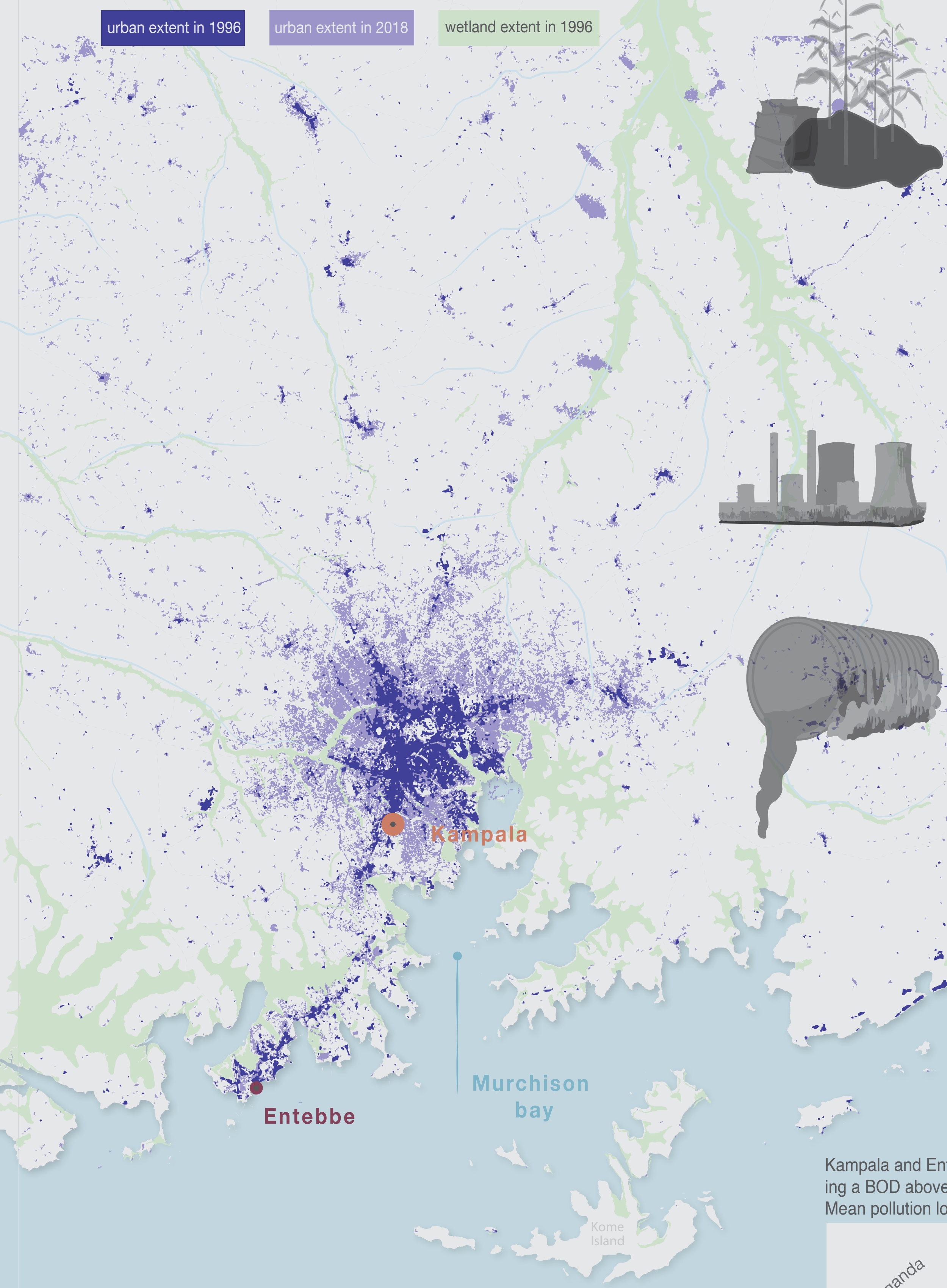
The expansion of the builtup areas in Kampala, Entebbe as well as surrounding smaller settlements is causing the loss of forested and wetland area, and increasing imprevious surfaces, which in turn increases runoff and reduces the capacity of the land to absorb pollution.

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



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.

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.

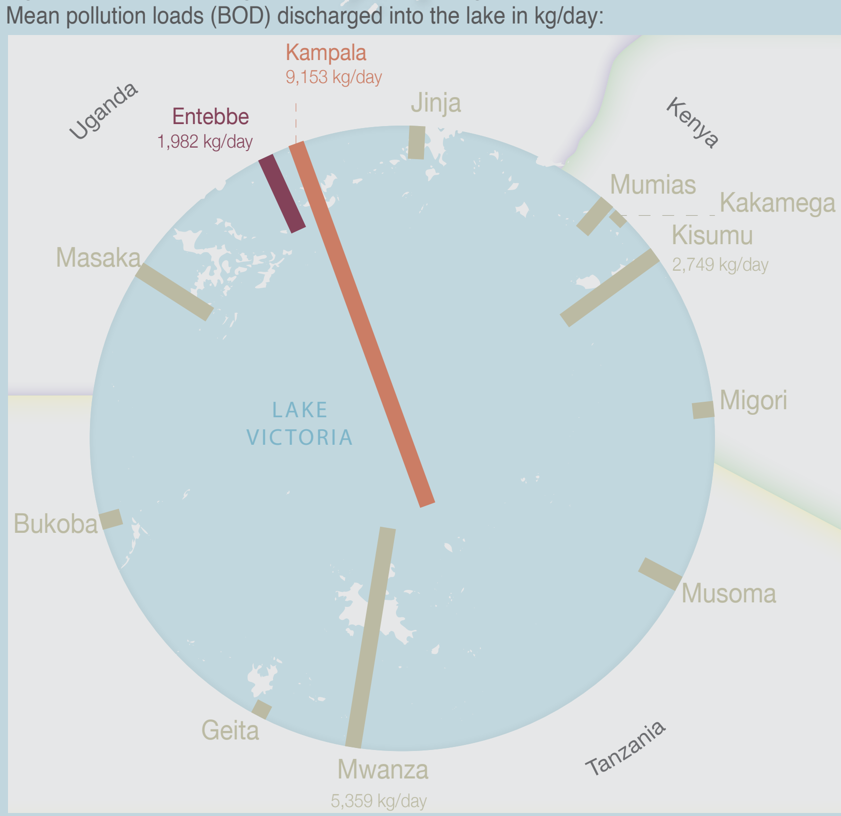
LAKE VICTORIA

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:



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)

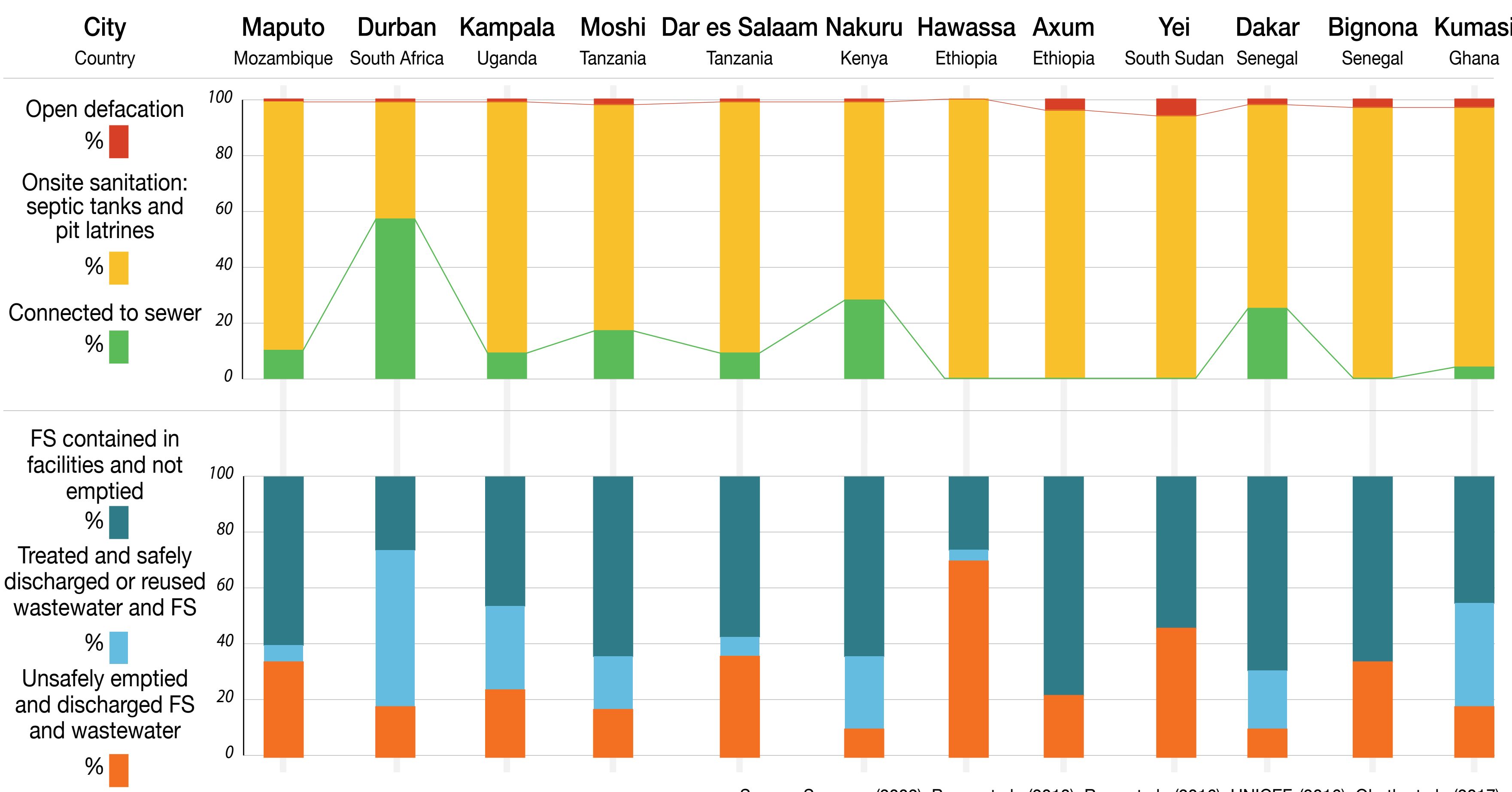
Traditional beliefs and laws are often used to guard against use of wastewater to irrigate root crops

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

Comparison of faecal sludge (FS) and wastewater flows across African countries



Source: Snyman, (2002); Baum et al., (2013); Ross et al., (2016); UNICEF, (2016); Okoth et al., (2017)

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

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.

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)

2.2.6 Use of municipal wastewater and faecal sludge

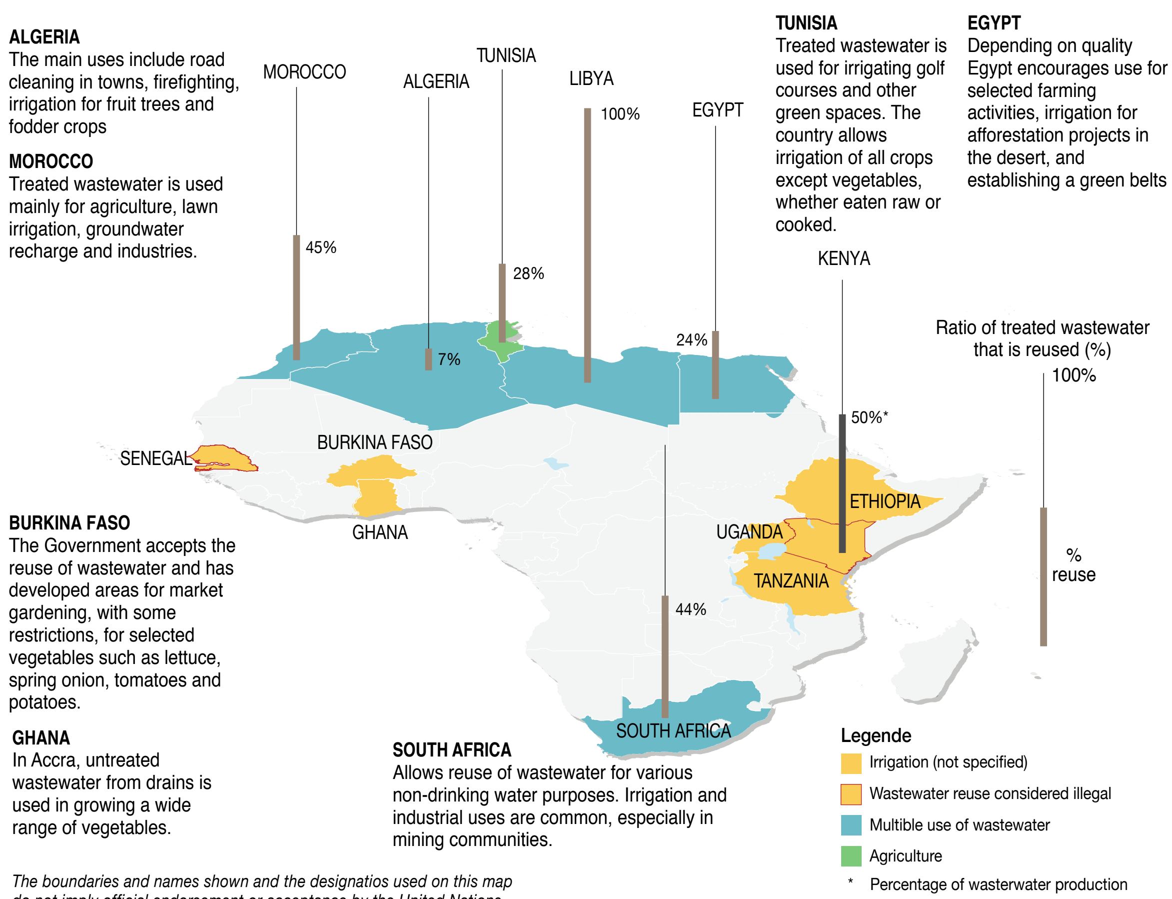
Dewatered sludge and effluent from municipal wastewater are considered a renewable resource from which water, energy (from anaerobic digestion processes) and fertilizers are derived (Bennamoun et al. 2013). Some African countries have ventured into innovative uses of dewatered sewage sludge/faecal sludge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



The boundaries and names shown and the designatios used on this map do not imply official endorsement or acceptance by the United Nations.
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).

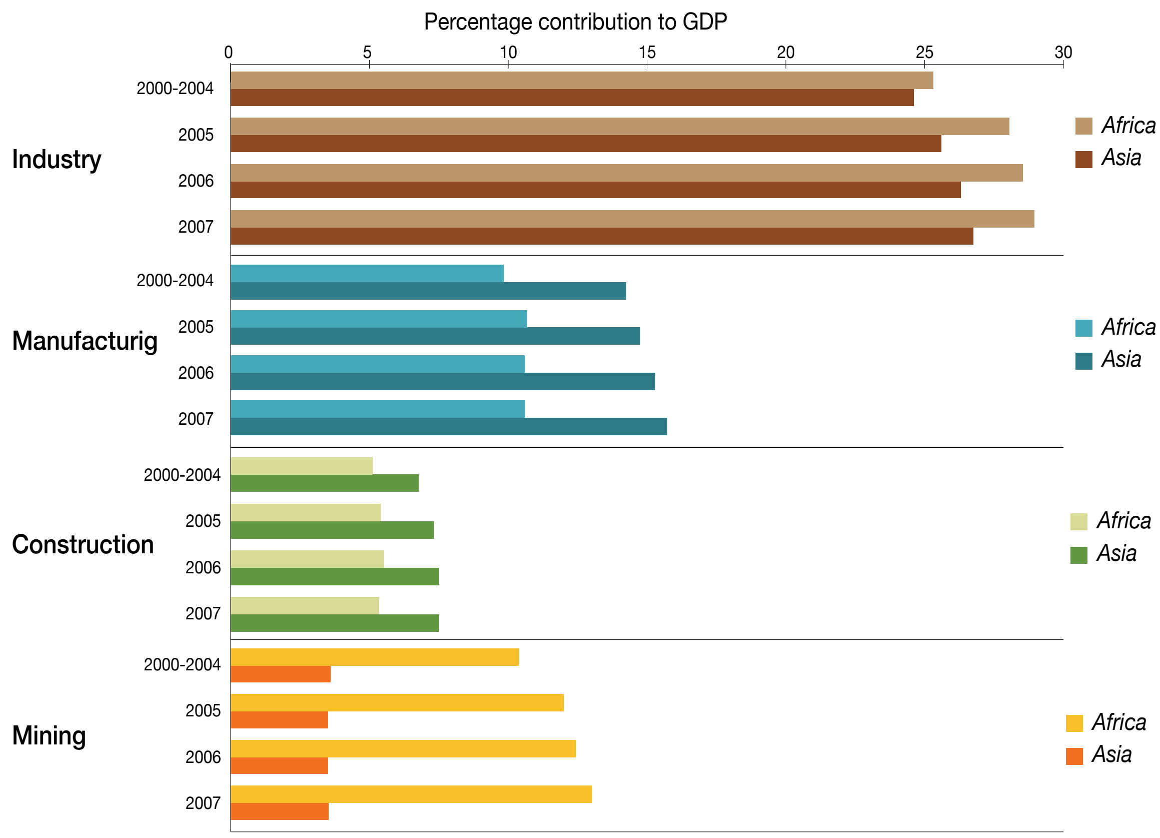
The infrastructure for waste management in many parts of Africa is either inadequate or broken

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.

African and Asian least developed countries trends in industrial sector composition



Source: United Nations Conference on Trade and Development [UNCTAD] (2009);
Included were 33 African and 8 Asian countries classified as LDCs by United Nations Economic and Social Council.

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)

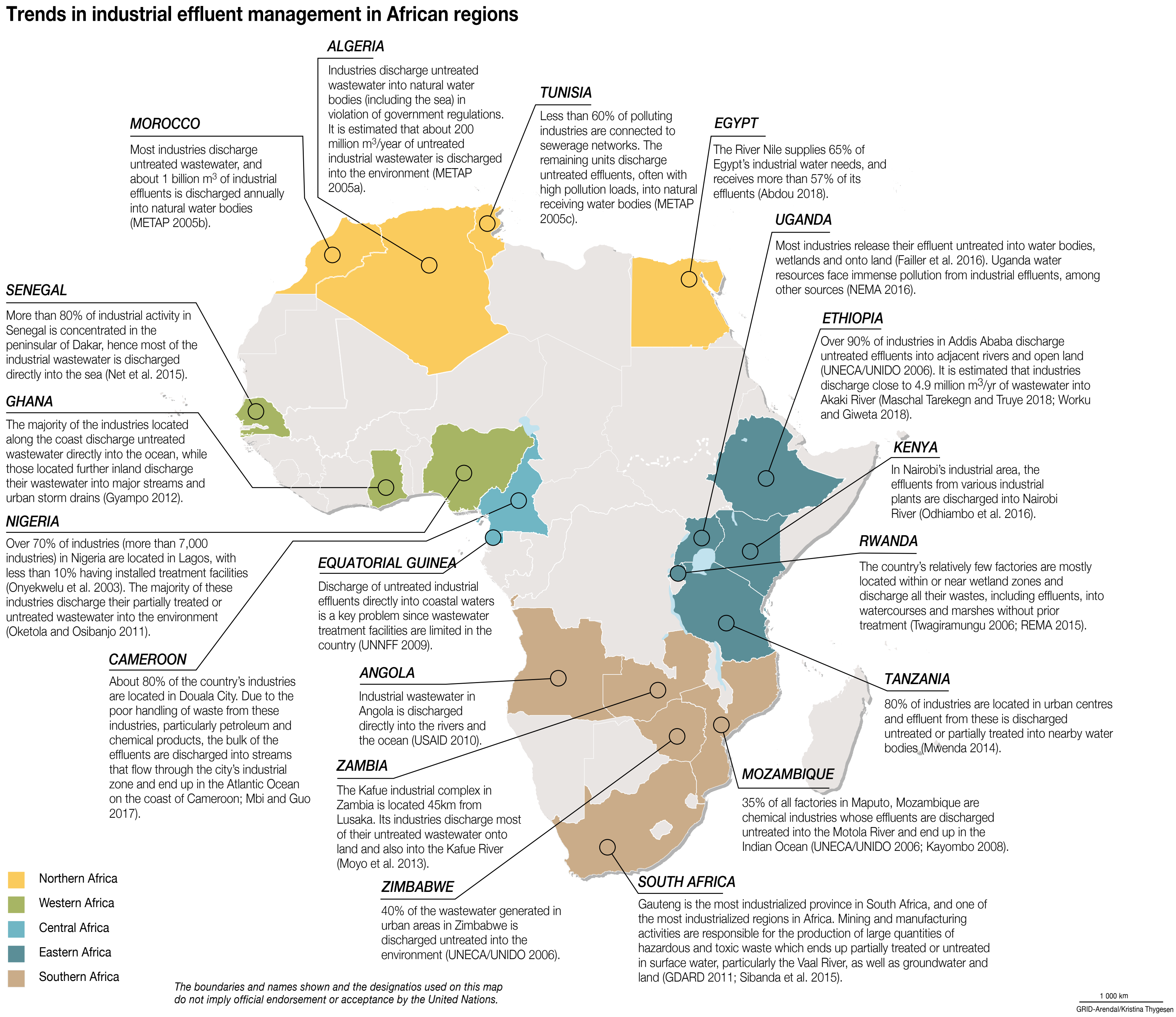


Figure 2.5. Industrial effluent management in African regions

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).

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

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.

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, Zink, 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

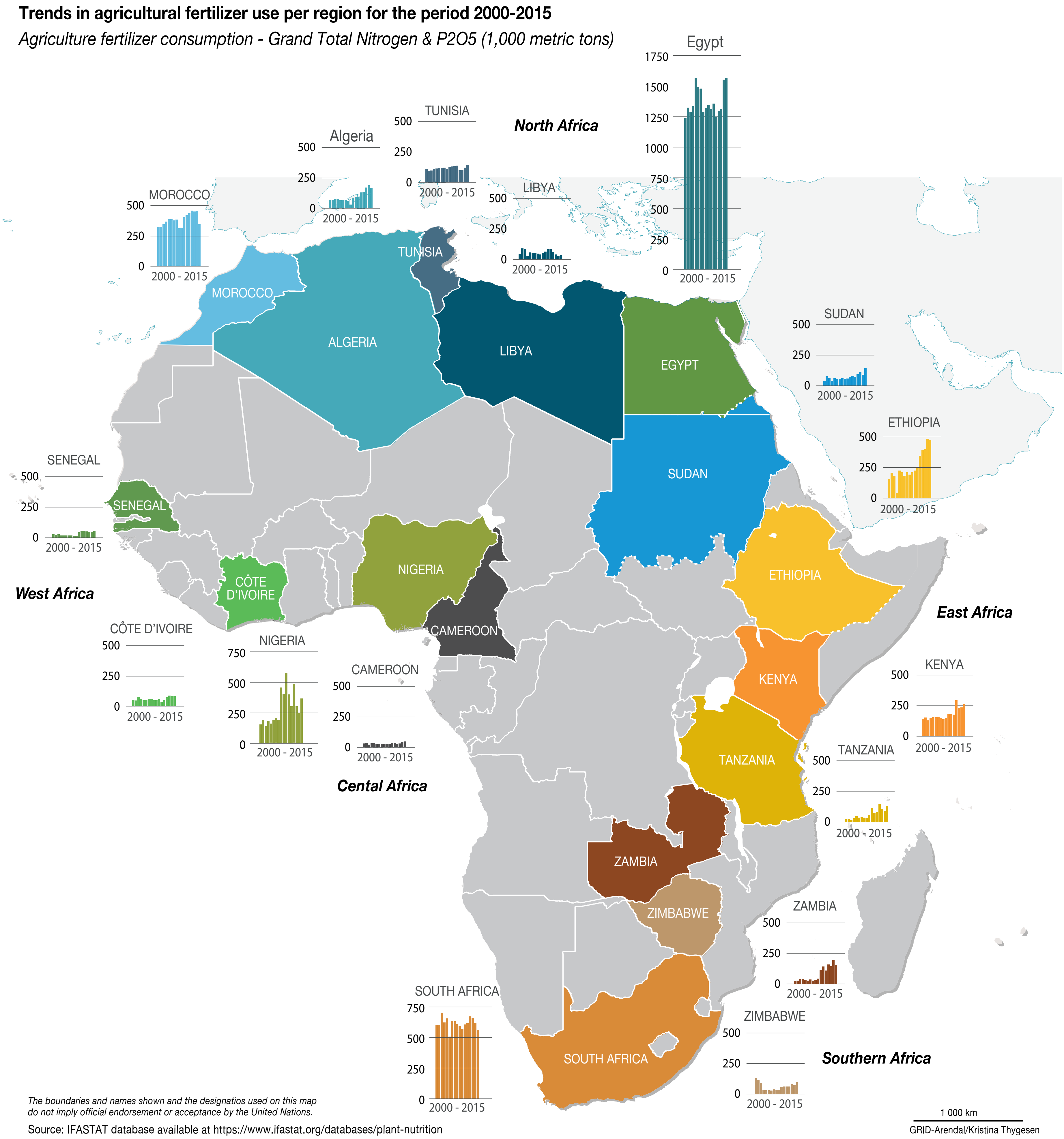


Figure 2.6. Trends in agricultural fertilizer use per region for the period 2000-2016

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

Storm water drainage is a key part of wastewater management

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.

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.

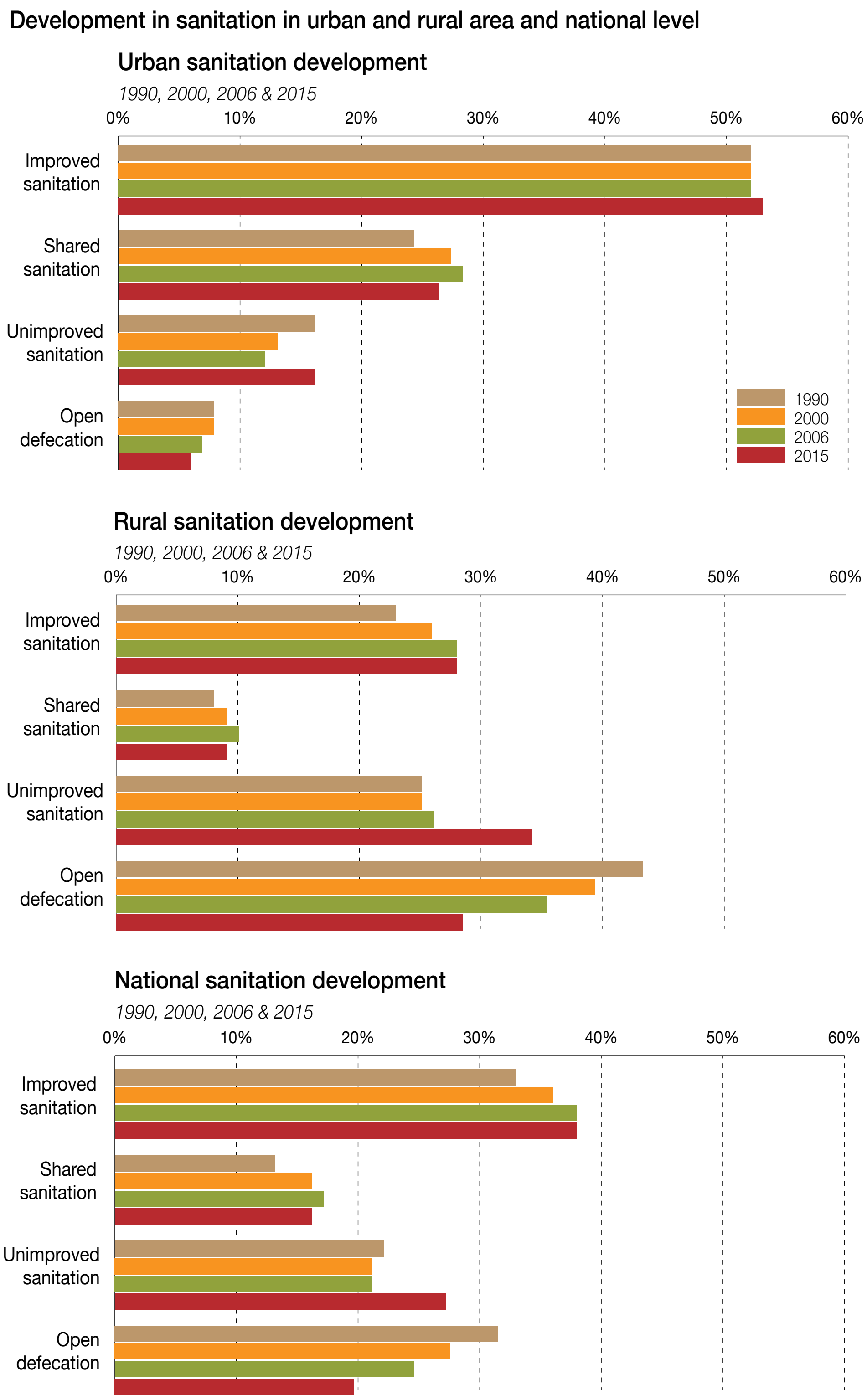
Source: https://publicworks.baltimorecity.gov/storm water-fee

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).

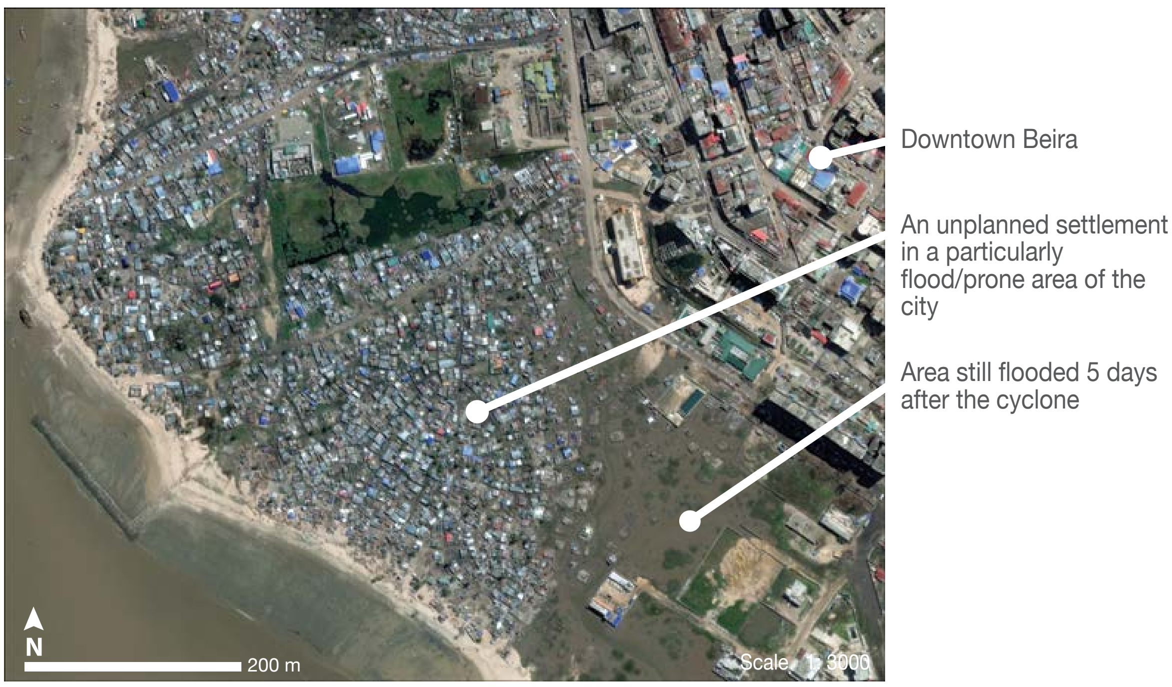
The Mozambique Red Cross (CVM) and other agencies moved to ensure that households had clean toilets and potable water by providing storage facilities and water treatment tablets. In addition, the CVM provided affected families with 50 emergency latrines (IFRC 2019). Measures were put in place to decommission 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.