

Review Paper

The sanitation and hygiene targets of the sustainable development goals: scope and challenges

Duncan Mara and Barbara Evans

ABSTRACT

The sanitation target of the Sustainable Development Goals is that everyone should have a 'safely-managed' sanitation facility by 2030 and that open defecation be eliminated. The scale of this target is unprecedentedly large: ~5.6 billion additional people will require safely-managed sanitation by 2030 (~1 million per day), and ~1.3 billion people will need to switch from open to fixed-defecation in a sanitation facility by 2030 (240,000 per day). Safely-managed shared sanitation and container-based sanitation are both likely to be part of the solution, particularly in urban slums. The SDG hygiene target covers facilities for handwashing with soap, menstrual-hygiene management, and food hygiene, but only handwashing with soap is monitored by WHO/UNICEF. In 2015, the percentage of people with handwashing-with-soap facilities at home ranged from 15% in Sub-Saharan Africa to 76% in Western Asia and North Africa. The costs to meet these targets are around US\$46 billion in urban areas, and US\$25 billion in rural areas, per year during 2016–2030. Benefit-cost ratios are ~18 in rural areas. There is a correspondingly considerable need for training local sanitation and hygiene professionals, so that they can plan and design interventions to meet the SDG target.

Key words | open defecation, safely-managed sanitation, safely-practised hygiene, sustainable development goals

Duncan Mara (corresponding author)

Barbara Evans

School of Civil Engineering,

University of Leeds,

Leeds LS2 9JT,

UK

E-mail: d.d.mara@leeds.ac.uk

INTRODUCTION

'Adequate sanitation is the most effective public-health intervention that the international community has at its disposal' (*The Lancet 2007*). It is clearly correct therefore that sanitation is a major component of the United Nations Sustainable Development Goals (SDGs) (*United Nations General Assembly 2015a*), of which Target #2 of Goal #6 is to:

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

This represents a significant increase in ambition when compared to the target for sanitation in the Millennium

Development Goals (MDGs). There is a required considerable step-change both in scale (essentially the SDG sanitation target calls for sanitation 'for all', whereas the MDG sanitation target was not 'for all'), and in level of service (going beyond 'improved' sanitation to 'safely-managed' sanitation, as detailed below).

SDG #6.2 is the latest in a long list of global sanitation challenges: the first was the International Drinking Water Supply and Sanitation Decade (1981–1990) which, like SDG #6.2, called for water and sanitation for all by 1990. This was followed by Safe Water 2000 (1991–2000) – water and sanitation for all by 2000. Next came the sanitation target of the MDGs (2001–2015), which was not sanitation for all by 2015, but to reduce by half the

proportion of people without ‘improved’ sanitation compared to the baseline in 1990. None of these targets was met and in 2015 there were 2.35 billion people without access to improved sanitation; this number included 882 million people who were without any sanitation facility whatsoever and thus forced to defecate in the open (WHO/UNICEF 2017).

In this paper we set out to understand the scale and nature of the challenge set by SDG #6.2 and identify some of the critical barriers and opportunities that they present in terms of sanitation and hygiene. In the first section we examine the definitions of sanitation and hygiene used in setting and monitoring these new targets. In the second section we look at four principal challenges associated with the SDG #6.2: population growth during 2016–2030, the number of people requiring safely-managed sanitation and hygiene in this period, the current wastewater and faecal sludge treatment deficit, and the elimination of open defecation. In the third section we summarise the most recent estimates of costs for achieving SDG #6.2 and determine benefit-cost ratios for safely-managed sanitation in rural areas. In the final section we propose some ways forward in light of the immense challenges which must be overcome before the world achieves universal access to safely-managed sanitation.

SANITATION AND HYGIENE DEFINITIONS

Improved sanitation

During the MDG period WHO and UNICEF, through their Joint Monitoring Programme for Water Supply and Sanitation (JMP), provided regular estimates of global access to water supplies and sanitation. For sanitation, WHO and UNICEF reported on household level access to an ‘improved’ sanitation facility which is not shared, defined as (WHO/UNICEF 2015):

‘Those that are likely to ensure hygienic separation of human excreta from human contact. They include the following facilities: flush/pour-flush facilities discharging to piped sewer systems, septic tanks and pit latrines;

ventilated improved pit (VIP) latrines; pit latrines with a slab; and composting toilets.’

However, numerous commentators have observed that both the MDG target and the indicators used have limitations. The Asian Development Bank (2009) noted that ‘the MDG goal [for improved sanitation] simply represents achievable levels if countries commit the resources and power to accomplish them. *They do not necessarily represent acceptable levels of service*’ [emphasis added]. Furthermore, in a study of 35 unplanned low-income sub-wards of Dar es Salaam, Tanzania, Jenkins *et al.* (2014) found that ‘[w]hile 56% of households used a facility that met the MDG improved technology definition, only 8% had a functional facility that could be considered as hygienically safe and sustainable sanitation’.

Basic and safely-managed sanitation

For the SDG period JMP has proposed a change in nomenclature – the use of the descriptor ‘basic’ to refer to ‘improved’ sanitation, as defined above, with specifically no sharing of the sanitation facility with other households (JMP 2015a). It also introduced the concept of ‘safely-managed’ sanitation facilities, which are defined as basic sanitation facilities from which excreta are safely disposed of *in situ* or, as faecal sludge and wastewater, are transported and treated off-site.

There are no definitions of the terms used in SDG #6.2, but ‘normative interpretations’ are given in JMP (2015a). ‘Adequate’ sanitation is interpreted as implying ‘a system which hygienically separates excreta from human contact as well as safe reuse/treatment of excreta *in situ*, or safe transport and treatment off-site’. Thus ‘adequate’ sanitation is ‘safely-managed’ sanitation.

Sanitation for all – discrimination and inequalities

‘Equitable’ sanitation in SDG #6.2 is interpreted by JMP (2015a) as implying the ‘progressive reduction and elimination of inequalities between population sub-groups’. It can be considered part of the definition of ‘for all’, which includes, *inter alios*, the disabled (Jones 2014; WSSCC & FANSA 2016), impoverished widows and indigenous

peoples (Jiménez *et al.* 2014; Moorhead 2016). Other groups of people that need to be included explicitly in ‘for all’ are slum-dwellers and the homeless – for example, pavement dwellers and, especially, street children (Panter-Brick 2002; van Rooyen & Hartell 2002; Patel 2015).

The developing world is riddled with social inequalities (Rama *et al.* 2015), including unequal access to sanitation (whether safely-managed, basic, shared or unimproved). The poor continue to gain the least satisfactory access to sanitation: in India, for example, the poorest wealth-quintile received only 3% of the sanitation improvements made during 1995–2008, whereas the two highest wealth-quintiles together received fully two-thirds of the improvements (JMP 2011).

Discrimination in access to sanitation and hygiene facilities is widespread in low- and middle-income countries. Groups and individuals particularly disadvantaged in obtaining access to sanitation and hygiene include those discriminated against on grounds of: (a) sex and gender, including sexual orientation and gender identity; (b) race, ethnicity, religion, national origin, birth, caste, language, and nationality; (c) disability, age, and health status; (d) property, tenure, residence, and economic and social status; and (e) political or other opinion, marital and family status, and those in vulnerable situations (see below) (Van de Lande 2015). An individual may experience discrimination on two or more of these grounds; such an effect is likely to be greater than the simple sum of the two or more grounds of discrimination.

Hygiene

‘Hygiene’, which has not been addressed hitherto in relation to global sanitation targets, is interpreted as implying ‘the conditions and practices that help maintain health and prevent spread of disease including handwashing, menstrual hygiene management (MHM) and food hygiene’ (WHO/UNICEF 2015).

Handwashing with soap

Recognizing the critical nature of handwashing with soap, JMP ‘proposes handwashing with soap at home as a core indicator for tracking target 6.2’ (JMP 2015b). This is important as IHME (2017) reports a global DALY (disability-

adjusted life year) loss due to ‘no access to handwashing facility’ of 35.3 million years in 2016 for both sexes and all ages. Most of this DALY loss occurred in Sub-Saharan Africa (21.4 million years) and in South Asia (10.7 million years). Simple facilities for handwashing with soap are available (for example, the ‘tippy tap’ described by Morgan 2007), but their availability and use need to be much more widespread than at present (Jenkins *et al.* 2013).

Menstrual hygiene management

There is a growing literature on the importance of water and sanitation, including at schools, for MHM (for example, House *et al.* 2012; Kandel 2015; WASH Advocates 2015; PSI 2016). In his Independence Day speech on 15 August 2014, the Prime Minister of India, Shri Narendra Modi, declared (Modi 2014):

‘I want to make a beginning today itself and that is – all schools in the country should have toilets with separate toilets for girls. Only then our daughters will not be compelled to leave schools midway.’

Those planning school-toilet facilities need therefore to design girl-friendly toilets by ascertaining what sanitation preferences local schoolgirls have, especially in relation to privacy and specifically their MHM needs, as well as designing sustainable facilities, including provision for handwashing with soap and for the sanitary disposal of menstrual waste (Adams *et al.* 2009; Abraham *et al.* 2012; Wendland *et al.* 2014).

Food hygiene

This is, of course, a very large field and a closer definition of what is appropriate in the context of meeting SDG #6.2 is required. This could be, for example, simply the availability of sufficient quantities of clean water for handwashing and food preparation and for cleansing cooking utensils after use, and the use of sanitation facilities to contain excreta such that flies and rodents are discouraged from spreading excreta-related diseases via the faeco-oral route: pathogens in excreta → flies/rodents → food → mouth; both should be coupled with food-hygiene education.

These wide-ranging requirements for hygiene in the JMP (2015a) interpretations of the terms used in SDG #6.2 really mean that the target should be ‘Safely-managed Sanitation and Safely-practised Hygiene for All by 2030’.

The needs of women and girls

Addressing the needs of women and girls ‘implies reducing the burden of water collection and enabling women and girls to manage sanitation and hygiene needs with dignity. Special attention should be given to the needs of women and girls in ‘high use’ settings such as schools and workplaces, and ‘high risk’ settings such as health care facilities and detention centres (JMP 2015a), to which we would add MHM, as detailed above. This aspect of the new framework also needs to address the risks associated with walking to and from open-defecation sites, especially at night, as women and adolescent girls are then subject to sexual harassment and physical violence, which has included murder, rape, knifing, stoning and other severe assaults, as well as serious longer-term psychological and psychosocial damage (Lennon 2011; Bhalla 2014; Frost 2014; House *et al.* 2014; Sommer *et al.* 2014; Gosling *et al.* 2015; Kulkarni *et al.* 2015; Sahoo *et al.* 2015; WSSCC & FANSA 2016).

Those in vulnerable situations

‘Those in vulnerable situations’ is interpreted as implying ‘attention to specific WASH (water, sanitation and hygiene) needs found in ‘special cases’, including refugee camps, detention centres, mass gatherings and pilgrimages’ (JMP 2015a). UNHCR (2017) reports the global mid-2015 number of refugees and those in refugee-like situations as 65.6 million. Approximately half this number is in refugee camps, many of which (even an approximate number is unknown) may be assumed to have suboptimal water, sanitation and hygiene facilities. Alwan (2015) notes that:

‘Jordan’s refugee population has doubled in recent years, whereas Lebanon’s has tripled to the point where almost 30% of its population today comprises refugees. These increases in numbers have put immense pressure on national systems as demands on services for health, education, water and sanitation have increased exponentially.’

Regarding ‘detention centres’ (which include prisons), Tka-chuk & Walmsley (2001) report that:

‘In many parts of the developing world the issue of prison overcrowding has led to conditions where [...] they are all too often unable to provide for the most basic of human needs, including the provision of food, clean water, blankets and shelter, and basic health care’ [to this we would also include the inability to provide safe sanitation].

Clearly much work remains to be done to provide safely-managed sanitation and hygiene to these vulnerable groups, and this represents a major Sanitation and Hygiene Challenge in itself.

Affordability

One descriptor missing in SDG #6.2, and in the proposed monitoring framework (JMP 2015b), is affordability. However, the United Nations General Assembly (2015b), in its Resolution of 15 December 2015 on sanitation as separate human right (separate, that is, from the human right to water), stated that:

‘The human right to sanitation entitles everyone, without discrimination, to have physical and affordable access to sanitation [emphasis added], in all spheres of life, that is safe, hygienic, secure, socially and culturally acceptable and that provides privacy and ensures dignity.’

There are five ‘new’ descriptors here (‘new’ in the sense of not having been part of earlier UN goals and targets for sanitation): safety, security, social and cultural acceptability, privacy, and dignity. These are all commendable additions to the definitions of both basic and safely-managed sanitation.

CHALLENGES TO ACHIEVING SDG #6.2

Population growth

One of the main difficulties in achieving the goal of Safely-managed Sanitation and Hygiene for All by 2030 is the projected rapid population growth in ‘less developed

regions' (Figure 1). By 2030 it is estimated that the urban population in low- and middle-income countries will be around 4 billion and the rural population around 3 billion (UNDESA 2012a).

Numbers requiring safely-managed sanitation during 2016–2030

WHO/UNICEF (2015) reported that 32% of the 2015 population in developing countries had received improved sanitation since 1990 – that is to say, $0.32 \times 6,028,124,000 = 1,928,999,680$, i.e. 211,397 per day during these 25 years. WHO/UNICEF (2017) presented data on global access to 'at least basic' sanitation: in 2000 there were 3.6 billion people so served and 5.0 billion in 2015; thus 1.4 billion received this level of service during the 16-year period 2000–2015, i.e. 240,000 per day. WHO/UNICEF (2017) do not give sanitation data for 'developing countries' as a whole, but only globally and for the eight SDG regions. This is not especially helpful as, for example, the SDG region 'Central Asia and Southern Asia' has 50% of its population with 'at least basic' sanitation, but this figure masks the large difference in sanitation provision in its two sub-regions: in Central Asia 98% of the population had

'improved' (now 'basic') sanitation in 2015, whereas only 47% were so served in Southern Asia (United Nations Economic and Social Council 2017).

The population in developing countries was 6.1 billion in 2015 and is projected to be 7.2 billion in 2030 (UNDESA 2015). Thus their population increase during 2016–2030 is estimated to be 1.1 billion. Adding 2.3 billion (the number without basic sanitation in 2015) to this population increase gives the number of people to receive basic sanitation during the 15-year period 2016–2030, i.e. some 3.4 billion people, or around 620,000 per day. This is ~3 times the number who received the same level of service (improved sanitation) per day during 1991–2015 (WHO/UNICEF 2015), and 2½ times the number served during 2001–2015 (WHO/UNICEF 2017). To achieve this target represents a really immense sanitation challenge, but one that does not, however, meet the requirements of SDG #6.2 as this number of people is only for basic sanitation and not for safely-managed sanitation. WHO/UNICEF (2017) report that globally 4.5 billion people lacked safely-managed sanitation in 2015. Thus during 2016–2030, 4.5 + 1.1 billion people will require this level of sanitation service, i.e. ~1 million people per day, which is ~4 times the number served with basic sanitation during 2001–2015. Clearly, this is an immense and, in its scale, an

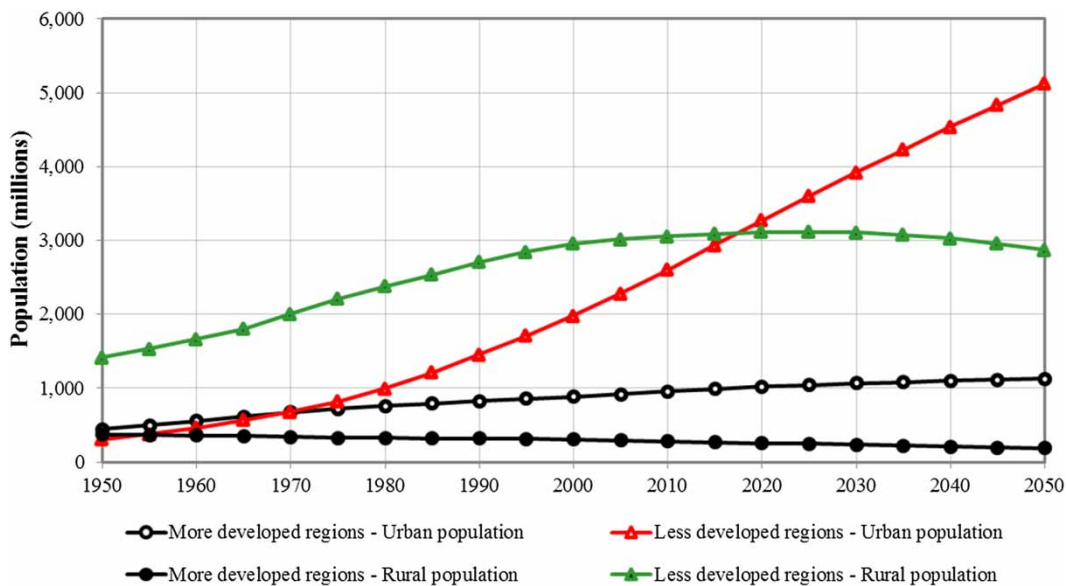


Figure 1 | World population from 1950 to 2050 based on the medium-variant projection (UNDESA 2012a).

unprecedented sanitation challenge, and one that is very unlikely to be able to be met.

Numbers requiring safely-practised hygiene during 2016–2030

The total number of people with access at home to ‘basic’ handwashing facilities with soap is unknown. WHO/UNICEF (2017) reported the percentage of people with handwashing-with-soap facilities at home in 70 countries: this varied from 15% in Sub-Saharan Africa to 76% in Western Asia and North Africa, but the available data were insufficient to produce a global estimate. The availability of handwashing-with-soap facilities at home does not mean that they are always used after use of a sanitation facility or contact with young children’s excreta, before preparing food, and before eating – in fact, the world is not good at this: Freeman *et al.* (2014) found that an estimated 81% of the global population did not always wash their hands with soap after contact with excreta. Clearly much remains not only to provide handwashing-with-soap facilities to those without them, but also to ensure that such facilities are actually *used*. This should be done through handwashing promotion programmes, including promotion of the correct handwashing procedures, and also through handwashing monitoring programmes (Chase & Do 2012; Galiani *et al.* 2012; Vujcic & Ram 2013).

JMP (2017), in its report on ‘New Global Indicators for Drinking Water, Sanitation and Hygiene’, makes no mention of either MHM or food hygiene, presumably because these are too difficult or impossible to monitor. Thus, although the target for the hygiene component of SDG #6.2 should be ‘Safely-practised Hygiene by All by 2030’, what is to be monitored by JMP is ‘Safely-practised *hand-hygiene* by All by 2030’.

Wastewater and faecal sludge collection and treatment

The safe collection and treatment of wastewater and faecal sludge are both required for ‘safely-managed’ sanitation. As noted above, WHO/UNICEF (2017) reported that 4.5 billion people lacked this level of service in 2015. Baum *et al.* (2013) estimated that in 2010 there were ~1.5 billion people connected to a sewerage system but without wastewater

treatment. Assuming that this figure is roughly the same for 2015, this would mean that there were then ~3 billion people with on-site sanitation facilities in which the in-situ disposal of excreta was not possible and from which faecal sludge was not safely transported to a safely-operated treatment plant.

Regarding wastewater treatment, SDG #6.3 is to:

‘By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally’ [emphasis added] (United Nations General Assembly 2015a).

In many developing countries the percentage of wastewater collected and treated is low – for example, it is 10% in Vietnam, 4% in the Philippines and 1% in Indonesia (World Bank 2013). In Africa, a few cities do well, but most do not – for example, 80% of the wastewater from the sewered parts of the city is collected and treated in Nairobi (Wang *et al.* 2014), but only 3% at most in Addis Ababa (Abiye *et al.* 2009). UN-Water (2014) reported that ~80% of the wastewater produced globally was not treated – thus the SDG #6.3 target means that there should be ‘only’ 40% untreated wastewater by 2030. The poor coverage of wastewater treatment is compounded by the poor, and often very poor, performance of treatment plants (where they exist) in terms of both the physicochemical and microbiological qualities of their effluents – but, of course, it is better to discharge partially treated wastewater than untreated wastewater.

Recent work by Peal *et al.* (2014a) noted that in a range of cities studied, illegal dumping of faecal sludge by emptiers was a common practice and that there was a general lack of faecal-sludge management and treatment facilities. Few cities have dedicated budgets for the management of faecal sludge, and where emptying equipment exists it is often not operational. Providing effective faecal-sludge and wastewater collection and transport to a safely-functioning treatment facility for these ~5.6 billion people (~4.5 billion people without safely-managed sanitation in 2015 + ~1.1 billion population increase during 2016–2030) is, in itself, a huge sanitation challenge. As noted above, the sheer

immensity of this existing service gap is likely to render the target of Safely-managed Sanitation for All by 2030 essentially impossible to achieve.

Elimination of open defecation

Open defecation has many adverse health effects: for example, frequent episodes of diarrheal disease and other gastrointestinal infections, high worm burdens (principally ascariasis, trichuriasis and hookworm disease), stunting and low weight-for-age, poorer cognitive skills, and adverse pregnancy outcomes such as low birth weight, preterm birth, stillbirth, and spontaneous abortion (Spears 2011; Spears *et al.* 2013; Clasen *et al.* 2014; Hathi *et al.* 2014; Augsburg & Rodríguez-Lesmes 2015; Padhi *et al.* 2015), and as noted above serious physical and psychological violence. Further detail on these adverse health effects is given in Mara (2017). The role of adequate WASH in supporting improved nutritional outcomes, and hence reducing stunting and improving cognition, is reviewed by Chase & Ngunjiri (2016).

In 2015 there were 892 million people practising open defecation (WHO/UNICEF 2017). If the same proportion of 'open defecators' to the total without improved sanitation in 2015 (2.35 billion, i.e. 38%) is assumed for 2030, then 38% of the 2016–2030 population increase of 1.1 billion, plus the current 892 million open defecators, requires safely-managed sanitation by 2030, i.e. a total of ~1.3 billion people, or some 237,000 per day during 2016–2030. In 2000 there were 1,229 million people practising open defecation, and this number was reduced by an average of 22 million per year during 2000–2015 (WHO/UNICEF 2017), i.e. by only ~60,000 per day, or around a quarter of what is required for 2016–2030. So, at the current rate of progress the target of no open defecation by 2030 cannot be achieved.

If progress is to be accelerated (and accelerated it has to be as eliminating open defecation by 2030 is part of SDG #6.2), then a clear understanding of what prevents and what drives the transition from open defecation to using a latrine is necessary. Augsburg *et al.* (2015) found that cost was the principal consideration that militated against latrine adoption in both India and Nigeria. This indicates that access to credit is clearly important – for example,

subsidized microfinance loans (Evans *et al.* 2009; Afrane & Adjei-Poku 2013; Ledgerwood *et al.* 2013).

Sanitation marketing (Cairncross 2004), behaviour-change communication (Devine & Kullmann 2011), and community-led total sanitation (Kar & Chambers 2008) are the three techniques, when applied together, that are the most likely approach, in our considered opinion, to lead to open-defecation-free (ODF) communities in both rural and periurban areas. Recently the application of 'nudging' (i.e. making small changes to the environment that can channel decision-making and behaviour in new ways) has been proposed to reduce OD by the application of eight 'System 1' principles – human behaviour is the product of both System 1 thinking (automatic, cue-driven habits) and System 2 thinking (rational, motivated). Current OD-elimination techniques are commonly based only on System 2 approaches, but a combination of System 1 and System 2 tactics working together are more likely to produce the desired ODF end-result (Neal *et al.* 2016). It is most important that communities become 100% ODF as OD by even a few households can negate the health benefits potentially accruing to those living in ODF households within the community (Andrés *et al.* 2014).

From the foregoing it is clear that ending open defecation is an immensely complicated and hugely painstaking task with major sociocultural and sociopolitical dimensions. However, it is an extremely good investment – for example, Lawson & Spears (2014), who investigated the relationship between adult wages and the early-life disease environment in India and reported on the fiscal externalities of sanitation, found that reducing open defecation would increase tax revenue by enough to completely offset a cost of up to US\$462 per household that stops defecating in the open, and that a fiscally neutral elimination of open defecation in India would increase the net present value of lifetime after-tax wages by more than US\$1,800 for an average male worker born in 2014.

Water scarcity

Mekonnen & Hoekstra (2016) estimated that currently ~4 billion people live under conditions of severe water scarcity for at least one month of the year, and ~500 million face severe water scarcity throughout the year. Water scarcity is

likely to increase in many parts of the developing world and it will have an impact on progress towards meeting SDG #6.2 as there may be insufficient, or only suboptimal quantities of, water for handwashing and personal cleanliness (including MHM), food hygiene, for low-volume latrine pour-flushing, and to sustain the hydraulic operation of even condominal sewerage (however, it should be noted that condominal sewerage was found to work perfectly well in part of Orangi, Karachi with a hand-carried water consumption of only ~20 litres per person per day (Sinnatambay *et al.* 1985)). Dry on-site systems, such as Arborloos (Morgan 2007), VIP latrines (Morgan & Mara 1982) and eThekwini latrines (WIN-SA 2005), will not be affected. Luh *et al.* (2017) reported on expert opinions of the resilience of sanitation systems to hazards induced by climate change: they were deemed mostly resilient to drought, but not to flooding, especially that from superstorms.

Proposed indicators for monitoring the progress of SDG targets #6.2 and #6.3

JMP (2015b) proposed that the ‘percentage of population using safely-managed sanitation services’ and the ‘percentage of population with handwashing facilities with soap and water at home’ be adopted as the two indicators for SDG #6.2, although it would continue to monitor households with basic, shared (now termed ‘limited’ by WHO/UNICEF 2017), and unimproved sanitation, and those practising open defecation. In the ‘medium term’ basic sanitation, handwashing with soap or ash, and MHM at schools and health-care facilities would also be monitored (‘medium term’ was not defined, but could be presumed to mean the beginning of the middle period of the SDGs, i.e. by 2021). These proposals were accepted by the Inter-agency Expert Group on SDG Indicators (2016) and the United Nations Statistical Commission (UNSC 2016a, 2016b), but with the modification that the above two indicators be combined into one: ‘[the] proportion of [the] population using safely-managed sanitation services, including a handwashing facility with soap and water’ [emphasis added]. This reinforces the suggestion made above that the hygiene target should be ‘Safely-practised Hygiene for All by 2030’.

The proposed indicator for SDG #6.3 is the ‘percentage of wastewater safely treated’, defined as the ‘proportion of

wastewater generated by households and by economic activities which is safely treated compared to [the] total wastewater generated by households and economic activities’; this is to be disaggregated into ‘domestic (on and off-site) and industrial wastewater’ (JMP 2015b), i.e. this implies that the flow of faecal sludge from on-site sanitation systems is to be included in the total wastewater flow (as confirmed by UNSC 2016a, 2016b). The Inter-agency Expert Group on SDG Indicators (2016) has recommended that wastewater treatment categories should follow those given in the *International Recommendations for Water Statistics* (UNDESA 2012b) and in the *System of Environmental – Economic Accounts for Water* (UNESCO & UNSD 2011).

What constitutes ‘safe’?

There are no definitions of ‘safe’ in either safely-managed sanitation or safely-treated wastewater in JMP (2015b), Inter-agency Expert Group on SDG Indicators (2016), or United Nations Statistical Commission (UNSC 2016a, 2016b) – clearly this is a major omission, but one hopefully to be rectified in the medium term (i.e. by 2021 at the latest). Assessing safe management of on-site systems is complex and highly context-specific. The faecal sludge in some on-site systems can be safely left in the ground and a new latrine constructed – for example, Arborloos and single-pit VIP and pour-flush latrines provide safely-managed sanitation if there is sufficient space to build a new toilet when the old one fills up. The extent to which on-site treatment is ‘safe’ is a function of various factors including housing density, groundwater and soil conditions, and water supply. A recent study of sanitation in a selection of cities found that rates of ‘safe management’ varied, but in general were extremely low: in Dhaka, Bangladesh, for example, as little as 2% of the population was considered to have access to safely-managed sanitation (Peal *et al.* 2014a).

Wastewater treatment efficiency (or safety) is important both in relation to safe wastewater use in agriculture and aquaculture (which, according to SDG #6.3, is to be ‘substantially’ increased) and in relation to the discharge of treated wastewater into surface or subsurface water bodies (which, again according to SDG #6.3, is to ‘improve water quality by reducing pollution, eliminating dumping, and

minimizing [the] release of hazardous chemicals and materials'). However, JMP (2015b) does say that 'the breakdown of treated wastewater can be calculated based on compliance records, related to national standards. Unless verified otherwise, through audited compliance records, the waste generated will be considered untreated.' Wastewater management and treatment should follow national regulations or international guidelines (UNEP 2004; Corcoran *et al.* 2010). For wastewater reuse, the World Health Organization has produced guidelines for the safe use of wastewater in agriculture (WHO 2006a) and in aquaculture (WHO 2006b), and for the safe use of faecal sludge and greywater in agriculture (WHO 2006c). There are also guidelines and a toolkit for faecal sludge management (Peal *et al.* 2014b; Strande *et al.* 2014; Ross *et al.* 2016; WSP 2016).

COSTS OF MEETING THE SDG SANITATION AND HYGIENE TARGETS

Costs are clearly important in achieving the safely-managed sanitation and hygiene target of SDG #6.2. However, it should be borne in mind that the current lack of sanitation is very expensive. The World Bank (2015) reports that:

'Poor sanitation costs billions to some countries, amounting to the equivalent of 6.3% of GDP [Gross Domestic Product] in Bangladesh, 6.4% of GDP in India, 7.2% of GDP in Cambodia, 2.4% of GDP in Niger, and 3.9% of GDP in Pakistan annually.'

Hutton & Varughese (2016), in their study on the costs required to meet SDG #6.2 in 142 countries (representing 85% of global population), report that: (a) the global costs of achieving safely-managed sanitation for all by 2030 in urban areas are US\$45 billion (range: \$26–73 billion in 2015 US\$) per year for 15 years – these costs include capital investment, programme delivery, operations, and major capital maintenance; (b) the corresponding figure for rural areas is US\$24 billion (range: \$14–37 billion) per year for 15 years; and (c) the cost of achieving basic hygiene (hand-washing with soap) for all by 2030 would cost US\$1.1 billion (range: \$0.9–1.3 billion) per year for 15 years in urban areas, and US\$0.9 billion (range: \$0.7–1.2 billion) per year for 15

years in rural areas. Hutton & Varughese (2016) present three key findings from their study:

1. Current levels of financing can cover the capital costs of achieving universal *basic* service for drinking water, sanitation, and hygiene by 2030, provided resources are targeted to the needs (i.e. to those in the bottom two wealth-quintiles in low-income and lower-middle-income countries).
2. The capital investments required to achieve universal *safely-managed* water supply, sanitation, and hygiene by 2030 amount to about three times the current investment levels.
3. Sustained universal coverage requires more than capital inflows: financial and institutional strengthening will be needed to ensure that capital investments translate into effective service delivery.

Hutton & Varughese (2016) further note that 'it is critical when choosing capital investments to take the financing of O&M costs into account'. Neglecting this may lead to poor planning of sanitation programmes and consequently poor outcomes. Peal *et al.* (2014a) and Balasubramanya *et al.* (2017) both highlight the significance of making sufficient provision to cover operational costs for sanitation services. Over the lifetime of a sanitation facility, the costs of running the service to support its operation and maintenance may constitute up to 80% of the total costs. Some contribution to O&M costs can be recovered from the users of the water and sanitation services through their monthly water and sanitation bills, but generally this does not cover the full costs. This was confirmed by GLAAS (2014): 70% of the countries included in the study reported that tariffs did not cover O&M costs, and consequently the quality and coverage of services were at risk of decline.

Benefit-cost ratios for eliminating OD and basic sanitation

Hutton (2015) investigated the benefits and costs of eliminating OD and of basic sanitation. The benefit-cost ratio (BCR) for eliminating OD in rural areas depended on the assumptions made for the latrine-pit lifespan for single-household latrines: for a one-year latrine-pit lifespan the global BCR was found to be 6.0 at discount rates of 3 and 5%, varying

from 3.9 in Sub-Saharan Africa to 33 in Oceania. However, a prudent latrine design engineer would choose a latrine-pit lifespan in rural areas of 10 years (for example, for single-pit VIP and pour-flush latrines (Mara 1984, 1985)). Taking the construction costs of Hutton's latrine with a one-year pit-lifespan as c monetary units, then his BCR of 6.0 for the latrine-pit lifespan of one year means that the benefits accruing over the one-year lifespan of the latrine are $6c$ monetary units. For a latrine with a pit-lifespan of 10 years the construction cost would be higher due to greater excavation and pit-lining costs – say, $2c$ monetary units, but the benefits would remain the same for each year of years 1–10. Assigning a (generous) 5% of construction costs for annual O&M costs, the resulting BCR for the latrine with a 10-year lifespan can be determined by discounting the annual costs (including O&M costs) and the annual benefits at rates of 3 and 5% (as used by Hutton), as follows:

$$\text{BCR} = \frac{\text{Sum of present values of future benefits in years 1–10}}{\text{Sum of present values of future costs in years 1–10}}$$

The present value (PV) of the future benefits (B_T) or costs (C_T) accrued in year T is given by:

$$\text{PV} = \frac{B_T \text{ (or } C_T)}{(1+r)^{T-1}}$$

where r is the fractional discount rate (%/100).

For a discount rate of 3% the Σ PV of the benefits is 52.7 c monetary units, and that of the costs 2.88 c . For a discount rate of 5%, these figures are 51.6 c and 2.81 c . Thus the BCR is 18.3 for the 3% discount rate and 18.4 for the 5% rate. These BCRs are 'phenomenal' (i.e. these sanitation systems are phenomenally good value) in the terminology adopted by the Copenhagen Consensus for BCRs > 15 (Lomborg 2015).

These BCR calculations are equally valid for the provision of safely-managed sanitation for those in rural areas currently with unimproved or shared sanitation and those currently practising OD. This is because Arborloos and single-pit VIP latrines and pour-flush latrines are safely-managed sanitation facilities since they safely dispose of all household excreta *in situ*.

WAYS FORWARD

Professional development of local sanitation and hygiene practitioners

One way forward is for sanitation and hygiene professionals to understand in detail the excreta-related diseases (Feachem *et al.* 1983), how sustainable sanitation and hygiene can reduce their incidence, and the technical options for low-cost sanitation and handwashing. In our experience, there are currently too few professionals in developing countries (especially at provincial/state and district levels) and too few professional consulting engineers in the development business, who know what the sanitation and hygiene options are, let alone how to design them; who know how to interact properly with low-income beneficiary communities; or know how to include the specific needs of women and girls, especially in relation to menstruation and personal safety.

SDG target #12.8 calls for the global community to 'By 2030, ensure that people everywhere have the relevant *information* and awareness for sustainable development' [emphasis added]. Thus, a key role for developing-country governments, and also for bilateral and multilateral aid agencies and NGOs, would be to end this current sanitation knowledge gap – for example, by developing training courses in local languages (including online courses where this is appropriate), and by translating key sanitation documents into these languages. This would enable local (i.e. state/provincial and district) sanitation professionals to have the information they need to work towards meeting SDG #6.2, and thus help to address the lack of sector capacity in many countries and the difficulty of recruiting and retaining sector staff (GLAAS 2014). Good sanitation planning is, of course, essential: Chattopadhyay (2015) presents a six-step approach to rural sanitation planning, and urban environmental sanitation planning is detailed in Lüthi *et al.* (2011) and Parkinson *et al.* (2014).

Safely-managed shared sanitation

A second way forward is to recognise that 'safely-managed *shared* sanitation' is the only solution in high-density

urban slums as there is often no space for individual households to have their own sanitation facility (Rheinländer *et al.* 2015; Mara 2016; Evans *et al.* 2017). Shared sanitation facilities are mostly very poorly operated and maintained, but this does not have to be the case: successful models for community-designed, -built, and -managed water and sanitation blocks exist which have demonstrated that safely-managed shared sanitation is a perfectly good sanitation system for those living in high-density slums and the homeless (Burra *et al.* 2003; Meredith *et al.* 2014). Container-based systems are also showing promise, and both solutions address some of the constraints associated with the unwillingness of landlords to make investments on behalf of tenants, a common constraint in urban slums. Given that there are currently some 881 million people living in slums (30% of the urban population in developing countries, up to 56% in Sub-Saharan Africa) (UN-Habitat 2015), we would recommend that WHO/UNICEF both revise their decision to exclude safely-managed shared sanitation and work to develop robust indicators for safe and well managed shared facilities. Without this SDG #6.2 cannot be met by 2030. Promisingly, WHO/UNICEF (2017) now accept that safely-managed shared sanitation does have a role in urban sanitation, albeit a limited one:

‘While universal use of private toilets accessible on premises remains the ultimate goal, high-quality shared sanitation facilities may be the best option in the short term in some low-income urban settings.’

No definition of ‘short term’ was given, but it may be assumed to be ‘up to (at least) 2030’.

SDG target #11.1 is to ‘By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums.’ However, ‘upgrade slums’ was not defined – does this SDG target mean that, by 2030, *all* slums be upgraded to provide ‘adequate, safe and affordable housing and basic services’? This would require that at least the current 881 million slum dwellers be upgraded, or 161,000 per day, during 2016–2030. During the MDG period 320 million slum dwellers were upgraded (United Nations 2015), or only 58,000 per day, showing that upgrading 161,000 slum dwellers per day (which does not include slum population growth

during 2016–2030) is unlikely to be achieved and that therefore slums are most likely to continue to exist after 2030.

Politically and financially smart sanitation

Finally, and despite the rather bleak numerical prospects given above for the achievement of the sanitation and hygiene target of the SDGs, developing countries and the international community need to find a way forward. Sanitation and hygiene have to be much more prominent in the political agenda of most developing countries, given that ‘there can be no solutions without political solutions’ (Feachem *et al.* 1977). A concomitant massive investment in sanitation and hygiene is required, but it should be remembered that sanitation is a ‘phenomenally’ good investment, as shown above.

The costs reported by Hutton & Varughese (2016), discussed above, have important implications for sanitation provision: do developing countries have the money for safely-managed sanitation and safely-practised hygiene, or will they opt for basic sanitation and basic hygiene as these cost much less? Our view is that in rural areas safely-managed sanitation and safely-practised hygiene is a reasonable objective (as Arborloos and single-pit VIP and pour-flush latrines, for example, provide the former, and there are low-cost options, such as the tippy-tap, to achieve the latter when combined with handwashing-promotion and education campaigns). In urban areas the costs for safely-managed sanitation are much higher, mainly due to the high costs of safe wastewater and faecal-sludge collection and treatment, although condominal sewerage with wastewater treatment can provide safely-managed sanitation at low cost (Melo 2005, 2008).

Wild *et al.* (2015) argue for a radically new approach to all the SDG goals, including therefore Goal #6.2:

‘If we are to avoid reproducing the pattern of uneven progress that has characterised the MDG campaign, there must be more explicit recognition of the political conditions that sometimes enable, but so often obstruct, development progress. In this context, domestic reformers and their international partners must pursue innovative and politically smart ways to tackle the most intractable problems.’

Sanitation is one of these ‘most intractable problems’, and sanitation and hygiene professionals should therefore ‘pursue innovative and politically-smart ways’ to deliver affordable and sustainable safely-managed sanitation and safely-practised hygiene to the urban and rural poor, including the massive reduction in open defecation, required to meet SDG #6.2.

CONCLUSIONS

1. Careful examination of all the requirements of SDGs #6.2 and #6.3, and considering the very large numbers of people needing safely-managed sanitation and safely-practised hygiene by 2030, shows that achieving this goal represents an extraordinarily great Sanitation and Hygiene Challenge, as it requires $\sim 2\frac{1}{2}$ times the number who received improved sanitation per day during the 15-year period 2001–2015 to be served with basic sanitation, and similarly large numbers to be served with safely-practised hygiene, during 2016–2030.
2. Inclusion of the numbers of people served by sewerage systems but whose wastewater is not treated, and of those served by on-site sanitation systems but whose faecal sludge is not safely collected and treated, while welcome, renders the target of safely-managed sanitation for all by 2030 much more difficult to attain, as it requires ~ 4 times the number who received improved sanitation per day during the 15-year period 2001–2015 to be served with safely-managed sanitation.
3. The ending of open defecation by 2030, whilst clearly an extremely laudable part of SDG #6.2, will be impossible to achieve without a huge step-change in the rate of success. The number of current and expected open defecators is simply too large, given that ending open defecation requires not only the provision of fixed-point, preferably household-level, sanitation facilities, but also a detailed understanding of local sociocultural defecation practices and preferences, and a sufficient number of local experienced sociocultural professionals and sanitation engineers to work with communities practising open defecation, concomitantly with large-scale social campaigns undertaken by national or state/

provincial governments, and access to subsidies and microcredit.

4. Safely-managed shared sanitation must be recognised as acceptable to enable slum dwellers to have access to a very good sanitation system.
5. If there is to be any chance of Safely-managed Sanitation and Safely-practised Hygiene for All (including no open defecation) by 2030, all sanitation professionals, and especially those at the local level, need to understand in detail the excreta-related diseases, how sustainable sanitation and hygiene can reduce their incidences and prevalences, and all the technical options for low-cost sanitation (including faecal-sludge and wastewater treatment) and hygiene, and how to choose between them and design them. They also need to understand the essentials of good sanitation and hygiene planning and implementation, including for safely-managed shared sanitation, and how to design and implement user education programmes to ensure sustained correct usage of their sanitation and hygiene facilities. All the information required for these activities must be readily available to them in their own languages. Bilateral and multilateral agencies must work with governments and domestic NGOs to produce novel ways that are locally appropriate in the quest for Safely-managed Sanitation and Hygiene for All by 2030.
6. Notwithstanding these huge challenges, SDGs #6.2 and #6.3 are central to the global development agenda since, as noted by *The Lancet* (2007) at the head of this paper, ‘adequate sanitation is the most effective public-health intervention that the international community has at its disposal’.

REFERENCES

- Abiye, T. A., Sulieman, H. & Ayalew, M. 2009 *Use of treated wastewater for managed aquifer recharge in highly populated urban centers: a case study in Addis Ababa, Ethiopia*. *Environ. Geol.* **58** (1), 55–59.
- Abraham, B., Fogde, M., von Muench, E. & Wendland, C. 2012 *Sustainable Sanitation for Schools*. Sustainable Sanitation Alliance, Deutsche Gesellschaft für Internationale Zusammenarbeit, Eschborn.
- Adams, J., Bartram, J., Chartier, C. & Sims, J. 2009 *Water, Sanitation and Hygiene Standards for Schools in Low-Cost Settings*. World Health Organization, Geneva.

- Afrane, S. K. & Adjei-Poku, B. 2013 Expanding the frontiers of microfinance in the service of the poor: experiment with water and sanitation. *Int. J. Academic Res. Business Social Sci.* 3 (8), 129–141.
- Alwan, A. 2015 *The Cost of War (WHO Commentary)*. World Health Organization, Geneva. Available from: www.who.int/mediacentre/commentaries/war-cost/en/ (accessed 18 December 2015).
- Andrés, L. A., Briceño, B., Chase, C. & Echenique, J. A. 2014 *Sanitation and Externalities: Evidence From Early Childhood Health in Rural India (Policy Research Working Paper No. 6737)*. World Bank, Washington, DC.
- Asian Development Bank 2009 *Sanitation in India: Progress, Differentials, Correlates, and Challenges*. Asian Development Bank, Manila.
- Augsburg, B. & Rodríguez-Lesmes, P. 2015 *Sanitation and Child Health in India (IFS Working Paper W15/32)*. Institute for Fiscal Studies, London.
- Augsburg, B., Caeyers, B. & Oteiza, F. 2015 *The Costs and Benefits of Investing in a Toilet: Views From Indian and Nigerian Households and Their Policy Implications*. Institute for Fiscal Studies, London.
- Balasubramanya, S., Evans, B., Hardy, R., Ahmed, R., Habib, A., Asad, N. S. M., Rahman, M., Hasan, M., Dey, D., Fletcher, L., Camargo-Valero, M. A., Rao, K. C. & Fernando, S. 2017 *Towards sustainable sanitation management: establishing the costs and willingness to pay for emptying and transporting sludge in rural districts with high rates of access to latrines*. *PLoS ONE* 12 (3), e0171735.
- Baum, R., Luh, J. & Bartram, J. 2013 *Sanitation: a global estimate of sewerage connections without treatment and the resulting impact on MDG progress*. *Environ. Sci. Technol.* 47 (4), 1994–2000.
- Bhalla, N. 2014 *Teen Girls Gang-Raped and Hanged from a Tree—Police*. Thomson Reuters Foundation, New Delhi. Available from: <http://in.reuters.com/article/uk-india-killings-idINKBN0E91AI20140529> (accessed 6 February 2016).
- Burra, S., Patel, S. & Kerr, T. 2003 *Community-designed, built and managed toilet blocks in Indian cities*. *Environ. Urban.* 15 (2), 11–32.
- Cairncross, S. 2004 *The Case for Marketing Sanitation*. Water and Sanitation Program, World Bank, Washington, DC.
- Chase, C. & Do, Q.-T. 2012 *Handwashing Behavior Change at Scale: Evidence From a Randomized Evaluation in Vietnam (Policy Research Working Paper No. 6207)*. World Bank, Washington, DC.
- Chase, C. & Ngunjiri, F. M. 2016 *Multisectoral Approaches to Improving Nutrition: Water, Sanitation, and Hygiene*. Water and Sanitation Program, World Bank, Washington, DC.
- Chattopadhyay, S. 2015 *Six Steps to a Successful Sanitation Campaign. People, Spaces, Deliberation*. World Bank, Washington, DC. Available from: <http://blogs.worldbank.org/publicsphere/print/six-steps-successful-sanitation-campaign> (accessed 19 December 2015).
- Clasen, T., Boisson, S., Routray, P., Torondel, B., Bell, M., Cumming, O., Ensink, J., Freeman, M., Jenkins, M., Odagiri, M., Ray, S., Sinha, A., Suar, M. & Schmidt, W.-P. 2014 *Effectiveness of a rural sanitation programme on diarrhoea, soil-transmitted helminth infection, and child malnutrition in Odisha, India: a cluster-randomised trial*. *Lancet Global Health* 2 (11), e645–e653. doi: 10.1016/S2214-109X(14)70307-9.
- Corcoran, E., Nellesmann, C., Baker, E., Bos, R., Osborn, D. & Savelli, H. 2010 *Sick Water? The Central Role of Wastewater Management in Sustainable Development: A Rapid Response Assessment*. United Nations Human Settlements Programme, Nairobi.
- Devine, J. & Kullmann, C. 2011 *Introductory Guide to Sanitation Marketing*. Water and Sanitation Program, World Bank, Washington, DC.
- Evans, B., van der Voorden, C. & Peal, A. 2009 *Public Funding for Sanitation: The Many Faces of Sanitation Subsidies*. Water Supply & Sanitation Collaborative Council, Geneva.
- Evans, B., Hueso, A., Johnston, R., Norman, G., Pérez, E., Slaymaker, T. & Trémolet, S. 2017 *Limited services? The role of shared sanitation in the 2030 agenda for sustainable development*. *J. Water Sanit. Hyg. Dev.* 7 (3), 349–351.
- Feachem, R., McGarry, M. & Mara, D. 1977 *Water, Wastes and Health in Hot Climates*. John Wiley & Sons, Chichester.
- Feachem, R., Bradley, D., Garlick, H. & Mara, D. 1983 *Sanitation and Disease: Health Implications of Excreta and Wastewater Management*. John Wiley & Sons, Chichester.
- Freeman, M. C., Stocks, M. E., Cumming, O., Jeandron, A., Higgins, J. P. T., Wolf, J., Prüss-Ustün, A., Bonjour, S., Hunter, P. R., Fewtrell, L. & Curtis, V. 2014 *Hygiene and health: systematic review of handwashing practices worldwide and update of health effects*. *Trop. Med. Int. Health* 19, 906–916.
- Frost, B. 2014 *Toilets can't end the violence - but are part of the solution*. WaterAid, London. <http://www.wateraid.org/uk/news/news/toilets-cant-end-the-violence-but-are-part-of-the-solution> (accessed 6 February 2016).
- Galiani, S., Gertler, P. & Orsola-Vidal, A. 2012 *Promoting Handwashing Behavior in Peru: The Effect of Large-Scale Mass-Media and Community Level Interventions (Policy Research Working Paper No. 6257)*. World Bank, Washington, DC.
- GLAAS 2014 *Investing in Water and Sanitation: Increasing Access, Reducing Inequalities*. UN-Water Global Analysis and Assessment of Sanitation and Drinking-water, World Health Organization, Geneva.
- Gosling, L., Irvine, C., Schechtman, L. & Velleman, Y. 2015 *Nowhere to Go: How a Lack of Safe Toilets Threatens to Increase Violence Against Women in Slums*. WaterAid Sverige, Stockholm.
- Hathi, P., Haque, S., Pant, L., Coffey, D. & Spears, D. 2014 *Place and Child Health: The Interaction of Population Density and Sanitation in Developing Countries (Policy Research Working Paper No. 7124)*. World Bank, Washington, DC.
- House, S., Mahon, T. & Cavill, S. 2012 *Menstrual Hygiene Matters: A Resource for Improving Menstrual Hygiene Around the World*. WaterAid, London.

- House, S., Ferron, S., Sommer, M. & Cavill, S. 2014 *Violence, Gender & WASH: A Practitioner's Toolkit – Making Water, Sanitation and Hygiene Safer Through Improved Programming and Services*. WaterAid, London and Share Research Consortium, London School of Hygiene and Tropical Medicine, London.
- Hutton, G. 2015 *Benefits and Costs of the Water, Sanitation and Hygiene Targets for the Post-2015 Development Agenda*. Copenhagen Consensus Center, Lowell, MA.
- Hutton, G. & Varughese, M. 2016 *The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation, and Hygiene*. Water and Sanitation Program, World Bank, Washington, DC.
- IHME 2017 *GBD [Global Burden of Disease] Compare 2017*. Institute of Health Metrics and Evaluation, University of Washington, Seattle, WA. Available from: <http://vizhub.healthdata.org/gbd-compare> (accessed 10 October 2017).
- Inter-agency Expert Group on SDG Indicators 2016 *Compilation of Metadata for the Proposed Global Indicators for the Review of the 2030 Agenda for Sustainable Development: Goal 6, Ensure Availability and Sustainable Management of Water and Sanitation for All (Updated on 31 March 2016)*. United Nations Statistics Division, New York, NY.
- Jenkins, M. W., Anand, A. R., Revell, G. & Sobsey, M. D. 2013 [Opportunities to improve domestic hygiene practices through new enabling products: a study of handwashing practices and equipment in rural Cambodia](#). *Int. Health* 5 (4), 295–301.
- Jenkins, M. W., Cumming, O., Scott, B. & Cairncross, S. 2014 [Beyond 'improved' towards 'safe and sustainable' urban sanitation: assessing the design, management and functionality of sanitation in poor communities of Dar es Salaam, Tanzania](#). *J. Water Sanit. Hyg. Dev.* 4 (1), 131–140.
- Jiménez, A., Cortobius, M. & Kjellén, M. 2014 [Water, sanitation and hygiene and indigenous peoples: a review of the literature](#). *Water Int.* 39 (3), 277–293.
- JMP 2011 *A Snapshot of Sanitation in South Asia with a Focus on Inequities*. WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, World Health Organization, Geneva.
- JMP 2015a *WASH Post-2015: Proposed Indicators for Drinking Water, Sanitation and Hygiene*. WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, World Health Organization, Geneva.
- JMP 2015b *Methodological Note: Proposed Indicator Framework for Monitoring SDG Targets on Drinking-Water, Sanitation, Hygiene and Wastewater*. WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, World Health Organization, Geneva.
- JMP 2017 *WASH in the 2030 Agenda: New Global Indicators for Drinking Water, Sanitation and Hygiene*. WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, World Health Organization, Geneva.
- Jones, H. 2014 *Mainstreaming Disability and Ageing in Water, Sanitation and Hygiene Programmes: A Mapping Study Carried out for WaterAid*. WaterAid, London.
- Kar, K. & Chambers, R. 2008 *Handbook on Community-led Total Sanitation*. CLTS Knowledge Hub, Institute for Development Studies, University of Sussex, Falmer, Brighton.
- Kandel, H. 2015 *Puberty Education & Menstrual Hygiene Management* (Good Policy and Practice in Health Education Booklet No. 9). United Nations Educational, Scientific and Cultural Organization, Paris.
- Kulkarni, S., O'Reilly, K. & Bhat, S. 2015 *Sanitation Vulnerabilities: Women's Stresses and Struggles for Violence-Free Sanitation*. Share Research Consortium, London School of Hygiene and Tropical Medicine, London and Water Supply and Sanitation Collaborative Council, Geneva.
- Lawson, N. & Spears, D. 2014 *What Doesn't Kill You Makes You Poorer: Adult Wages and the Early-Life Disease Environment in India (Policy Research Working Paper No. WPS 7121)*. World Bank, Washington, DC.
- Ledgerwood, J., Earne, J. & Nelson, C. 2013 *The New Microfinance Handbook: A Financial Market System Perspective*. World Bank, Washington, DC.
- Lennon, S. 2011 *Fear and Anger: Perceptions of Risks Related to Sexual Violence Against Women Linked to Water and Sanitation in Delhi, India*. Share Research Consortium, London School of Hygiene and Tropical Medicine, London.
- Lomborg, B. 2015 *The Nobel Laureates' Guide to the Smartest Targets for the World: 2016–2030*. Copenhagen Consensus Center, Lowell, MA.
- Luh, J., Royster, S., Sebastian, D., Ojomo, E. & Bartram, J. 2017 [Expert assessment of the resilience of drinking water and sanitation systems to climate-related hazards](#). *Sci. Total Environ.* 592, 334–344.
- Lüthi, C., Morel, A., Tilley, E. & Ulrich, L. 2011 *Community-led Urban Environmental Sanitation (CLUES)*. Department of Sanitation, Water and Solid Waste for Development (Sandec), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf.
- Mara, D. 1984 *The Design of Ventilated Improved Pit Latrines (TAG Technical Note No. 13)*. World Bank, Washington, DC.
- Mara, D. 1985 *The Design of Pour-Flush Latrines (TAG Technical Note No. 15)*. World Bank, Washington, DC.
- Mara, D. 2016 [Shared sanitation: to include or to exclude?](#) *Trans. R. Soc. Trop. Med. Hyg.* 110 (5), 265–267.
- Mara, D. 2017 [The elimination of open defecation and its adverse health effects: A moral imperative for governments and development professionals](#). *Journal of Water, Sanitation and Hygiene for Development* 7 (1), 112. doi: 10.2166/washdev.2017.027.
- Mekonnen, M. M. & Hoekstra, A. Y. 2016 [Four billion people facing severe water scarcity](#). *Sci. Adv.* 2 (2), e1500323.
- Melo, J. C. 2005 *The Experience of Condominial Water and Sewerage Systems in Brazil: Case Studies From Brasília, Salvador, and Parauapebas*. Water and Sanitation Program, World Bank, Washington, DC.
- Melo, J. C. 2008 *Sistema Condominial: Uma Resposta ao Desafio da Universalização do Saneamento*. Ministério das Cidades, Brasília.

- Meredith, T., MacDonald, M. & Alabaster, G. 2014 *Kibera Integrated Water Sanitation and Waste Management Project—Progress and Promise: Innovations in Slum Upgrading*. United Nations Human Settlements Programme, Nairobi.
- Modi, N. 2014 Prime Minister Narendra Modi's Speech on 68th Independence Day at Red Fort, 16 August. Available from: www.narendramodi.in/text-of-pms-speech-at-red-fort-6464 (accessed 18 January 2016).
- Moorhead, J. 2016 From widows to indigenous people: can the SDGs really leave no one behind? Global Development Professionals Network, *The Guardian*, 4 February. Available from: www.theguardian.com/global-development-professionals-network/ng-interactive/2016/feb/04/sustainable-development-goals-marginalised-people-leave-no-one-behind?CMP=ema-1702&CMP= (accessed 12 February 2016).
- Morgan, P. 2007 *Toilets That Make Compost: Low-Cost Sanitary Toilets That Produce Valuable Compost for Crops in an African Context*. EcoSanRes Programme, Stockholm Environment Institute, Stockholm.
- Morgan, P. R. & Mara, D. D. 1982 *Ventilated Improved Pit Latrines: Recent Developments in Zimbabwe (World Bank Technical Paper No. 3)*. The World Bank, Washington, DC.
- Neal, D., Vujcic, J., Burns, R., Wood, W. & Devine, J. 2016 *Nudging and Habit Change for Open Defecation: New Tactics From Behavioral Science*. Water and Sanitation Program, World Bank, Washington, DC.
- Padhi, B. K., Baker, K. K., Dutta, A., Cumming, O., Freeman, M. C., Satpathy, R., Das, B. S. & Panigrahi, P. 2015 Risk of adverse pregnancy outcomes among women practicing poor sanitation in rural India: a population-based prospective cohort study. *PLoS Med.* **12** (7), e1001851.
- Panter-Brick, C. 2002 *Street children, human rights, and public health: a critique and future directions*. *Annu. Rev. Anthropol.* **31**, 147–171.
- Parkinson, J., Lüthi, C. & Walther, D. 2014 *Sanitation21 – A Planning Framework for Improving City-Wide Sanitation Services*. International Water Association, Den Haag; Abteilung Siedlungshygiene und Wasser für Entwicklung, Eidgenössische Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz, Dübendorf; and Deutsche Gesellschaft für Internationale Zusammenarbeit. Eschborn.
- Patel, S. 2015 *The 20-year sanitation partnership of Mumbai and the Indian Alliance*. *Environ. Urban.* **27** (1), 55–72.
- Peal, A., Evans, B. E., Blackett, I., Hawkins, P. & Heymans, C. 2014a *Fecal sludge management: a comparative assessment of 12 cities*. *J. Water Sanit. Hyg. Dev.* **4**, 563–575.
- Peal, A., Evans, B. E., Blackett, I., Hawkins, P. & Heymans, C. 2014b *Fecal sludge management: analytical tools for assessing FSM in cities*. *J. Water Sanit. Hyg. Dev.* **4**, 371–383.
- PSI 2016 *Menstrual Hygiene Management*. Population Services International, Washington, DC.
- Rama, M., Béteille, T., Li, Y., Mitra, P. K. & Newman, J. L. 2015 *Addressing Inequality in South Asia*. World Bank, Washington, DC.
- Rheinländer, T., Konradsen, F., Keraita, B., Apoya, P. & Gyapong, M. 2015 *Redefining shared sanitation*. *Bull. World Health Organ.* **93**, 509–510.
- Ross, I., Scott, R., Blackett, I. C. & Hawkins, P. M. 2016 *World: Fecal Sludge Management: Diagnostics and Guidelines for Service Delivery in Poor Urban Areas—Summary Report*. Water and Sanitation Program, World Bank, Washington, DC.
- Sahoo, K. C., Hulland, K. R. S., Caruso, B. A., Swain, R., Freeman, M. C., Panigrahi, P. & Dreibelbis, R. 2015 *Sanitation-related psychosocial stress: a grounded theory study of women across the life-course in Odisha, India*. *Soc. Sci. Med.* **139**, 80–89.
- Sinnatamby, G., McGarry, M. & Mara, D. 1985 Sewerage: shallow systems offer hope to slums. *World Water* **9** (1), 39–41.
- Sommer, M., Ferron, S., Cavill, S. & House, S. 2014 *Violence, gender and WASH: Spurring action on a complex, under-documented and sensitive topic*. *Environ. Urban.* **27** (1), 105–116.
- Spears, D. 2011 *Height and Cognitive Achievement among Indian Children (Working Paper No. 1)*. RICE Institute, Amston, CT.
- Spears, D., Ghosh, A. & Cumming, O. 2013 *Open defecation and childhood stunting in India: an ecological analysis of new data from 112 Districts*. *PLoS One* **8** (9), e73784.
- Strande, L., Ronteltap, M. & Brdjanovic, D. 2014 *Faecal Sludge Management: Systems Approach for Implementation and Operation*. IWA Publishing, London.
- The Lancet* 2007 Access to toilets for all. *The Lancet* **370**, 1590.
- Tkachuk, B. & Walmsley, R. 2001 *World Prison Population: Facts, Trends and Solutions (HEUNI Paper No. 15)*. The European Institute for Crime Prevention and Control, Helsinki.
- UNDESA 2012a *World Urbanization Prospects: The 2011 Revision – Highlights*. United Nations Department of Economic and Social Affairs, Population Division, New York, NY.
- UNDESA 2012b *International Recommendations for Water Statistics (Statistical Papers Series M, No. 91)*. Statistics Division, Department of Economic and Social Affairs, United Nations, New York, NY.
- UNDESA 2015 *World Urbanization Prospects: The 2015 Revision – Volume I: Comprehensive Tables (Report No. ST/ESA/SER.A/379)*. United Nations Department of Economic and Social Affairs, Population Division, New York, NY.
- UNEP 2004 *Guidelines on Municipal Wastewater Management: A Practical Guide for Decision-Makers and Professionals on How to Plan, Design, and Finance Appropriate and Environmentally Sound Municipal Wastewater Discharge Systems, Version 3*. Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, United Nations Environment Programme, The Hague.
- UNESCO & UNSD 2011 *Monitoring Framework for Water: The System of Environmental-Economic Accounts for Water (SEEA-Water) and the International Recommendations for Water Statistics (IRWS)*. United Nations World Water Assessment Programme, Office for Global Water

- Assessment, Division of Water Sciences, United Nations Educational, Scientific and Cultural Organization, Perugia, and United Nations Statistical Commission, Department of Economic and Social Affairs, United Nations, New York, NY.
- UN-Habitat 2015 *Slum Almanac 2015–2016: Tracking Improvement in the Lives of Slum Dwellers*. United Nations Human Settlements Programme, Nairobi.
- UNHCR 2017 *Global Trends: Forced Displacement in 2016*. United Nations High Commissioner for Refugees, Geneva.
- United Nations 2015 *The Millennium Development Goals Report 2015*. United Nations, New York, NY.
- United Nations Economic and Social Council 2017 *Progress Towards the Sustainable Development Goals: Report of the Secretary-General (Document No. E/2017/66, 7 June)*. United Nations, New York, NY.
- United Nations General Assembly 2015a *Transforming our World: The 2030 Agenda for Sustainable Development (Document A/RES/70/1, 25 September)*. United Nations, New York, NY.
- United Nations General Assembly 2015b *The Human Rights to Safe Drinking Water and Sanitation (Document A/C.3/70/L.55/Rev.1, 18 November)*. United Nations, New York, NY.
- UNSC 2016a *Report of the Inter-Agency Expert Group on Sustainable Development Goal Indicators (Document No. E/CN.3/2016/2/Rev.1, 29 February)*. United Nations Statistical Commission, Department of Economic and Social Affairs, United Nations, New York, NY.
- UNSC 2016b *Provisional Proposed Tiers for Global SDG Indicators as of March 24, 2016*. United Nations Statistical Commission, Department of Economic and Social Affairs, United Nations, New York, NY. Available from: <http://unstats.un.org/sdgs/files/meetings/iaeg-sdgs-meeting-03/Provisional-Proposed-Tiers-for-SDG-Indicators-24-03-16.pdf> (accessed 22 June 2016).
- UN-Water 2014 *Over 80% of Wastewater is not Collected or Treated Worldwide*. UN-Water, Paris. Available from: www.unwater.org/statistics/statistics-detail/en/c/211793/ (accessed 14 February 2016).
- Van de Lande, L. 2015 *Eliminating Discrimination and Inequalities in Access to Water and Sanitation*. UN-Water, Paris.
- van Rooyen, L. & Hartell, C. G. 2002 Health of the street child: the relation between life-style, immunity and HIV/AIDS – A synergy of research. *S. Afr. J. Educ.* **22** (3), 188–192.
- Vujcic, J. & Ram, P. K. 2013 *Handwashing Promotion: Monitoring and Evaluation Module*. United Nations Children's Fund, New York, NY.
- Wang, H., Wang, T., Zhang, B., Li, F., Toure, B., Omosa, I. B., Chiramba, T., Abdel-Monem, M. & Pradhan, M. 2014 *Water and wastewater treatment in Africa – current practices and challenges*. *Clean Soil Air Water* **42** (8), 1029–1035.
- WASH Advocates 2015 *Water, Sanitation, and Hygiene and Menstrual Hygiene Management: A Resource Guide*. WASH Advocates, Washington, DC.
- Wendland, C., Rieck, C., Roenitzsch, S. & van Epps, A. 2014 *Making WASH in Schools More Sustainable*. Sustainable Sanitation Alliance, Deutsche Gesellschaft für Internationale Zusammenarbeit, Eschborn.
- WHO 2006a *Guidelines for the Safe Use of Wastewater, Excreta and Greywater: Volume 2, Wastewater Use in Agriculture*. World Health Organization, Geneva.
- WHO 2006b *Guidelines for the Safe Use of Wastewater, Excreta and Greywater: Volume 3, Wastewater and Excreta Use in Aquaculture*. World Health Organization, Geneva.
- WHO 2006c *Guidelines for the Safe Use of Wastewater, Excreta and Greywater: Volume 4, Excreta and Greywater Use in Agriculture*. World Health Organization, Geneva.
- WHO/UNICEF 2015 *Progress on Sanitation and Drinking-Water–2015 Update and MDG Assessment*. World Health Organization, Geneva.
- WHO/UNICEF 2017 *Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines*. World Health Organization, Geneva.
- Wild, L., Booth, D., Cummings, C., Foresti, M. & Wales, J. 2015 *Adapting Development: Improving Services to the Poor*. Overseas Development Institute, London.
- WIN-SA 2005 *eThekweni's Water & Sanitation Programme*. Water Information Network–South Africa, Pretoria.
- World Bank 2013 *East Asia and the Pacific Region Urban Sanitation Review: A Call for Action*. World Bank, Washington, DC.
- World Bank 2015 *Sanitation Overview*. World Bank, Washington, DC. Available from: www.worldbank.org/en/topic/sanitation/overview (accessed 30 June 2016).
- WSP 2016 *Fecal Sludge Management Tools*. Water and Sanitation Program, World Bank, Washington, DC. Available from: www.worldbank.org/en/topic/sanitation/brief/fecal-sludge-management-tools (accessed 1 July 2016).
- WSSCC & FANSA 2016 *Leave No One Behind: Voices of Women, Adolescent Girls, Elderly, Persons with Disabilities, and Sanitation Workforce*. Water Supply and Sanitation Collaborative Council, Geneva, and Freshwater Action Network South Asia, Hyderabad.

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