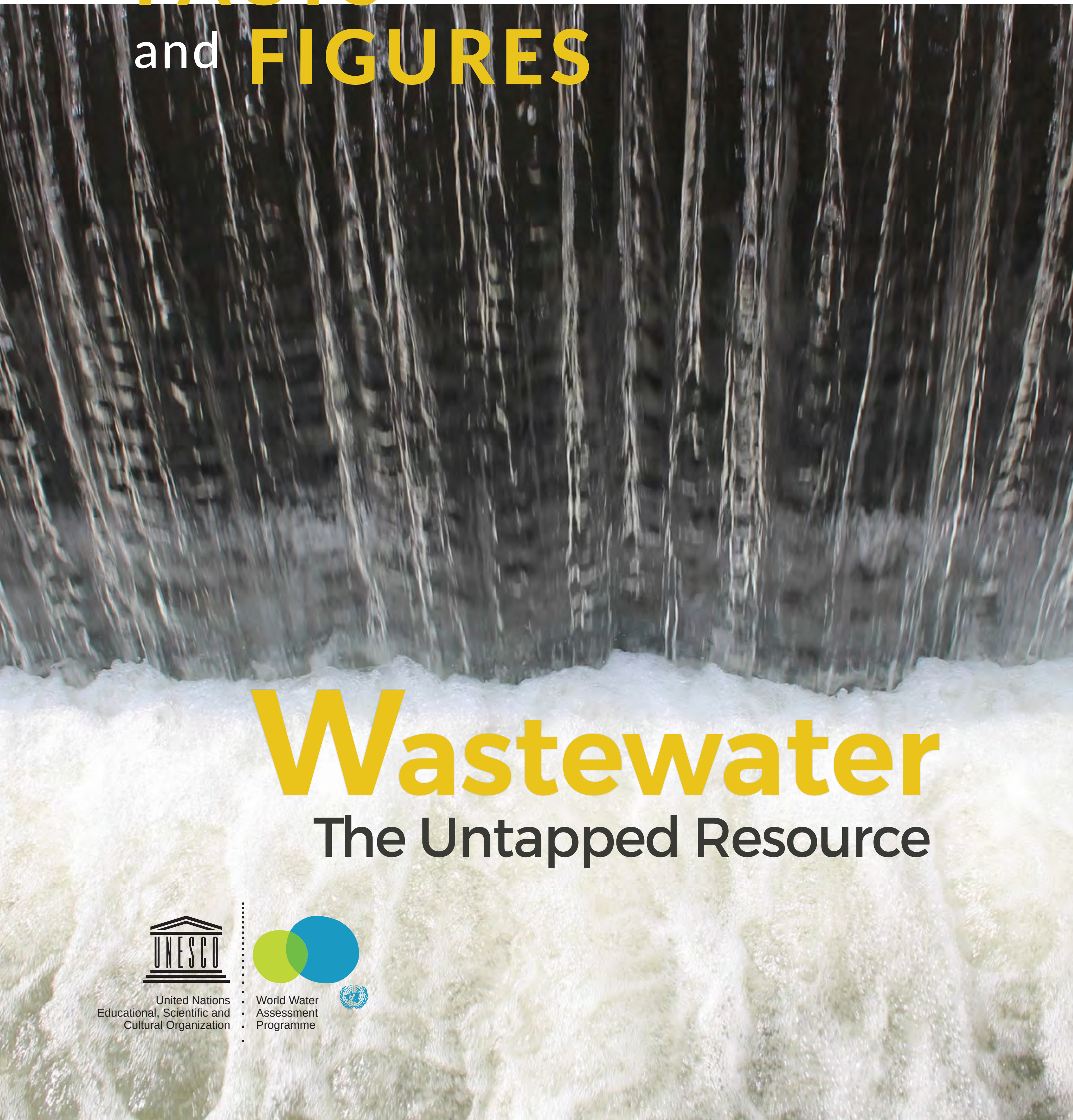
UN WATER

Report

The United Nations World Water Development Report 2017

FACTS and FIGURES



Wastewater

The Untapped Resource

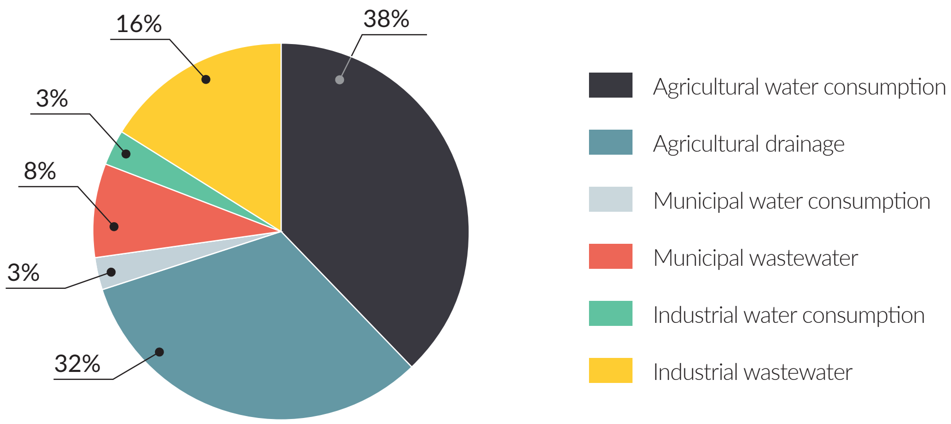
United Nations Educational, Scientific and Cultural Organization

World Water Assessment Programme

WASTEWATER: GENERATION AND IMPACT ON ENVIRONMENT AND HUMAN HEALTH

FAO's AQUASTAT database estimates global freshwater withdrawals at 3,928 km³ per year. An estimated 44% (1,716 km³ per year) of this water is consumed, mainly by agriculture through evaporation in irrigated cropland. The remaining 56% (2,212 km³ per year) is released into the environment as wastewater in the form of municipal and industrial effluent and agricultural drainage water (Figure 1).

Figure 1 Fate of global freshwater withdrawals: Consumption and wastewater production by major water use sector (circa 2010)



Source: Based on data from AQUASTAT (n.d.a.); Mateo-Sagasta et al. (2015); and Shiklomanov (1999).

Contributed by Sara Marjani Zadeh (FAO).

Globally, water demand is predicted to increase significantly over the coming decades. In addition to the water demand of the agricultural sector which is currently responsible for 70% of water abstractions worldwide, large increases in water demand are predicted, particularly for industry and energy production (WWAP, 2015).

Changing consumption patterns, including shifting diets towards highly water-intensive foods such as meat (i.e. 15,000 litres of water are needed for 1 kg of beef) will worsen the situation.

In Europe, the manufacturing of food products consumes on average about 5 m³ of water per person, per day (Förster, 2014). At the same time, with as much as 1.3 billion tonnes of food wasted annually (WWF, 2015), 250 km³ of water is being 'lost' per year worldwide (FAO, 2013a).

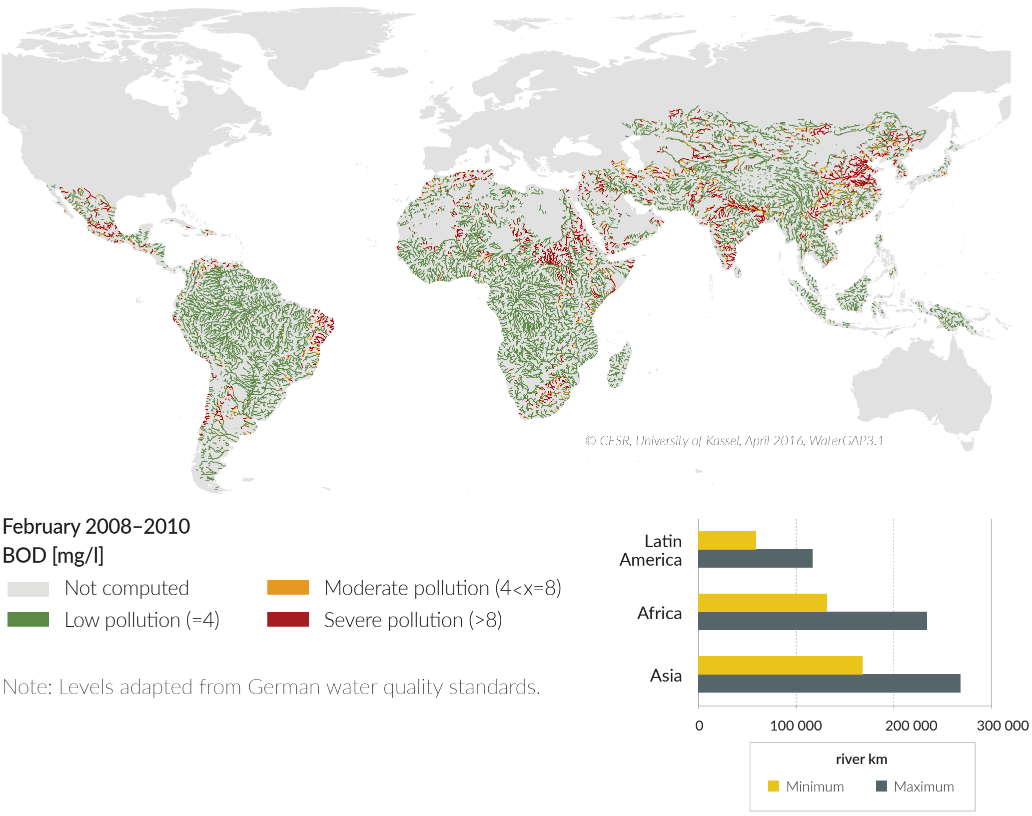
On average, high-income countries treat about 70% of the wastewater they generate, while that ratio drops to 38% in upper middle-income countries and to 28% in lower middle-income countries. In low-income countries, only 8% of industrial and municipal wastewater undergoes treatment of any kind (Sato et. al, 2013). This exasperates the situation for the poor, particularly in slums, who are often directly exposed to untreated wastewater due to a lack of water and sanitation services.

The above estimates support the often-cited approximation that, globally, it is likely that over 80% of wastewater is released to the environment without adequate treatment (WWAP, 2012; UN-Water 2015a).

Increased discharges of inadequately treated wastewater are contributing to the further degradation of water quality in surface and groundwater. As water pollution critically affects water availability, it needs to be properly managed in order to mitigate the impacts of increasing water scarcity.

Organic pollution (measured in terms of biochemical oxygen demand – BOD) can have severe impacts on inland fisheries, food security and notably livelihoods of poor rural communities. Severe organic pollution already affects around one-seventh of all river stretches in Africa, Asia and Latin America (Figure 2), and has been steadily increasing for years (UNEP, 2016).

Figure 2 Estimated in-stream concentrations of biochemical oxygen demand (BOD) for Africa, Asia and Latin America (February 2008–2010)*



Note: Levels adapted from German water quality standards.

* Bar charts show minimum and maximum monthly estimates of river stretches in the severe pollution class per continent in the period from 2008 to 2010.

Source: UNEP (2016, Fig. 3.13, p. 33).

Inadequate wastewater management has also a direct impact on ecosystems and the services they provide (Corcoran et al., 2010).

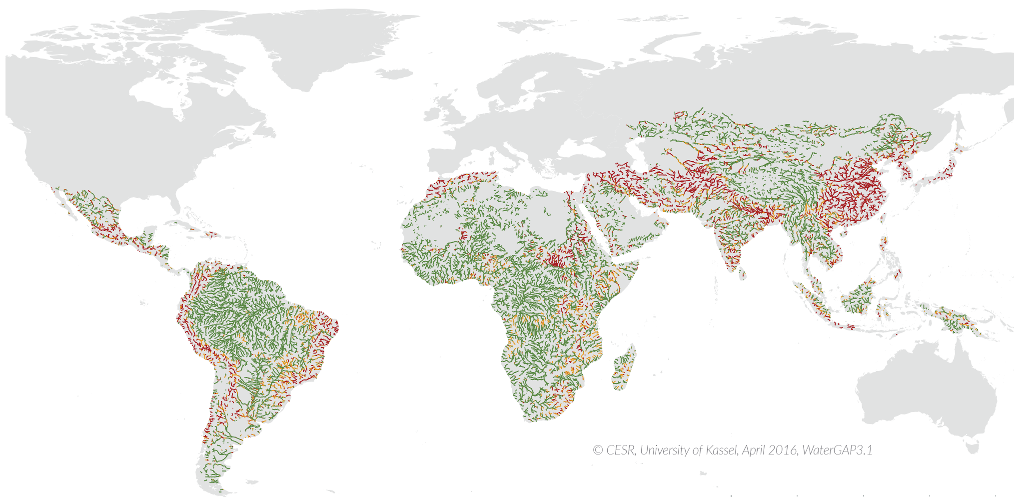
The release of nutrients (nitrogen, phosphorus and potassium) and agrochemicals from intensive agriculture and animal waste can further accelerate the eutrophication of freshwater and coastal marine ecosystems and increase groundwater pollution. Eutrophication can lead to potentially toxic algal blooms and declines in biodiversity. Most of the largest lakes in Latin America and Africa have seen increasing anthropogenic loads of phosphorus.

The discharge of untreated wastewater into seas and oceans partially explains why de-oxygenated dead zones are rapidly growing: an estimated 245,000 km^2 of marine ecosystems are affected, and this affects fisheries, livelihoods, and food chains (Corcoran et al., 2010).

Household sanitation facilities have increasingly improved since 1990. However, risks to public health remain due to poor containment, leakages during emptying and transport, and ineffective sewage treatment. It is estimated that only 26% of urban and 34% of rural sanitation and wastewater services effectively prevent human contact with excreta along the entire sanitation chain and can therefore be considered safely managed (Hutton and Varughese, 2016).

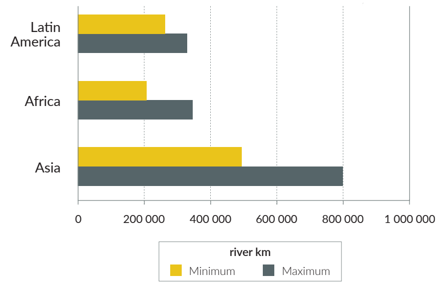
Even though sanitation coverage has increased and wastewater treatment levels have improved in some countries (UNICEF/WHO, 2015), such improvements need to happen simultaneously in order to avoid increased contaminant loadings. This could probably explain the early findings from the global water quality monitoring programme that severe pathogen pollution (originating from human and animal excreta) affects around one-third of all river stretches in Africa, Asia and Latin America (Figure 3), putting the health of millions of people at risk (UNEP, 2016).

Figure 3 **Estimated in-stream concentrations of faecal coliform bacteria (FC) for Africa, Asia and Latin America (February 2008–2010)***



February 2008–2010
FC [cfu/100ml]

- Not computed
- Low pollution (=200)
- Moderate pollution (200<x=1000)
- Severe pollution (>1000)



Notes: *Low*: Suitable for primary contact; *Moderate*: Suitable for irrigation; *Severe*: Exceeds thresholds

* Bar charts show minimum and maximum monthly estimates of river stretches in the severe pollution class per continent in the period from 2008 to 2010.

Source: UNEP (2016, Fig. 3.3, p. 20).

Sanitation and wastewater-related diseases remain widespread in countries where the coverage of these services is low, where informal use of untreated wastewater for food production is high, and where reliance on contaminated surface water for drinking and recreational use is common.

In 2012, an estimated 842,000 deaths in middle- and low-income countries were caused by contaminated drinking water, inadequate handwashing facilities and sanitation services (WHO, 2014b). The health burden of poor sanitation and wastewater management is primarily borne by children. During the same year, 361,000 deaths among children under 5 years old could have been prevented through reduction of risks related to inadequate hand hygiene, sanitation and water (Prüss-Üstün et al., 2014).

WASTEWATER: A RELIABLE RESOURCE FOR ALLEVIATING WATER SCARCITY

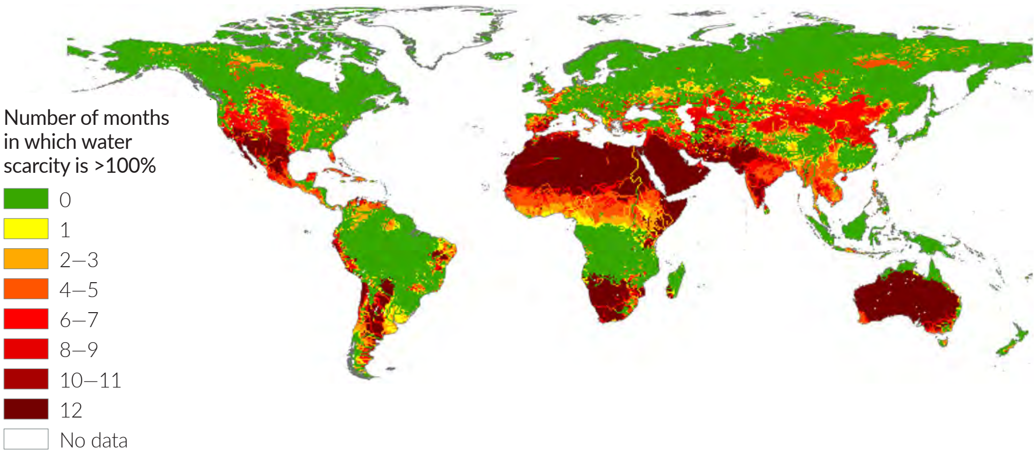
Wastewater is roughly composed of 99% water and 1% suspended, colloidal and dissolved solids (UN-Water, 2015a). Although the exact composition of wastewater obviously varies between different sources and over time, water remains, by far, its principal constituent.

Wastewater management generally receives little social and political attention in comparison to water supply challenges, especially in the context of water scarcity. Yet, the two are intrinsically related – neglecting wastewater can have highly detrimental impacts on the sustainability of water supplies, human health, the economy and the environment.

The World Economic Forum has consecutively assessed the water crisis as one of the major global risks over the past five years. In 2016, the water crisis was determined as the global risk of highest concern for people and economies for the next ten years (WEF, 2016).

Recent research has demonstrated that two thirds of the world's population currently lives in areas that experience water scarcity for at least one month a year (Figure 4). Noteworthy is that about 50% of the people facing this level of water scarcity live in China and India.

Figure 4 **Number of months per year in which the volume of surface water and groundwater that is withdrawn and not returned exceeds 1.0 at 30 x 30 arc min resolution (1996–2005)***



*Quarterly averaged monthly blue water scarcity at 30 × 30 arc min resolution. Water scarcity at the grid cell level is defined as the ratio of the blue water footprint within the grid cell to the sum of the blue water generated within the cell and the blue water inflow from upstream cells. Period: 1996–2005.

Source: Mekonnen and Hoekstra (2016, Fig. 3, p. 3).

About 500 million people live in areas where water consumption exceeds the locally renewable water resources by a factor of two (Mekonnen and Hoekstra, 2016). This includes parts of India, China, the Mediterranean region and the Middle East, Central Asia, arid parts of sub-Saharan Africa, Australia, Central and Western South America, and Central and Western North America. Areas where non-renewable resources (i.e. fossil groundwater) continue to decrease have become highly vulnerable and dependent on water transfers from areas with abundant water.

Projections show a large increase in flood frequency in many areas, including India, Southeast Asia and Central and Eastern Africa, while in other areas the projected flood frequency decreases (Hirabayashi et al., 2013).

Having too much (floods) or too little (drought) water, which is often accompanied by too dirty water (higher pollution concentrations in both extremes), make the necessity for wastewater use even greater.

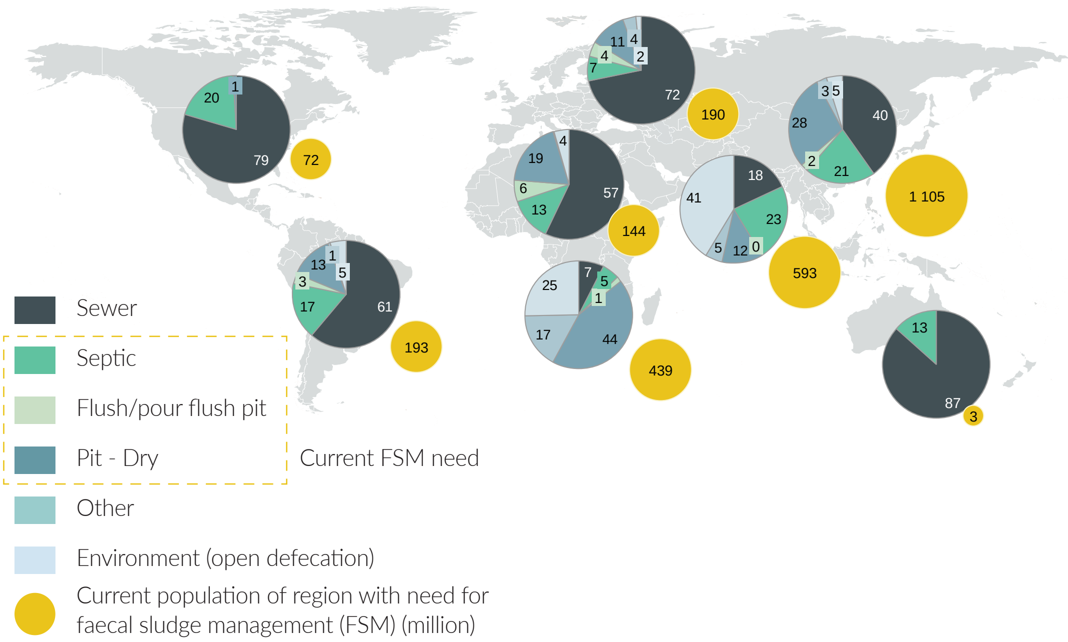
INFRASTRUCTURE, COVERAGE AND INVESTMENT NEEDS

About two thirds of the world's population have access to improved sanitation (UNICEF/WHO, 2015). Sewer connections are only common in high-income countries, and in urban areas in China and middle-income countries of Latin America (Kjellén et al., 2012). Most people in developing countries rely on some form of decentralized or self-provided services, sometimes with NGO support but commonly without any assistance from central authorities.

The number of households connected to sewer systems correlates with the connections to a water supply, although always in much lower proportions. Recent reports (UNICEF/WHO, 2015) show that, globally, the proportion of people connected to a sewer system (60%) is higher than had been previously assumed.

Wastewater treatment can follow a centralized or decentralized approach. In centralized systems, wastewater is collected from a large number of users (Figure 5), like an urban area, and treated at one or more sites. Collection costs account for over 60% of the total budget for wastewater management in a centralized system, particularly in communities with low population densities (Massoud et al., 2009).

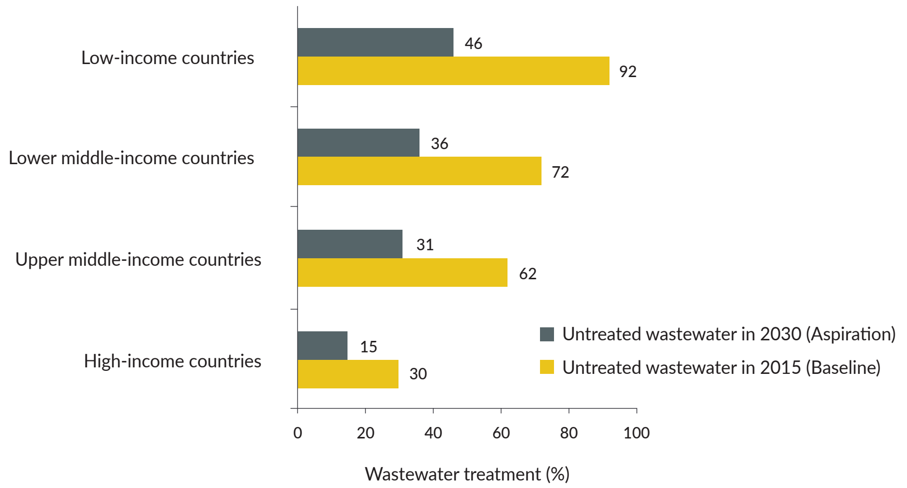
Figure 5 **Population (%) served by different types of sanitation systems**



Source: Cairns-Smith et al. (2014, Fig. 8, p. 25, based on data from WHO/UNICEF JMP). Courtesy of The Boston Consulting Group.

Due to the differences in the current levels of wastewater treatment overall, the efforts required to achieve SDG Target 6.3 (related to wastewater management) will place a higher financial burden on low-income and lower middle-income countries (Figure 6), putting them at an economic disadvantage compared to high-income and upper middle-income countries (Sato et al., 2013).

Figure 6 **Percentage of untreated wastewater in 2015 in countries with different income levels, and aspirations for 2030 (50% reduction over 2015 baseline)**



Source: Based on data from Sato et al. (2013).

The United States Environmental Protection Agency (US EPA, 2016) has estimated that combined sewer overflows correction, the rehabilitation and replacement of existing conveyance systems, and the installation of new sewer collection systems account for 52% of the US$271 billion in investments needed to meet the country's wastewater infrastructure needs.

Worldwide, the annual capital expenditures on water infrastructure and wastewater infrastructure by utilities have been estimated at US$100 billion and US$104 billion, respectively (Heymann et al., 2010).

In Brazil, the cost of simplified sewerage (a type of low-cost sewerage) per person has been shown to be two times lower than the cost of conventional sewerage (i.e. US$170 vs US$390) (Mara, 1996).

The benefits to society of managing human waste are considerable, for public health as well as for the environment. For every US$1 spent on sanitation, the estimated return is US$5.5 (Hutton and Haller, 2004).

WASTEWATER USE AND RESOURCE RECOVERY

It has been estimated that for some major rivers in the USA, the water has been used and reused over 20 times before it reaches the sea (TSG, 2014).

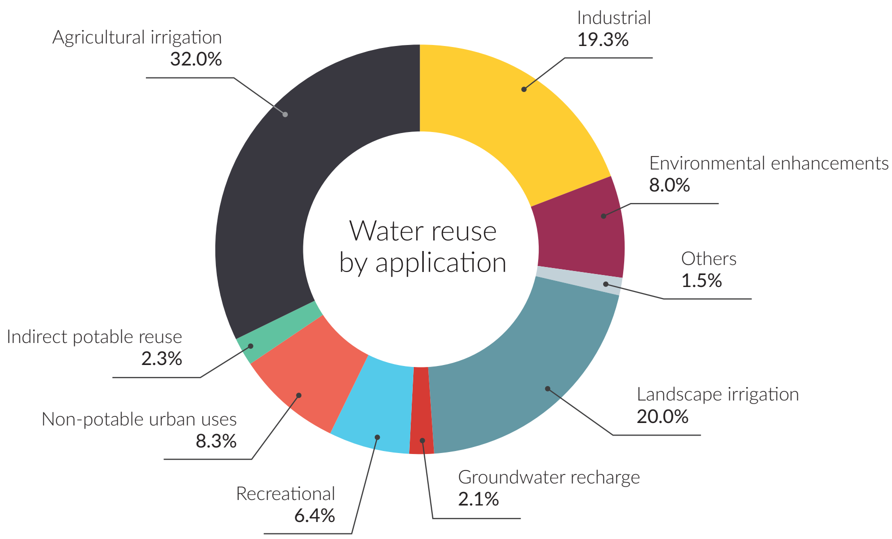
Extractable phosphorus (P) resources are predicted to become scarce or exhausted in the next 50 to 100 years (Steen, 1998; Van Vuuren et al., 2010). Thus, P recovery from wastewater is becoming an increasingly viable alternative. An estimated 22% of global P demand could be satisfied by recycling human urine and faeces worldwide (Mihelcic et al., 2011).

Recovering nitrogen (N) and P from sewage or sewage sludge requires advanced technologies, which large scale applications are still in the stage of development, but with significant progress in recent years.

Recycling nutrients or extracting energy from wastewater can bring in new opportunities for income generation and enlarge the resource base available to poor households (Winblad and Simpson-Hébert, 2004). An example is composting toilets, which have the potential of providing a low-cost solution to improved agricultural productivity, alongside increased nutrition and the reduction of health and environmental impacts from open defecation (Kvarnström et al., 2014).

Figure 7 shows global water reuse after advanced (tertiary) treatment. However, it is important to note that, of all the wastewater produced worldwide, only a very small fraction actually undergoes tertiary treatment.

Figure 7 **Global water reuse after advanced (tertiary) treatment: Market share by application**



Source: Lautze et al. (2014, Figure 2, p. 5, based on Global Water Intelligence data).

HIGHLIGHTS FROM THE SECTORS

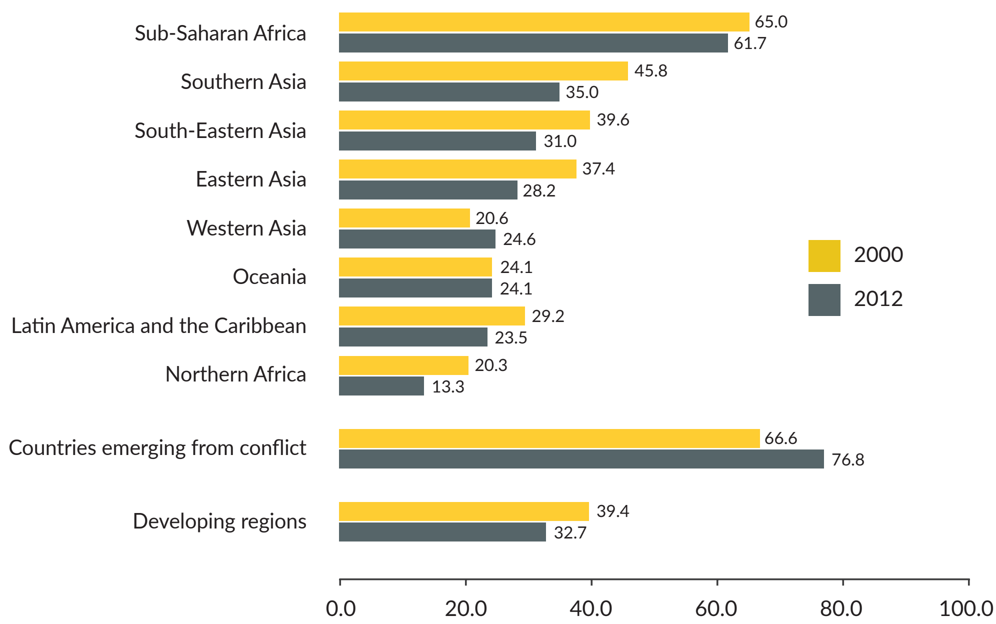
A Municipal and urban

In the next one or two decades, the largest rates of urbanization will occur in the smaller urban centres (between 500,000 and 1 million inhabitants) (UN-Habitat, 2016). This will greatly impact wastewater production and the potential for both decentralized treatment and use.

By 2030, global demand for energy and water is expected to grow by 40% and 50%, respectively (UN-Habitat, 2016). Most of this growth will be in cities, which will require new approaches to wastewater management. At the same time, wastewater management may also provide some of the answers to other challenges, including food production and industrial development.

Wastewater generation is one of the biggest challenges associated to the growth of informal settlements (slums) in the developing world. Although the proportion of slum dwellers in urban areas has slightly decreased since 2000 in terms of percentages (Figure 8), there were more slum dwellers in 2012 than in 2000. In sub-Saharan African, 62% of the urban population lives in slums. The most alarming statistics can be found in countries emerging from conflict and in West Asia, where the proportion living in slums has increased from 67% to 77% and 21% to 25% respectively (UN-Habitat, 2012).

Figure 8 **Urban population living in slums, 2000-2012 (%)**



Note: Countries emerging from conflicts included in the aggregate figures as: Angola, Cambodia, Central African Republic, Chad, Democratic Republic of the Congo, Guinea-Bissau, Iraq, Lao People's Democratic Republic, Lebanon, Mozambique, Sierra Leone, Somalia and Sudan.

Source: Based on data from UN-Habitat (2012, Table 3, p.127).

In Windhoek, Namibia, which lacks affordable water alternatives, up to 35% of the city's wastewater is treated and blended with other potable sources to increase the drinking water supply (Lazarova et al., 2013).

B Industry

Water is not only an operational challenge and a cost item in industry, it is also an opportunity for growth as the incentives for minimizing water use (which include wastewater use and recycling) are cost savings and reduce water dependency (WBCSD, n.d.).

One estimate suggests that the volumes of industrial wastewater will double by 2025 (presumably around 2007) (UNEP FI, 2007).

Some consolidated information is available from the developed countries. In the European Union, for example, limited data show that wastewater generation has generally decreased (Eurostat, n.d.). The data also show that manufacturing is the greatest generator of wastewater among the main industrial sectors.

By 2020, the market for industrial water treatment technologies is predicted to grow by 50% (GWI, 2015).

C Agriculture

Over the past half century, agriculture has expanded and intensified in order to meet the increasing food demand triggered mainly by population growth and changes in diet. The area equipped for irrigation has more than doubled, from circa 1.4 million km² in 1961 to circa 3.2 million km² in 2012 (AQUASTAT, 2014). Total livestock has more than tripled from 7.3 billion units in 1970 to 24.2 billion in 2011 (FAOSTAT, n.d.a.). Aquaculture, especially inland fed aquaculture and particularly in Asia, has grown more than twentyfold since the 1980s (FAO, 2012).

Municipal water demand corresponds to 11% of global water withdrawal (AQUASTAT, n.d.b.). Out of this, only 3% is consumed and the remaining 8% is discharged as wastewater, representing 330 km³ per year (Mateo-Sagasta et al., 2015) (see Figure 1). This could potentially irrigate 40 million hectares (with approximately 8,000 m³ per hectare) (Mateo-Sagasta et al., 2015), or 15% of all irrigated lands.

Municipal wastewater accounts for the majority of wastewater directly used in agriculture and the planned use of municipal wastewater is a common pattern in Australia, countries of the Mediterranean, Middle East and North Africa, as well as in Mexico, China and the USA (AQUASTAT n.d.b.).

However, there is no comprehensive inventory of the extent of treated or untreated wastewater used in agriculture. Estimates of the total area that is being irrigated with raw and diluted wastewater are likely to range between 5 and 20 million hectares, with the largest share probably in China (Drechsel and Evans, 2010), which translates to between 2 to 7% of the world's total irrigated area.

Inadequate wastewater treatment and the resulting large-scale water pollution suggest that the area irrigated with unsafe wastewater is probably ten times larger than the area using treated wastewater (Drechsel and Evans, 2010).

In Jordan, where the planned use of wastewater has been promoted since 1977, 90% of the treated wastewater is being used for irrigation (MWI, 2016a). In Israel, treated wastewater accounts for 40% of all water used for irrigation (OECD, 2011b).

DATA AND INFORMATION NEEDS

Data on wastewater collection and treatment are sparse, particularly (but not only) in developing countries. According to Sato et al. (2013), only 55 out of 181 countries analysed had reliable statistical information on generation, treatment, and use of wastewater, 69 countries had data on one or two aspects, and 57 countries had no information at all. Moreover, data from approximately two thirds (63%) of the countries were over five years old.

PUBLIC ACCEPTANCE

The use of wastewater can encounter strong public resistance due to a lack of awareness and trust with regard to the human health risks. Other factors include different cultural and religious perceptions about water in general and/or using treated wastewater. Whereas public health and safety concerns have traditionally been the main reason for public resistance to wastewater use, cultural aspects and consumer behaviour seem to be the overriding factors in most cases today, even when the reclaimed water resulting from advanced treatment processes is entirely safe.

In order to reduce negative public perception, Singapore National Water Agency translated technical information into simple language and provided tools for community outreach such as the mobile game 'Save My Water'. Social acceptance regarding wastewater increased as a result of these educational efforts for awareness-raising and outreach.

REGIONS

There appears to be significant variability on wastewater management across different regions. In Europe, most of the municipal and industrial wastewater generated (71%) undergoes treatment, while only 20% is treated in the Latin American countries. In the Middle East and North Africa, an estimated 51% of municipal and industrial wastewater is treated. In African countries, the lack of financial resources for the development of wastewater facilities is a major constraint in managing wastewater, while 32 out of 48 sub-Saharan African countries had no data available on wastewater generation and treatment (Sato et al., 2013).

The treatment of wastewater and its use and/or disposal in the humid regions of high-income countries are motivated by stringent effluent discharge regulations and public awareness about environmental quality (e.g. North America, northern Europe and Japan). The situation is different in high-income countries in dryer regions, where treated wastewater is often used for irrigation, given the increasing competition for water between agriculture and other sectors (e.g. parts of North America, Australia, the Middle East and southern Europe).

a Africa

The gap between water availability and water demand is growing fast, especially in cities, where the urban population is expected to nearly quadruple by 2037 (World Bank, 2012). This suggests that there will probably be a massive increase in wastewater production from African cities (World Bank, 2012).

Current water management systems cannot keep up with the growing demand. It has been estimated that half of the urban infrastructure that will make up African cities by 2035 has yet to be built (World Bank, 2012). This scenario poses several challenges and, at the same time, offers opportunities to break away from past (inadequate) water management approaches and to shift to innovative water management solutions, such as integrated urban water management, which includes the use of treated wastewater to help meet increasing water demand.

Mining, oil and gas, logging, and manufacturing represent the main industries in the region. All of these produce wastewater, which is often released into the environment with minimal or no treatment. For example, in Nigeria, less than 10% of industries reportedly treat their effluents before discharging them into surface waters (Taiwo et al., 2012; Ebiare and Zejiao, 2010).

b The Arab Region

In the Arab Region, 18 out of 22 Arab countries fall below the water poverty line of 1,000 m^3 per capita in 2014 (AQUASTAT, n.d.b.).

The data (from the MDG+ initiative) show that 69% of the wastewater collected in Arab States was safely treated, with 46% undergoing secondary treatment and 23% undergoing tertiary treatment during the year 2013. Furthermore, 84% of all wastewater collected in the water-scarce Gulf Cooperation Countries underwent tertiary treatment, and 44% of their total safely treated wastewater volume was then used. At the Arab regional level, 23% of the safely treated wastewater is being used, mostly for irrigation and groundwater recharge (LAS/UNESCWA/ACWUA, 2016).

Provision of water, sanitation and wastewater treatment for refugees in camps, informal settlements and host communities in Arab States has become a serious challenge. Conflict and the internal displacement of people in Iraq, Libya, Palestine, Somalia and Syria have also strained the operating capacity of wastewater facilities and damaged sewage networks.

At least 11 out of 22 Arab states have adopted legislation permitting the use of treated wastewater, issued by the national institutions responsible for the use and discharge of wastewater, be it the ministries responsible for the environment in Kuwait, Lebanon and Oman, health in Iraq, agriculture in Tunisia, housing in Egypt, or the institutes responsible for standards in Jordan and Yemen (WHO, 2006b).

The As-Samra Wastewater Treatment Plant, the largest in Jordan, serves 2.27 million people and achieves 80% energy self-sufficiency through a biogas-powered generator supported by an anaerobic sludge digestor (UNESCWA, 2015).

c Asia and the Pacific

The region's urban population more than doubled between 1950 and 2000 (UNESCAP/UN-Habitat, 2015), creating a huge demand for new and improved wastewater treatment systems. As of 2009, 30% of the region's urban population lived in slums and over half of the regional rural residents still lacked access to improved sanitation, compared to 25% of urban residents (UNESCAP, 2014).

There is a growing recognition of wastewater as a resource for different sectors. However, an estimated 80–90% of all wastewater produced in the Asia and the Pacific region is released untreated, polluting ground and surface water resources, as well as coastal ecosystems (UNESCAP, 2010).

Natural disasters, 90% of which are water-related, are increasing in frequency and intensity due to climate change (UNESCAP, 2015b). During floods, which caused an estimated total damage of US$61 billion in the region in 2011 (ADB, 2013), the sewage effluent often mixes with already-contaminated stormwater, creating a sanitation crisis and increasing the risk of waterborne diseases.

According to one study, green roofs can retain 60–100% of the stormwater they receive, depending on the substrate depth and the quantity and intensity of the precipitation received (Thomson et al., 1998).

Analyses of case studies in South-East Asia have shown that revenues from wastewater by-products, such as fertilizer, are significantly higher than the operational costs of by-product-harvesting wastewater systems, providing evidence that resource recovery from wastewater is a viable and profit-producing business model for sustainable practices and economic development (UNESCAP/UN-Habitat/AIT, 2015).

d Europe and North America

Large parts of the UNECE region are covered by water supply and sanitation systems, but demographic and economic changes have rendered the effectiveness of some of the larger centralized systems suboptimal.

The low efficiency of water systems, characterized by high resource use and lack of incentives for efficient water use, is a major issue in Eastern Europe, the Caucasus and Central Asia (UNECE/OECD, 2014), where large volumes of supplied water translate into wastewater, and where all too often only a primary treatment is in place. The water supply and sanitation tariffs are generally too low to cover the costs of operation and maintenance of the services (OECD, 2011a). This poses significant challenges to meeting the infrastructure investment needs and lowers incentives for reasonable usage levels, while raising sustainability concerns.

Wastewater treatment in the region has improved during the last 15–20 years. Tertiary treatment has increased gradually but, in South-Eastern Europe and the rest of Eastern pan-Europe, significant volumes of wastewater are still collected and discharged without treatment.

e Latin America and the Caribbean

With 80% of the population living in urban areas, this is one of the most urbanized regions in the world, and it is expected to urbanize even further, with 86% of its population projected to reside in cities by 2050 (UNDESA, 2014).

While water supply and sanitation services expanded rapidly, and 88% of the urban population had access to improved sanitation facilities in 2015 (UNICEF/WHO, 2015), there was no parallel expansion of wastewater treatment in most of the region: the coverage of urban wastewater treatment is now estimated between 20% (Sato et al., 2013) and 30% (Ballestero et al., 2015) of the wastewater collected in urban sewerage systems. Thus, urban sewage is a key concern for governments as the principal source of water pollution.

A few other countries in the region have made substantial progress in the expansion of wastewater treatment. Countries that treat more than a half of their urban sewage include Brazil, Mexico and Uruguay (Lentini, 2015). Chile has virtually universal urban wastewater treatment (SISS, 2015).

The expansion of urban wastewater treatment requires significant investments, which until recently most countries could not afford. Latin America and the Caribbean would need to invest more than US$33 billion to increase the coverage of wastewater treatment to 64% by 2030 (Mejía et al., 2012). According to another estimate, about US$30 billion is needed to halve the percentage of wastewater that currently does not receive treatment (Lentini, 2015). In addition, approximately US$34 billion is required for the expansion of stormwater drainage systems (Mejía et al., 2012), which would reduce pollution resulting from uncontrolled urban runoff.

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